SESPE
CONSULTING, INC.

374 Poli Street, Suite 200 • Ventura, California 93001

DRAINAGE REPORT
AREA Q MINE

Vulcan Materials Company – Western Division
San Bernardino County, California

November 2019

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DRAINAGE REPORT
AREA Q MINE

Vulcan Materials Company
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DRAINAGE REPORT
AREA Q MINE

Vulcan Materials Company
San Bernardino County, California

November 2019

1.0 INTRODUCTION

CalMat Co., dba Vulcan Materials Company – Western Division (Vulcan) owns and operates the Cajon Creek Quarry, located on the northwest side of the City of San Bernardino. The Cajon Creek Quarry is currently providing high-quality aggregates (sand and gravel) to Vulcan's San Bernardino processing facility to the south. Upon depletion of the aggregate resources currently extracted from the Cajon Creek Quarry (referred to as Area L), Vulcan is proposing to relocate the mining operation to an adjacent site, referred to as Area Q. In preparation for transferring the mining operation to the adjacent site, Vulcan has submitted an application to the County of San Bernardino (County) to conduct aggregate material extraction and ancillary activities on the 196.0-acre Area Q property located adjacent to the Cajon Creek Quarry (Project).

1.1 Purpose and Scope

This report has been prepared to satisfy the County of San Bernardino hydrology requirements and the requirements of the Surface Mining and Reclamation Act (SMARA). The scope of this report is as follows:

- Identification of the tributary watershed to the Project site.
- Identification of floodplain(s) impacting the site.
- Identification and calculation of existing conditions (prior to mining activity) on-site total peak flow rates and runoff volumes.
- Calculation of final conditions (reclamation) on-site runoff volumes and pit inundation depth.
- Summary of impacts and conclusions.

Note that the existing operations at the Cajon Creek Quarry are not part of the Project and have not been evaluated in this report.

2.0 PROJECT DETAILS

2.1 Project Location

The Area Q site is located in unincorporated San Bernardino County, east of Cajon Creek and north of the community of Muscoy (Exhibit 1). The Project site is bounded by the Devil Creek Diversion Channel and residential neighborhoods to the south, the Southern Pacific Railroad (SPRR) to the west, Cajon Boulevard to the east, and Vulcan's existing Cajon Creek Quarry—specifically Area L—to the north. The Area Q site is located approximately 2.5 miles away from Vulcan's existing San Bernardino facility, which is located

directly north of State Route 210 and Highland Avenue. Nearby communities include Muscoy, the City of San Bernardino (adjacent to the east/north), and the City of Rialto (1.25 miles west).

2.2 Project Overview

Vulcan currently operates two distinct yet integrated operations adjacent to the site. Vulcan transports material from its Cajon Creek extraction site to the San Bernardino facility for processing. The Area Q Project will provide a high-quality source of local aggregate and allow for the continued operation of Vulcan's Cajon Creek and San Bernardino facilities. Aggregate material extraction and ancillary activities will occur on 182.1 acres within the Area Q property and will include:

- Mineral resource extraction activities in one (1) phase to a maximum depth of mining of 120 feet below natural ground surface (bgs). Final reclaimed slope configuration will be 2:1 (horizontal to vertical).
- Construction of a minimum 10-foot tall vegetated earthen berm along the southeastern portion of the site (along the Devil Creek Diversion Channel) using overburden and top soil from the site to extend the existing berm on Area L to the southern end of Area Q.
- Construction and operation of a conveyor system across the site, connecting with Vulcan's existing conveyor system located on the Cajon Creek site.
- Construction and maintenance of onsite roads.
- Operation of haul trucks, loaders, conveyors, and related equipment as necessary to move material from the site to the conveyor system.

2.3 Reclamation

The final, reclaimed condition of the site is a pit with a maximum depth of 120 feet bgs and final reclaimed slope configuration of 2:1 (horizontal to vertical). Revegetation of slopes and the pit bottom will be conducted by hydroseeding and planting of containerized plants. The planned end use of the site is open space.

3.0 EXISTING SETTING

3.1 Description of Existing Area Q Study Area

The Area Q Site includes several single-story residential structures houses and general storage buildings and yards. These structures will be decommissioned prior to the start of mining. The site consists of a low-lying, relatively flat area. The elevations range from approximately 1,574 feet above mean sea level (amsl) to 1,495 feet amsl. The site is located on a broad alluvial fan with a gentle southeastern slope that extends southeast from the base of the San Bernardino Mountains, and is underlain by alluvial fan deposits and older wash deposits. The general direction of the surface slope follows the trend of the Cajon Wash; the site gently slopes to the south-southeast at a gradient of approximately two percent (2%).

The general flow direction of surface water across the site is to the southeast, toward the concrete-lined flood control channel (Devil Creek Diversion Channel) on the southeastern boundary. The confluence of the Cajon Wash and Lytle Creek Wash are just east of the site. The site's western boundary is bordered by the Muscoy Groin No. 3, which has been designed to direct flows from Lytle Creek or Cajon Creek away from the site.

The existing site conditions are shown on Exhibit 1 (Attachment 1).

3.2 Lytle and Cajon Creek Watershed

Area Q lies within the greater Lytle and Cajon Creek watershed, which is located within the midsection of the San Bernardino County valley. Water bodies in the watershed include Lytle Creek, Cajon Creek, Devil Canyon Creek, Macy Storm Drain, Cable Creek, Muscoy Storm Drain, Santa Ana Reach 3 and 4. The watershed is shown in Figure 1.

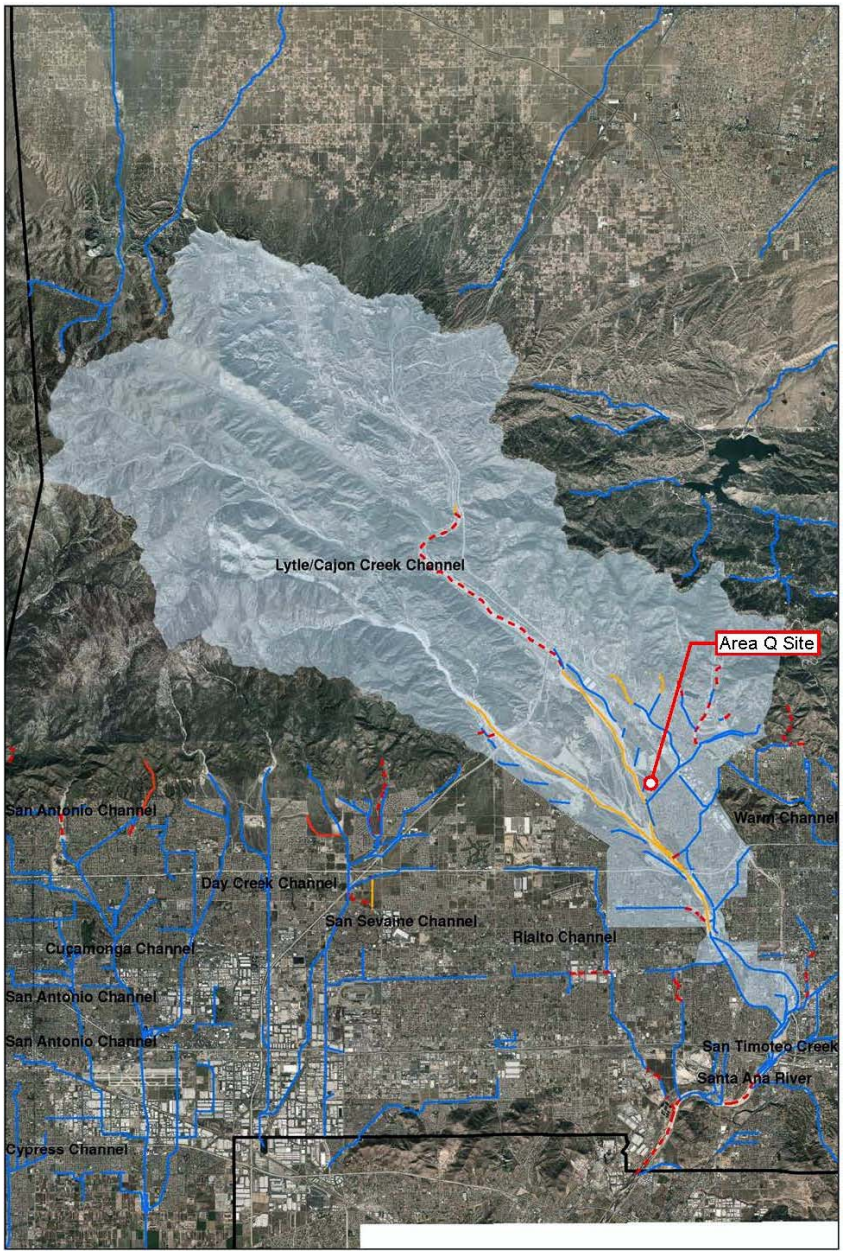


Figure 1: Lytle / Cajon Creek Watershed (source: San Bernardino County Areawide Stormwater Program, Subwatershed Fact Sheets)

3.3 FEMA Floodplain

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) No. 06071C7940J, (Effective Date - September 2, 2016), the project site is impacted by a Zone A and Zone X floodplain. The above referenced FIRM is included in Attachment 2.

Zone A is identified by FEMA as areas subject to inundation by the 1% (100-year) annual chance of flood. Zone X is identified by FEMA as areas of 0.2% (500-year) annual chance of flood; areas of 1% (100-Year) annual chance of flood with depths of less than 1 foot or areas with drainage areas less than 1 square mile; and areas protected by levees from 1% (100-year) annual chance of flood.

However, as identified in the December 26, 2018 letter from Change Consultants, "Zone A floodplain is an *approximate* 100-year floodplain… The FEMA mapping shows the floodplain extending beyond the [Devil Creek Diversion] Channel and into a portion of Area Q. [Chang Consultants] have performed research to assess the accuracy of the FEMA floodplain… 100-year and greater flows will be contained within the Channel and will have no impact on, or be impacted by, Vulcan's future operations in Area Q." The complete analysis from Chang Consultants is provided in Attachment 4.

4.0 METHODOLOGY

As identified in the San Bernardino County Hydrology Manual, the goal of the County of San Bernardino is to provide 100-year return frequency flood protection. This report analyzes the impacts of the Project during the 100-year, 1-hour and 100-year, 24-hour storm events.

The Surface Mining and Reclamation Act (SMARA) regulations require surface mining and reclamation activities to be conducted in such a way to protect both on-site and downstream beneficial uses of water. In addition, erosion and sedimentation control is necessary during all phases of construction, operation, reclamation, and final closure of the mine. Per SMARA requirements, erosion control methods on site must be designed to handle runoff from not less than the 20-year, 1-hour storm.

4.1 General Methodology

The requirements and recommendations found in the San Bernardino County Hydrology Manual were used as the basis for the methodology and calculations found in this report. On-site calculations were performed using the rational and unit hydrograph methods.

For the 20-year storm event, Antecedent Moisture Condition (AMC) II was used. For the 100-year storm event, AMC III was used. Calculations in this report were done using HydroCAD® storm water modeling software which utilizes the TR-20 methodology for watershed modeling developed by the Natural Resources Conservation Service (NRCS).

The TR-20 methodology scales a synthetic rainfall distribution based on a user provided rainfall depth. Precipitation values used in the model were obtained from National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 6, Version 2, Precipitation Frequency Data Server (PFDS). Because the NOAA PFDS does not have a 20-year, 1-hour storm precipitation estimate, the 25-year, 1-hour point precipitation frequency was used in its place.

The NRCS has developed four synthetic rainfall distributions for use in runoff modeling. The western portion of San Bernardino County is within the Type I boundary, as identified in Figure 2.

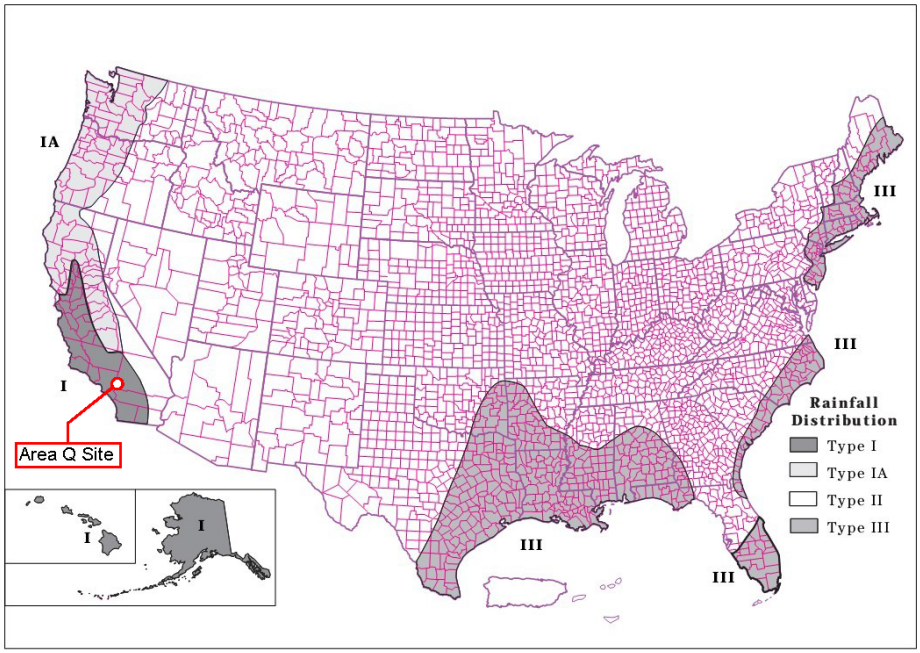


Figure 2: NRCS Synthetic Rainfall Distribution Areas

The TR-20 methodology uses curve numbers, which are parameters used to predict rainfall excess (i.e., runoff). Composite curve numbers were calculated in HydroCAD® based on the site's hydraulic soil group (HSG), the existing ground cover, and reclaimed ground cover conditions.

Time of concentrations (Tc) values, the time it takes for water to flow from the most remote part of a watershed to the outlet, were estimated using HydroCAD® and flowpath characteristics (e.g., length, slope, and groundcover). The contributing drainage area, flowpath lengths, and slope estimated were determined from topographic contours provided by Vulcan and publicly-available aerial photographs.

5.0 HYDROLOGY

The Project site is not expected to receive significant local runoff from the surrounding properties due to the existing topography and surrounding land uses. A small tributary area east of the Cajon Creek Quarry, known as Area K, is expected to contribute to on-site flows during large rain events. As described previously, Muscoy Groin No. 3 has been designed to direct flows from Cajon Creek away from the site. The Cajon Creek Quarry (i.e., Area L) to the north and Cajon Boulevard to the east direct storm flows away from the site. Historical aerial photography suggests that low to moderate rain events rarely discharge to Devil Creek Diversion Channel and are primarily captured in low areas on the site, where water naturally evaporates or infiltrates into the ground.

The mining Project will ultimately result in the reduction of runoff from the study area. A HydroCAD® model for the existing site conditions was prepared to estimate the maximum runoff flow from the site.

At the completion of mining and post-reclamation, the Project area will result in a lowered pit that will retain on-site rainfall.

Table 1: Precipitation Values

Storm Frequency	Duration	Precipitation (inches)
25-year	1-hour	1.44
100-year	1-hour	1.91
	24-hour	7.76

As identified in the analysis by Chang Consultants, the Devil Creek Diversion Channel is sized to contain flows from a 500-year event. Therefore, the 100-year and greater flows will be contained within the Channel and will have no impact on operations in Area Q.

5.1 Existing Condition

The Area Q site includes some houses and general storage buildings and yards. These structures will be decommissioned prior to the start of mining. The site consists of a low-lying, relatively flat area. The general flow direction of surface water across the site appears to be to the southeast, toward the Devil Creek Diversion Channel. The existing condition of the site is shown in Exhibit 1 (Attachment 1).

Composite curve numbers were calculated for the existing condition in HydroCAD® based on the ground cover designations in the Habitat and Jurisdictional Assessment performed by Element Consulting (May 2018) and the site's hydraulic soil group (HSG) as determined by the NRCS web soil survey. The entire site is underlain by gravelly loamy sand (HSG A) based on information gathered from the web soil survey. The existing condition land cover detail is shown in Table 2.

Table 2: Vegetation Communities/Land Cover Types, Existing Condition

Vegetation-Habitat Community / Land Cover*	Corresponding HydroCAD® Land Cover Description Selected	Area (acres)	SCS Curve Number (AMC II)
Non-native grassland	Desert shrub range, fair condition	70.2	55
Disturbed/isolated intermediate riversidean alluvial fan sage scrub	Desert shrub range, poor condition	35.3	63
Developed	Unconnected pavement	31.3	98
Disturbed	Newly graded area	25.1	77
Disturbed/isolated mature riversidean alluvial fan sage scrub	Desert shrub range, fair condition	23.1	55
Buckwheat scrub	Desert shrub range, fair condition	9.9	55
Ornamental	<50% grass cover	1.1	68
Area outside the Biologic Study Area (BSA)	Desert shrub range, poor condition	58.5	63

*As identified in the Habitat and Jurisdictional Assessment

The HydroCAD® model used for the existing site conditions assumes that drainage to Area Q is comprised of one (1) subwatershed that drains to the south toward the Devil Creek Diversion Channel via sheet flow and shallow, concentrated flows. Table 3 displays the model inputs and computed adjusted curve number,

time of concentration, peak flows, and anticipated runoff from the existing site during various storm events. HydroCAD® model output files are included in Attachment 3.

Table 3: Area Q Mine Hydrologic Data, Existing Condition

Drainage Area	Area (acres)	Storm Event	Adjusted CN*	Tc (minutes)	Peak Flow (cfs)	Total Runoff (acre-feet)
AREA Q	254.5	25-year, 1-hour	63	77.2	2.53	0.243
		100-year, 1-hour	80		104.4	10.8
		100-year, 24-hour	80		369.6	114.5

* The adjusted CN is the weighted curve number shown in Table 2 multiplied by an adjustment factor to convert the CN for AMC II to different antecedent moisture conditions.

5.2 Reclaimed Condition

During and post-mining, on-site rainfall will not flow from the site. At the initiation of mining, topsoil and overburden from Area Q will be used to construct a 10-foot tall earthen berm along the entire southern site boundary, adjacent to the Devil Creek Diversion Channel. The mining pit will capture all on-site rainfall and any local runoff from the surrounding properties.

The reclaimed condition land cover detail, as described in the Revegetation Plan (Area Q Mine Reclamation Plan, Sespe Consulting), and subsequent curve numbers are shown in Table 4.

Table 4: Land Cover Type, Reclaimed Condition

Land Cover	Corresponding HydroCAD® Land Cover Description Selected	Area (acres)	SCS Curve Number (AMC II)
Non-native grassland	Desert shrub range, good condition	187.6	49
Disturbed/isolated intermediate riversidean alluvial fan sage scrub	Desert shrub range, poor condition	66.9	63

The HydroCAD® model used for the reclaimed site conditions assumes that drainage to Area Q is comprised of one (1) subwatershed that drains to the mining pit bottom via sheet flow and shallow, concentrated flows. Table 5 displays the model inputs and computed adjusted curve number, time of concentration, anticipated runoff, and pit inundation depth for the reclaimed site during various storm events. HydroCAD® model output files are included in Attachment 3.

Table 5: Area Q Mine Hydrologic Data, Reclaimed Condition

Drainage Area	Area (acres)	Storm Event	Adjusted CN*	Tc (minutes)	Total Runoff (acre-feet)	Pit Inundation Depth (feet)
AREA Q	254.5	25-year, 1-hour	52	165.1	0.0	0.0
		100-year, 1-hour	80		5.4	3.0
		100-year, 24-hour	80		95.1	13.7

* The adjusted CN is the weighted curve number shown in Table 4 multiplied by an adjustment factor to convert the CN for AMC II to different antecedent moisture conditions.

Note that, as modeled, the reclaimed site conditions are not expected to generate any significant runoff during the 25-year storm event. The inundation area for the 100-year storm events are shown on Exhibits 2 and 3 (Attachment 1).

6.0 SUMMARY OF IMPACTS

The implementation of the Area Q mining Project, as described in this report, is not expected to cause any adverse flooding effects on the surrounding properties. In accordance with the San Bernardino County Hydrology Manual, the Project provides sufficient flood control protection for the 100-year return frequency event.

Additionally, as identified below, implementation of the Project is in conformance with SMARA performance standards, which require surface mining and reclamation activities to be conducted in such a way to protect both on-site and downstream beneficial uses of water.

6.1 Potential Impacts to Surrounding Water Bodies

No direct encroachment into the surrounding water bodies (e.g., Cajon Creek or Devil Creek Diversion Channel) or existing floodplain is planned during the Area Q mining project. Local drainage within the mining operation will be collected in the excavated pit and will not be released to the Devil Creek Diversion Channel.

In order to control erosion during the initiation of mining and construction of the earthen berm along the southern boundary of the site, it is recommended that the California Stormwater Quality Association (CASQA) Best Management Handbook's sediment control measures (SE-1, SE-5, or similar) be installed and maintained as needed to eliminate discharge of sediment from the site until vegetation is established on the berm. Erosion control methods implemented at the site must be designed to handle runoff from not less than the 20-year, 1-hour storm.

6.2 Potential Impacts on the Project Site Drainage

As shown on the exhibits in Attachment 1, the bottom of the pit will retain all storm water from the modeled storm events on-site.

After the completion of mining, the proposed mining pit as well as the tributary area to the north will not contribute to off-site flow. The formation of the pit as a result of the mining operation will provide a storage basin capable of capturing the full extents of the modeled storm events. Due to the small tributary area and nature of the soil, debris flows are anticipated to be negligible and to be contained within the pit. As such, the site is not expected to have any significant impacts to downstream areas.

7.0 REFERENCES

California Stormwater Quality Association (CASQA) Best Management Handbook. July 2012.

Custom Soil Resource Report for Vulcan Area Q (San Bernardino County Southwestern Part, California). United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soils Survey (Web). December 1, 2018.

Federal Emergency Management Agency (FEMA) National Flood Insurance Program Flood Insurance Rate Map (FIRM). Flood Map Service Center (Web). Panel 7940 of 9375, effective 09/02/2016.

Letter from Chang Consultants to Adam Guernsey, December 26, 2018.

Report on Geotechnical Evaluation, Vulcan Materials Company Area Q Project. Haley & Aldrich, Inc. July 2018.

Reclamation Plan, Area Q Mine (Draft). Sespe Consulting, Inc., January 2019.

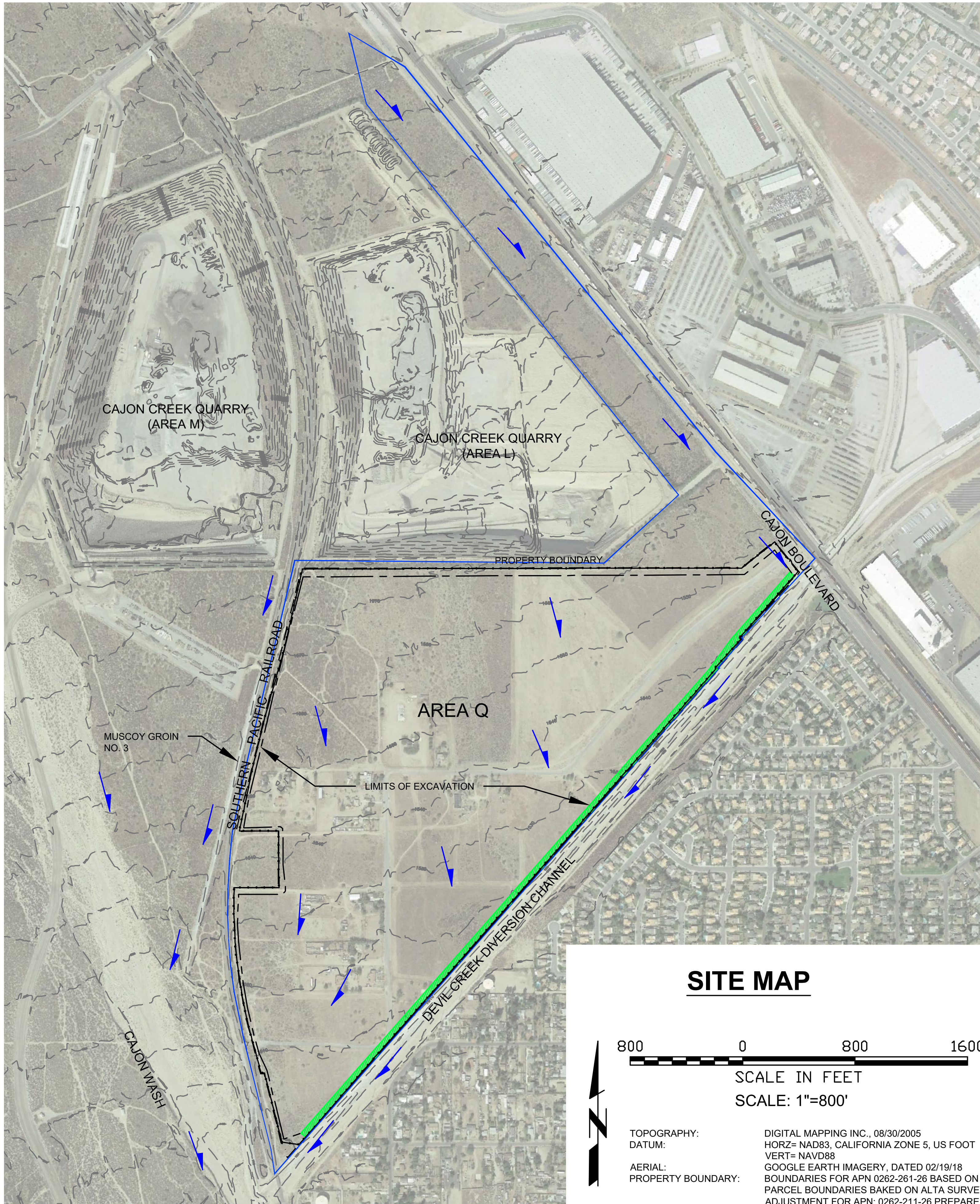
San Bernardino County Areawide Stormwater Program. Watershed Action Plan. Appendix L: San Bernardino County (Santa Ana Watershed Region) Subwatershed Fact Sheets. November 5, 2014.

San Bernardino County Department of Public Works Hydrology Manual. August 1986.

Vulcan Area Q Habitat and Jurisdictional Assessment. ELMT Consulting, Inc. June 2019.

ATTACHMENT 1

FIGURES



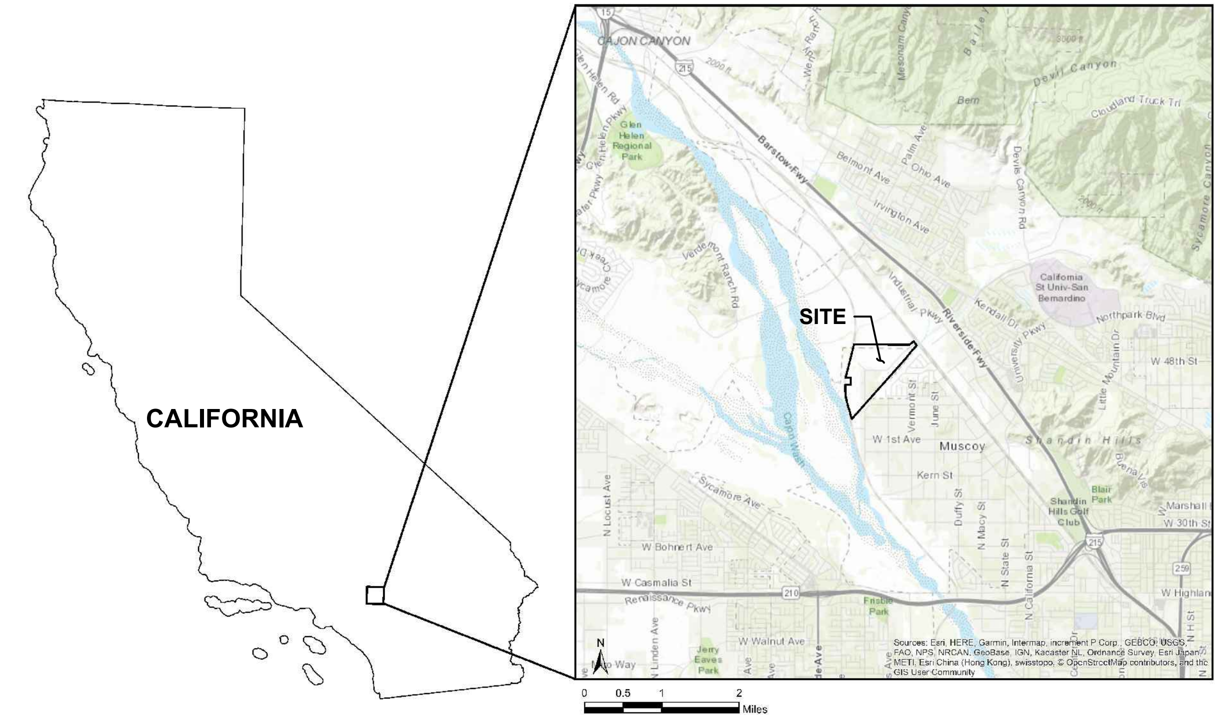
SITE MAP

800 0 800 1600

SCALE IN FEET

SCALE: 1"=800'

TOPOGRAPHY:	DIGITAL MAPPING INC., 08/30/2005
DATUM:	HORZ= NAD83, CALIFORNIA ZONE 5, US FOOT VERT= NAVD88
AERIAL:	GOOGLE EARTH IMAGERY, DATED 02/19/18
PROPERTY BOUNDARY:	BOUNDARIES FOR APN 0262-261-26 BASED ON JUNE 2008 ALTA SURVEY PREPARED BY GORDON EDWARDS, PLS #6678. PARCEL BOUNDARIES BAKED ON ALTA SURVEY PREPARED APRIL 2006 BY DAWSON SURVEYING, INC. AND LOT LINE ADJUSTMENT FOR APN: 0262-211-26 PREPARED JUNE 2008 BY GORDON EDWARDS, PLS #6678.



VICINITY MAP

N.T.S.

LEGEND

- EXISTING TOPOGRAPHY
- WASTERSHED LIMIT
- FACILITY BOUNDARY
- PROJECT SITE AREA BOUNDARY
- TOP OF PIT
- 45' WIDE BERM LANDSCAPED AREA
- SURFACE DRAINAGE DIRECTION

PROJECT SITE PLAN
DRAINAGE REPORT

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VULCAN MATERIALS COMPANY
AREA Q
DRAINAGE REPORT - SITE PLAN

SCALE: HORIZ. AS SHOWN VERT. AS SHOWN	EXHIBIT 1 OF 3
DRAWN BY: G.CAMUS	
CHECKED BY: APS	DATE: JUNE 2019

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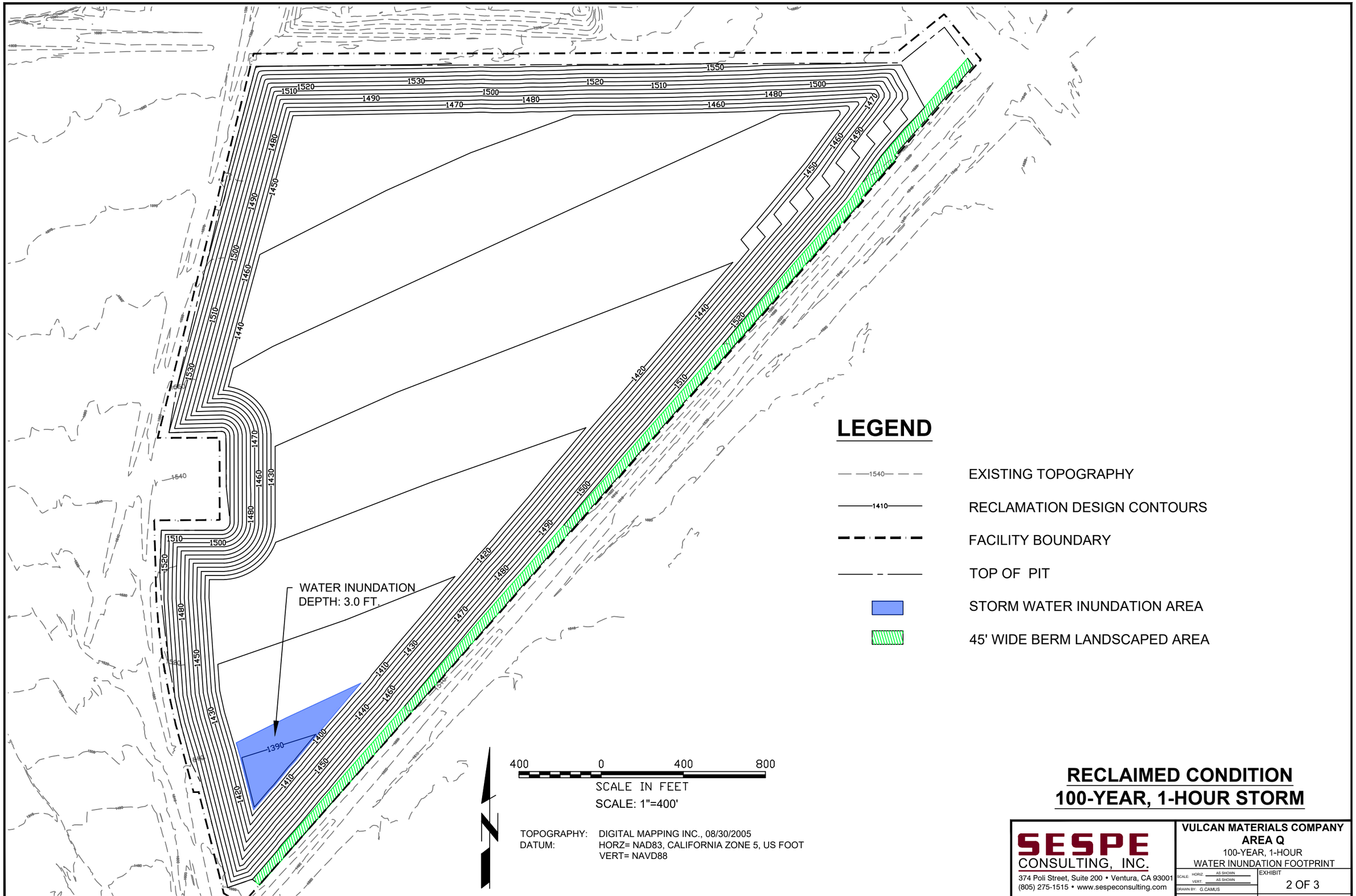

RECLAIMED CONDITION
100-YEAR, 1-HOUR STORM

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VULCAN MATERIALS COMPANY
AREA Q
100-YEAR, 1-HOUR
WATER INUNDATION FOOTPRINT

SCALE: HORIZ. AS SHOWN
VERT. AS SHOWN
DRAWN BY: G.CAMUS
CHECKED BY: APS
EXHIBIT
2 OF 3
DATE: JUNE 2019

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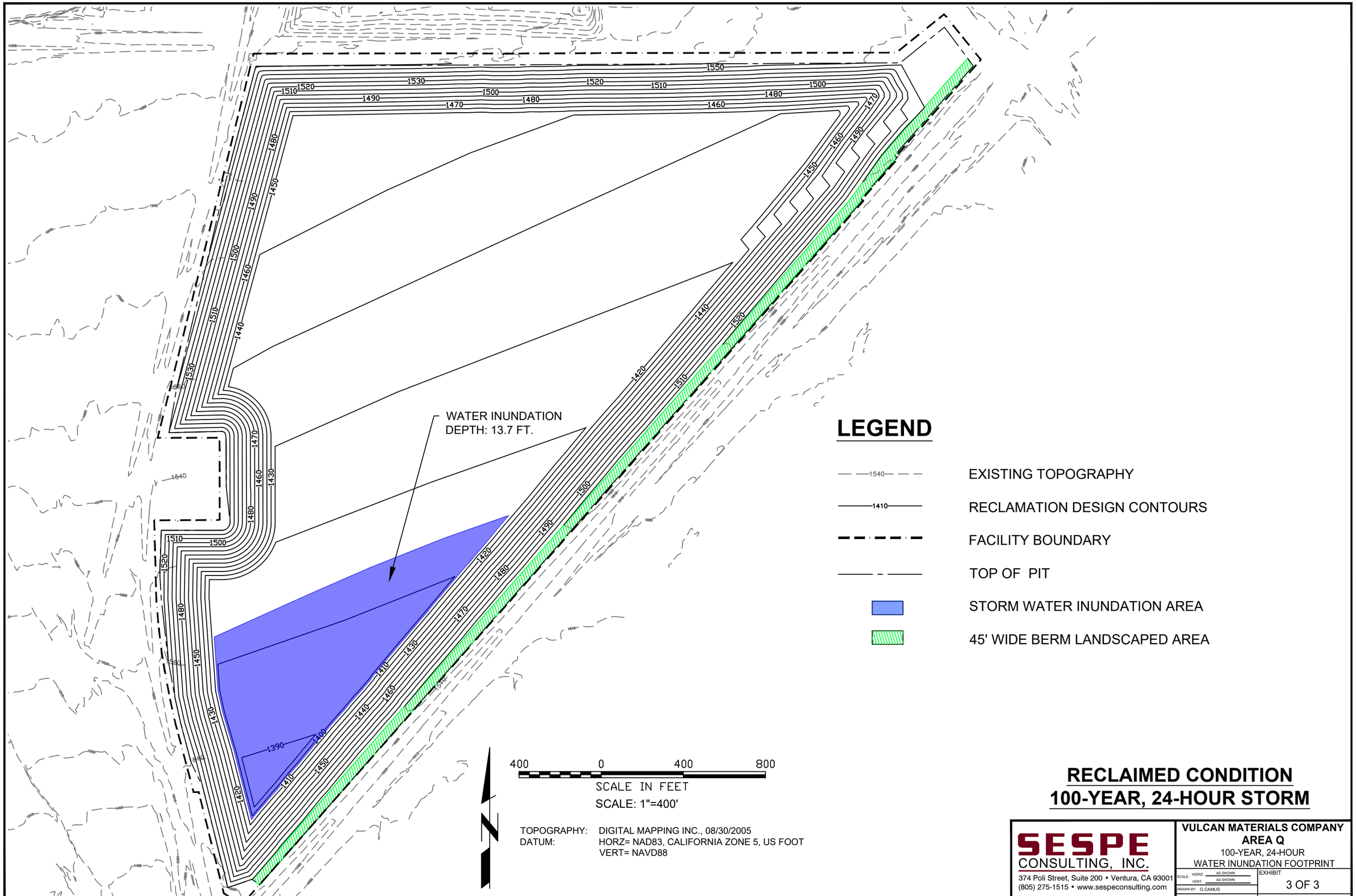

RECLAIMED CONDITION
100-YEAR, 24-HOUR STORM

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VULCAN MATERIALS COMPANY
AREA Q
100-YEAR, 24-HOUR
WATER INUNDATION FOOTPRINT

SCALE: HORIZ. AS SHOWN
VERT. AS SHOWN
DRAWN BY: G.CAMUS
CHECKED BY: APS
EXHIBIT
3 OF 3
DATE: JUNE 2019

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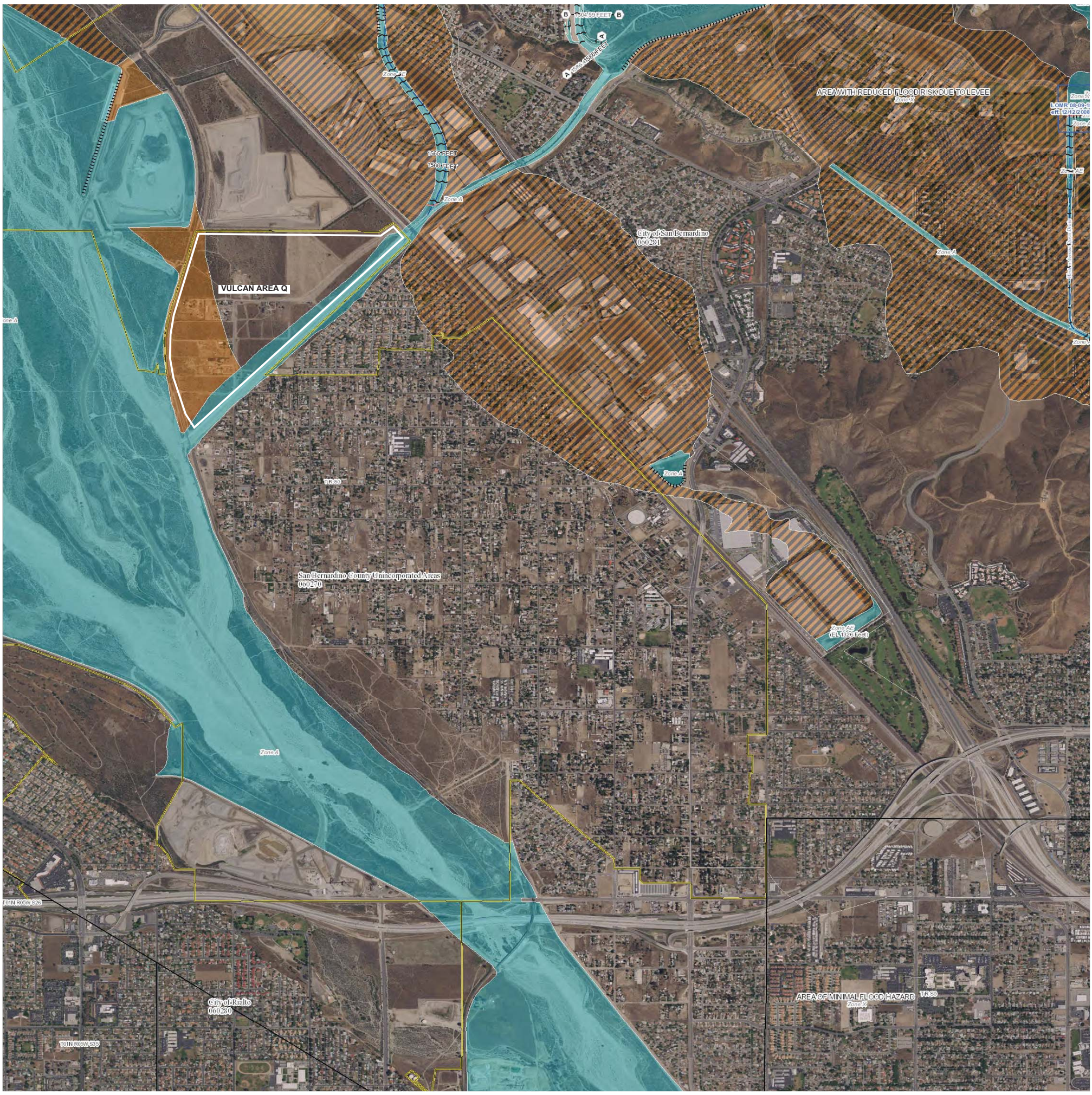
ATTACHMENT 2

FLOOD INSURANCE RATE MAP (FIRM)

34°11'28.34"N

117°22'31.03"W



USGS The National Map: Orthoimagery. Data refreshed October 2017.

34°7'16.70"N

117°18'44.06"W

FLOOD HAZARD INFORMATION

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- B 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- 8 Coastal Transect
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary

NOTES TO USERS

For information and questions about this Flood Insurance Rate Map (FIRM), available products associated with this FIRM, including historic versions, the current map date for each FIRM panel, how to order products, or the National Flood Insurance Program (NFIP) in general, please call the FEMA Map Information eXchange at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA Flood Map Service Center website at http://msc.fema.gov. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can beordered or obtained directly from the website.

Communities annexing land on adjacent FIRM panels must obtain a current copy of the adjacent panel as well as the current FIRM Index. These may be ordered directly from the Flood Map Service Center at the number listed above.

For community and countywide map dates refer to the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your Insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

Basemap information shown on this FIRM was provided in digital format by USDA, Farm Service Agency (FSA). This information was derived from NAIP, dated April 11, 2018.

This map was exported from FEMA's National Flood Hazard Layer (NFHL) on **8/29/2018 2:16:12 PM** and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time. For additional information, please see the Flood Hazard Mapping Updates Overview Fact Sheet at https://www.fema.gov/media-library/assets/documents/118418

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date.

ATTENTION: The levee, dike, or other structure that impacts flood hazards inside this boundary has not been shown to comply with Section 65.10 of the NFIP Regulations. As such, this FIRM panel will be revised at a later date to update the flood hazard information associated with this structure. The flood hazard data inside this boundary on the FIRM panel has been republished from the previous effective (historic) FIRM for this area, after being converted from NGVD 29 to NAVD 88.

ACCREDITED LEVEE SYSTEM: Check with your local community to obtain more information, such as the estimated level of protection provided (which may exceed the 1-percent-annual-chance level) and Emergency Action Plan, on the levee system(s) shown as providing protection for areas on this panel. To mitigate flood risk in residual risk areas, property owners and residents are encouraged to consider flood insurance and floodproofing or other protective measures. For more information on flood insurance, interested parties should visit http://www.fema.gov/national-flood-insurance-program.

SCALE

N

Map Projection:
GCS, Geodetic Reference System 1980;
Vertical Datum: NAVD88
For information about the specific vertical datum for elevation features, datum conversions, or vertical monuments used to create this map please see the Flood Insurance Study(FIS) Report for your community at https://msc.fema.gov

1 inch = 1,000 feet 1:12,000

0 500 1,000 2,000 3,000 4,000 Feet

0 105 210 420 630 840 Meters

FEMA

National Flood Insurance Program

NATIONAL FLOOD INSURANCE PROGRAM

FLOOD INSURANCE RATE MAP

SAN BERNARDINO COUNTY
CALIFORNIA
AND INCORPORATED AREAS

PANEL **7940** OF **9375**

Panel Contains:

COMMUNITY	NUMBER	PANEL
CITY OF SAN BERNARDINO CALIFORNIA	060281	7940
CITY OF RIALTO CALIFORNIA	060280	7940
SAN BERNARDINO COUNTY UNINCORPORATED AREAS CALIFORNIA	060270	7940

MAP NUMBER
06071C7940J
EFFECTIVE DATE
09/02/2016

ATTACHMENT 3

SUPPORTING DOCUMENTATION

HYDROCAD® MODEL OUTPUT FILES
NOAA PRECIPITATION ESTIMATES

Summary for Subcatchment 1S: Area Q Drainage

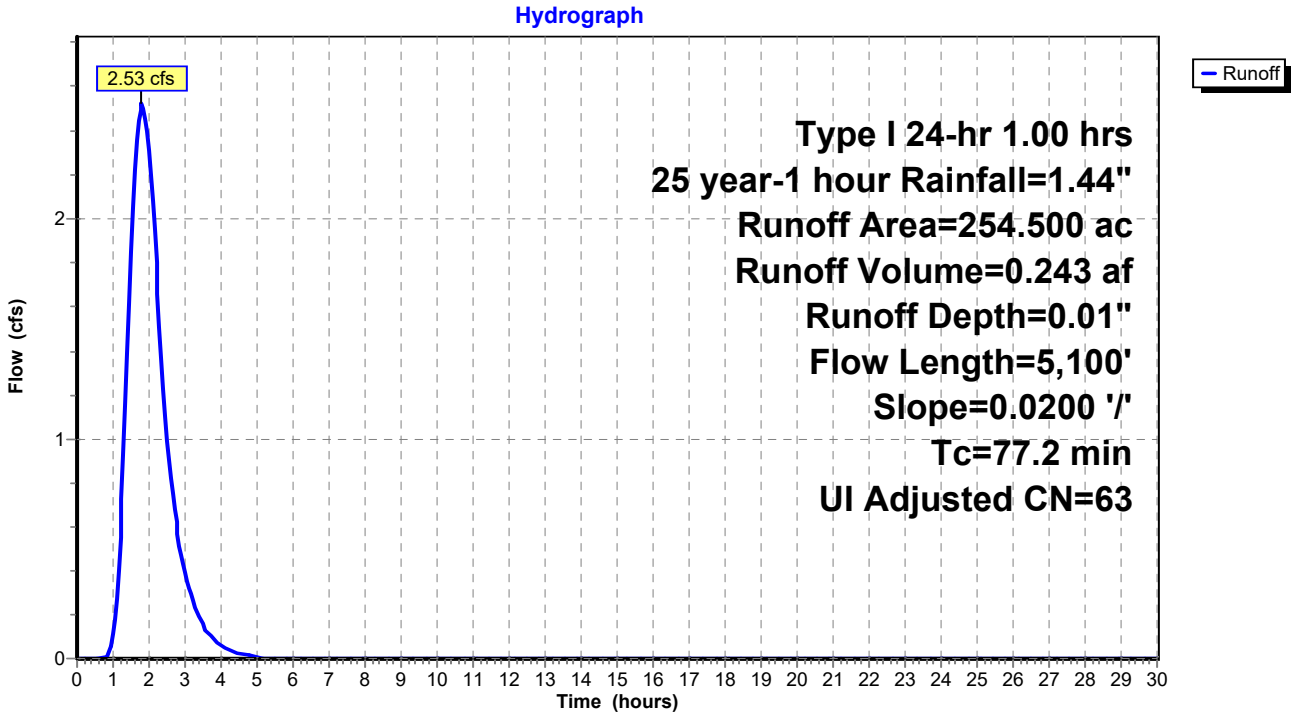
Runoff = 2.53 cfs @ 1.80 hrs, Volume= 0.243 af, Depth= 0.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 1.00 hrs 25 year-1 hour Rainfall=1.44"

Area (ac)	CN	Adj	Description
70.200	55		Desert shrub range, Fair, HSG A
36.130	63		Desert shrub range, Poor, HSG A
31.300	98		Unconnected pavement, HSG A
25.100	77		Newly graded area, HSG A
23.100	55		Desert shrub range, Fair, HSG A
9.900	55		Desert shrub range, Fair, HSG A
1.100	68		<50% Grass cover, Poor, HSG A
57.670	63		Desert shrub range, Poor, HSG A
254.500	65	63	Weighted Average, UI Adjusted
223.200			87.70% Pervious Area
31.300			12.30% Impervious Area
31.300			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.6	300	0.0200	0.24		**Sheet Flow, Sheet Flow**
					Range n= 0.130 P2= 3.34"
56.6	4,800	0.0200	1.41		**Shallow Concentrated Flow, Shallow Concentrate Flow**
					Nearly Bare & Untilled Kv= 10.0 fps
77.2	5,100	Total			

Subcatchment 1S: Area Q Drainage



Summary for Subcatchment 1S: Area Q Drainage

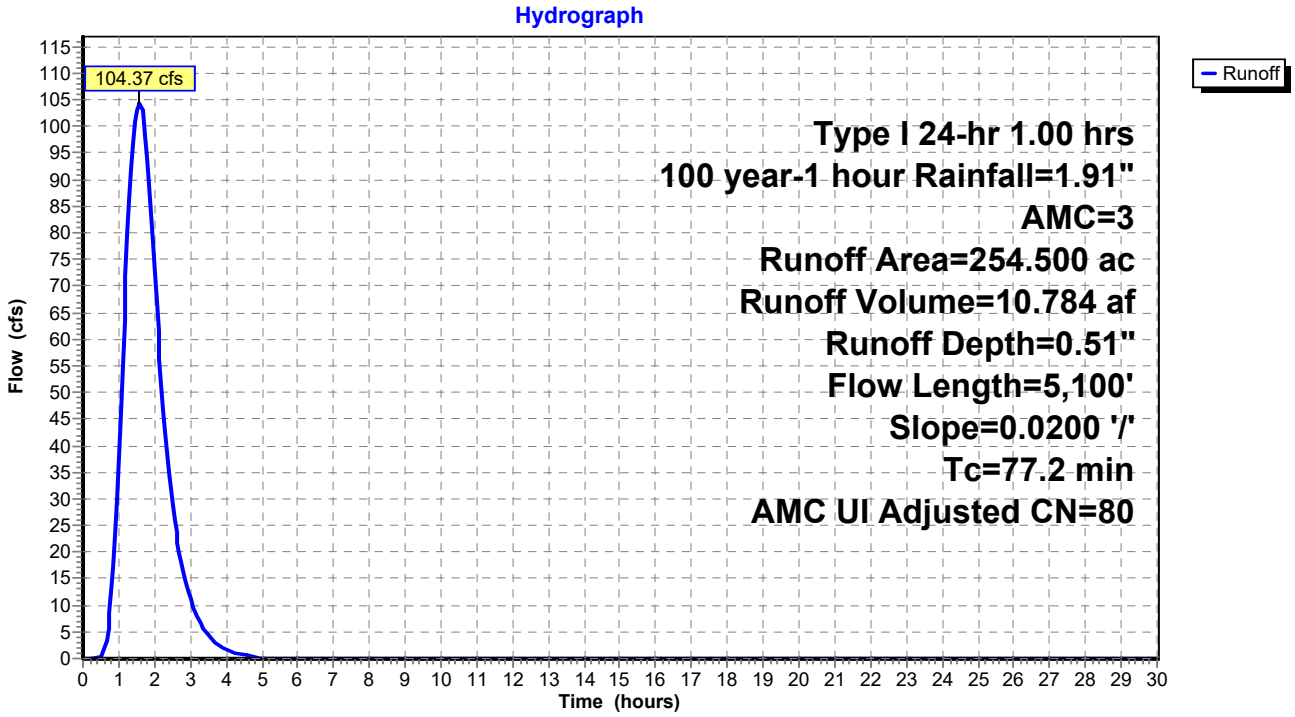
Runoff = 104.37 cfs @ 1.58 hrs, Volume= 10.784 af, Depth= 0.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 1.00 hrs 100 year-1 hour Rainfall=1.91", AMC=3

Area (ac)	CN	Adj	Description
70.200	55		Desert shrub range, Fair, HSG A
36.130	63		Desert shrub range, Poor, HSG A
31.300	98		Unconnected pavement, HSG A
25.100	77		Newly graded area, HSG A
23.100	55		Desert shrub range, Fair, HSG A
9.900	55		Desert shrub range, Fair, HSG A
1.100	68		<50% Grass cover, Poor, HSG A
57.670	63		Desert shrub range, Poor, HSG A
254.500	65	80	Weighted Average, AMC UI Adjusted
223.200			87.70% Pervious Area
31.300			12.30% Impervious Area
31.300			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.6	300	0.0200	0.24		**Sheet Flow, Sheet Flow**
					Range n= 0.130 P2= 3.34"
56.6	4,800	0.0200	1.41		**Shallow Concentrated Flow, Shallow Concentrate Flow**
					Nearly Bare & Untilled Kv= 10.0 fps
77.2	5,100	Total			

Subcatchment 1S: Area Q Drainage



Summary for Subcatchment 1S: Area Q Drainage

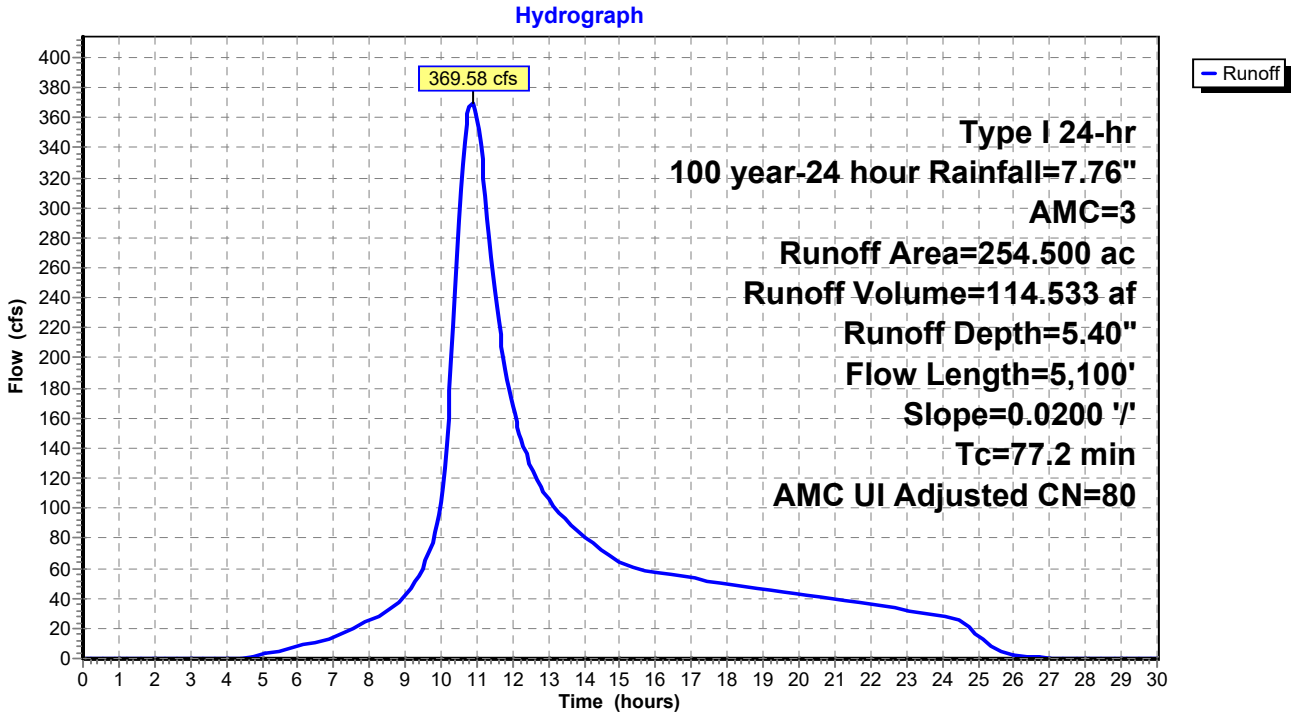
Runoff = 369.58 cfs @ 10.88 hrs, Volume= 114.533 af, Depth= 5.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100 year-24 hour Rainfall=7.76", AMC=3

Area (ac)	CN	Adj	Description
70.200	55		Desert shrub range, Fair, HSG A
36.130	63		Desert shrub range, Poor, HSG A
31.300	98		Unconnected pavement, HSG A
25.100	77		Newly graded area, HSG A
23.100	55		Desert shrub range, Fair, HSG A
9.900	55		Desert shrub range, Fair, HSG A
1.100	68		<50% Grass cover, Poor, HSG A
57.670	63		Desert shrub range, Poor, HSG A
254.500	65	80	Weighted Average, AMC UI Adjusted
223.200			87.70% Pervious Area
31.300			12.30% Impervious Area
31.300			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.6	300	0.0200	0.24		**Sheet Flow, Sheet Flow**
					Range n= 0.130 P2= 3.34"
56.6	4,800	0.0200	1.41		**Shallow Concentrated Flow, Shallow Concentrate Flow**
					Nearly Bare & Untilled Kv= 10.0 fps
77.2	5,100	Total			

Subcatchment 1S: Area Q Drainage



Summary for Subcatchment 1S: Area Q Drainage

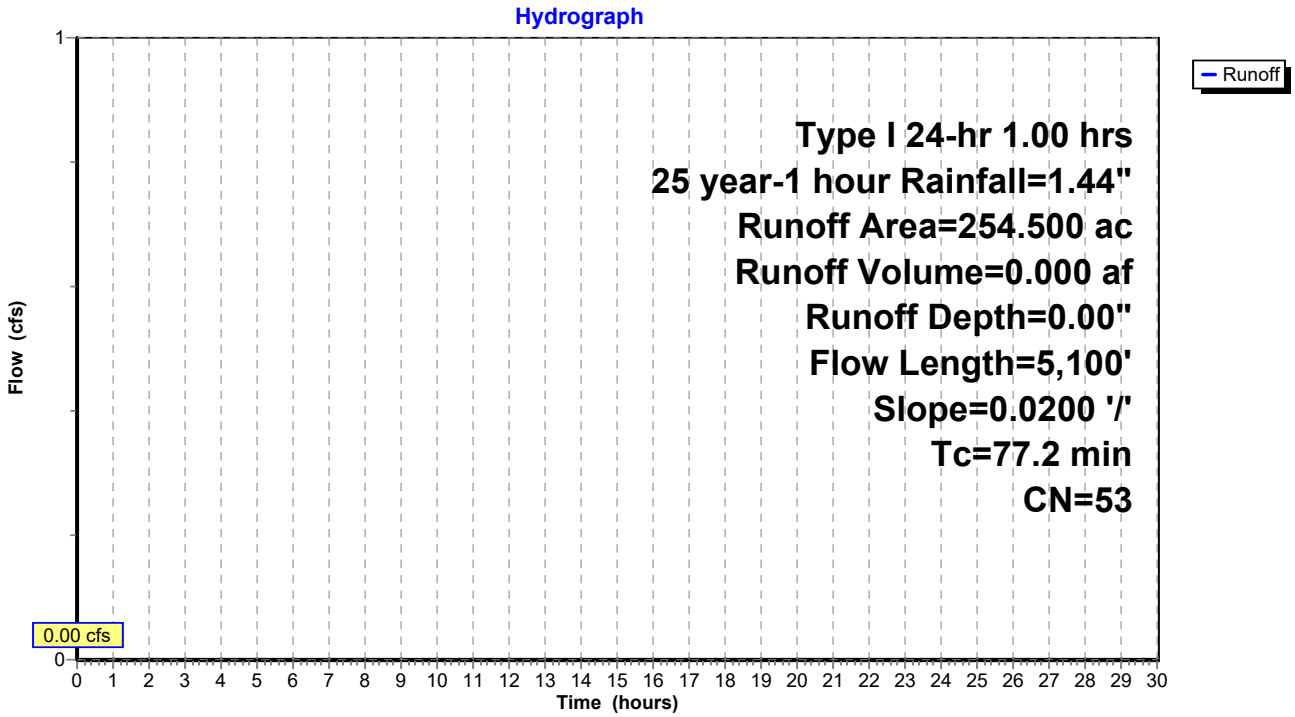
Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 1.00 hrs 25 year-1 hour Rainfall=1.44"

Area (ac)	CN	Description
187.600	49	Desert shrub range, Good, HSG A
66.900	63	Desert shrub range, Poor, HSG A
254.500	53	Weighted Average
254.500		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.6	300	0.0200	0.24		**Sheet Flow, Sheet Flow** Range n= 0.130 P2= 3.34"
56.6	4,800	0.0200	1.41		**Shallow Concentrated Flow, Shallow Concentrate Flow** Nearly Bare & Untilled Kv= 10.0 fps
77.2	5,100	Total			

Subcatchment 1S: Area Q Drainage



Summary for Subcatchment 1S: Area Q Drainage

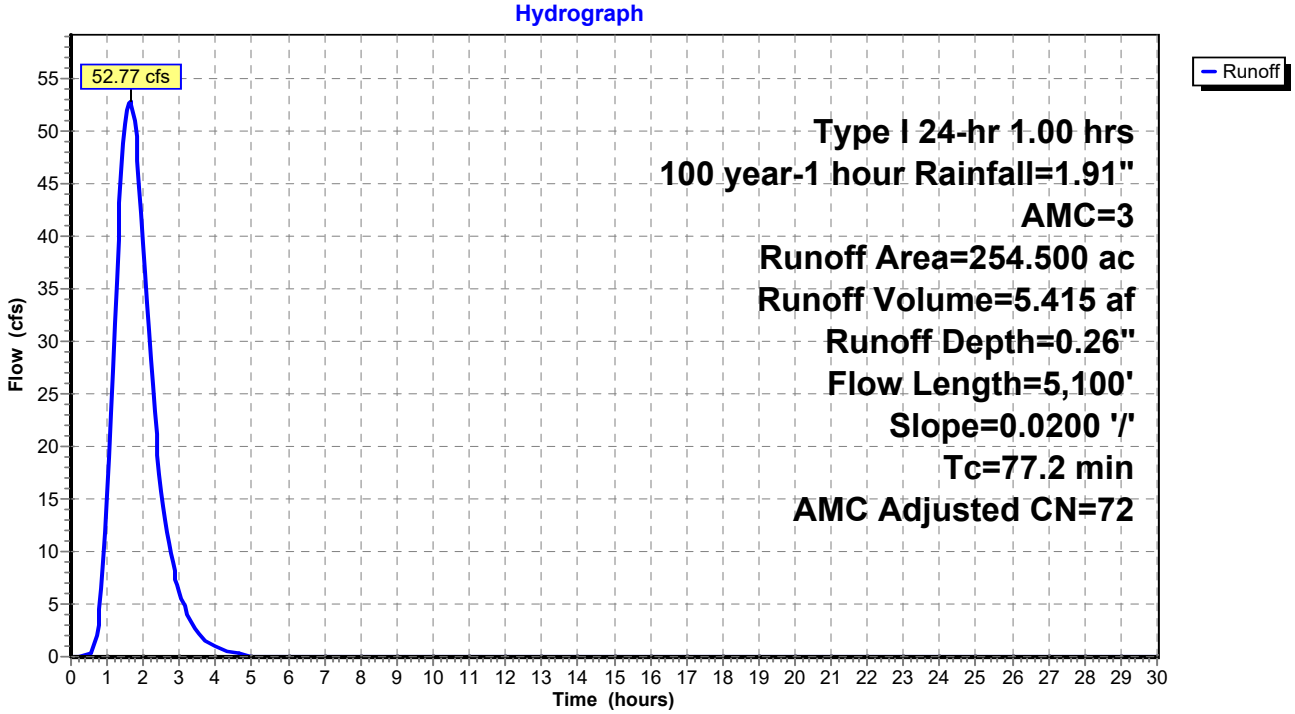
Runoff = 52.77 cfs @ 1.63 hrs, Volume= 5.415 af, Depth= 0.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 1.00 hrs 100 year-1 hour Rainfall=1.91", AMC=3

Area (ac)	CN	Adj	Description
187.600	49		Desert shrub range, Good, HSG A
66.900	63		Desert shrub range, Poor, HSG A
254.500	53	72	Weighted Average, AMC Adjusted
254.500			100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.6	300	0.0200	0.24		**Sheet Flow, Sheet Flow** Range n= 0.130 P2= 3.34"
56.6	4,800	0.0200	1.41		**Shallow Concentrated Flow, Shallow Concentrate Flow** Nearly Bare & Untilled Kv= 10.0 fps
77.2	5,100	Total			

Subcatchment 1S: Area Q Drainage



Summary for Subcatchment 1S: Area Q Drainage

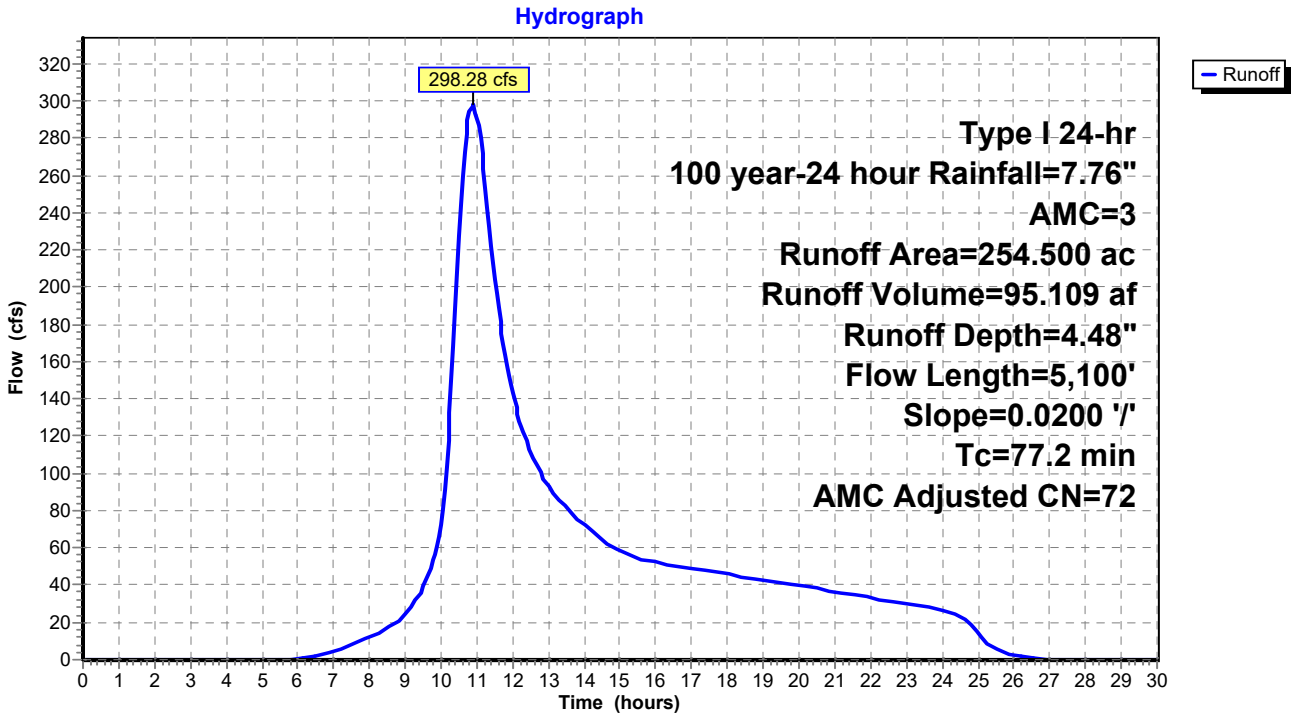
Runoff = 298.28 cfs @ 10.89 hrs, Volume= 95.109 af, Depth= 4.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs
Type I 24-hr 100 year-24 hour Rainfall=7.76", AMC=3

Area (ac)	CN	Adj	Description
187.600	49		Desert shrub range, Good, HSG A
66.900	63		Desert shrub range, Poor, HSG A
254.500	53	72	Weighted Average, AMC Adjusted
254.500			100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.6	300	0.0200	0.24		**Sheet Flow, Sheet Flow**
					Range n= 0.130 P2= 3.34"
56.6	4,800	0.0200	1.41		**Shallow Concentrated Flow, Shallow Concentrate Flow**
					Nearly Bare & Untilled Kv= 10.0 fps
77.2	5,100	Total			

Subcatchment 1S: Area Q Drainage



NOAA Atlas 14, Volume 6, Version 2
Location name: San Bernardino, California, USA*
Latitude: 34.1707°, Longitude: -117.3617°
Elevation: 1551.04 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.139 (0.115-0.169)	0.186 (0.154-0.226)	0.249 (0.206-0.303)	0.301 (0.247-0.371)	0.376 (0.298-0.478)	0.435 (0.338-0.566)	0.497 (0.377-0.663)	0.564 (0.415-0.774)	0.659 (0.465-0.943)	0.736 (0.501-1.09)
10-min	0.199 (0.165-0.242)	0.266 (0.221-0.324)	0.356 (0.295-0.435)	0.432 (0.355-0.531)	0.538 (0.427-0.685)	0.623 (0.484-0.811)	0.713 (0.540-0.951)	0.808 (0.595-1.11)	0.944 (0.666-1.35)	1.06 (0.718-1.56)
15-min	0.241 (0.200-0.292)	0.322 (0.267-0.391)	0.431 (0.357-0.526)	0.522 (0.429-0.643)	0.651 (0.517-0.829)	0.754 (0.586-0.980)	0.862 (0.653-1.15)	0.978 (0.720-1.34)	1.14 (0.806-1.64)	1.27 (0.869-1.89)
30-min	0.356 (0.296-0.432)	0.476 (0.395-0.579)	0.637 (0.528-0.777)	0.772 (0.634-0.950)	0.963 (0.764-1.23)	1.12 (0.866-1.45)	1.27 (0.966-1.70)	1.45 (1.06-1.98)	1.69 (1.19-2.42)	1.89 (1.29-2.80)
60-min	0.534 (0.444-0.648)	0.713 (0.592-0.868)	0.956 (0.791-1.17)	1.16 (0.951-1.43)	1.44 (1.15-1.84)	1.67 (1.30-2.17)	1.91 (1.45-2.55)	2.17 (1.60-2.98)	2.53 (1.79-3.63)	2.83 (1.93-4.20)
2-hr	0.790 (0.657-0.960)	1.02 (0.851-1.25)	1.34 (1.11-1.63)	1.60 (1.31-1.97)	1.96 (1.56-2.50)	2.25 (1.75-2.93)	2.55 (1.93-3.40)	2.87 (2.11-3.93)	3.31 (2.34-4.74)	3.67 (2.50-5.44)
3-hr	0.987 (0.820-1.20)	1.27 (1.05-1.54)	1.64 (1.36-2.00)	1.95 (1.60-2.40)	2.37 (1.88-3.02)	2.71 (2.10-3.52)	3.05 (2.31-4.07)	3.42 (2.51-4.69)	3.92 (2.77-5.61)	4.32 (2.94-6.41)
6-hr	1.43 (1.19-1.74)	1.83 (1.52-2.22)	2.34 (1.94-2.86)	2.76 (2.27-3.40)	3.34 (2.65-4.25)	3.78 (2.94-4.92)	4.24 (3.21-5.65)	4.71 (3.47-6.47)	5.36 (3.78-7.68)	5.87 (4.00-8.71)
12-hr	1.91 (1.59-2.32)	2.45 (2.03-2.98)	3.14 (2.60-3.83)	3.70 (3.04-4.55)	4.46 (3.54-5.67)	5.03 (3.91-6.54)	5.61 (4.25-7.48)	6.20 (4.57-8.51)	7.00 (4.94-10.0)	7.62 (5.19-11.3)
24-hr	2.57 (2.28-2.96)	3.34 (2.95-3.85)	4.33 (3.82-5.00)	5.12 (4.48-5.97)	6.17 (5.23-7.43)	6.97 (5.78-8.57)	7.76 (6.29-9.78)	8.57 (6.75-11.1)	9.65 (7.30-13.0)	10.5 (7.66-14.6)
2-day	3.15 (2.79-3.62)	4.17 (3.69-4.81)	5.50 (4.85-6.36)	6.57 (5.75-7.66)	8.02 (6.79-9.66)	9.12 (7.57-11.2)	10.2 (8.29-12.9)	11.4 (8.96-14.7)	12.9 (9.76-17.4)	14.1 (10.3-19.7)
3-day	3.35 (2.97-3.86)	4.52 (4.00-5.21)	6.05 (5.34-7.00)	7.30 (6.39-8.51)	9.01 (7.63-10.9)	10.3 (8.58-12.7)	11.7 (9.47-14.7)	13.1 (10.3-16.9)	15.0 (11.3-20.2)	16.5 (12.1-23.0)
4-day	3.56 (3.16-4.11)	4.86 (4.30-5.60)	6.57 (5.79-7.59)	7.97 (6.98-9.30)	9.91 (8.40-11.9)	11.4 (9.48-14.1)	13.0 (10.5-16.4)	14.6 (11.5-18.9)	16.8 (12.7-22.7)	18.6 (13.6-26.0)
7-day	4.01 (3.55-4.62)	5.55 (4.91-6.40)	7.60 (6.70-8.79)	9.30 (8.14-10.8)	11.7 (9.87-14.0)	13.5 (11.2-16.6)	15.4 (12.5-19.4)	17.4 (13.7-22.6)	20.2 (15.3-27.3)	22.5 (16.4-31.3)
10-day	4.36 (3.86-5.03)	6.09 (5.38-7.02)	8.40 (7.41-9.71)	10.3 (9.04-12.0)	13.0 (11.0-15.7)	15.1 (12.6-18.6)	17.3 (14.0-21.8)	19.7 (15.5-25.5)	22.9 (17.3-30.9)	25.5 (18.6-35.6)
20-day	5.35 (4.74-6.16)	7.56 (6.69-8.72)	10.5 (9.31-12.2)	13.1 (11.4-15.2)	16.6 (14.1-20.0)	19.4 (16.1-23.9)	22.4 (18.1-28.2)	25.5 (20.1-33.1)	30.0 (22.7-40.4)	33.5 (24.5-46.8)
30-day	6.31 (5.58-7.26)	8.91 (7.89-10.3)	12.5 (11.0-14.4)	15.5 (13.5-18.0)	19.7 (16.7-23.8)	23.1 (19.2-28.5)	26.7 (21.7-33.7)	30.6 (24.1-39.6)	36.0 (27.3-48.6)	40.5 (29.6-56.5)
45-day	7.62 (6.75-8.78)	10.7 (9.45-12.3)	14.9 (13.1-17.2)	18.5 (16.2-21.5)	23.5 (19.9-28.4)	27.6 (22.9-34.0)	32.0 (25.9-40.3)	36.6 (28.9-47.4)	43.3 (32.8-58.4)	48.7 (35.6-68.0)
60-day	8.95 (7.92-10.3)	12.4 (11.0-14.3)	17.1 (15.1-19.8)	21.2 (18.5-24.7)	27.0 (22.8-32.5)	31.6 (26.3-38.9)	36.6 (29.7-46.1)	42.0 (33.1-54.4)	49.7 (37.6-67.0)	56.0 (40.9-78.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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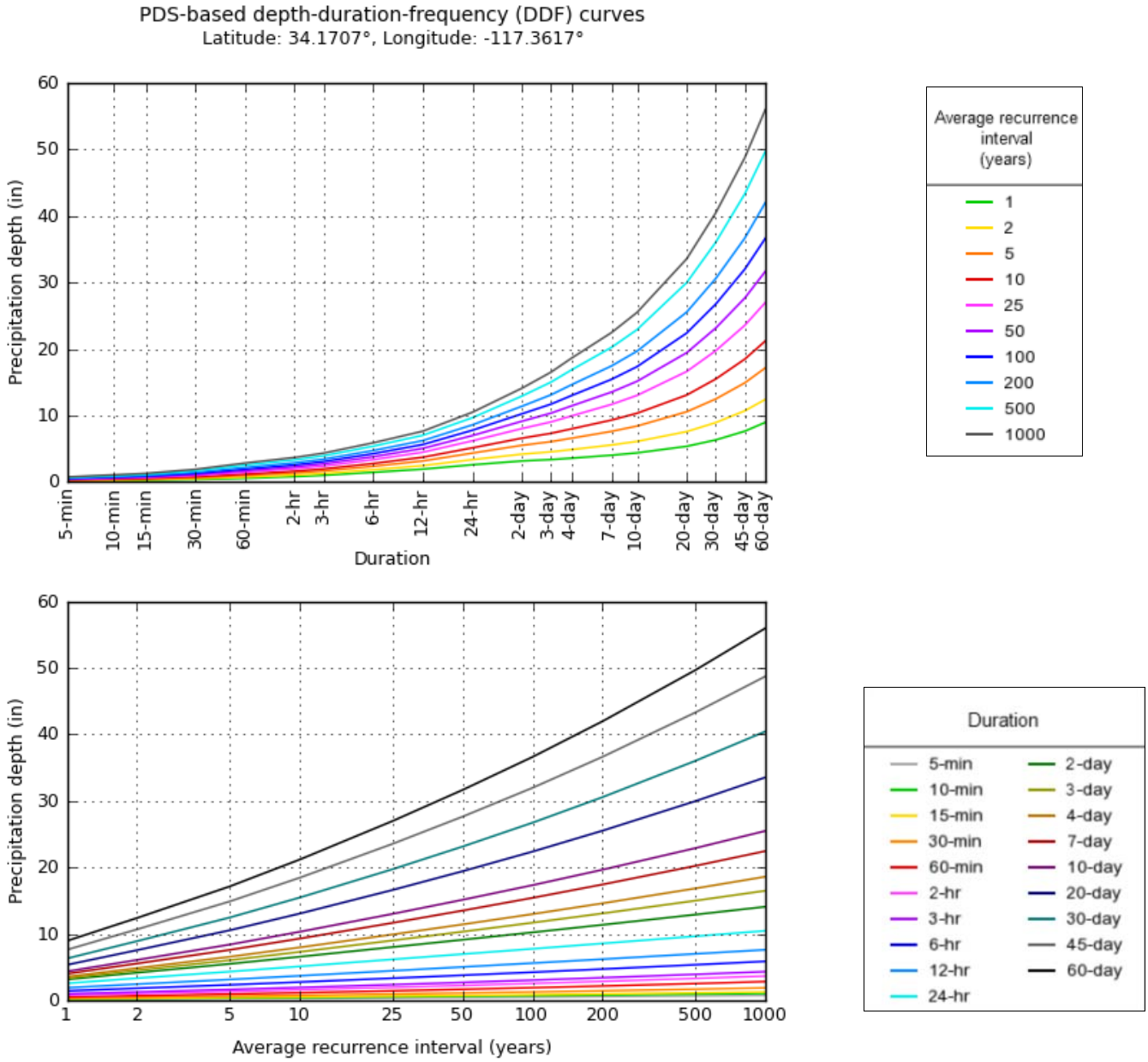
PF graphical



NOAA Atlas 14, Volume 6, Version 2 Created (GMT): Tue Dec 4 19:33:45 2018

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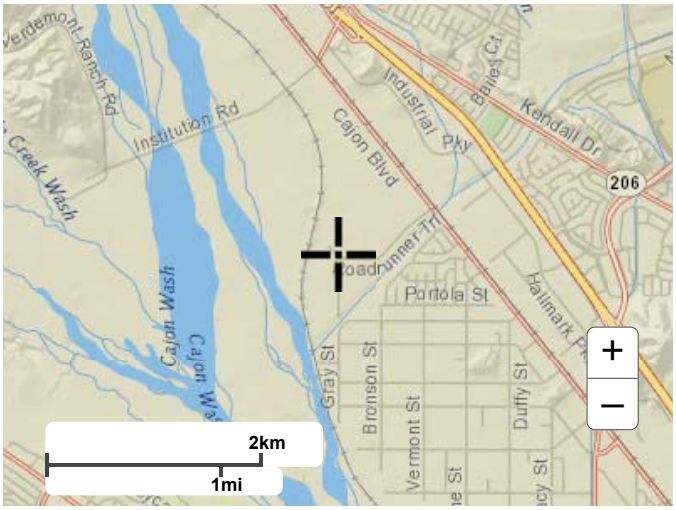
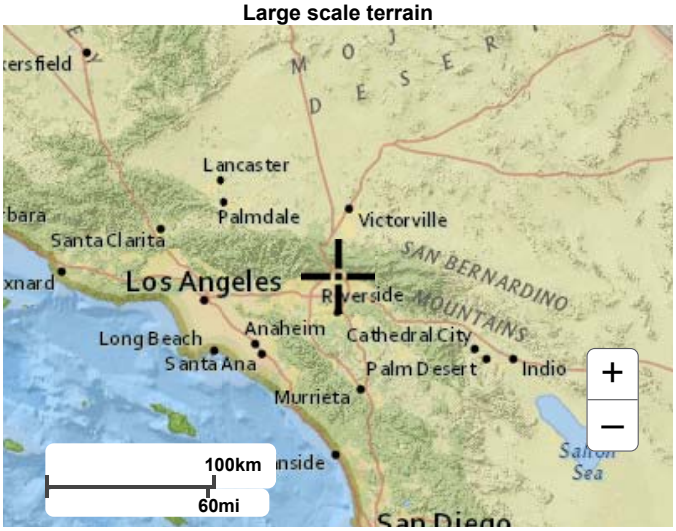
Maps & aerials

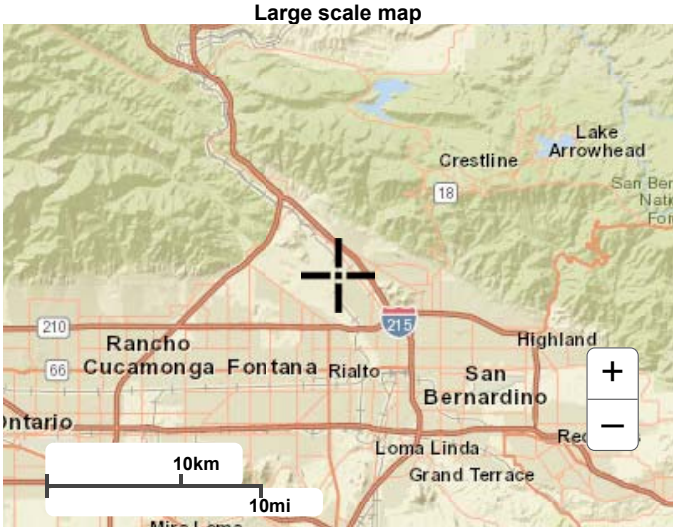
Small scale terrain



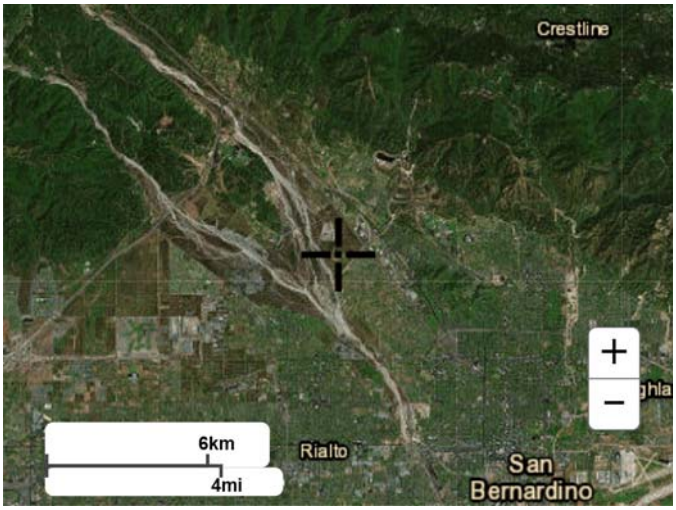
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

ATTACHMENT 4

DEVIL CREEK DIVERSION CHANNEL FLOOD ANALYSIS

ChangConsultants
Civil Engineering◦Hydrology◦Hydraulics◦Sedimentation

P.O. Box 9496
Rancho Santa Fe, CA 92067-4496
T: 858.692.0760
F: 858.832.1402
wayne@changconsultants.com

December 26, 2018

Adam Guernsey
Harrison, Temblador, Hungerford & Johnson LLP
2801 T Street
Sacramento, CA 95816

Subject: Devil Creek Diversion Channel

Dear Adam:

The Devil Creek Diversion Channel (Channel) conveys storm flows in a southwest direction along Vulcan Materials Company's future Cajon Creek Area Q mining site in San Bernardino County. This reach is a concrete trapezoidal channel and confluences with the Cajon Wash near the south end of Area Q. The Federal Emergency Management Agency has mapped a Zone A floodplain along the channel (see the attached floodplain map). A Zone A floodplain is an approximate 100-year floodplain. Detailed engineering analyses were not performed to establish the floodplain, so the water surface elevations are unknown and the delineation is not precise. The FEMA mapping shows the floodplain extending beyond the Channel and into a portion of Area Q. I have performed research to assess the accuracy of the FEMA floodplain. As discussed below, 100-year and greater flows will be contained within the Channel and will have no impact on, or be impacted by, Vulcan's future operations in Area Q.

Tetra Tech prepared two July 2009 reports titled *Devil Creek Diversion Channel, County of San Bernardino, California, Hydrologic Analysis* and *Devil Creek Diversion Channel, County of San Bernardino, California, Hydraulic Analysis.* These reports contain detailed engineering analyses of the Channel and its watershed as part of a levee study. The levee reach is just upstream of the Area Q reach, but the analyses extend into Area Q. The San Bernardino County Flood Control District stated that the reports were approved. Relevant excerpts from the reports are attached.

The *Hydrologic Analysis* report determined the 100-year flow rate in the Channel just upstream of Area Q. The Watershed Map shows that the watershed area tributary to the Channel as it enters Area Q is 9.78 square miles. Table 9 indicates that the 100-year flow rate contributed from this area is 4,380 cubic feet per second (cfs). The flow rate along Area Q will be similar because the additional tributary drainage area added along Area Q is minor compared to the 9.78 square mile watershed area.

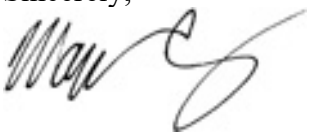
The *Hydraulic Analysis* report contains a HEC-RAS analysis of the Channel from Cajon Creek to upstream of Area Q. The report includes tabulated results, a work map showing cross-section locations, and cross-section plots. Area Q is located along HEC-RAS cross-section -29+35.00 to

27+49.42. The Table 1 results indicate that the 100-year flow depths along Area Q vary between 6.22 to 12.21 feet. The cross-section plots show that the channel has several feet of freeboard over these depths, so the 100-year flow will be contained with excess capacity.

I performed a normal depth analysis based on the average longitudinal slope and channel cross-section along Area Q using topographic mapping provided by Vulcan. The attached results show that the approximate capacity is just over 12,000 cfs. The *Hydrologic Analysis* report determined a 500-year flow rate of 11,800 cfs, so the channel can convey an extreme event above the 100-year design storm.

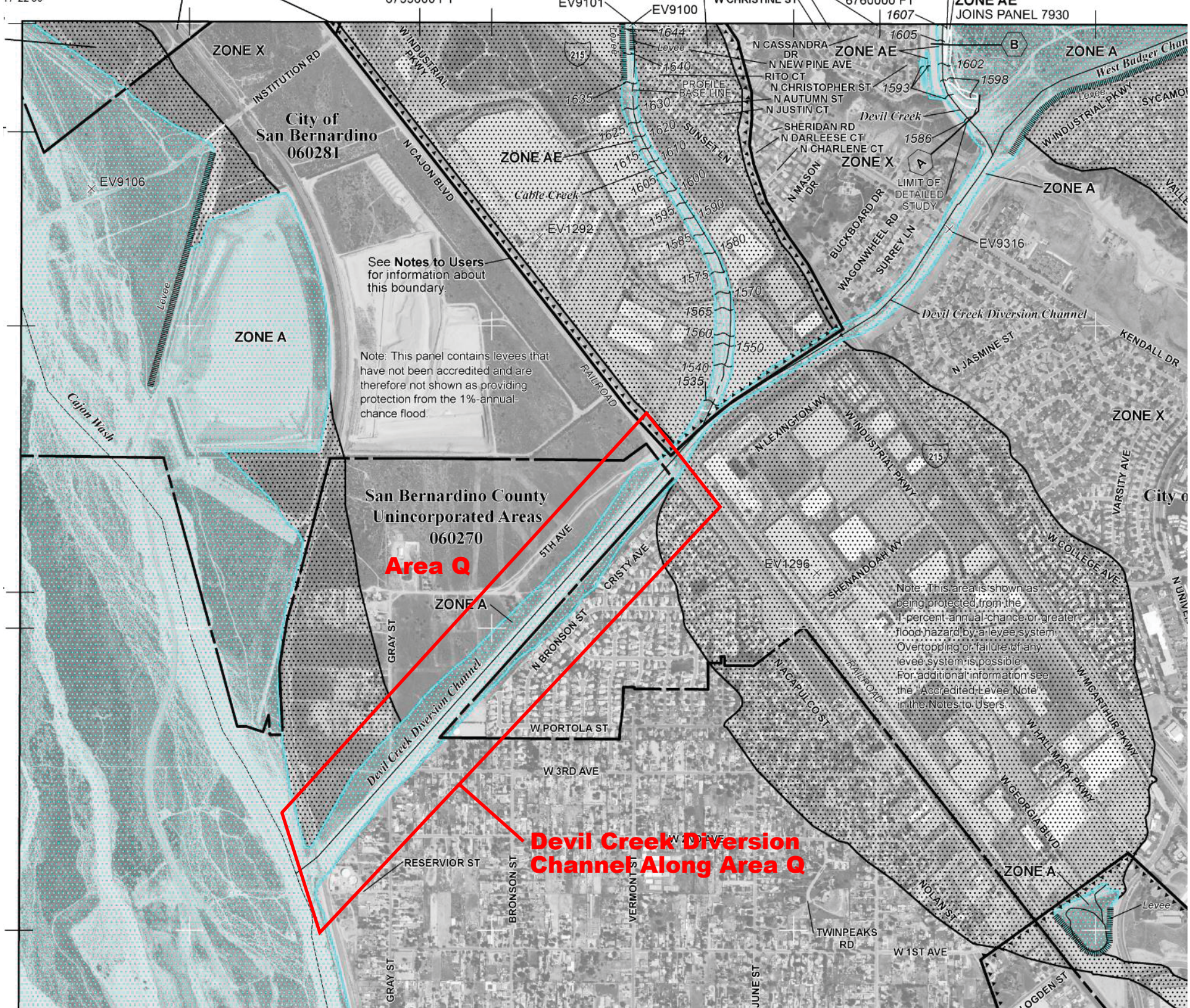
In summary, Tetra Tech's detailed engineering analyses of the Devil Creek Diversion Channel along Area Q are more accurate than FEMA's approximate Zone A floodplain. Tetra Tech's analyses were approved by the San Bernardino County Flood Control District. The Channel and watershed conditions have not changed significantly since the 2009 studies. Based on this, the 100-year and greater flows will be contained within the Channel and will have no impact on, or be impacted by, Vulcan's future operations in Area Q.

Sincerely,



Wayne W. Chang, M.S., P.E.

Enclosures



ZONE X
INSTITUTION RD
City of San Bernardino 060281
EV9106
Levee
ZONE A
Cajon Wash
W INDUSTRIAL PKWY
N CAJON BLVD
RAILROAD
See Notes to Users for information about this boundary.
Note: This panel contains levees that have not been accredited and are therefore not shown as providing protection from the 1%-annual-chance flood.
ZONE AE
Cable Creek
EV1292
SUNSET LN
PROFILE BASE LINE
N CASSANDRA DR
N NEW PINE AVE
RITO CT
N CHRISTOPHER ST
N AUTUMN ST
N JUSTIN CT
SHERIDAN RD
N DARLEESE CT
N CHARLENE CT
N MASON DR
BUCKBOARD DR
WAGONWHEEL RD
SURREY LN
LIMIT OF DETAILED STUDY
Devil Creek
EV9316
ZONE A
West Badger Chan
W INDUSTRIAL PKWY
SYCAMO
Devil Creek Diversion Channel
N JASMINE ST
KENDALL DR
N LEXINGTON WY
W INDUSTRIAL PKWY
ZONE X
VARSITY AVE
City o
San Bernardino County Unincorporated Areas 060270
Area Q
5TH AVE
CRISTY AVE
ZONE A
GRAY ST
N BRONSON ST
Devil Creek Diversion Channel
EV1296
SHENANDOAH WY
W COLLEGE AVE
Note: This area is shown as being protected from the 1-percent-annual-chance or greater flood hazard by a levee system. Overtopping or failure of any levee system is possible. For additional information see the "Accredited Levee Note" in the Notes to Users.
N ACAPULCO ST
RAILROAD
W MCARTHUR PKWY
W HALLMARK PKWY
W GEORGIA BLVD
W PORTOLA ST
W 3RD AVE
Devil Creek Diversion Channel Along Area Q
RESERVIOR ST
BRONSON ST
VERMONT ST
ZONE A
Levee
NOLAN ST
TWINPEAKS RD
W 1ST AVE
GRAY ST
JUNE ST
OGDEN ST

C. REVIEW FEE

Has the review fee for the appropriate request category been included? ☐ Yes Fee amount: $_____

☒ No, Attach Explanation

Please see the DHS-FEMA Web site at http://www.fema.gov/plan/prevent/fhm/frm_fees.shtm **for Fee Amounts and Exemptions.**

D. SIGNATURE

All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Name: Granville M. Bowman	Company: County of San Bernardino	
Mailing Address: 825 E Third Street, Room 101 San Bernardino, CA 92415-0835	Daytime Telephone No.: 909-387-7906	Fax No.: 909-387-7911
	E-Mail Address: gbowman@dpw.sbcounty.gov	
Signature of Requester (required):	Date: 7/23/09	

As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision (LOMR) or conditional LOMR request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirement that no fill be placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a conditional LOMR, will be obtained. In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44CFR 65.2(c), and that we have available upon request by FEMA, all analyses and documentation used to make this determination.

Community Official's Name and Title: Granville M. Bowman, Flood Control Engineer	Community Name: County of San Bernardino	
Mailing Address: 825 E Third Street, Room 101 San Bernardino, CA 92415-0835	Daytime Telephone No.: 909-387-7906	Fax No.: 909-387-7911
	E-Mail Address: gbowman@dpw.sbcounty.gov	
Community Official's Signature (required):	Date: 7/23/09	

CERTIFICATION BY REGISTERED PROFESSIONAL ENGINEER AND/OR LAND SURVEYOR

This certification is to be signed and sealed by a licensed land surveyor, registered professional engineer, or architect authorized by law to certify elevation information data, hydrologic and hydraulic analysis, and any other supporting information as per NFIP regulations paragraph 65.2(b) and as described in the MT-2 Forms Instructions. All documents submitted in support of this request are correct to the best of my knowledge. I understand that any false statement may be punishable by fine or imprisonment under Title 18 of the United States Code, Section 1001.

Certifier's Name: Yen Hsu Chen	License No.: 37763	Expiration Date: 12-31-2010
Company Name: Tetra Tech Inc.	Telephone No.: (949) 250-6788	Fax No.: (949) 250-6776
Signature:		Date: 07/24/09

Ensure the forms that are appropriate to your revision request are included in your submittal.

Form Name and (Number)	Required if ...
☒ Riverine Hydrology and Hydraulics Form (Form 2)	New or revised discharges or water-surface elevations
☒ Riverine Structures Form (Form 3)	Channel is modified, addition/revision of bridge/culverts, addition/revision of levee/floodwall, addition/revision of dam
☐ Coastal Analysis Form (Form 4)	New or revised coastal elevations
☐ Coastal Structures Form (Form 5)	Addition/revision of coastal structure
☐ Alluvial Fan Flooding Form (Form 6)	Flood control measures on alluvial fans

REGISTERED PROFESSIONAL ENGINEER
YEN-HSU CHEN
No. 37763
Exp. 12/31/10
Seal (Optional)
CIVIL
STATE OF CALIFORNIA

County of San Bernardino Certification of Tetra Tech Studies

Devil Creek Diversion Channel
County of San Bernardino, California

FEMA ID No.: 70
County System No.: 2-307-1A
Flood Source: Devil and Bailey Canyons and West Badger Channel
Communities: City of San Bernardino

Hydrologic Analysis

July 2009

TETRA TECH
17770 CARTWRIGHT ROAD, SUITE 500
IRVINE, CALIFORNIA 92614

streamflow data and the FEMA-approved analytical approach (Bulletin #17B). The Standard Project Flood (SPF) peak discharge documented in design memorandums for Devil Creek Diversion Channel is 16,500 cfs.

Table 9 – Adopted Discharge-Frequency Results for Devil Creek Diversion Channel (D.A. = 9.78 sq. mi.)

Return Frequency (years)	Adopted Discharge-Frequency Results for Devil Creek Diversion Channel[1] (Flow, cfs)
2	125
5	410
10	790
20	1,400
50	2,740
100	4,380
200	6,820
500	11,800

In order to perform a risk based analysis it was necessary to determine the appropriate equivalent record length to describe uncertainty based on the USACE's EM 1110-2-1619 (Risk-Based Analysis for Flood Damage Reduction Studies). Using the equivalent record length guidelines in Table 4-5 of the EM, 60 years should be used as the equivalent record length for the Devil Creek Diversion channel discharge-frequency relationship based on: (1) using 75 percent of the 81 year period of record for the Devil Canyon Creek gage, and (2) the fact that the USGS regional flood frequency analysis results were consistent with the adopted results at the Devil Diversion Channel.

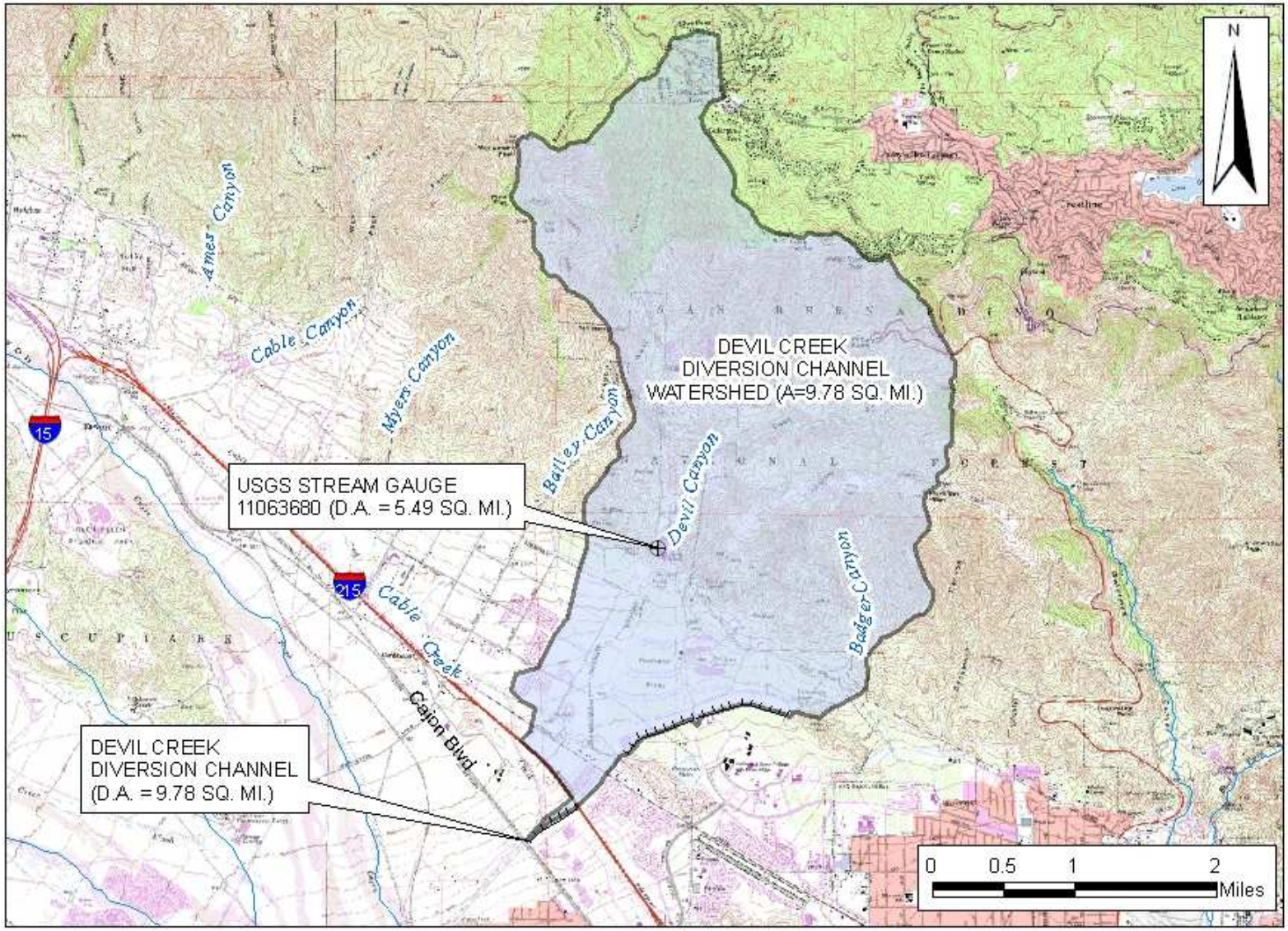


Figure 3 – Devil Creek Diversion Channel Watershed Map

Devil Creek Diversion Channel
County of San Bernardino, California

FEMA ID No.: 70
County System No.: 2-307-1A
Flood Source: Devil and Bailey Canyons and West Badger Channel
Communities: City of San Bernardino

Hydraulic Analysis

July 2009

TETRA TECH
17770 CARTWRIGHT ROAD, SUITE 500
IRVINE, CALIFORNIA 92614

Starting Water Surface Elevations

The critical flow depth elevations for each magnitude flood event were used as the starting upstream water surface elevation for each water surface profile. The computed water surface elevations along Cajon Creek at its confluence with the channel were used as the downstream controlling water surface elevations.

Determination of Stage-Discharge Uncertainty

Corps of Engineers guidelines for certification of levee systems are based on explicit incorporation of risk in assessing levee performance for hydrology and hydraulic engineering aspects. Hence a determination of stage-discharge uncertainty was performed in accordance with Chapter 5 of the Corps Engineering Manual 1110-2-1619 (Risk-Based Analysis for Flood Damage Reduction Studies). The results from the stage-discharge study are included in the Risk and Uncertainty Analysis Report.

HEC-RAS Results

A risk-based analysis of levee performance requires water surface profile determinations for a wide range of flow magnitudes. Water surface profiles were computed for the 2-year through 1000-year flood events using discharge frequency values determined in the Tetra Tech hydrologic analysis. Since FEMA certification requirements are based on the 100-year flood event (one percent chance exceedance flood), hydraulic results summarized below display only the 100-year flood event results. The hydraulic analysis was conducted using the 100-year peak discharges determined in the Tetra Tech hydrologic analysis of 4,380-cfs and 7,690-cfs at beginning of the channel and at the Cable Creek confluence, respectively. Table 1 shows the computed channel hydraulics of the 100-year peak discharge based on the mixed flow regime analysis. The computed water surface profile was plotted on Figure 2. The HEC-RAS computer printouts are presented in Appendix A.

Table 1 100-year Flood Event Computed Channel Hydraulics

HEC-RAS Station	100-Year Discharge (cfs)	Minimum Channel Elevation (ft.)	Estimated Water Surface Elevation (ft.)	Maximum Flow Depth (ft.)	Average Flow Velocity (ft./sec.)	Top Width (ft.)	Froude Number
77+10.77	4,380	1,576.72	1,579.69	2.97	9.83	150.00	1.00
76+31.91	4,380	1,565.47	1,566.63	1.16	27.12	139.50	4.44
75+48.36	4,380	1,555.27	1,556.35	1.08	31.58	128.40	5.35
73+94.91	4,380	1,555.27	1,557.31	2.04	19.93	107.90	2.46
72+49.94	4,380	1,552.28	1,559.29	7.01	7.06	89.27	0.47
70+90.61	4,380	1,551.44	1,558.68	7.24	8.99	67.30	0.59
69+38.99	4,380	1,550.29	1,557.02	6.73	13.01	50.00	0.88
68+81.71	Kendall Drive Bridge						

68+31.02	4,380	1,548.49	1,556.57	8.08	10.84	50.00	0.67
66+38.71	4,380	1,548.74	1,555.63	6.89	12.72	50.00	0.85
64+52.92	4,380	1,548.08	1,555.71	7.63	11.48	50.00	0.73
62+77.38	4,380	1,547.98	1,555.44	7.46	11.74	50.00	0.76
61+09.99	4,380	1,547.84	1,555.19	7.35	11.91	50.00	0.77
59+54.95	4,380	1,547.43	1,555.17	7.74	11.33	50.00	0.72
57+90.35	4,380	1,547.17	1,555.01	7.84	11.17	50.00	0.70
56+44.24	4,380	1,547.22	1,554.61	7.39	11.85	50.00	0.77
54+93.14	4,380	1,547.02	1,554.42	7.40	11.83	50.00	0.77
53+37.31	4,380	1,546.76	1,554.26	7.50	11.69	50.00	0.75
52+82.68	I-215 Freeway Bridge (Upstream end of Levee)						
51+59.66	4,380	1,546.43	1,554.09	7.66	11.44	50.00	0.73
50+25.34	4,380	1,546.20	1,553.97	7.77	11.28	50.00	0.71
48+65.43	4,380	1,546.14	1,553.71	7.57	11.57	50.00	0.74
47+36.18	4,380	1,546.23	1,553.03	6.80	12.87	50.00	0.87
46+79.95	Industrial Pkwy. Bridge						
46+24.43	4,380	1,545.60	1,552.40	6.80	12.89	50.00	0.87
44+75.15	4,380	1,545.35	1,552.17	6.82	12.85	50.00	0.87
43+10.12	4,380	1,545.15	1,551.80	6.65	13.18	50.00	0.90
41+41.01	4,380	1,544.85	1,551.03	6.18	14.17	50.00	1.00
39+89.99	4,380	1,544.06	1,549.94	5.88	14.89	50.00	1.08
38+05.32	4,380	1,541.90	1,546.38	4.48	19.56	50.00	1.63
36+15.66	4,380	1,539.66	1,543.73	4.07	21.52	50.00	1.88
34+42.94	4,380	1,537.69	1,541.59	3.90	22.44	50.00	2.00
32+72.56	4,380	1,536.14	1,540.03	3.89	22.49	50.00	2.01
31+11.43	4,380	1,534.11	1,539.12	5.01	21.85	40.00	1.72
29+64.18	4,380	1,532.47	1,537.25	4.78	22.92	40.00	1.85
29+14.02	BNSF Railroad Bridge (Downstream End of Levee)						
28+74.28	4,380	1,531.42	1,536.13	4.71	23.26	40.00	1.89
28+41.60	4,380	1,530.95	1,535.54	4.59	23.85	40.00	1.96
27+90.49	Cajon Blvd. Bridge						
27+49.42	4,380	1,529.46	1,541.06	11.60	5.03	75.00	0.26
26+91.83	7,690	1,529.38	1,541.05	11.67	8.79	75.00	0.45
26+28.36	7,690	1,528.67	1,534.89	6.22	20.78	79.55	1.70
25+40.42	7,690	1,528.34	1,539.49	11.15	8.66	110.78	0.54
24+34.11	7,690	1,527.65	1,539.35	11.70	8.98	103.42	0.55
23+21.91	7,690	1,527.00	1,538.89	11.89	10.19	92.87	0.63
22+00.73	7,690	1,526.00	1,538.21	12.21	11.75	81.34	0.73
20+81.76	7,690	1,525.20	1,536.50	11.30	15.22	70.66	1.00
19+66.33	7,690	1,525.00	1,535.64	10.64	16.06	69.57	1.07
18+45.60	7,690	1,524.00	1,534.97	10.97	15.80	69.66	1.02
17+21.77	7,690	1,523.56	1,533.90	10.34	16.71	67.75	1.10
15+93.19	7,690	1,523.00	1,533.28	10.28	16.60	69.57	1.09
14+65.63	7,690	1,522.00	1,532.32	10.32	16.82	68.95	1.10
13+31.79	7,690	1,521.00	1,531.13	10.13	17.10	68.55	1.12

Channel along Area Q in red.

11+81.31	7,690	1,519.17	1,529.31	10.14	18.60	65.29	1.24
10+55.47	7,690	1,519.00	1,529.21	10.21	16.56	70.54	1.11
09+42.19	7,690	1,517.87	1,527.14	9.27	19.42	64.68	1.37
08+32.22	7,690	1,517.00	1,525.70	8.70	20.95	62.86	1.53
07+02.70	7,690	1,516.00	1,524.29	8.29	22.10	61.03	1.61
05+83.29	7,690	1,515.00	1,523.29	8.29	22.66	60.61	1.69
04+44.43	7,690	1,513.15	1,521.50	8.35	24.01	58.04	1.80
03+33.02	7,690	1,513.00	1,520.97	7.97	23.81	59.82	1.80
02+13.23	7,690	1,512.00	1,519.84	7.84	24.34	58.75	1.85
00+93.61	7,690	1,510.41	1,518.50	8.09	25.02	57.28	1.90
00+14.84	7,690	1,510.00	1,517.89	7.89	25.14	57.64	1.92
-29+35.00	7,690	1,485.00	1,492.44	7.44	27.45	55.55	2.15

The computed water surface elevations with respect to the top of levee elevations are summarized in Table 2 for the 100-year flood event. Figure 2 depicts the profile of the top of levee, current channel invert, and computed water surface along the channel's leveed reach. The table and figure indicate that the top of levee is a minimum of 10.11-feet higher than the computed water surface for the 100-year flood event.

Table 2 100-year Flood Event Computed Water Surface Elevations versus Top of Levee Elevations

HEC-RAS Station	Top of Levee Elevation (ft.)	Channel Invert Elevation (ft.)	Computed 100-year Water Surface Elevation (ft.)	Freeboard (ft.)	FEMA Required Freeboard (ft.)
52+82.68	I-215 Freeway Bridge (Upstream end of Levee)				
51+59.66	1564.96	1546.43	1554.09	10.87	3.5
50+25.34	1564.09	1546.20	1553.97	10.12	3
48+65.43	1564.32	1546.14	1553.71	10.61	3
47+36.18	1566.44	1546.23	1553.03	13.41	3
46+24.43	1566.05	1545.60	1552.40	13.65	3
44+75.15	1567.29	1545.35	1552.17	15.12	3
43+10.12	1566.84	1545.15	1551.8	15.04	3
41+41.01	1564.89	1544.85	1551.03	13.86	3
39+89.99	1562.82	1544.06	1549.94	12.88	3
38+05.32	1560.45	1541.90	1546.38	14.07	3
36+15.66	1559.59	1539.66	1543.73	15.86	3
34+42.94	1558.24	1537.69	1541.59	16.65	3
32+72.56	1553.86	1536.14	1540.03	13.83	3
31+11.43	1549.23	1534.11	1539.12	10.11	3
29+64.18	1551.59	1532.47	1537.25	14.34	3
29+14.02	BNSF Railroad Bridge (Downstream End of Levee)				

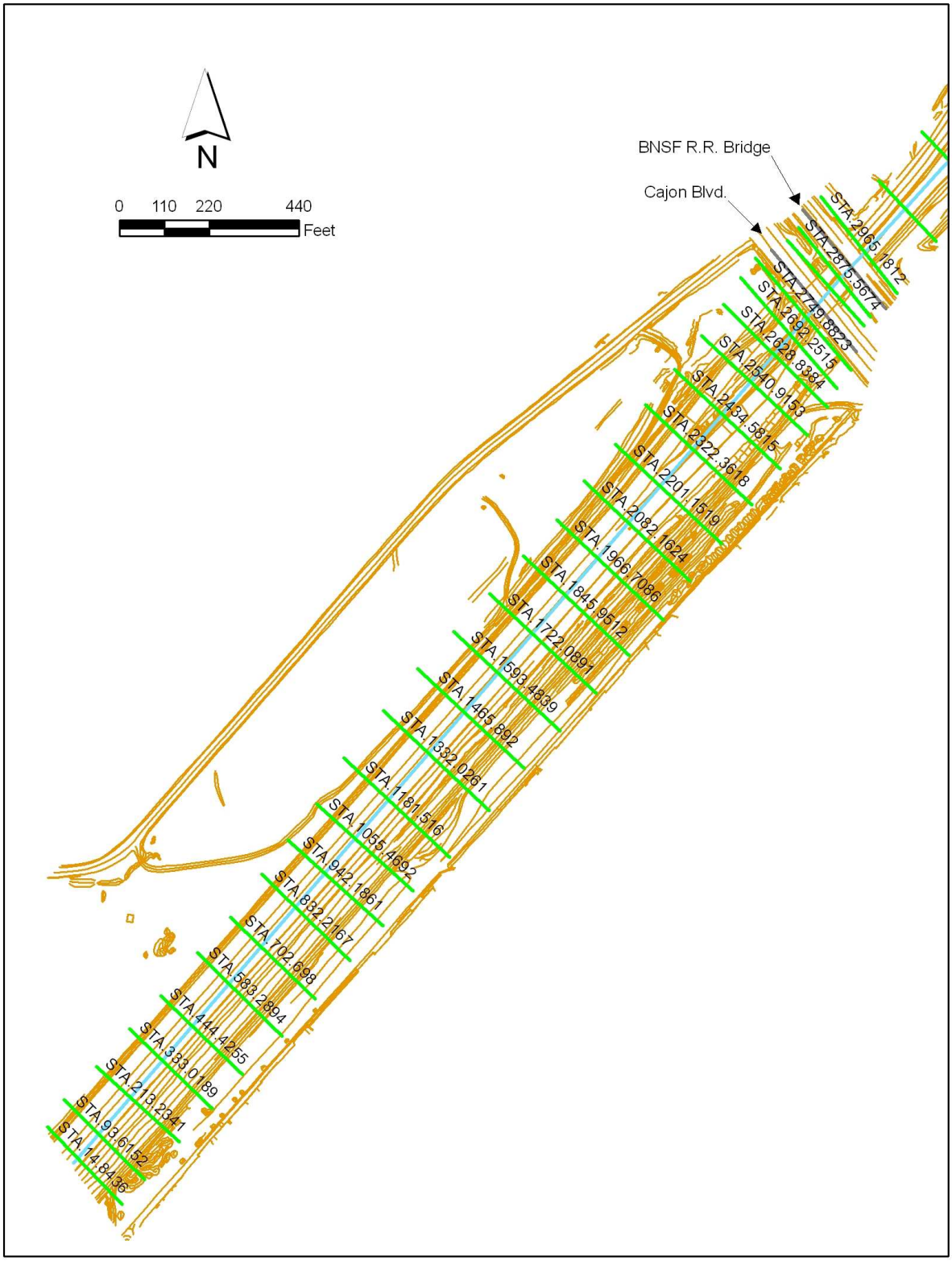
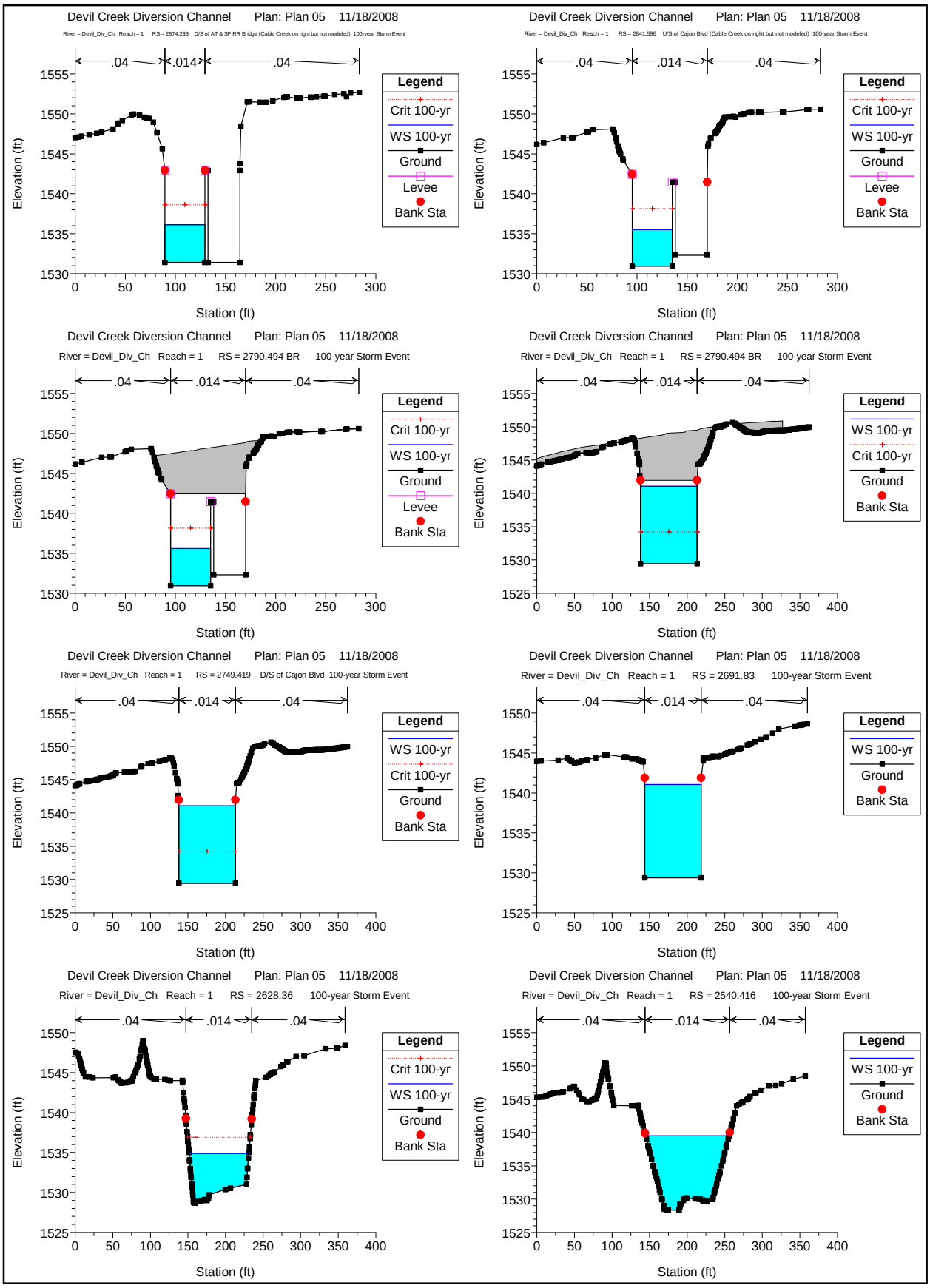


Figure 1 – (Continued)


Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2874.283 D/S of AT & SF RR Bridge (Cable Creek on right but not modeled) 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2841.596 U/S of Cajon Blvd (Cable Creek on right but not modeled) 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2790.494 BR 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2790.494 BR 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2749.419 D/S of Cajon Blvd 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2691.83 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
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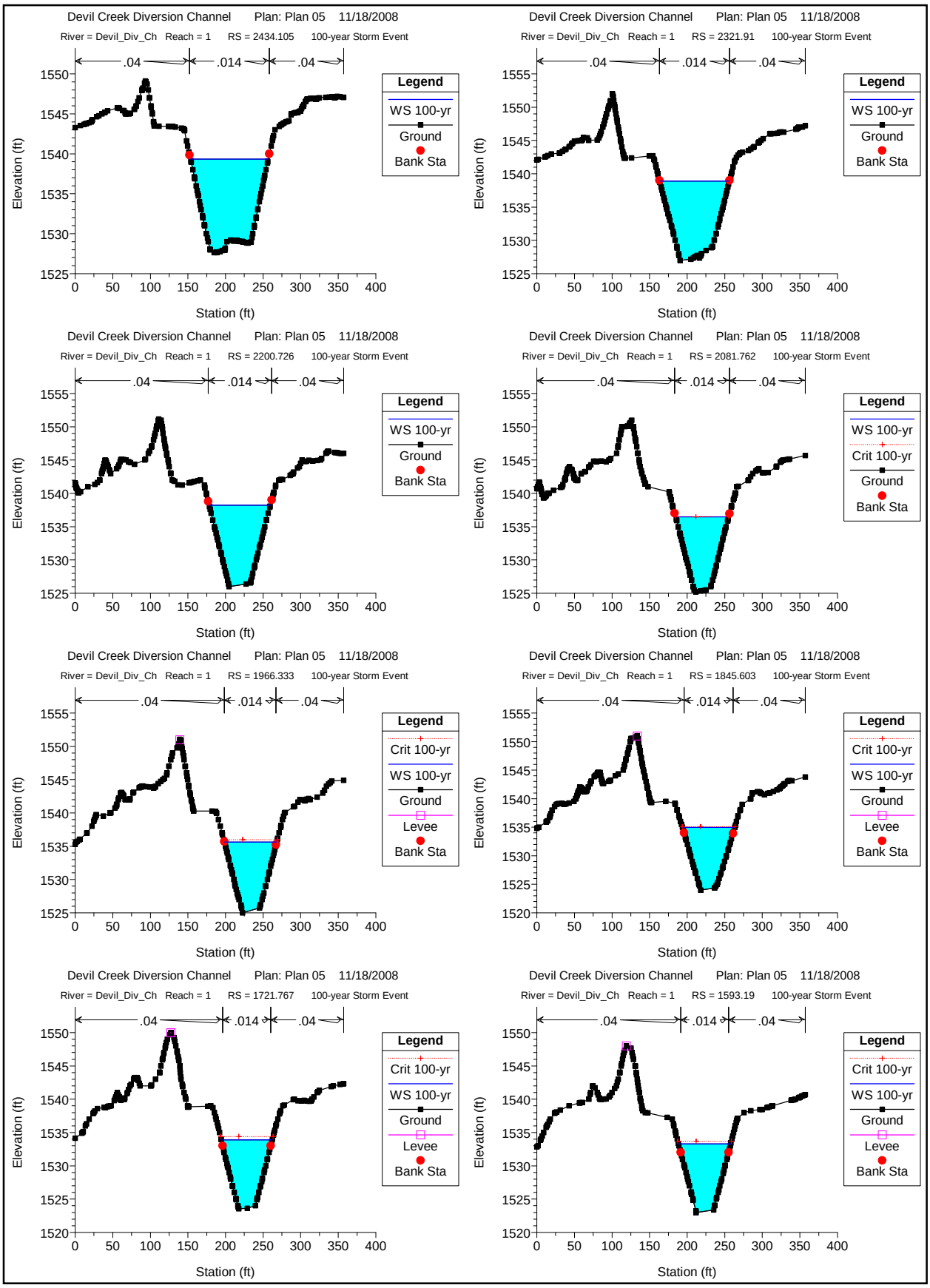
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2540.416 100-year Storm Event
.04
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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.04 .014 .04
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2321.91 100-year Storm Event
.04 .014 .04
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2200.726 100-year Storm Event
.04 .014 .04
Legend
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 2081.762 100-year Storm Event
.04 .014 .04
Legend
WS 100-yr
Crit 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)
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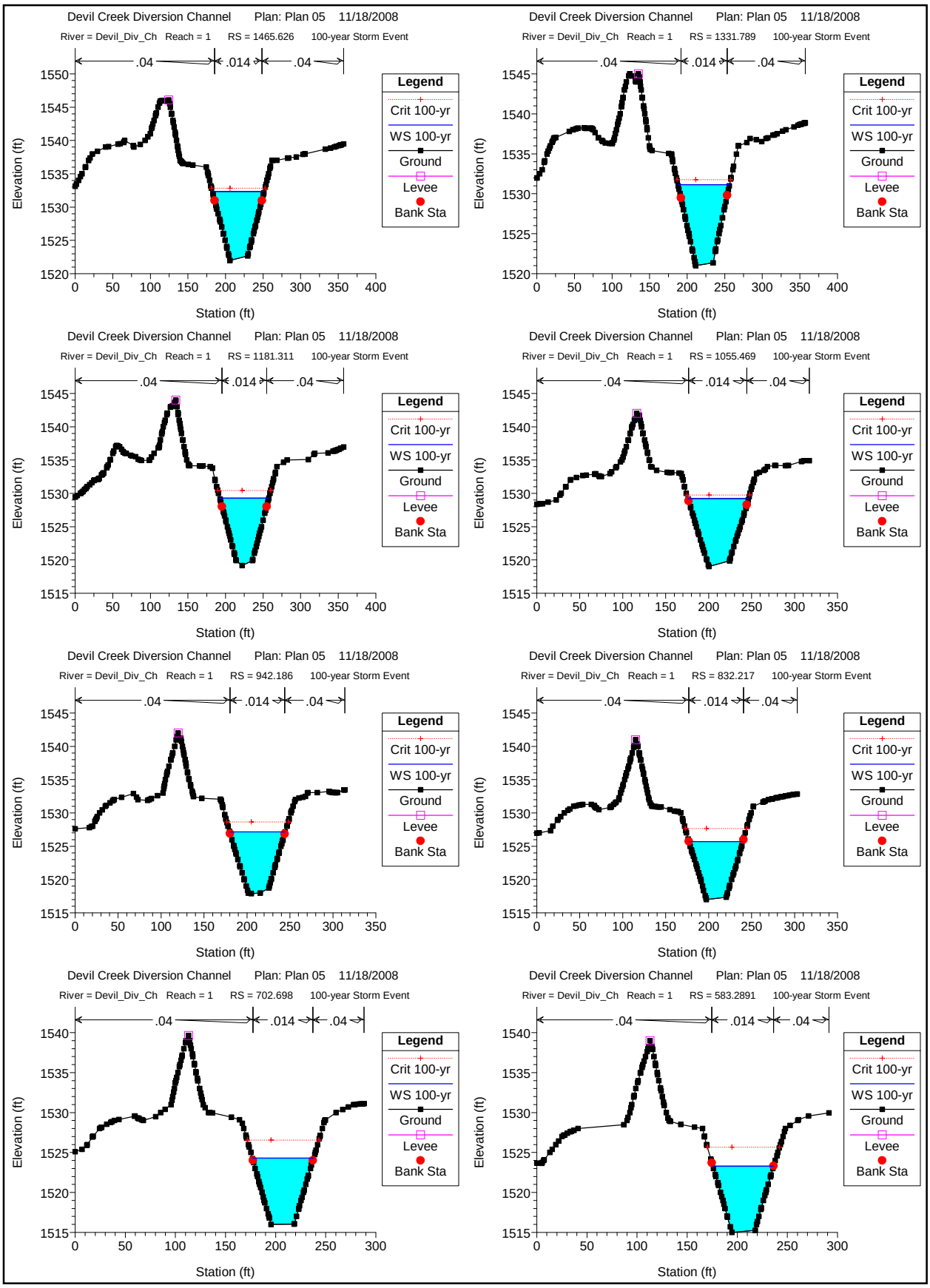
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1845.603 100-year Storm Event
.04 .014 .04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1721.767 100-year Storm Event
.04 .014 .04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1593.19 100-year Storm Event
.04 .014 .04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)


Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1465.626 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1331.789 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1181.311 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 1055.469 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 942.186 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 832.217 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 702.698 100-year Storm Event
Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = 583.2891 100-year Storm Event
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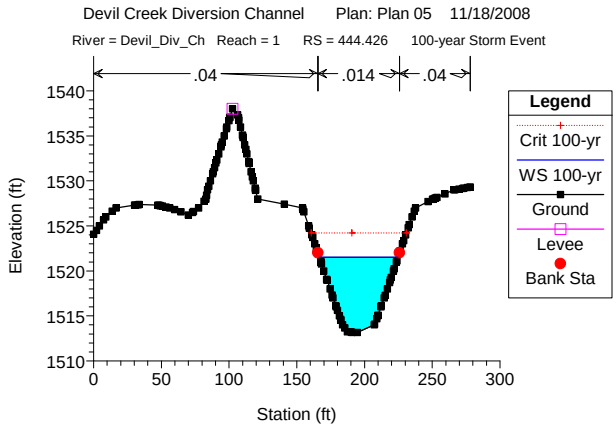
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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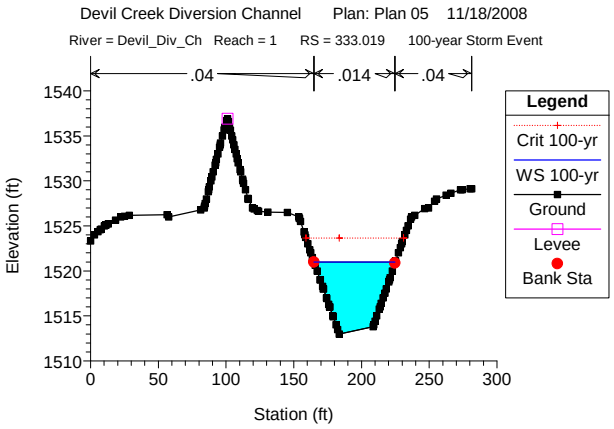
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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River = Devil_Div_Ch Reach = 1 RS = 333.019 100-year Storm Event
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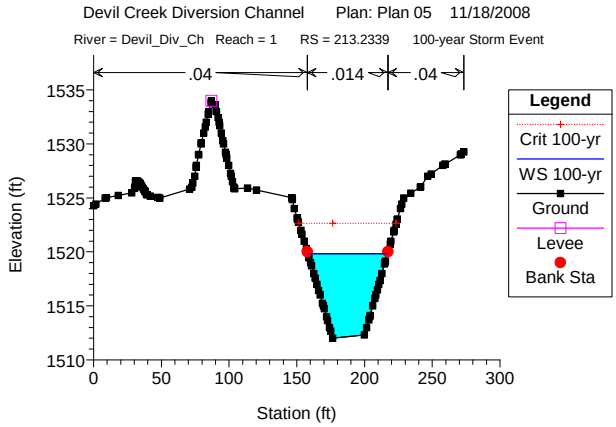
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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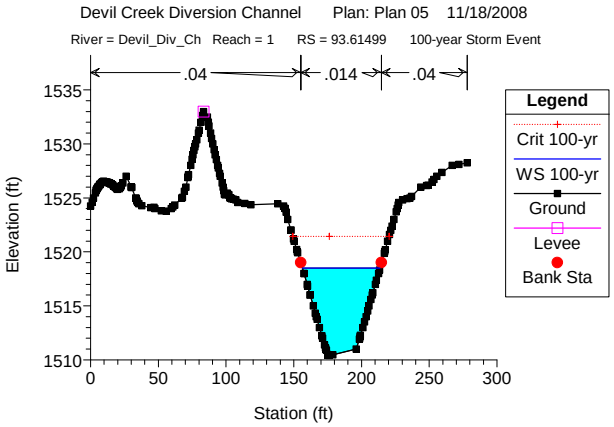
River = Devil_Div_Ch Reach = 1 RS = 213.2339 100-year Storm Event
.04
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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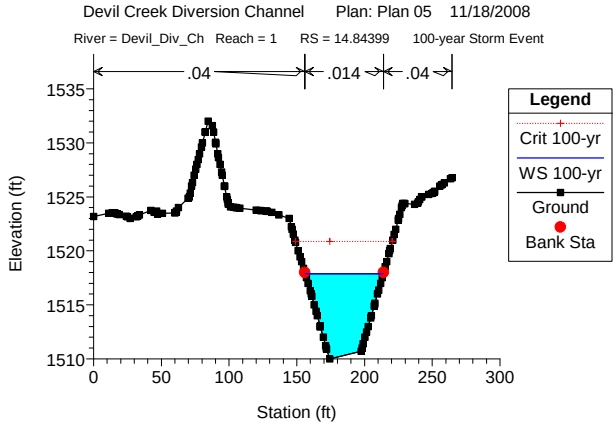
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Levee
Bank Sta
Elevation (ft)
Station (ft)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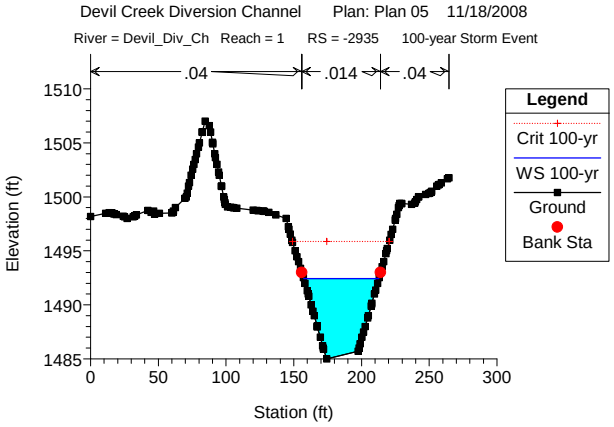
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)


Devil Creek Diversion Channel Plan: Plan 05 11/18/2008
River = Devil_Div_Ch Reach = 1 RS = -2935 100-year Storm Event
.04
.014
.04
Legend
Crit 100-yr
WS 100-yr
Ground
Bank Sta
Elevation (ft)
Station (ft)

Normal Depth Analysis

Worksheet for Trapezoidal Channel - 1

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.014	
Channel Slope	0.00300	ft/ft
Normal Depth	12.00	ft
Left Side Slope	2.25	ft/ft (H:V)
Right Side Slope	2.25	ft/ft (H:V)
Bottom Width	20.00	ft

Results

Discharge	12146.94	ft^3/s
Flow Area	564.00	ft^2
Wetted Perimeter	79.09	ft
Hydraulic Radius	7.13	ft
Top Width	74.00	ft
Critical Depth	14.05	ft
Critical Slope	0.00152	ft/ft
Velocity	21.54	ft/s
Velocity Head	7.21	ft
Specific Energy	19.21	ft
Froude Number	1.38	
Flow Type	Supercritical	

GVF Input Data

Downstream Depth	0.00	ft
Length	0.00	ft
Number Of Steps	0	

GVF Output Data

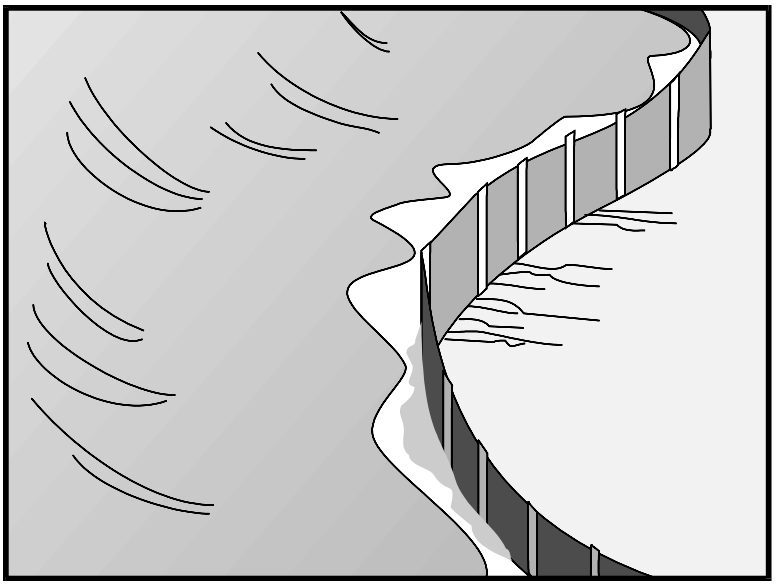
Upstream Depth	0.00	ft
Profile Description		
Profile Headloss	0.00	ft
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	12.00	ft
Critical Depth	14.05	ft
Channel Slope	0.00300	ft/ft

ATTACHMENT 5

CASQA BEST MANAGEMENT HANDBOOK DETAILS

SILT FENCE (SE-1)
FIBER ROLLS (SE-5)

Silt Fence SE-1



Categories

EC	Erosion Control	
SE	Sediment Control	☑
TC	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	
WM	Waste Management and Materials Pollution Control	

Legend:

☑ **Primary Category**

☒ **Secondary Category**

Description and Purpose

A silt fence is made of a woven geotextile that has been entrenched, attached to supporting poles, and sometimes backed by a plastic or wire mesh for support. The silt fence detains water, promoting sedimentation of coarse sediment behind the fence. Silt fence does not retain soil fine particles like clays or silts.

Suitable Applications

Silt fences are suitable for perimeter control, placed below areas where sheet flows discharge from the site. They could also be used as interior controls below disturbed areas where runoff may occur in the form of sheet and rill erosion and around inlets within disturbed areas (SE-10). Silt fences should not be used in locations where the flow is concentrated. Silt fences should always be used in combination with erosion controls. Suitable applications include:

- At perimeter of a project.
- Below the toe or down slope of exposed and erodible slopes.
- Along streams and channels.
- Around temporary spoil areas and stockpiles.
- Around inlets.
- Below other small cleared areas.

Targeted Constituents

Sediment (coarse sediment)	☑
Nutrients	
Trash	
Metals	
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

SE-5 Fiber Rolls

SE-6 Gravel Bag Berm SE-12 Manufactured Linear Sediment Controls

SE-13 Compost Socks and Berms

SE-14 Biofilter Bags

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Limitations

- Do not use in streams, channels, drain inlets, or anywhere flow is concentrated.
- Do not use in locations where ponded water may cause a flooding hazard.
- Do not use silt fence to divert water flows or place across any contour line.
- Improperly installed fences are subject to failure from undercutting, overtopping, or collapsing.
- Must be trenched and keyed in.
- Not intended for use as a substitute for Fiber Rolls (SE-5), when fiber rolls are being used as a slope interruption device.
- Do not use on slopes subject to creeping, slumping, or landslides.

Implementation

General

A silt fence is a temporary sediment barrier consisting of woven geotextile stretched across and attached to supporting posts, trenched-in, and, depending upon the strength of fabric used, supported with plastic or wire mesh fence. Silt fences trap coarse sediment by intercepting and detaining sediment-laden runoff from disturbed areas in order to promote sedimentation behind the fence.

The following layout and installation guidance can improve performance and should be followed:

- Silt fence should be used in combination with erosion controls up-slope in order to provide the most effective sediment control.
- Silt fence alone is not effective at reducing turbidity. (Barrett and Malina, 2004)
- Designers should consider diverting sediment laden water to a temporary sediment basin or trap. (EPA, 2012)
- Use principally in areas where sheet flow occurs.
- Install along a level contour, so water does not pond more than 1.5 ft at any point along the silt fence.
- Provide sufficient room for runoff to pond behind the fence and to allow sediment removal equipment to pass between the silt fence and toes of slopes or other obstructions. About 1200 ft^2 of ponding area should be provided for every acre draining to the fence.
- Efficiency of silt fences is primarily dependent on the detention time of the runoff behind the control. (Barrett and Malina, 2004)
- The drainage area above any fence should not exceed a quarter of an acre. (Rule of Thumb-100-feet of silt fence per 10,000 square feet of disturbed area.) (EPA 2012)

- The maximum length of slope draining to any point along the silt fence should be 100 ft per foot of silt fence.
- Turn the ends of the filter fence uphill to prevent stormwater from flowing around the fence.
- Leave an undisturbed or stabilized area immediately down slope from the fence where feasible.
- Silt fences should remain in place until the disturbed area draining to the silt fence is permanently stabilized, after which, the silt fence fabric and posts should be removed and properly disposed.
- J-Hooks, which have ends turning up the slope to break up long runs of fence and provide multiple storage areas that work like mini-retention areas, may be used to increase the effectiveness of silt fence.
- Be aware of local regulations regarding the type and installation requirements of silt fence, which may differ from those presented in this fact sheet.

Design and Layout

In areas where high winds are anticipated the fence should be supported by a plastic or wire mesh. The geotextile fabric of the silt fence should contain ultraviolet inhibitors and stabilizers to provide longevity equivalent to the project life or replacement schedule.

- Layout in accordance with the attached figures.
- For slopes that contain a high number of rocks or large dirt clods that tend to dislodge, it may be necessary to protect silt fence from rocks (e.g., rockfall netting) ensure the integrity of the silt fence installation.

Standard vs. Heavy Duty Silt Fence

Standard Silt Fence

- Generally applicable in cases where the area draining to fence produces moderate sediment loads.

Heavy Duty Silt Fence

- Heavy duty silt fence usually has 1 or more of the following characteristics, not possessed by standard silt fence.
  - Fabric is reinforced with wire backing or additional support.
  - Posts are spaced closer than pre-manufactured, standard silt fence products.
- Use is generally limited to areas affected by high winds.
- Area draining to fence produces moderate sediment loads.

Materials

Standard Silt Fence

- Silt fence material should be woven geotextile with a minimum width of 36 in. The fabric should conform to the requirements in ASTM designation D6461.
- Wooden stakes should be commercial quality lumber of the size and shape shown on the plans. Each stake should be free from decay, splits or cracks longer than the

thickness of the stake or other defects that would weaken the stakes and cause the stakes to be structurally unsuitable.

- Staples used to fasten the fence fabric to the stakes should be not less than 1.75 in. long and should be fabricated from 15 gauge or heavier wire. The wire used to fasten the tops of the stakes together when joining two sections of fence should be 9 gauge or heavier wire. Galvanizing of the fastening wire will not be required.

Heavy-Duty Silt Fence

- Some silt fence has a wire backing to provide additional support, and there are products that may use prefabricated plastic holders for the silt fence and use metal posts instead of wood stakes.

Installation Guidelines – Traditional Method

Silt fences are to be constructed on a level contour. Sufficient area should exist behind the fence for ponding to occur without flooding or overtopping the fence.

- A trench should be excavated approximately 6 in. wide and 6 in. deep along the line of the proposed silt fence (trenches should not be excavated wider or deeper than necessary for proper silt fence installation).
- Bottom of the silt fence should be keyed-in a minimum of 12 in.
- Posts should be spaced a maximum of 6 ft apart and driven securely into the ground a minimum of 18 in. or 12 in. below the bottom of the trench.
- When standard strength geotextile is used, a plastic or wire mesh support fence should be fastened securely to the upslope side of posts using heavy–duty wire staples at least 1 in. long. The mesh should extend into the trench.
- When extra-strength geotextile and closer post spacing are used, the mesh support fence may be eliminated.
- Woven geotextile should be purchased in a long roll, then cut to the length of the barrier. When joints are necessary, geotextile should be spliced together only at a support post, with a minimum 6 in. overlap and both ends securely fastened to the post.
- The trench should be backfilled with native material and compacted.
- Construct the length of each reach so that the change in base elevation along the reach does not exceed 1/3 the height of the barrier; in no case should the reach exceed 500 ft.
- Cross barriers should be a minimum of 1/3 and a maximum of ½ the height of the linear barrier.
- See typical installation details at the end of this fact sheet.

Installation Guidelines - Static Slicing Method

- Static Slicing is defined as insertion of a narrow blade pulled behind a tractor, similar to a plow blade, at least 10 inches into the soil while at the same time pulling silt geotextile fabric into the ground through the opening created by the blade to the depth of the blade. Once the geotextile is installed, the soil is compacted using tractor tires.
- This method will not work with pre-fabricated, wire backed silt fence.
- Benefits:
  - Ease of installation (most often done with a 2 person crew).
  - Minimal soil disturbance.
  - Better level of compaction along fence, less susceptible to undercutting
  - Uniform installation.
- Limitations:
  - Does not work in shallow or rocky soils.
  - Complete removal of geotextile material after use is difficult.
  - Be cautious when digging near potential underground utilities.

Costs

- It should be noted that costs vary greatly across regions due to available supplies and labor costs.
- Average annual cost for installation using the traditional silt fence installation method (assumes 6 month useful life) is $7 per linear foot based on vendor research. Range of cost is $3.50 - $9.10 per linear foot.

Inspection and Maintenance

- BMPs must be inspected in accordance with General Permit requirements for the associated project type and risk level. It is recommended that at a minimum, BMPs be inspected weekly, prior to forecasted rain events, daily during extended rain events, and after the conclusion of rain events.
- Repair undercut silt fences.
- Repair or replace split, torn, slumping, or weathered fabric. The lifespan of silt fence fabric is generally 5 to 8 months.
- Silt fences that are damaged and become unsuitable for the intended purpose should be removed from the site of work, disposed, and replaced with new silt fence barriers.
- Sediment that accumulates in the BMP should be periodically removed in order to maintain BMP effectiveness. Sediment should be removed when the sediment accumulation reaches 1/3 of the barrier height.
- Silt fences should be left in place until the upgradient area is permanently stabilized. Until then, the silt fence should be inspected and maintained regularly.

- Remove silt fence when upgradient areas are stabilized. Fill and compact post holes and anchor trench, remove sediment accumulation, grade fence alignment to blend with adjacent ground, and stabilize disturbed area.

References

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Stormwater Management Manual for The Puget Sound Basin, Washington State Department of Ecology, Public Review Draft, 1991.

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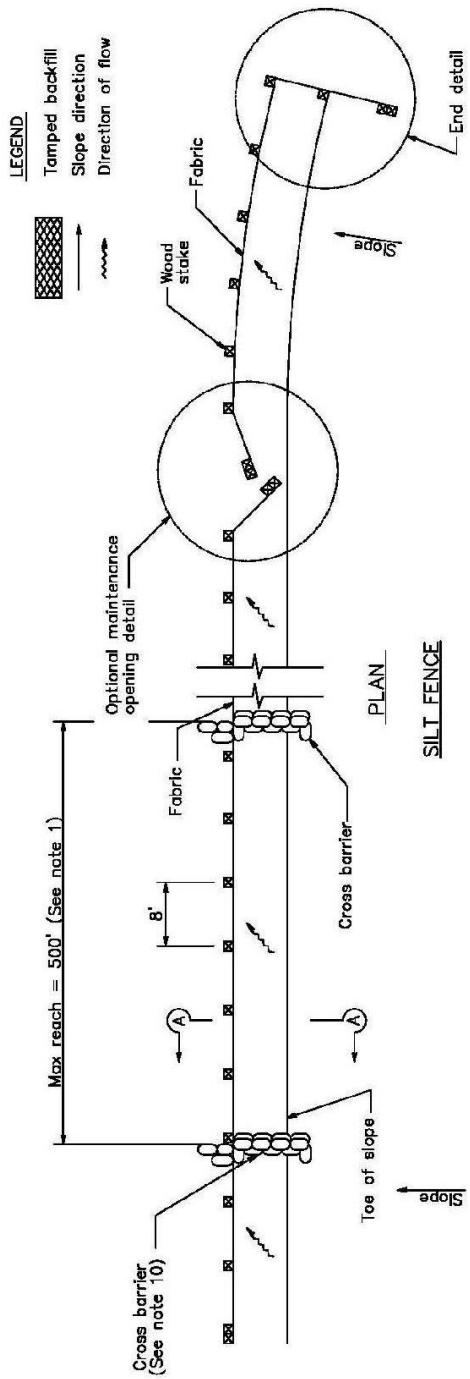
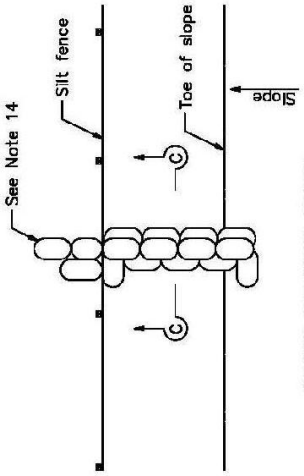
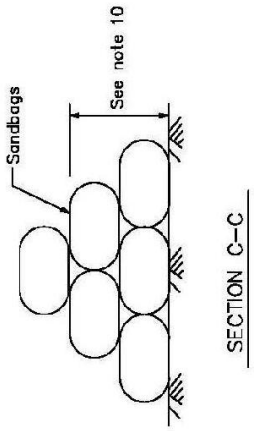
Erosion and Sediment Control Manual, Oregon Department of Environmental Quality, February 2005.

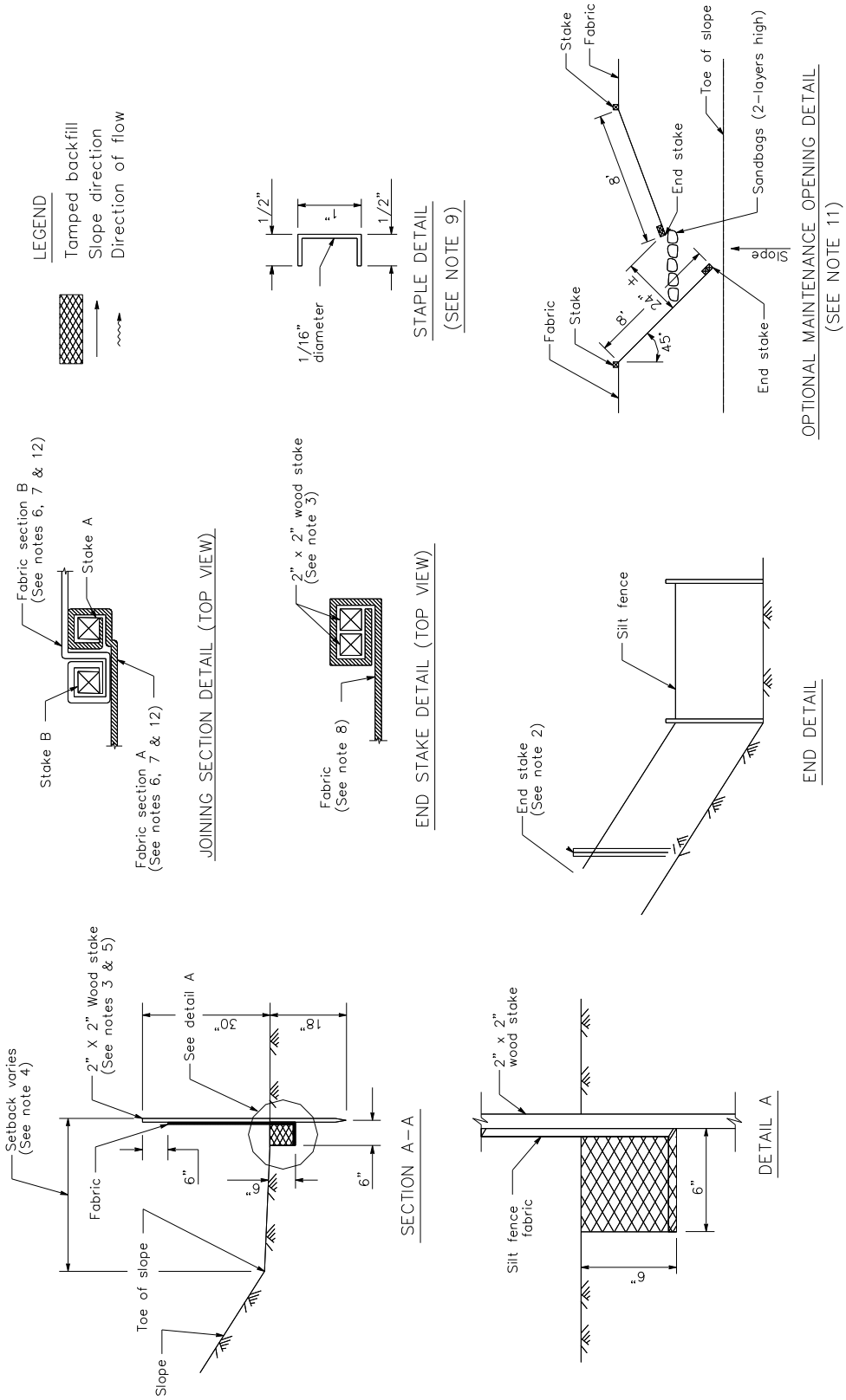


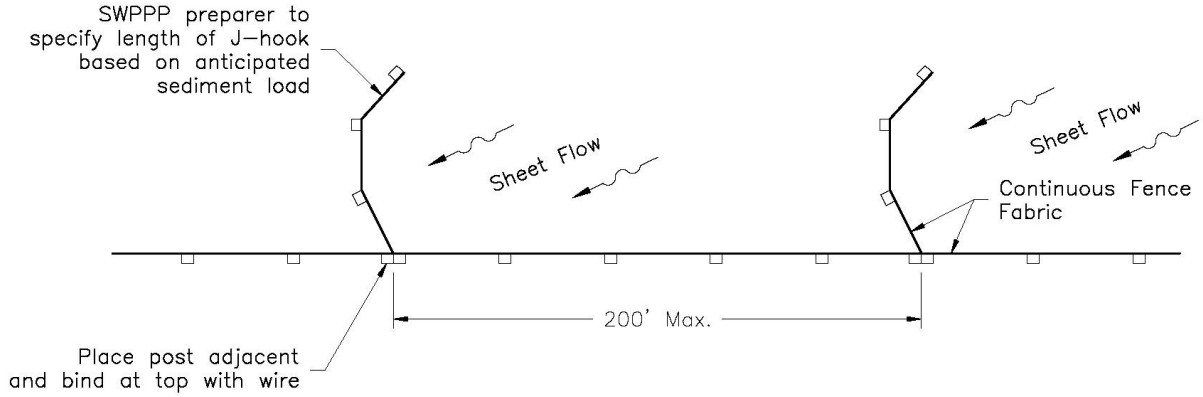




NOTES

1. Construct the length of each reach so that the change in base elevation along the reach does not exceed 1/3 the height of the linear barrier, in no case shall the reach length exceed 500'.
2. The last 8'–0" of fence shall be turned up slope.
3. Stake dimensions are nominal.
4. Dimension may vary to fit field condition.
5. Stakes shall be spaced at 8'–0" maximum and shall be positioned on downstream side of fence.
6. Stakes to overlap and fence fabric to fold around each stake one full turn. Secure fabric to stake with 4 staples.
7. Stakes shall be driven tightly together to prevent potential flow–through of sediment at joint. The tops of the stakes shall be secured with wire.
8. For end stake, fence fabric shall be folded around two stakes one full turn and secured with 4 staples.
9. Minimum 4 staples per stake. Dimensions shown are typical.
10. Cross barriers shall be a minimum of 1/3 and a maximum of 1/2 the height of the linear barrier.
11. Maintenance openings shall be constructed in a manner to ensure sediment remains behind silt fence.
12. Joining sections shall not be placed at sump locations.
13. Sandbag rows and layers shall be offset to eliminate gaps.
14. Add 3–4 bags to cross barrier on downgradient side of silt fence as needed to prevent bypass or undermining and as allowable based on site limits of disturbance.

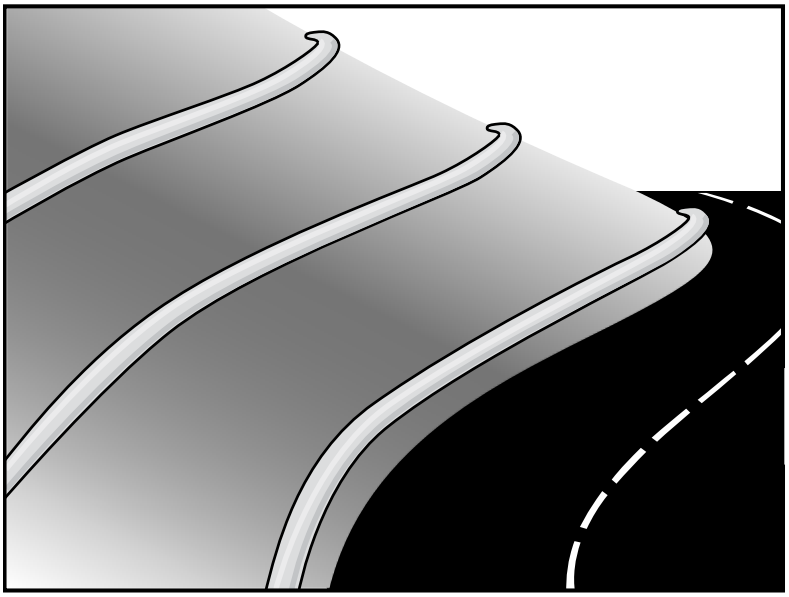

LEGEND
Tamped backfill
Slope direction
Direction of flow
1/2"
1"
1/2"
1/16" diameter
STAPLE DETAIL
(SEE NOTE 9)
Stake
Fabric
Toe of slope
Sandbags (2-layers high)
End stake
8'
4'
2'
8'
45°
Fabric
Stake
End stake
Slope
OPTIONAL MAINTENANCE OPENING DETAIL
(SEE NOTE 11)
Fabric section B
(See notes 6, 7 & 12)
Stake A
Stake B
Fabric section A
(See notes 6, 7 & 12)
JOINING SECTION DETAIL (TOP VIEW)
2" x 2" wood stake
(See note 3)
Fabric
(See note 8)
END STAKE DETAIL (TOP VIEW)
Silt fence
End stake
(See note 2)
END DETAIL
Setback varies
(See note 4)
2" X 2" Wood stake
(See notes 3 & 5)
See detail A
30"
18"
Fabric
6"
6"
6"
Toe of slope
Slope
SECTION A-A
2" x 2"
wood stake
Silt fence
fabric
6"
6"
DETAIL A


SWPPP preparer to specify length of J–hook based on anticipated sediment load
Sheet Flow
Sheet Flow
Continuous Fence Fabric
200' Max.
Place post adjacent and bind at top with wire

Plan

J–HOOK

Fiber Rolls SE-5



Categories

EC	Erosion Control	☒
SE	Sediment Control	☑
TC	Tracking Control	
WE	Wind Erosion Control	
NS	Non-Stormwater Management Control	
WM	Waste Management and Materials Pollution Control	

Legend:

☑ **Primary Category**

☒ **Secondary Category**

Targeted Constituents

Sediment	☑
Nutrients	
Trash	
Metals	
Bacteria	
Oil and Grease	
Organics	

Potential Alternatives

SE-1 Silt Fence

SE-6 Gravel Bag Berm

SE-8 Sandbag Barrier

SE-12 Manufactured Linear Sediment Controls

SE-14 Biofilter Bags

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Description and Purpose

A fiber roll consists of straw, coir, or other biodegradable materials bound into a tight tubular roll wrapped by netting, which can be photodegradable or natural. Additionally, gravel core fiber rolls are available, which contain an imbedded ballast material such as gravel or sand for additional weight when staking the rolls are not feasible (such as use as inlet protection). When fiber rolls are placed at the toe and on the face of slopes along the contours, they intercept runoff, reduce its flow velocity, release the runoff as sheet flow, and provide removal of sediment from the runoff (through sedimentation). By interrupting the length of a slope, fiber rolls can also reduce sheet and rill erosion until vegetation is established.

Suitable Applications

Fiber rolls may be suitable:

- Along the toe, top, face, and at grade breaks of exposed and erodible slopes to shorten slope length and spread runoff as sheet flow.
- At the end of a downward slope where it transitions to a steeper slope.
- Along the perimeter of a project.
- As check dams in unlined ditches with minimal grade.
- Down-slope of exposed soil areas.
- At operational storm drains as a form of inlet protection.

- Around temporary stockpiles.

Limitations

- Fiber rolls are not effective unless trenched in and staked.
- Not intended for use in high flow situations.
- Difficult to move once saturated.
- If not properly staked and trenched in, fiber rolls could be transported by high flows.
- Fiber rolls have a very limited sediment capture zone.
- Fiber rolls should not be used on slopes subject to creep, slumping, or landslide.
- Rolls typically function for 12-24 months depending upon local conditions.

Implementation

Fiber Roll Materials

- Fiber rolls should be prefabricated.
- Fiber rolls may come manufactured containing polyacrylamide (PAM), a flocculating agent within the roll. Fiber rolls impregnated with PAM provide additional sediment removal capabilities and should be used in areas with fine, clayey or silty soils to provide additional sediment removal capabilities. Monitoring may be required for these installations.
- Fiber rolls are made from weed free rice straw, flax, or a similar agricultural material bound into a tight tubular roll by netting.
- Typical fiber rolls vary in diameter from 9 in. to 20 in. Larger diameter rolls are available as well.

Installation

- Locate fiber rolls on level contours spaced as follows:
  - Slope inclination of 4:1 (H:V) or flatter: Fiber rolls should be placed at a maximum interval of 20 ft.
  - Slope inclination between 4:1 and 2:1 (H:V): Fiber Rolls should be placed at a maximum interval of 15 ft. (a closer spacing is more effective).
  - Slope inclination 2:1 (H:V) or greater: Fiber Rolls should be placed at a maximum interval of 10 ft. (a closer spacing is more effective).
- Prepare the slope before beginning installation.
- Dig small trenches across the slope on the contour. The trench depth should be ¼ to 1/3 of the thickness of the roll, and the width should equal the roll diameter, in order to provide area to backfill the trench.

- It is critical that rolls are installed perpendicular to water movement, and parallel to the slope contour.
- Start building trenches and installing rolls from the bottom of the slope and work up.
- It is recommended that pilot holes be driven through the fiber roll. Use a straight bar to drive holes through the roll and into the soil for the wooden stakes.
- Turn the ends of the fiber roll up slope to prevent runoff from going around the roll.
- Stake fiber rolls into the trench.
  - Drive stakes at the end of each fiber roll and spaced 4 ft maximum on center.
  - Use wood stakes with a nominal classification of 0.75 by 0.75 in. and minimum length of 24 in.
- If more than one fiber roll is placed in a row, the rolls should be overlapped, not abutted.
- See typical fiber roll installation details at the end of this fact sheet.

Removal

- Fiber rolls can be left in place or removed depending on the type of fiber roll and application (temporary vs. permanent installation). Typically, fiber rolls encased with plastic netting are used for a temporary application because the netting does not biodegrade. Fiber rolls used in a permanent application are typically encased with a biodegradeable material and are left in place. Removal of a fiber roll used in a permanent application can result in greater disturbance.
- Temporary installations should only be removed when up gradient areas are stabilized per General Permit requirements, and/or pollutant sources no longer present a hazard. But, they should also be removed before vegetation becomes too mature so that the removal process does not disturb more soil and vegetation than is necessary.

Costs

Material costs for regular fiber rolls range from $20 - $30 per 25 ft roll.

Material costs for PAM impregnated fiber rolls range between 7.00-$9.00 per linear foot, based upon vendor research.

Inspection and Maintenance

- BMPs must be inspected in accordance with General Permit requirements for the associated project type and risk level. It is recommended that at a minimum, BMPs be inspected weekly, prior to forecasted rain events, daily during extended rain events, and after the conclusion of rain events.
- Repair or replace split, torn, unraveling, or slumping fiber rolls.
- If the fiber roll is used as a sediment capture device, or as an erosion control device to maintain sheet flows, sediment that accumulates in the BMP should be periodically removed

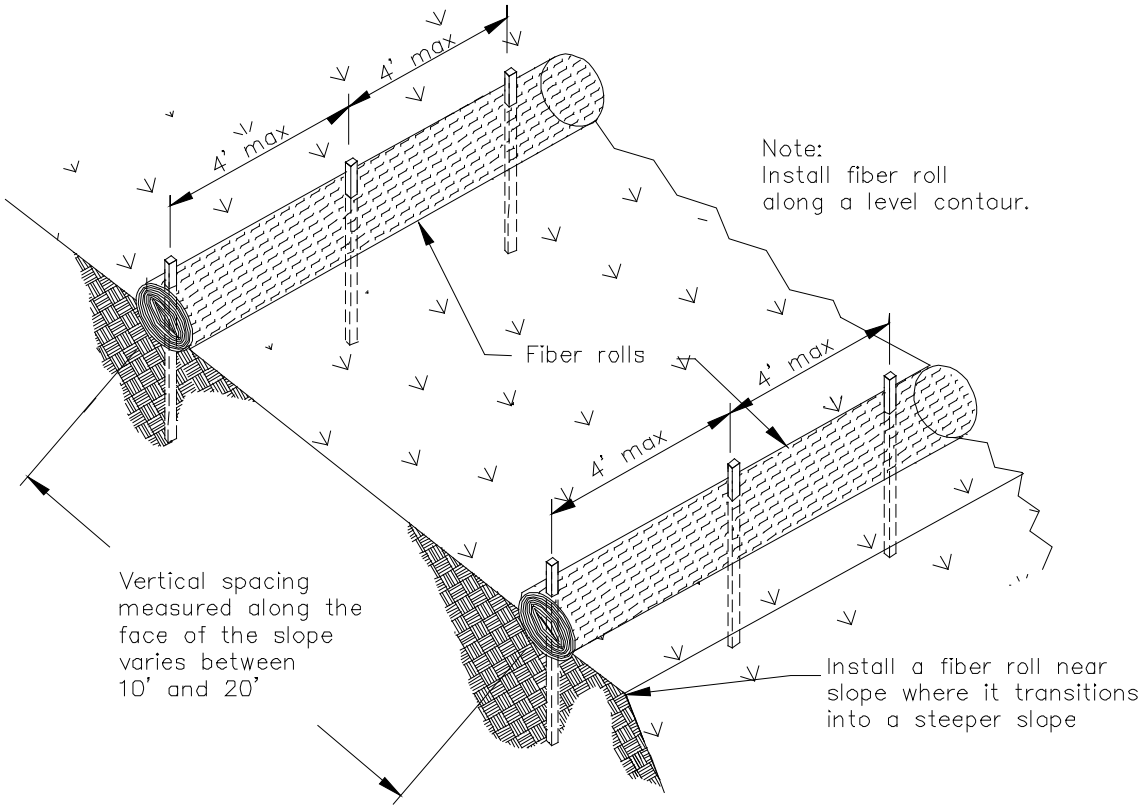
in order to maintain BMP effectiveness. Sediment should be removed when sediment accumulation reaches one-third the designated sediment storage depth.

- If fiber rolls are used for erosion control, such as in a check dam, sediment removal should not be required as long as the system continues to control the grade. Sediment control BMPs will likely be required in conjunction with this type of application.
- Repair any rills or gullies promptly.

References

Stormwater Quality Handbooks - Construction Site Best Management Practices (BMPs) Manual, State of California Department of Transportation (Caltrans), March 2003.

Erosion and Sediment Control Manual, Oregon Department of Environmental Quality, February 2005.



TYPICAL FIBER ROLL INSTALLATION

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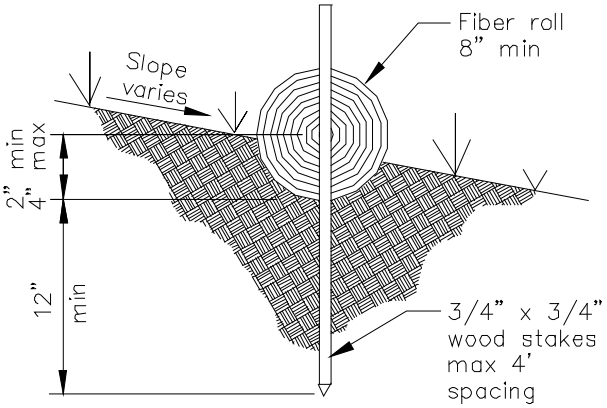

ENTRENCHMENT DETAIL

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