Arrowhead Villas MSC Storage Tank Improvements Draft Drainage Study

APN: 0332-094-32-00
CUP Application No.: P201900072

San Bernardino County, CA

October 2019

Prepared for:
Arrowhead Villas Mutual Service Company
P.O. Box 77
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Prepared by:
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San Diego, CA 92128

NV5

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FIGURES

TABLES

APPENDICES

1 INTRODUCTION

Nolte Vertical Five (NV5) has been retained by Arrowhead Villas Mutual Service Company (MSC) to perform supporting hydrologic and hydraulic analyses for the proposed Storage Tank Improvements Project (Project). The proposed Project entails the construction of two bolted steel water storage tanks at a site that previously contained two water storage tanks. The site is located west of the intersection of Sycamore Drive and Altamont Court, north of the existing storage tank and Sycamore Street, and south of Altamont Court. Refer to **Figure 1** and **Figure 2** for the Project's Location and Vicinity Maps, respectively. In its existing conditions, the project site consists of a pump house and concrete foundation, gate and fence posts, and above- and below-ground piping and appurtenances. These existing structures will be removed prior to the construction of the proposed improvements.

This report has been prepared in accordance with the methodology presented within the San Bernardino Hydrology Manual (dated August 1986). To this end, the 100-year design storm event was used to quantify the hydrologic impacts of the project under existing and proposed conditions. The following sections discuss the comprehensive analysis in further detail.

The Project area lies within the San Bernardino National Forest within FEMA Flood Insurance Rate Map (FIRM) Panel 06071C7956H, with an effective date of August 28, 2008. The project is located within a FEMA designated "other flood areas" Zone D which is an area "which flood hazards are undetermined, but possible". Please refer to **Exhibit 1**, FIRMette Map, in **Appendix A**.

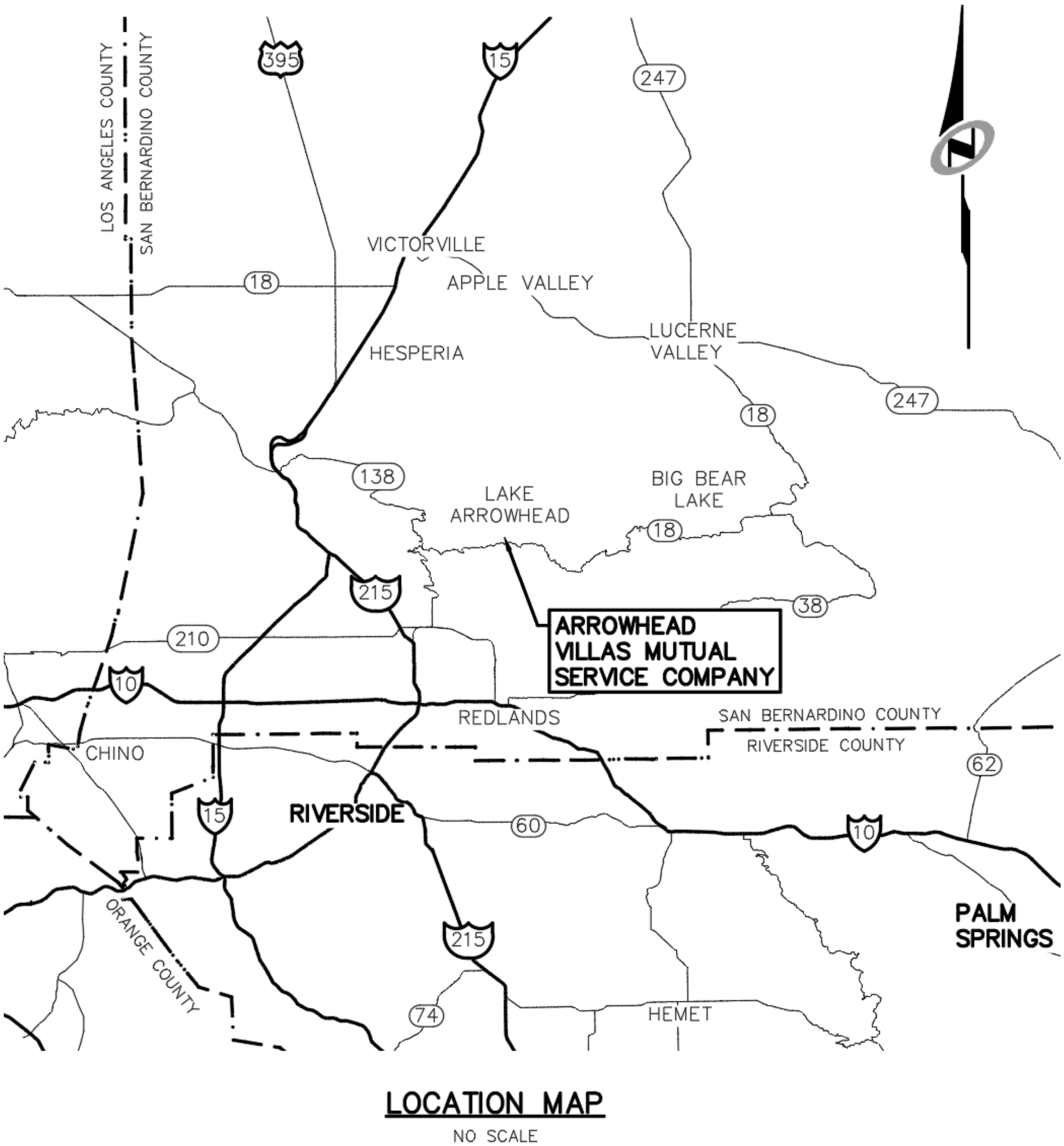


Figure 1. Location Map

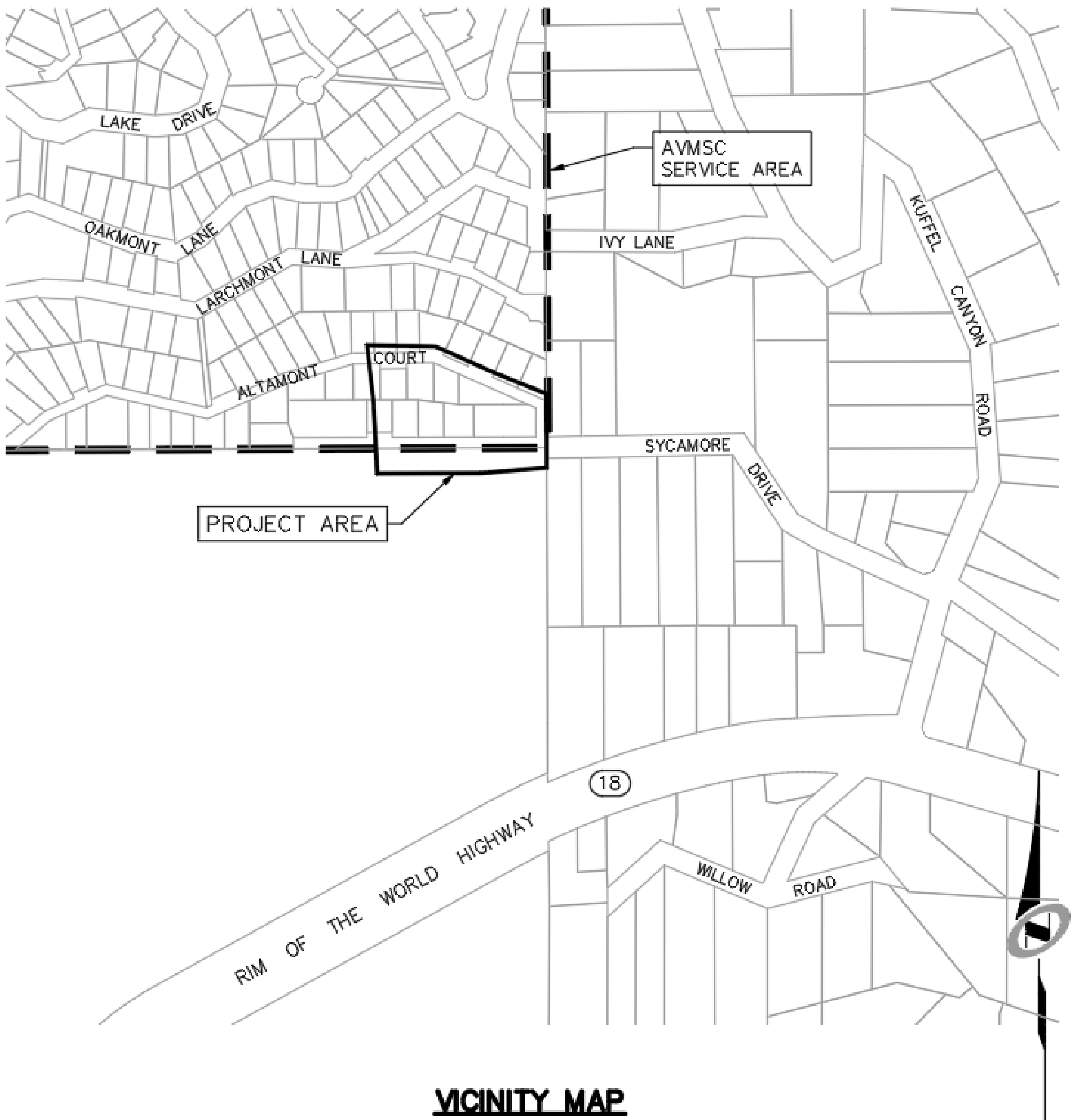


Figure 2. Vicinity Map

2 EXISTING AND PROPOSED DRAINAGE PATTERNS AND IMPROVEMENTS

The following sections provide descriptions of the existing and proposed drainage patterns and improvements for the Project.

2.1 Existing Drainage Patterns

The Project site's watershed consists of one drainage basin, Basin 100, and is comprised of three sub-basins totaling approximately 0.40 acres. The land cover for the watershed is comprised of trees, asphalt, and natural ground with an average slope of 0.22 ft/ft. The Project on-site area, Sub-Basin 102, consists of a pump house and concrete foundation, gate and fence posts, and above- and below-ground piping and appurtenances. The total impervious area for the watershed is approximately 1,023 sq.ft. which includes a portion of Sycamore Drive. The storm water runoff generated from the upgradient off-site area, Sub-Basin 104, will flow north onto the project site area as sheet flow and combine with the on-site runoff. Runoff will continue northward down a slope through Sub-Basin 100 onto Altamont Court. These flows eventually reach Lake Arrowhead, approximately 0.9 miles downstream, which is part of the Deep Creek Watershed within the Mojave Hydrologic Unit (HU). Refer to **Exhibit 2** for the existing conditions drainage map included in **Appendix A**.

2.2 Proposed Drainage Patterns and Improvements

Proposed Project improvements consists of the construction of two bolted steel water storage tanks at a site that previously contained two water storage tanks. The redevelopment activities will take place in the project site area, Sub-Basin 102. The proposed condition watershed is approximately 0.4 acres in size and will maintain the existing drainage patterns. Storm water runoff generated in Sub-Basin 104 will continue to drain onto the project site area where it will combine with the runoff generated in Sub-Basin 102 and sheet flow northward down the slope onto Altamont Court. Refer to **Exhibit 3** for the proposed conditions drainage map included in **Appendix A**. Conservatively, this drainage study assumed ultimate build-out conditions which includes both steel water storage tanks. The total impervious area for the project's watershed is approximately 3,097 sq.ft. in the ultimate build-out conditions.

3 HYDROLOGIC CRITERIA, METHODOLOGY, AND RESULTS

3.1 Hydrologic Criteria

The drainage basins were delineated using available topography (NV5, 2015) and the proposed grading layout for the project. **Table 1** summarizes the key hydrology assumptions and criteria used for the hydrologic modeling.

Table 1. Hydrology Criteria

Existing and Proposed Hydrology Design Strom:	100-Year Storm Frequency
Soil Type:	Hydrologic Soil Group Type "A" (1986 San Bernardino Hydrology Manual. Figure C-11, Hydrologic Soils Group Map for Southcentral Area.).
Land Use/Runoff Coefficients:	The project site previously consisted of a potable water storage tank but now is currently vacant. The Project proposes construction of two storage tanks. The runoff coefficients for the analysis were based on impervious percentages.
Rainfall Intensity:	Based on intensity-duration-frequency relationships (Figures B-3 and B4) presented in the 1986 San Bernardino Hydrology Manual.
Topography:	The horizontal datum used was the North American Datum (NAD) 1983 and the vertical datum was the North American Vertical Datum (NAVD) 1988.

3.2 Hydrologic Methodology

The hydrologic methodology for the Project uses the Modified Rational Method to determine the storm flows for the design of the storm drain improvements. The goal of the Project hydrologic analysis was to:

- Determine pre- and post-development storm flows for the sizing of the on-site storm drain system facilities.

- A comparative analysis was performed between the existing runoff and proposed design storm runoff at Altamont Court. For results of the analysis refer to **Appendices B and C** for the Rational Method result files. Summaries for the flows are provided in **Table 2**.

- The existing and proposed conditions hydrology models were based on the existing topography and the proposed site plan and grading for the site.

3.3 Description of Hydrologic Modeling Software

The Rational Method was used to determine the 100-year storm flow. The Advanced Engineering Software (AES) HydroWIN version 2014, Rational Method Analysis for San Bernardino County was used to perform the hydrologic calculations.

The AES Rational Method Hydrology Program is a computer-aided design program where the user develops a node-link model of the watershed. Developing independent node link models for each interior watershed and linking these sub-models together at confluence points creates the node link model. The intensity-duration-frequency relationships are applied to each of the drainage areas in the model to get the peak flow rates at each point of interest. The model follows the 1986 San Bernardino Hydrology Manual (Manual) methodology.

3.4 Hydrology Results

Project hydrology results were used to verify that the project does not adversely impact existing downstream properties.

Table 2 summarizes the runoff for existing and proposed conditions at the drainage outfall points of the project.

Table 2. Summary of Rational Method Results

Drainage Basin	Existing Condition Tributary Area	Existing Condition 100-Year Flow	Existing t_c	Proposed Condition Tributary Area	Proposed Condition 100-Year Flow	Proposed t_c
	(ac)	**(cfs)**	**(min)**	**(ac)**	**(cfs)**	**(min)**
100	0.4	3.31	6.14	0.4	3.34	6.12
Total	**0.4**	**3.31**		**0.4**	**3.34**	

Results show an increase of 0.03 cfs (0.91%) in the 100-year discharge generated from the project site between the existing and proposed conditions. The increase in flow rate can be attributed to the increased impervious area from the proposed two bolted steel water storage tanks. The average travel time in the existing and proposed conditions are 6.14 minutes and 6.12 minutes, respectively. The average travel time in the proposed condition decreased by 0.02 minutes. This minor increase in the 100-year flow will not adversely affect downstream flooding conditions.

4 CONCLUSION

This drainage report has been prepared in support of hydrologic and hydraulic analyses for the proposed Storage Tank Improvements Project. The purpose of this report is to provide peak discharges for use in comparing the existing and proposed conditions storm water discharge. There is an increase of 0.03 cfs during a 100-year storm event due to the proposed improvements. This minor increase will not adversely affect downstream flooding conditions.

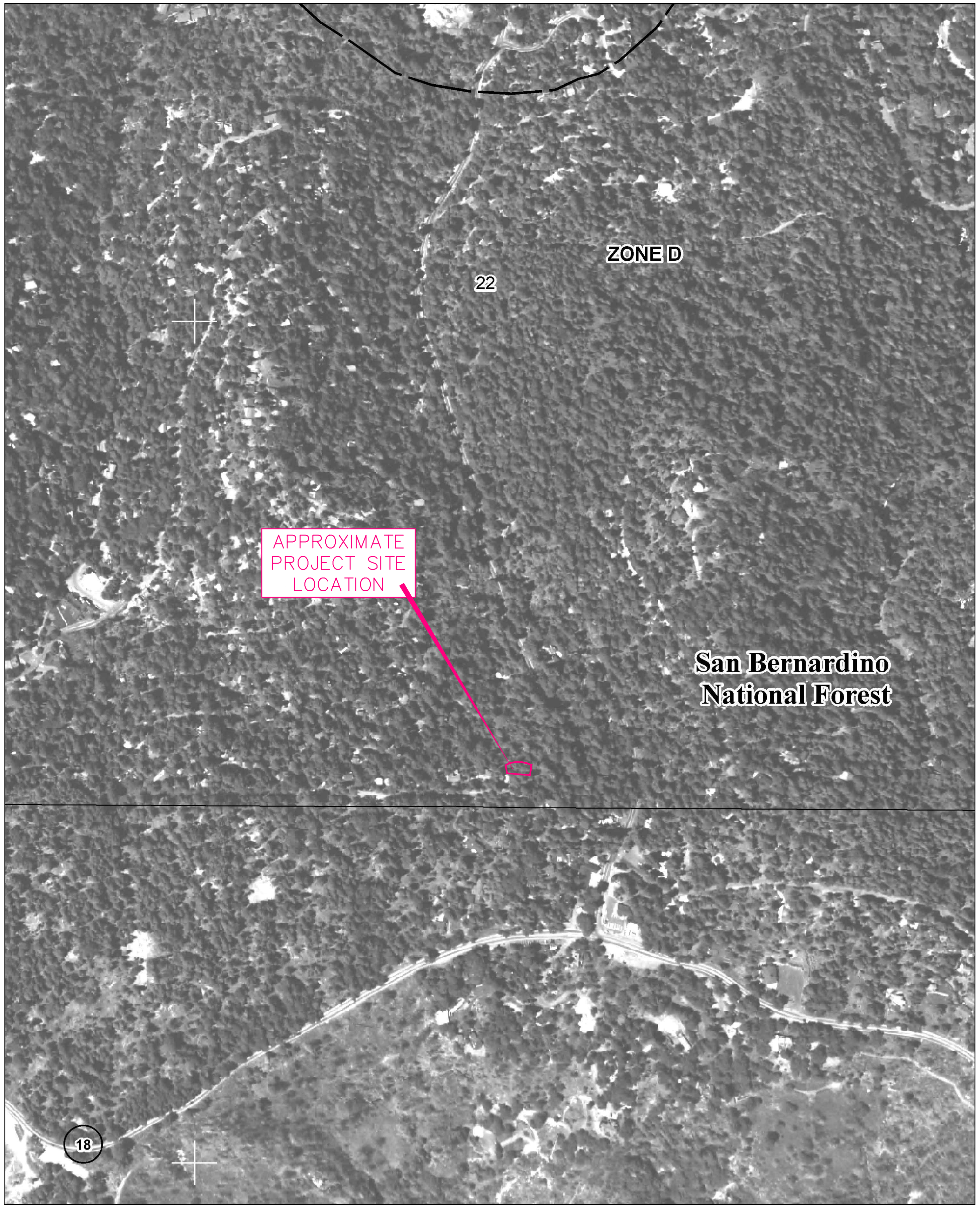
5 REFERENCES

Advanced Engineering Software, Rational Method Hydrology System Model, Version 19.0.

San Bernardino County, Hydrology Manual, August 1986.

Appendices

Appendix A
Exhibits



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X — Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X — Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D — Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% annual chance floodplain boundary

0.2% annual chance floodplain boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

~~~ 513 ~~~ Base Flood Elevation line and value; elevation in feet*

(EL 987) Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988

A—A Cross section line

23 - - - - 23 Transect line

87°07'45", 32°22'30" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere

2476000mN 1000-meter Universal Transverse Mercator grid values, zone 11N

600000 FT 5000-foot grid ticks: California State Plane coordinate system, zone V (FIPSZONE 0405), Lambert Conformal Conic projection

DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)

●M1.5 River Mile

MAP REPOSITORY
Refer to listing of Map Repositories on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
March 18, 1996

N

MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 7956H

FIRM

FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY, CALIFORNIA
AND INCORPORATED AREAS

PANEL 7956 OF 9400

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
SAN BERNARDINO COUNTY	060270	7956	H

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
06071C7956H

MAP REVISED
AUGUST 28, 2008

Federal Emergency Management Agency

SAN BERNARDINO COUNTY

ARROWHEAD VILLAS MSC

STORAGE TANK IMPROVEMENTS
FEMA FIRM PANEL 06071C7956H
EXHIBIT 1

N:\226817-0000209-00\CADD\HH\EXHIBIT 1_FEMA FIRM.DWG 10/14/2019 3:25 PM
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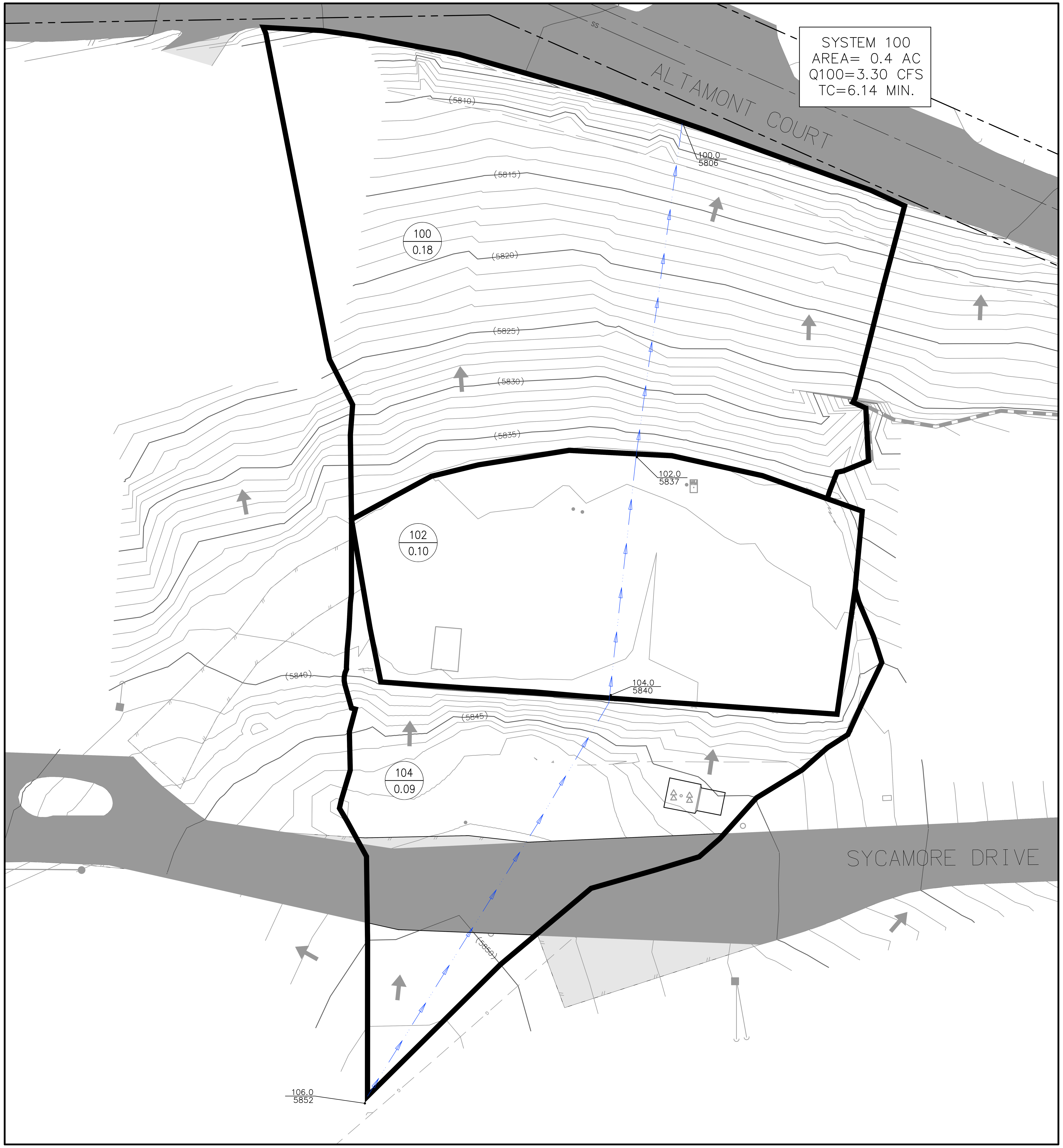


LEGEND

101 / 56.1 — BASIN I.D. / AREA (ac)

175.2 / 3520 — NODE I.D. / INVERT ELEVATION (FT)

BASIN BOUNDARY

FLOW DIRECTION

FLOW PATH

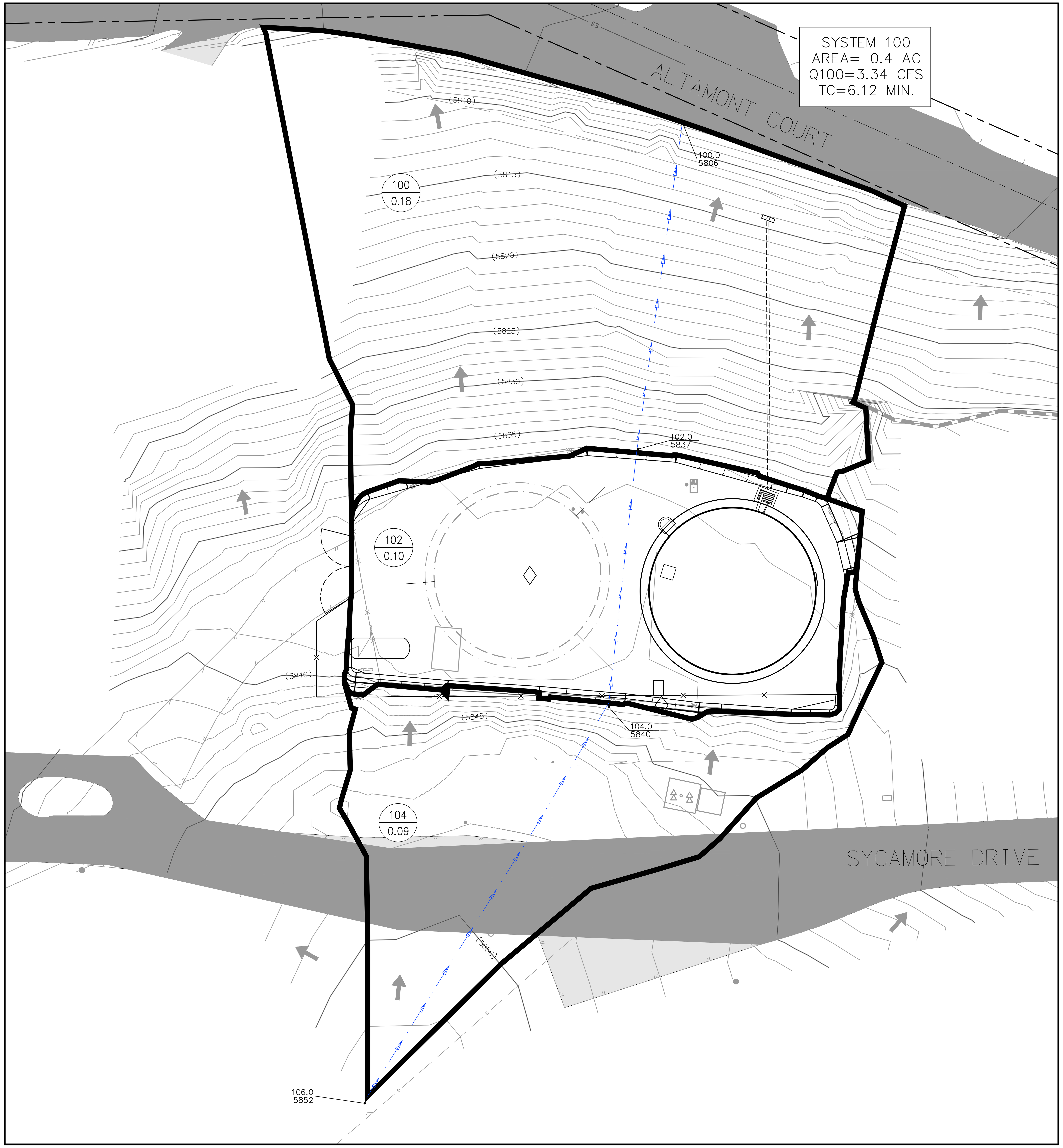
(5835) CONTOUR ELEVATION (FEET)

0' 10' 20' 30'

SCALE 1"= 10'

SCALE 1" = 10'	NV5	SAN BERNARDINO COUNTY
JOB NUMBER 226817-0000209	15092 AVENUE OF SCIENCE, SUITE 200 SAN DIEGO, CA 92128 858.385.0500 TEL 858.385.0400 FAX WWW.NV5.COM	ARROWHEAD VILLAS MSC
CREATED: 10/10/219		STORAGE TANK IMPROVEMENTS EXISTING CONDITIONS HYDROLOGY WORK MAP EXHIBIT 2

N:\226817-0000209-00\CADD\HH\EXHIBIT 2_EXISTING CONDITION HH.DWG 10/10/2019 11:56 AM



LEGEND

101	BASIN I.D.
56.1	AREA (ac)
175.2	NODE I.D.
3520	INVERT ELEVATION (FT)
	BASIN BOUNDARY
	FLOW DIRECTION
	FLOW PATH
(5835)	CONTOUR ELEVATION (FEET)

0' 10' 20' 30'
SCALE 1"= 10'

SCALE 1" = 10'	NV5	SAN BERNARDINO COUNTY
JOB NUMBER 226817-0000209	15092 AVENUE OF SCIENCE, SUITE 200 SAN DIEGO, CA 92128	ARROWHEAD VILLAS MSC
CREATED: 10/10/2019	858.385.0500 TEL 858.385.0400 FAX WWW.NV5.COM	STORAGE TANK IMPROVEMENTS PROPOSED CONDITIONS HYDROLOGY WORK MAP EXHIBIT 3

N:\226817-0000209-00\CADD\HH\EXHIBIT 3_PROPOSED CONDITION HH_TWO.DWG 10/10/2019 11:58 AM

Appendix B
Existing Condition Rational Method Results

```
****************************************************************************
          RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
       (c) Copyright 1983-2014 Advanced Engineering Software (aes)
          Ver. 21.0  Release Date: 06/01/2014  License ID 1504

                         Analysis prepared by:

                                 NV5
                      15092 Avenue of Science
                             Suite 200
                        San Diego, CA 92128

 ************************** DESCRIPTION OF STUDY **************************
* ARROWHEAD VILLAS MSC                                                     *
* EXISTING CONDITION                                                       *
* 100-YEAR STORM EVENT                                                     *
 **************************************************************************

  FILE NAME: 100EX100.DAT
  TIME/DATE OF STUDY: 10:36 10/10/2019
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  18.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*
  10-YEAR STORM 60-MINUTE INTENSITY(INCH/HOUR) =  1.500
  100-YEAR STORM 60-MINUTE INTENSITY(INCH/HOUR) =  2.150
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) = 2.1500
  SLOPE OF INTENSITY DURATION CURVE = 0.7000

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN- / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE    106.00 TO NODE    104.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =    90.00
  ELEVATION DATA: UPSTREAM(FEET) =   5852.00  DOWNSTREAM(FEET) =   5840.00
```


N:\226817-0000209-00\HH\AES\Existing**100EX100.RES**

```
  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    5.000
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) = 12.242
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 A       0.02      0.74     0.100    52    5.00
  RESIDENTIAL
  ".4 DWELLING/ACRE"         A       0.07      0.74     0.900    52    5.00
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.722
  SUBAREA RUNOFF(CFS) =      0.95
  TOTAL AREA(ACRES) =      0.09   PEAK FLOW RATE(CFS) =      0.95

****************************************************************************
  FLOW PROCESS FROM NODE    104.00 TO NODE    102.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   5840.00  DOWNSTREAM(FEET) =   5837.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =    50.00   CHANNEL SLOPE =  0.0600
  CHANNEL BASE(FEET) =   50.00   "Z" FACTOR =   1.000
  MANNING'S FACTOR = 0.025   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) = 11.093
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  RESIDENTIAL
  ".4 DWELLING/ACRE"         A       0.10      0.74     0.900    52
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.900
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      1.42
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.10
  AVERAGE FLOW DEPTH(FEET) =   0.03   TRAVEL TIME(MIN.) =   0.76
  Tc(MIN.) =    5.76
  SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.94
  EFFECTIVE AREA(ACRES) =      0.19     AREA-AVERAGED Fm(INCH/HR) =   0.61
  AREA-AVERAGED Fp(INCH/HR) =   0.74  AREA-AVERAGED Ap =   0.82
  TOTAL AREA(ACRES) =        0.2         PEAK FLOW RATE(CFS) =       1.79

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.03   FLOW VELOCITY(FEET/SEC.) =   1.30
  LONGEST FLOWPATH FROM NODE    106.00 TO NODE    102.00 =     140.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    100.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   5837.00  DOWNSTREAM(FEET) =   5806.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =    65.00   CHANNEL SLOPE =  0.4769
  CHANNEL BASE(FEET) =   50.00   "Z" FACTOR =   1.000
  MANNING'S FACTOR = 0.025   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) = 10.609
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  NATURAL GOOD COVER
  "CHAPARRAL,BROADLEAF"      A       0.18      0.76     1.000    51
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.76
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  1.000
```

```
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =       2.59
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.86
  AVERAGE FLOW DEPTH(FEET) =   0.02   TRAVEL TIME(MIN.) =   0.38
  Tc(MIN.) =    6.14
  SUBAREA AREA(ACRES) =     0.18       SUBAREA RUNOFF(CFS) =    1.60
  EFFECTIVE AREA(ACRES) =      0.37     AREA-AVERAGED Fm(INCH/HR) =   0.68
  AREA-AVERAGED Fp(INCH/HR) =   0.75  AREA-AVERAGED Ap =   0.91
  TOTAL AREA(ACRES) =        0.4         PEAK FLOW RATE(CFS) =       3.31

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.02   FLOW VELOCITY(FEET/SEC.) =   3.30
  LONGEST FLOWPATH FROM NODE    106.00 TO NODE    100.00 =     205.00 FEET.
============================================================================
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  TOTAL AREA(ACRES)     =        0.4  TC(MIN.) =      6.14
  EFFECTIVE AREA(ACRES) =      0.37  AREA-AVERAGED Fm(INCH/HR)=  0.68
  AREA-AVERAGED Fp(INCH/HR) =  0.75  AREA-AVERAGED Ap = 0.905
  PEAK FLOW RATE(CFS)   =       3.31
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

Appendix C
Proposed Condition Rational Method Results

```
____________________________________________________________________________
****************************************************************************
            RATIONAL METHOD HYDROLOGY COMPUTER PROGRAM PACKAGE
          (Reference: 1986 SAN BERNARDINO CO. HYDROLOGY CRITERION)
         (c) Copyright 1983-2014 Advanced Engineering Software (aes)
            Ver. 21.0  Release Date: 06/01/2014  License ID 1504

                          Analysis prepared by:

                                   NV5
                         15092 Avenue of Science
                                Suite 200
                           San Diego, CA 92128

 ************************** DESCRIPTION OF STUDY **************************
* ARROWHEAD VILLAS MSC                                                     *
* SYSTEM 100 - PROPOSED CONDITION                                          *
* 100-YEAR STORM EVENT                                                     *
 **************************************************************************

  FILE NAME: 100PR100.DAT
  TIME/DATE OF STUDY: 11:13 10/10/2019
============================================================================
  USER SPECIFIED HYDROLOGY AND HYDRAULIC MODEL INFORMATION:
============================================================================
                    --*TIME-OF-CONCENTRATION MODEL*--

  USER SPECIFIED STORM EVENT(YEAR) =  100.00
  SPECIFIED MINIMUM PIPE SIZE(INCH) =  18.00
  SPECIFIED PERCENT OF GRADIENTS(DECIMAL) TO USE FOR FRICTION SLOPE = 0.90
  *USER-DEFINED LOGARITHMIC INTERPOLATION USED FOR RAINFALL*
  10-YEAR STORM 60-MINUTE INTENSITY(INCH/HOUR) =  1.500
  100-YEAR STORM 60-MINUTE INTENSITY(INCH/HOUR) =  2.150
  COMPUTED RAINFALL INTENSITY DATA:
  STORM EVENT =  100.00   1-HOUR INTENSITY(INCH/HOUR) = 2.1500
  SLOPE OF INTENSITY DURATION CURVE = 0.7000

  *ANTECEDENT MOISTURE CONDITION (AMC) III ASSUMED FOR RATIONAL METHOD*

  *USER-DEFINED STREET-SECTIONS FOR COUPLED PIPEFLOW AND STREETFLOW MODEL*
     HALF-  CROWN TO   STREET-CROSSFALL:   CURB  GUTTER-GEOMETRIES:  MANNING
     WIDTH  CROSSFALL  IN- / OUT-/PARK-  HEIGHT  WIDTH  LIP   HIKE  FACTOR
NO.   (FT)     (FT)    SIDE / SIDE/ WAY    (FT)    (FT)  (FT)  (FT)    (n)
===  =====  =========  ================  ======  ===== ====== ===== =======
  1   30.0     20.0    0.018/0.018/0.020   0.67    2.00 0.0313 0.167 0.0150

  GLOBAL STREET FLOW-DEPTH CONSTRAINTS:
    1. Relative Flow-Depth =  0.00 FEET
       as (Maximum Allowable Street Flow Depth) - (Top-of-Curb)
    2. (Depth)*(Velocity) Constraint =  6.0 (FT*FT/S)
  *SIZE PIPE WITH A FLOW CAPACITY GREATER THAN
   OR EQUAL TO THE UPSTREAM TRIBUTARY PIPE.*
  *USER-SPECIFIED MINIMUM TOPOGRAPHIC SLOPE ADJUSTMENT NOT SELECTED

****************************************************************************
  FLOW PROCESS FROM NODE    106.00 TO NODE    104.00 IS CODE =  21
----------------------------------------------------------------------------
  >>>>>RATIONAL METHOD INITIAL SUBAREA ANALYSIS<<<<<
  >>USE TIME-OF-CONCENTRATION NOMOGRAPH FOR INITIAL SUBAREA<<
============================================================================
  INITIAL SUBAREA FLOW-LENGTH(FEET) =    90.00
  ELEVATION DATA: UPSTREAM(FEET) =   5852.00  DOWNSTREAM(FEET) =   5840.00
```



```
  Tc = K*[(LENGTH** 3.00)/(ELEVATION CHANGE)]**0.20
  SUBAREA ANALYSIS USED MINIMUM Tc(MIN.) =    5.000
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) = 12.242
  SUBAREA Tc AND LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS   Tc
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN  (MIN.)
  COMMERCIAL                 A       0.02      0.74     0.100    52    5.00
  RESIDENTIAL
  ".4 DWELLING/ACRE"         A       0.07      0.74     0.900    52    5.00
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.722
  SUBAREA RUNOFF(CFS) =      0.95
  TOTAL AREA(ACRES) =      0.09   PEAK FLOW RATE(CFS) =      0.95

****************************************************************************
  FLOW PROCESS FROM NODE    104.00 TO NODE    102.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   5840.00  DOWNSTREAM(FEET) =   5837.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =    50.00   CHANNEL SLOPE =  0.0600
  CHANNEL BASE(FEET) =   50.00   "Z" FACTOR =   1.000
  MANNING'S FACTOR = 0.025   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) = 11.102
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  COMMERCIAL                 A       0.05      0.74     0.100    52
  RESIDENTIAL
  ".4 DWELLING/ACRE"         A       0.05      0.74     0.900    52
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.74
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  0.500
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      1.43
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   1.11
  AVERAGE FLOW DEPTH(FEET) =   0.03   TRAVEL TIME(MIN.) =   0.75
  Tc(MIN.) =    5.75
  SUBAREA AREA(ACRES) =     0.10       SUBAREA RUNOFF(CFS) =    0.97
  EFFECTIVE AREA(ACRES) =      0.19     AREA-AVERAGED Fm(INCH/HR) =   0.45
  AREA-AVERAGED Fp(INCH/HR) =   0.74  AREA-AVERAGED Ap =   0.61
  TOTAL AREA(ACRES) =        0.2        PEAK FLOW RATE(CFS) =      1.82

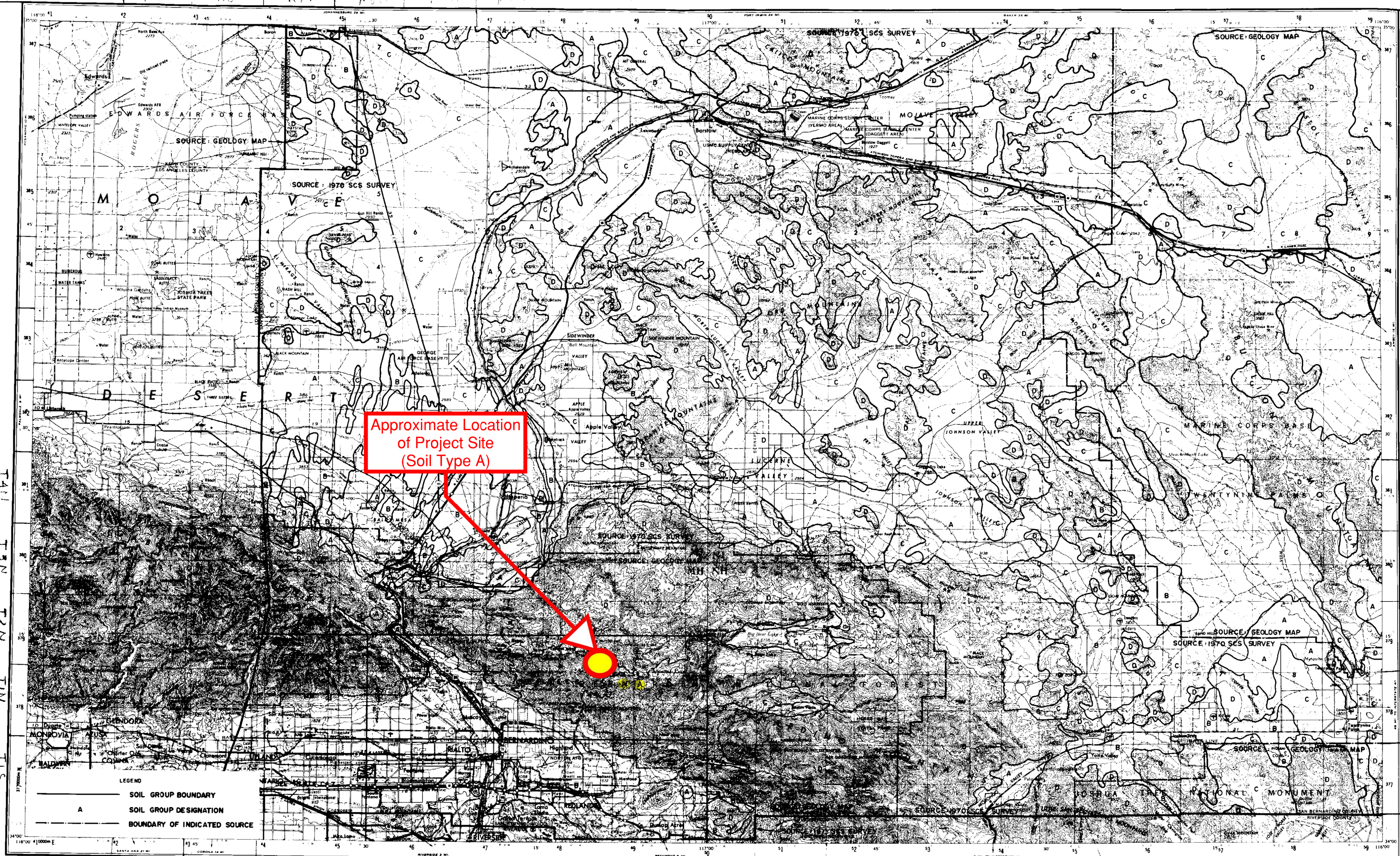
  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.03   FLOW VELOCITY(FEET/SEC.) =   1.32
  LONGEST FLOWPATH FROM NODE    106.00 TO NODE    102.00 =    140.00 FEET.

****************************************************************************
  FLOW PROCESS FROM NODE    102.00 TO NODE    100.00 IS CODE =  51
----------------------------------------------------------------------------
  >>>>>COMPUTE TRAPEZOIDAL CHANNEL FLOW<<<<<
  >>>>>TRAVELTIME THRU SUBAREA (EXISTING ELEMENT)<<<<<
============================================================================
  ELEVATION DATA: UPSTREAM(FEET) =   5837.00  DOWNSTREAM(FEET) =   5806.00
  CHANNEL LENGTH THRU SUBAREA(FEET) =    65.00   CHANNEL SLOPE =  0.4769
  CHANNEL BASE(FEET) =   50.00   "Z" FACTOR =   1.000
  MANNING'S FACTOR = 0.025   MAXIMUM DEPTH(FEET) =   2.00
  * 100 YEAR RAINFALL INTENSITY(INCH/HR) = 10.622
  SUBAREA LOSS RATE DATA(AMC III):
   DEVELOPMENT TYPE/      SCS SOIL   AREA      Fp         Ap     SCS
       LAND USE            GROUP   (ACRES)  (INCH/HR)  (DECIMAL)  CN
  NATURAL GOOD COVER
  "CHAPARRAL,BROADLEAF"      A       0.18      0.76     1.000    51
  SUBAREA AVERAGE PERVIOUS LOSS RATE, Fp(INCH/HR) =  0.76
```

```
  SUBAREA AVERAGE PERVIOUS AREA FRACTION, Ap =  1.000
  TRAVEL TIME COMPUTED USING ESTIMATED FLOW(CFS) =      2.62
  TRAVEL TIME THRU SUBAREA BASED ON VELOCITY(FEET/SEC.) =   2.89
  AVERAGE FLOW DEPTH(FEET) =   0.02   TRAVEL TIME(MIN.) =   0.37
  Tc(MIN.) =    6.12
  SUBAREA AREA(ACRES) =     0.18       SUBAREA RUNOFF(CFS) =    1.60
  EFFECTIVE AREA(ACRES) =      0.37     AREA-AVERAGED Fm(INCH/HR) =   0.60
  AREA-AVERAGED Fp(INCH/HR) =   0.75  AREA-AVERAGED Ap =   0.80
  TOTAL AREA(ACRES) =       0.4         PEAK FLOW RATE(CFS) =      3.34

  END OF SUBAREA CHANNEL FLOW HYDRAULICS:
  DEPTH(FEET) =  0.02   FLOW VELOCITY(FEET/SEC.) =   3.33
  LONGEST FLOWPATH FROM NODE    106.00 TO NODE    100.00 =     205.00 FEET.
============================================================================
  END OF STUDY SUMMARY:
  TOTAL AREA(ACRES)     =       0.4  TC(MIN.) =      6.12
  EFFECTIVE AREA(ACRES) =      0.37  AREA-AVERAGED Fm(INCH/HR)=  0.60
  AREA-AVERAGED Fp(INCH/HR) =  0.75  AREA-AVERAGED Ap = 0.797
  PEAK FLOW RATE(CFS)   =      3.34
============================================================================
============================================================================
  END OF RATIONAL METHOD ANALYSIS
```

Appendix D
Reference Materials



SAN BERNARDINO COUNTY

HYDROLOGY MANUAL

SCALE REDUCED BY 1/2

HYDROLOGIC SOILS GROUP MAP
FOR
SOUTHCENTRAL AREA

FIGURE C-11

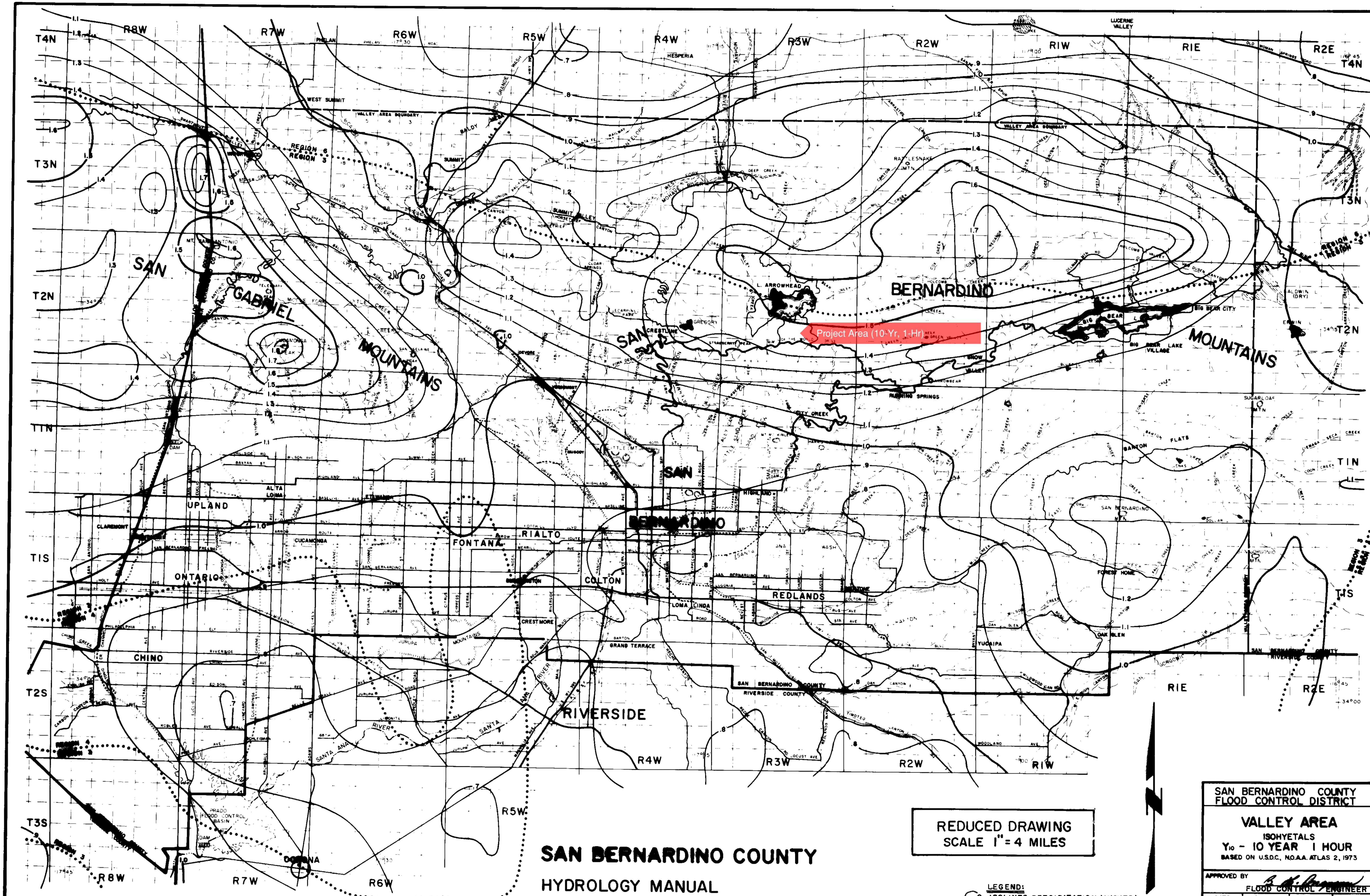
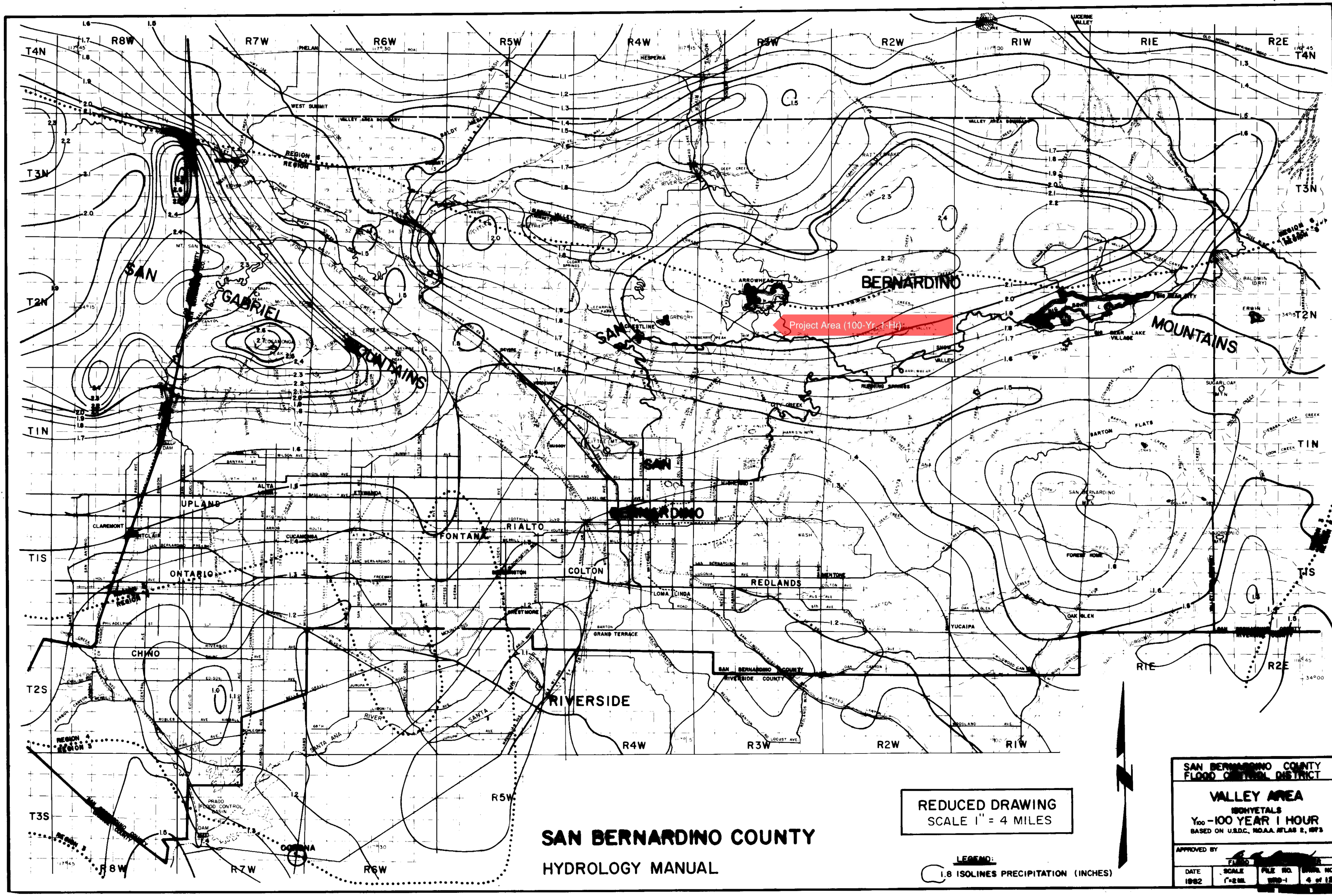

SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT
VALLEY AREA
ISOHYETALS
Y10 - 10 YEAR 1 HOUR
BASED ON U.S.D.C., N.O.A.A. ATLAS 2, 1973
APPROVED BY
FLOOD CONTROL ENGINEER
DATE 1982
SCALE 1"=2 MI.
FILE NO. WRD-1
DRWG. NO. 3 of 12
REDUCED DRAWING
SCALE 1" = 4 MILES
SAN BERNARDINO COUNTY
HYDROLOGY MANUAL
LEGEND:
.8 ISOLINES PRECIPITATION (INCHES)
Project Area (10-Yr, 1-Hr)
SAN GABRIEL MOUNTAINS
SAN BERNARDINO MOUNTAINS
UPLAND
ONTARIO
CHINO
FONTANA
RIALTO
COLTON
SAN BERNARDINO
REDLANDS
LOMA LINDA
RIVERSIDE
YUCAIPA
HESPERIA
L. ARROWHEAD
CRESTLINE
BIG BEAR CITY
BIG BEAR LAKE VILLAGE
RUNNING SPRINGS
R8W
R7W
R6W
R5W
R4W
R3W
R2W
R1W
R1E
R2E
T4N
T3N
T2N
T1N
T1S
T2S
T3S

FIGURE B-3



Project Area (100-Yr, 1-Hr)
SAN GABRIEL MOUNTAINS
SAN BERNARDINO MOUNTAINS
UPLAND
ONTARIO
CHINO
FONTANA
RIALTO
COLTON
SAN BERNARDINO
REDLANDS
LOMA LINDA
YUCAIPA
RIVERSIDE
GRAND TERRACE
CORONA
CLAREMONT
REDUCED DRAWING
SCALE 1" = 4 MILES
SAN BERNARDINO COUNTY
HYDROLOGY MANUAL
LEGEND:
1.8 ISOLINES PRECIPITATION (INCHES)
SAN BERNARDINO COUNTY FLOOD CONTROL DISTRICT
VALLEY AREA
ISOHYETALS
Y_{100} -100 YEAR 1 HOUR
BASED ON U.S.D.C., NOAA ATLAS 2, 1973
APPROVED BY
DATE 1982
SCALE 1"=2 MI.
FILE NO. WRO-1
DWG. NO. 4 of 12

FIGURE B-4