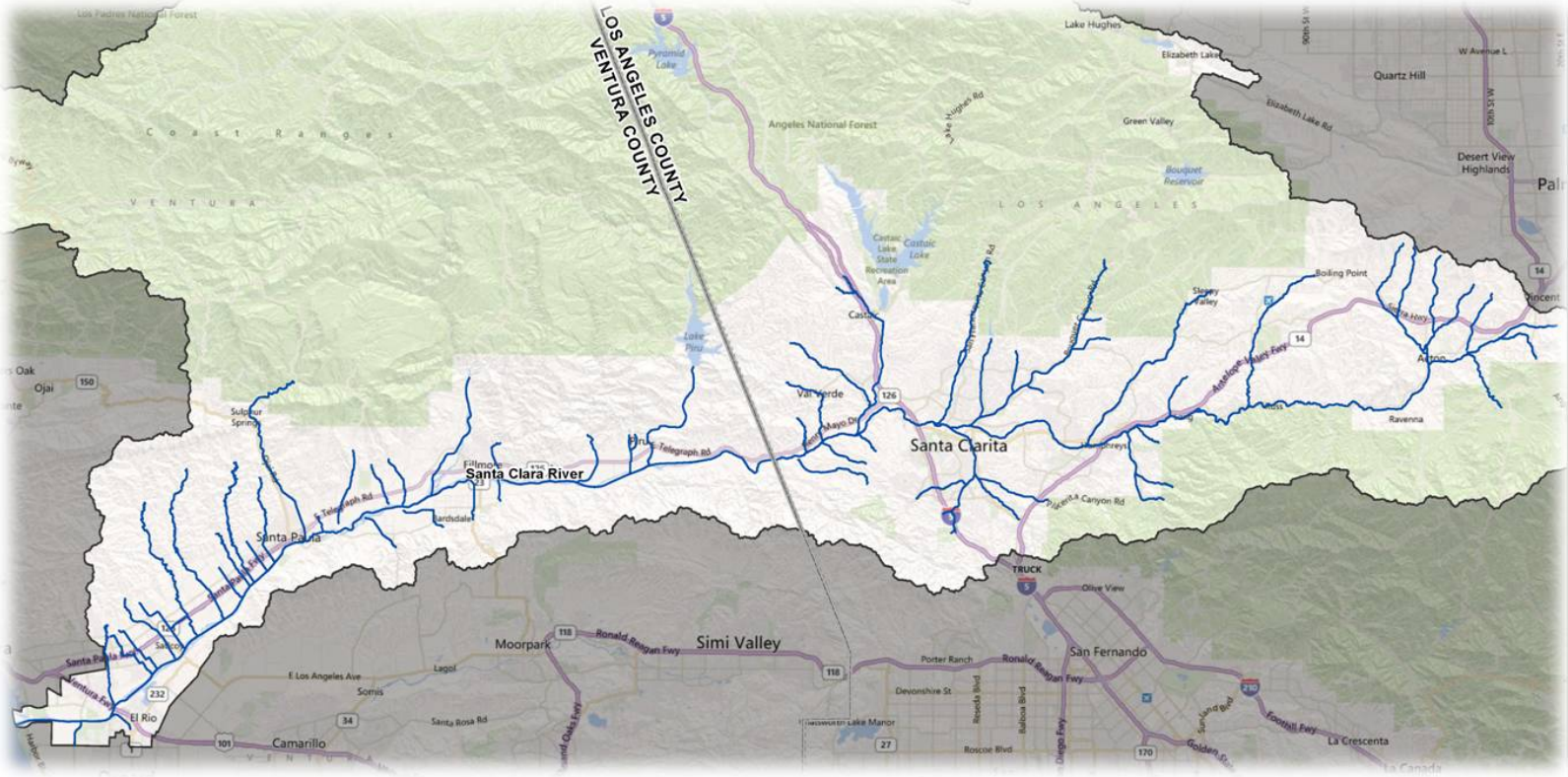

Santa Clara River Watershed Feasibility Study

Without Project Conditions Overflow Analysis Report

October 2012

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Ventura County & Los Angeles County, California

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Appendix B Written Field Notes of each USACE Reach
Appendix C Manning's Roughness Values Calculations of each USACE Reach
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Appendix F Hydrologic concentration points for FEMA reaches

Note: Appendices are Provided on the Accompanying CD.

Acronyms

AEP	Annual Exceedance Probability
Ave	Avenue
Blvd	Boulevard
CDTDM	California Department of Transportation Division of Maintenance
Ck	Creek
cfs	Cubic feet per second
CMP	Corrugated Metal Pipe
COLA	County of Los Angeles
DEM	Digital Elevation Model
DS	Downstream
Etc.	And so on
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
ft	Feet
HEC-RAS	Hydrologic Engineering Center's River Analysis System Version 4.1
HEC-GeoRAS	Hydrologic Engineering Center's Geo-referenced River Analysis System
i.e.	In other words
LA	Los Angeles
LACFCD	Los Angeles County Flood Control District
LIDAR	Light Detection and Ranging
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
No.	Number
RCP	Rectangular concrete pipe
Rd	Road
SCR	Santa Clara River
St	Street
Sta.	Station
US	Upstream
USACE	United States Army Corps of Engineers
UTM	Universal Transverse Mercator
WSE	Water Surface Elevation
XS	Cross-section
Yr.	Year

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Section I
Introduction

This report presents the results of an assessment of the without project hydraulic conditions within the Santa Clara River watershed. The study is one component of the Santa Clara River Watershed Feasibility Study currently being conducted by the U.S. Army Corps of Engineers (USACE), Ventura County and Los Angeles County. The Feasibility Study is being done to develop technical data required for identifying and understanding the water resources problems and opportunities in the watershed. During the feasibility study, opportunities that are identified with justified Federal interests can be directed into new spin-off studies that may lead to a Federal construction project.

The Santa Clara River watershed encompasses approximately 1,690 square miles, extending over portions of both Los Angeles and Ventura Counties. The Santa Clara River is the mainstem of the Santa Clara River watershed and includes over 60 different tributaries. The Santa Clara River has a history of flooding with flood waters overtopping the banks and causing damage to roads, bridges, infrastructure and loss of agricultural land due to erosion and sedimentation. Major flooding events, some containing record peak flows, occurred in 1969, 1978, 1983, 1992 and 1995. Other issues which affect the river include development and encroachment; construction of levees, dikes and diversions; degradation and encroachment due to historic sand and gravel extraction; and natural riverbed degradation and aggradation. Possible effects associated with urbanization include loss of habitat, increased runoff volume and flow rates, decrease in water quality, and changes to river hydraulics and sediment transport.

This report documents the hydraulic features of the mainstem and its major and minor tributaries. The estimated inundation boundaries and water surface profiles for multiple flood events (e.g., events with 50, 20, 10, 4, 2, 1, 0.5, and 0.2 percent annual exceedance probability [AEP]) are also presented for each water course.

The intent of this document is to summarize the flood hazard potential throughout the Santa Clara River watershed. The USACE and Federal Emergency Management Agency (FEMA), working independently, have produced updated hydraulic models for the study reaches examined in this study. This document presents the flood hazard areas delineated using the USACE and FEMA hydraulic models. Detailed reach characteristics including a list of hydraulic structures and hydraulic modeling assumptions are presented in the respective sections for the reaches examined as part of the USACE efforts (the USACE reaches). For the reaches modeled as part of FEMA's efforts (the FEMA reaches), the models, flood boundaries and profiles are presented, but less detail is provided regarding reach characteristics and modeling assumptions.

Study Authorization

This study was authorized by (1) Resolution by the Committee on Public Works, June 18, 1963, and (2) Public Law 406, 75th Congress, approved August 28, 1937.

Study Purpose

This study was conducted to assess the frequency and extent of flood hazard within the Santa Clara River watershed. Hydraulic models were developed and floodplain boundaries were determined which identify areas of concern for planning purposes. Where future projects are anticipated, or where very accurate water surface profile elevations are needed, more detailed analyses should be completed to supplement these initial assessments. The intent of this study was not to produce FEMA Flood Insurance Rate Maps (FIRMs); however, the provided models could be further refined to develop floodplains that meet FEMA mapping standards.

The study is a watershed-wide look at the flood hazard potential along the Santa Clara River and its many tributaries. The resulting maps show areas of concern, but should not be used to identify specific properties at risk. Additional examination/refinement of the hydrologic quantities, sediment effects, bank stability, levee adequacy, and other assumptions applied for this study would be required to quantify the potential hazard at very local levels.

I.1 Study Reaches

The study area is located in northern Los Angeles County and eastern Ventura County. The watershed covers an area of about 1,600 square miles and is bordered by three mountain ranges: the South Mountain range along the south border in Ventura County, the Santa Susana Mountains to the southeast in Los Angeles County and the San Gabriel Mountains at the upper end of the drainage area in Los Angeles County. Upper portions of the Santa Clara River watershed lie in the Angeles and Los Padres National Forest.

The Los Angeles-Ventura County line divides the basin into two parts. The drainage area in Los Angeles County comprises 650 square miles in the eastern (upstream) part of the basin, and the drainage area in Ventura County comprises 1,040 square miles in the western (downstream) part of the basin. About two square miles in the western part and a fraction of a square mile in the northwestern part are in Santa Barbara and Kern Counties, respectively.

The headwaters of the Santa Clara River rise in the San Gabriel Mountains in Los Angeles County. The River flows approximately 84 miles westward where it empties into the Pacific Ocean near Ventura. The major tributaries of the Santa Clara River in Los Angeles County are Bouquet Canyon, San Francisquito Creek, and Castaic Creek. The major tributaries in Ventura County are Piru Creek, Sespe Creek and Santa Paula Creek. All of the major tributaries enter the Santa Clara River from the northern drainage areas.

The study reaches examined in this study include the mainstem of the Santa Clara River and 65 tributaries, as shown in Figure I-1. The tributaries are irregularly spaced along the length of the Santa Clara River, starting in the headwaters with Soledad Canyon and ending with Patterson Drain, which joins the mainstem immediately upstream of its mouth at the Pacific Ocean.

The tributaries located in the headwaters drain rural sub-watersheds with open terrain and some agricultural land use. Progressing downstream, the sub-watersheds become more developed, and many tributaries include improved channels and buried culverts.

I.2 Report Organization

This report is organized into 65 sections to describe the individual tributaries within the watershed. The sections present the tributaries from upstream to downstream, as shown in Figure I-2. In general, each section describes one tributary, except for Section 59 which describes three adjacent tributaries Sudden Barranca, Brown Barranca and Franklin Barranca. These tributaries were summarized into one section to allow the reader to better understand how these tributaries are hydraulically connected (see Section 59 for more detail).

Additional supplementary information is provided in the Appendices. Appendix A includes annotated photographs documenting each USACE reach, Appendix B includes the written field notes on each USACE reach, Appendix C includes the results of the Manning's roughness values calculation for the USACE reaches, and Appendix D presents reach profiles for all flood events, including the FEMA and USACE study reaches. Appendix E includes digital copies of the Hydrologic Engineering Center's River Analysis System Version 4.1 (HEC-RAS) input files, delineated floodplain shapefiles, cross-section cutline shapefiles and river centerline shapefiles. Appendix F includes a table showing hydrologic concentration points for the FEMA reaches.

I.3 Hydrologic Data

The flow data used in this study were obtained from the hydrologic analysis conducted for the Santa Clara Watershed Feasibility Study, summarized in: *Report Addendum Final: Hydrologic Modeling of the Santa Clara River with U.S EPA Hydrologic Simulation Program – FORTRAN (HSPF*). The hydrologic study was completed by the Los Angeles District of the U.S. Army Corps of Engineers, Los Angeles County Department of Public Works, and Ventura County Watershed Protection District. The hydrologic data from the report were used as provided. No adjustments to the discharge rates were made to account for attenuation associated with ponding upstream of structures, for example.

The hydrology report provided multiple concentration points along many of the study reaches. Hydrologic concentration point data tables are provided for the USACE reaches in the respective sections. River stations and flow quantities for concentration points located along the FEMA reaches are provided in Appendix F.

To obtain a conservative estimate of the maximum flow appropriate for a given reach, the channel flow provided at each concentration point was applied to the reach extending upstream to the next concentration point. Figure I-3 shows the different concentration point locations specified throughout the Santa Clara River Watershed. Note that in some cases the concentration points are somewhat widely spaced along

the study reaches, as is typical for a watershed-wide study of this type. It is recommended that further refinement of the hydrologic variation be conducted along study reaches of particular concern as part of future detailed floodplain and channel improvement studies, to more accurately account for the distribution of local drainage inflows.

Existing reservoirs, dams, detention basins, or debris basins were not included in the hydraulic models. Significant structures were included in the hydrologic analysis. The hydrology report has a description of analysis assumptions and identification of the specific structures modeled.

I.4 Hydraulic Models

Two sets of hydraulic models and their results are presented in this report: those associated with the USACE reaches, and those associated with the FEMA reaches. The hydraulic modeling conventions used for this study follow the orientation standards used by the USACE. Cross section geometries look downstream, with the terms “left” and “right” used in respect to this perspective. River stationing begins downstream and continues upstream. This convention is used throughout the report to describe river stations, cross-sections, floodplains and overbank reaches.

Input and output files for the hydraulic models discussed in this report are presented in Appendix E. Details regarding main channel and overflow reach connectivity, lateral weirs, bridge/culvert characteristics, cross-section geometry, etc., are best examined through the geometric viewer window in HEC-RAS. The report provides an overview of model structure and results for each reach examined; however, the model input files should be accessed for additional detail.

I.4.1 FEMA Hydraulic Models

Finalized hydraulic models were provided to USACE from FEMA for all of the FEMA reaches, see Figure I-4 for FEMA reach locations. The FEMA models located in Los Angeles County were provided in the HEC-RAS format using horizontal reference of North American Datum (NAD) 1983, vertical reference of North American Vertical Datum (NAVD) 1988 and projected in Universal Transverse Mecator (UTM) 11 North. Whereas the FEMA models located in Ventura County were provided in HEC-RAS format using horizontal reference of NAD 1983 and vertical reference of NAVD 1988 and projected in State Plane. The FEMA hydraulic models were assumed accurate and were not adjusted for this study except, in some cases, for the hydrology. The recently updated hydrology was compared to the FEMA hydrology used in the hydraulic models, and if a difference of more than ten percent was noted, the model was revised to reflect the updated discharge values.

Additional return period events were added to the FEMA models. The FEMA models included peak discharges for the 10-year, 50-year, 100-year and 500-year flood events only. Peak discharges for the 2-year, 5-year, 25-year and 200-year flood events were added to the FEMA models to be consistent with the range of events examined in the USACE reaches.

Floodplain Delineation and Profiles

Floodplain boundaries were re-delineated for the FEMA tributaries if the 100-year and 500-year discharges were revised (which included all of the FEMA reaches located in Los Angeles County, and none of the FEMA reaches located in Ventura County). Flood profiles were re-computed for all of the FEMA reaches to include the additional flood events as described above.

I.4.2 USACE Hydraulic Models

Hydraulic models for the USACE reaches, see Figure I-4 for USACE reach locations, were developed using HEC-RAS and the Hydrologic Engineering Center's Geo-referenced River Analysis System (HEC-GeoRAS).

The hydraulic models underwent several iterations. The models were initially developed prior to the completion of the finalized hydrologic study. In the initial models, cross-section widths were exaggerated into the overbank areas. Draft flow discharges were added to the hydraulic models, and HEC-RAS tools such as levees and blocked obstructions were used to block areas of the cross-section where the flow was not hydraulically connected. Once the hydrology report was finalized, the final flow rates were added into the model and the cross-sections were reduced to only include hydraulically connected and inundated areas.

Field Reconnaissance

The project team completed several different field reconnaissance trips to note general channel features and to measure, where accessible, many of the bridges and culverts eventually incorporated within the hydraulic models for the Santa Clara River and tributaries. Details of the field reconnaissance are summarized below:

On November 13 and 14, 2007, and March 3 through March 7, 2008, the project team performed field reconnaissance of 24 tributaries of the Santa Clara River located in Ventura County. The tributaries are located along the Santa Clara River between Highway 101 and Piru. The western tributaries (including those from Harmon Barranca to Fagan Canyon) are located in urban subwatersheds and primarily consist of improved channels and buried culverts; the eastern tributaries (including those from Santa Paula Creek to Piru Creek) drain rural subwatersheds and include both improved and unimproved channels.

On September 11 and September 12, 2008, October 22 through October 24, 2008, and on November 20, 2008, the project team performed field reconnaissance of 34 tributaries to the Santa Clara River located in Los Angeles County. The tributaries are located along the Santa Clara River between Soledad Canyon and the Ventura County border. Some of the tributaries are located in urban subwatersheds where the reaches primarily consist of improved channels and buried culverts; however, most of the tributaries, especially east of Tick Canyon, are located in rural subwatersheds and consist of both improved and unimproved channels.

On March 31, 2010, the project team performed field reconnaissance of four FEMA reaches where disconnectivity occurred between the USACE reaches and the FEMA floodplain extents. The tributaries visited included the downstream portion of Soledad Canyon, the downstream portion of Acton Canyon B, the downstream portion of Escondido Canyon and the downstream portion of Haskell Canyon. Haskell Canyon is located in an urban subwatershed where there are improved channels and buried culverts; however, Escondido Canyon, Acton Canyon B and Soledad Canyon are located in rural subwatersheds and consist of unimproved channels.

Geometric Data and Cross-sections

Topographic, imagery and GIS data used to develop hydraulic models for the USACE tributaries included the following:

a. LIDAR data – Light Detection and Ranging (LIDAR) is a remote sensing technology used to develop topographic data. Ventura and Los Angeles County provided bare ground LIDAR data which is equivalent to bare earth elevations not including trees, industrial or residential structures. Ventura County provided LIDAR data taken in 2005. Los Angeles County provided LIDAR data taken in 2008. Both LIDAR data sets were provided in the NAD 1983, NAVD88, and State Plane California Zone V (feet) projection.

b. Aerial photographs – Aerial photographs of the study area were provided by Ventura County (flown in 2005) and Los Angeles County (flown in 2008).

c. Stream/Reaches – Study stream/reaches shapefiles were provide by Los Angeles County and Ventura County.

HEC-GeoRAS and ArcGIS 9.3.1 were used to produce the initial HEC-RAS models from the provided topography. Bridge and culvert geometries and channel improvements were added to the models based on field data and as-built drawings (provided by Ventura County, Los Angeles County and Caltrans).

In the HEC-GeoRAS, cross-section cutlines were drawn at all significant changes in channel geometry, invert slope, and hydraulic roughness, such that the average of the conveyance of the upstream and downstream cross-sections is a reasonable representative of the reach between them. Also, cross-section cutlines were drawn immediately upstream and downstream of all bridges, culverts, and other hydraulic structures. All cross-sections were oriented normal to the direction of the flow across the main channel. Cross-sections were occasionally bent or dog-legged across the floodplain to properly orient with the overbank contours.

The geometric data including cross section geometry, reach lengths, and bank points were exported from HEC-GeoRAS into the HEC-RAS model. The bank stations were further adjusted to accurately represent the main flow channel. Additional geometric

data such as bridge and culvert geometry, ineffective flow areas, blocked obstructions, levees, and lateral weirs were also added where appropriate into the HEC-RAS model.

Several urban areas in the watershed contain improved reaches. Due to limitations of the LIDAR data, improved reach side slopes and channel bed widths were found to typically be inaccurate. Available as-built drawings were obtained for the improved tributaries and incorporated into the hydraulic model for the main channel. As-built references and identification of the reaches containing improved sections are included in the tributary sections of this report.

Bridge Geometry

Bridges and culverts were added to each tributary based on the field reconnaissance notes, as-built drawings, and LIDAR geometry upstream and downstream of each bridge/culvert structure. As recommended in the HEC-RAS User Manual, four cross-sections were used for bridge/culvert modeling to incorporate the expansion and contraction of flow upstream and downstream of the bridge/culvert structures. Engineering judgment was used to incorporate reasonable representation of the existing bridge geometry if the measured culvert or deck geometry didn't physically fit into the existing LIDAR geometry.

The bridge modeling approach was adjusted based the different hydraulic conditions for each bridge. The pressure and/or weir flow option was selected for all bridges to accurately simulate bridge overtopping. For the 100-year and 500-year floods, a majority of the bridge structures were inundated. For low flow methods, the energy equation was generally used; however, for bridges with piers the "highest energy" option was selected, which chose between the solutions computed using the energy, momentum and Yarnell's bridge calculations.

Many long underground culverts exist in urban areas within the watershed, specifically for tributaries in Ventura County. These long culverts were added into the hydraulic models using geometries representing the limiting culvert capacity conditions along the length of the structure. The limiting slope and shape of the culvert was determined using normal depth capacity calculations and applied for the entire length of the culvert.

Manning's Roughness

In this study a variety of land use and channel types were encountered. Manning's roughness values for unlined channels were estimated using Cowan's method (see Chow's Open Channel Hydraulics, 1973). For overbank areas and concrete-lined channels, Manning's roughness values were estimated using USACE's Manning's roughness value tables prepared for the draft FIS for the Santa Clara River (USACE 2008), shown in Table I-1. The Manning's roughness value for an overbank consisting of a mixture of types was estimated based on a weighted average. The Table I-1 values were used as a starting point for model development, and were refined as modeling progressed.

Table I-1
General Manning's Roughness Values for Concrete-Lined Channel and Overbanks (USACE, 2008)

Channel/Overbank Type	Manning's Roughness
Concrete-lined channel	0.015
Dense Farm Land	0.085
Medium Farm Land	0.060
Light Farm Land	0.050
Dense Tree Cover	0.115
Medium Tree Cover	0.090
Grazing Land	0.055
Urban	0.130
Residential	0.130
Park	0.045
Water	0.030
Road	0.016
Plain Land	0.035
Low Vegetation	0.040
Medium Vegetation	0.055
Dense Vegetation	0.085

Manning roughness values were estimated on a reach by reach basis. The estimated Manning roughness values are summarized for each reach in the individual tributary sections of this report, with detailed tables provided in Appendix C. These reach roughness tables were used as a guide in developing the hydraulic models; however, the roughness coefficients used for a particular cross-section may vary from the reach table based on information obtained from the site and aerial photographs and field notes. For example, the overbank roughness values of cross-sections within urban or residential areas were adjusted depending on urban densities and street patterns.

Although the actual channel conditions may change with maintenance (e.g. removal of dense vegetation, or vegetation overgrowth), for modeling purposes it was assumed that the vegetative condition of each channel was the same as the condition observed during the field reconnaissance.

Ineffective Flow Areas and Artificial Levees

Ineffective flow areas were added at applicable cross-sections throughout the hydraulic models. The following situations required the use of the ineffective flow area option:

a. Floodplain areas significantly below the top of the channel bank that are not hydraulically connected to the channel downstream.

b. Floodplain areas upstream and downstream of the bridge/culvert encroachments caused by contraction and expansion of flow through the culvert openings. These areas were estimated using 4:1 expansion and 1:1 contraction ratios.

c. Floodplain areas within the hydraulic shadow of other obstructions and depressions that don't actively convey flow.

Ineffective flow areas located upstream and downstream of bridge or culvert structures were added in coordination with the width and height of the effective conveyance area for the culvert or bridge structure. The top of the ineffective flow was selected as the soffit of the culvert or bridge – at this height the nominal effective flow area becomes sealed and the entire cross-section becomes active.

In addition to ineffective flow areas, artificial levees were added to perched cross-sections to confine flow to the main channel, specifically for low flow frequencies. Artificial levees were also used to confine flows into adjacent flow concentration areas prior to overtopping into the overbank areas, specifically for worst case main channel profiles.

Flood control leveed reaches were assumed to remain intact when overflow occurred. Additional breach analysis should be conducted in the future to verify this assumption.

Expansion and Contraction Coefficients

Expansion and contraction coefficients were used to represent non-roughness based losses associated with variation in channel cross-section shape. The expansion and contraction coefficients applied to typical cross-sections are 0.3 and 0.1, respectively. These values are recommended in the HEC-RAS Hydraulic Reference Manual based on measured field data.

At abrupt flow changes including upstream and downstream of bridge structures, drop structure, and dip crossings, the expansion and contraction coefficients were adjusted to 0.5 and 0.3, respectively. These values are also recommended in the HEC-RAS Hydraulic Reference Manual.

Debris and Sediment Accumulation

Debris and sediment loading was accounted for in all modeled bridges, piers, and culverts based on the Hydrology and Hydraulics Section Policy Memorandum No.4 - Debris Loading on Bridges and Culverts, by U.S. Army Corps of Engineers (USACE, 2004). The debris loading guidelines are summarized as follows:

a. <u>Piers without sloping pier extensions</u> – Assume two feet of debris loading on each side of the pier for the full depth of flow,

b. Piers with sloping pier extensions – Assume two feet of debris loading on each side of the pier for a depth of six feet below the computed water surface,

c. Circular, elliptical or streamlined piers with widths greater than six feet – Assume no debris loading,

d. Multi-barrel rectangular culverts – Reduce the width of all interior barrels by two feet on each adjacent pier (total of four feet), and reduce the width of all outside barrels by two feet,

e. Multi-barrel circular culverts – Calculate the equivalent reduced diameter of all interior barrels to reflect two feet of debris on each adjacent pier (total of four feet), and reduce the outside barrel diameters by two feet,

f. Limiting size of culverts for debris loading – Assume complete debris blockage for all culverts with widths or diameters of three feet or less.

Modeling Overflow and Lateral Weirs

Overflow modeling was an important part of these analyses due to the numerous perched channel conditions found throughout the watershed. Overflow modeling was used where flow magnitudes exceeded the main channel capacity, and the overflows were expected to divert from the main channel path (rather than immediately return to the main channel).

Overflow reach geometries were developed in the same way as the main channel models were developed – using Geo-RAS and ArcGIS. Cross-sections perpendicular to the general overbank flow were pulled from the provided topography, and estimated flow paths and bank stations were added to the overflow reaches. The overflow models were not developed to the same level of detail as the main channel models – overflow path and bank stations are approximate and were not adjusted after importing the geometry into HEC-RAS. No attempt was made to simulate the numerous obstructions (i.e. houses and other structures) that the overflows would be expected to encounter. Constant (and approximate) Manning roughness values were used for both the main channel and overbank areas of these overflow models, so bank station definition was not considered a sensitive parameter of concern.

Bank stations were assigned to each section based on the plan view of the overbank area. These bank stations are not true banks, and should be viewed as approximations of the horizontal extent of the main flow path through the overbank area, based on general topographic trends.

The overtopping flows were estimated using lateral weirs in the HEC-RAS geometry. Lateral weirs were added between cross-sections where overtopping flow conditions were computed. Estimated tail-water locations were chosen for the weirs based on the topography of the overbank adjacent to each weir. In order to estimate overflow at each weir, the split flow optimization option was selected in HEC-RAS for each of the

weirs, (see HEC-RAS Hydraulic Reference Manual for further detail), which iteratively calculates the amount of expected overflow that occurs between cross-sections along the weir. The estimated overflow is automatically added to the overflow model and subtracted from the main channel flow. All of the overflow models developed for this study should be considered approximate representations of the two-dimensional flow conditions that are apparent throughout the watershed under certain flood events.

Boundary Conditions and Flow Regime

The models were run assuming steady state conditions and using the mixed flow regime option. The mixed flow regime option was chosen to allow the model to accurately predict transition between subcritical and supercritical flow regimes. To use the mixed flow regime, both upstream and downstream boundary conditions are required. Normal depth boundary conditions were applied for both upstream and downstream boundaries of each model.

Known water surface boundary conditions were not applied to the downstream boundaries of the tributaries (at the Santa Clara River) due to the timing differences between peak flow occurrence on the tributaries and the mainstem. Flood boundaries for the tributaries and the mainstem were developed independently, and the union of these inundation boundaries are judged to reasonably represent the extent of flood hazard along the study reaches. However, additional studies would be required to further define overflows at confluences. These areas may show flooding from both the mainstem and tributary for the same frequency event.

Model Review and Adjustment

Review of the computed hydraulic parameters (such as water depth, water velocity, top width of flow, energy slope, critical depth, and estimated weir overflow) was conducted to verify that no abrupt changes were calculated in the HEC-RAS. Abrupt changes would violate the assumption of gradually varied flow during flood events. Additional review was completed at the bridges, culverts, and lateral weirs to determine if the calculated water surface elevations and/or overflow quantities were reasonable. As a result of these reviews, input parameters were sometimes adjusted, and cross-sections added, to achieve simulations that are judged to be reasonable representations of the physical flood situation. Cross-sectional density was sometimes increased by using the channel interpolation option, in areas where the change in water surface elevations between cross-sections was determined to be unacceptably abrupt, but the change in cross-section geometry was minimal.

Floodplain Delineation and Profiles

Floodplains were delineated using the output from the HEC-RAS simulations and the same terrain data that had been used for developing the hydraulic models. ArcGIS 9.3.1 and HEC-GeoRAS version 4.2.93 were used to read the HEC-RAS export file. The hydraulic models for the different tributaries in this study are geo-referenced. HEC-GoeRAS reads the water surface elevation from the imported cross-sections and develops a water surface elevation grid. The floodplain grid is developed from

subtracting the water surface elevation grid from the terrain DEM (or LIDAR data). The floodplains generated by HEC-GeoRAS were manually smoothed and adjusted based on engineering judgment to represent realistic floodplains. Additional floodplain adjustments were made at the junctions of the USACE and FEMA reaches and between overflow reaches and lateral weirs. Detailed flood boundaries are provided within the report.

Profiles were developed for the peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events using the HEC-RAS profile generation routine. These profiles are provided in Appendix D. In general, the profiles are parallel to each other as expected. However, because the model was run under the mixed flow regime, the water surface profiles sometimes cross (for example, upstream and downstream of bridges or at critical flow locations) Since the flow regime may change, and the hydraulic jump location may move depending on flow magnitude, crossing water surface profiles in certain situations is not unreasonable.

I.4.3 FEMA and USACE Tributary Junctions and Coordinate System Issues

Many of the tributaries, especially in Los Angeles County, contain both USACE and FEMA reaches. Due to the different model projections and independent river stationing used in the FEMA and USACE hydraulic models, the models were not combined. Floodplains were developed independently for both models and then merged into a single shapefile in the NAD83 State Plane Zone V projection.

Normal depth boundary conditions were applied for each of the independent models, rather than attempting to translate the boundary conditions between models. The floodplain limits at model junctions were reviewed and adjusted to produce smooth connectivity of the results of the abutting models.

I.4.4 Hydraulic Model Limitations and Assumptions

The hydraulic models for the Santa Clara Watershed Feasibility Study were developed to estimate the hydraulic characteristics and flooding extents along the study channels over a range of flood events. The models are judged to produce reasonable approximations of the hydraulic conditions that may occur along the study reaches over a range of flow conditions, but it should be noted that several limitations are inherent in these models. Some of these limitations are discussed below.

The models were developed using available topography, modified with information obtained from field measurements and as-built plans of channel improvements and crossing structures. Not all structure plans were available, and sometimes assumptions were made in areas that were not accessible. The hydraulic models contain notes where assumptions have been made regarding local geometries.

The models assume rigid geometries for the channels. The channels studied are predominantly alluvial. Potentially significant erosion and deposition processes are

likely to occur during flood passage, which will change cross section geometries. In addition, a static flow resistance condition, representing conditions observed in the field, was assumed for the models. In reality, flow resistance conditions will change depending on channel processes (during an individual flood as well as long-term), maintenance activities, and general climate cycles.

Significant overtopping occurs in the downstream reaches of many modeled channels during major flood events, resulting in transfer and mingling of flows between tributaries. A one-dimensional model (HEC-RAS) was used to evaluate what is definitely a two-dimensional situation in many areas. A quasi two-dimensional simulation was accomplished using lateral weirs at potential overflow areas, with overbank reach models added when the overflow was judged to follow an independent flow path. Overbank models created for this study were less rigorously developed than the main channel models and should be considered as approximations only.

Overflows of the main channel may cause modification of the geometry of the channel banks (i.e. levee erosion) such that the lateral weir geometry may change as the flood occurs. This potential dynamic nature of the lateral weir geometry was not simulated in the developed models.

Levee encroachment options were sometimes used to keep flow contained in the main channel area before overtopping into an overbank. The use of the levee option does not necessarily mean that the levee meets FEMA certification requirements or USACE evaluation requirements.

Major drop structures observed along the study reaches were incorporated into the hydraulic models. Minor drop structures that did not show as obvious discontinuities in the LIDAR data were assumed insignificant for hydraulic modeling purposes, and were not summarized in this report.

No additional breach analyses were completed for any reach, including the perched channels. The channel banks were assumed to remain intact if overflow occurred.

Channel conveyance and capacities were determined based on bankfull capacity and did not account for required freeboard.

This study did not determine non-damaging discharges.

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Figure I-1: Santa Clara River Watershed Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5 10 20 Miles

N

Legend
Modeled Reaches
Watershed Boundary

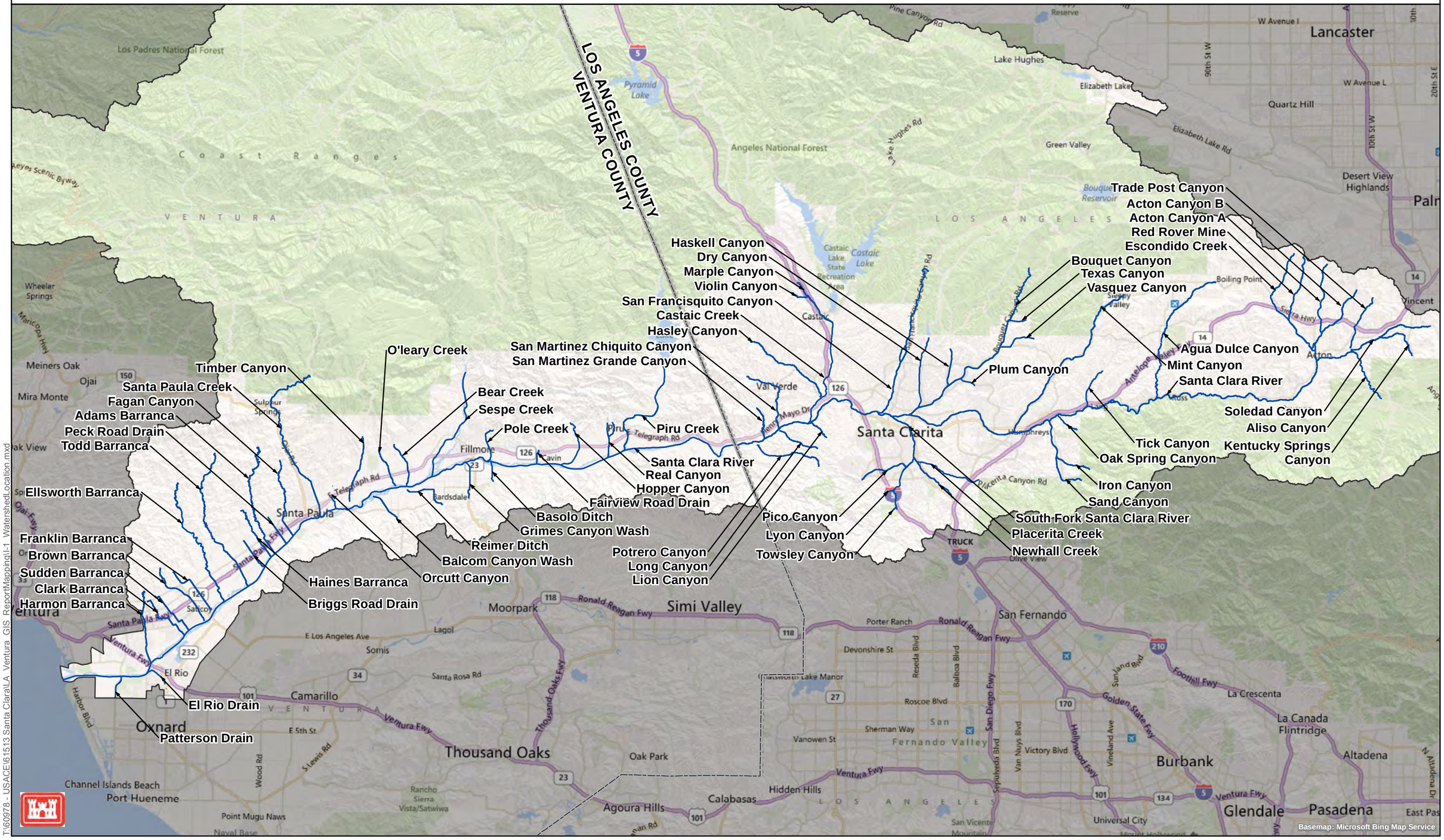

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Figure I-2: Santa Clara River Watershed Index
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5 10 20 Miles

N

Legend
Modeled Reaches
Watershed Boundary

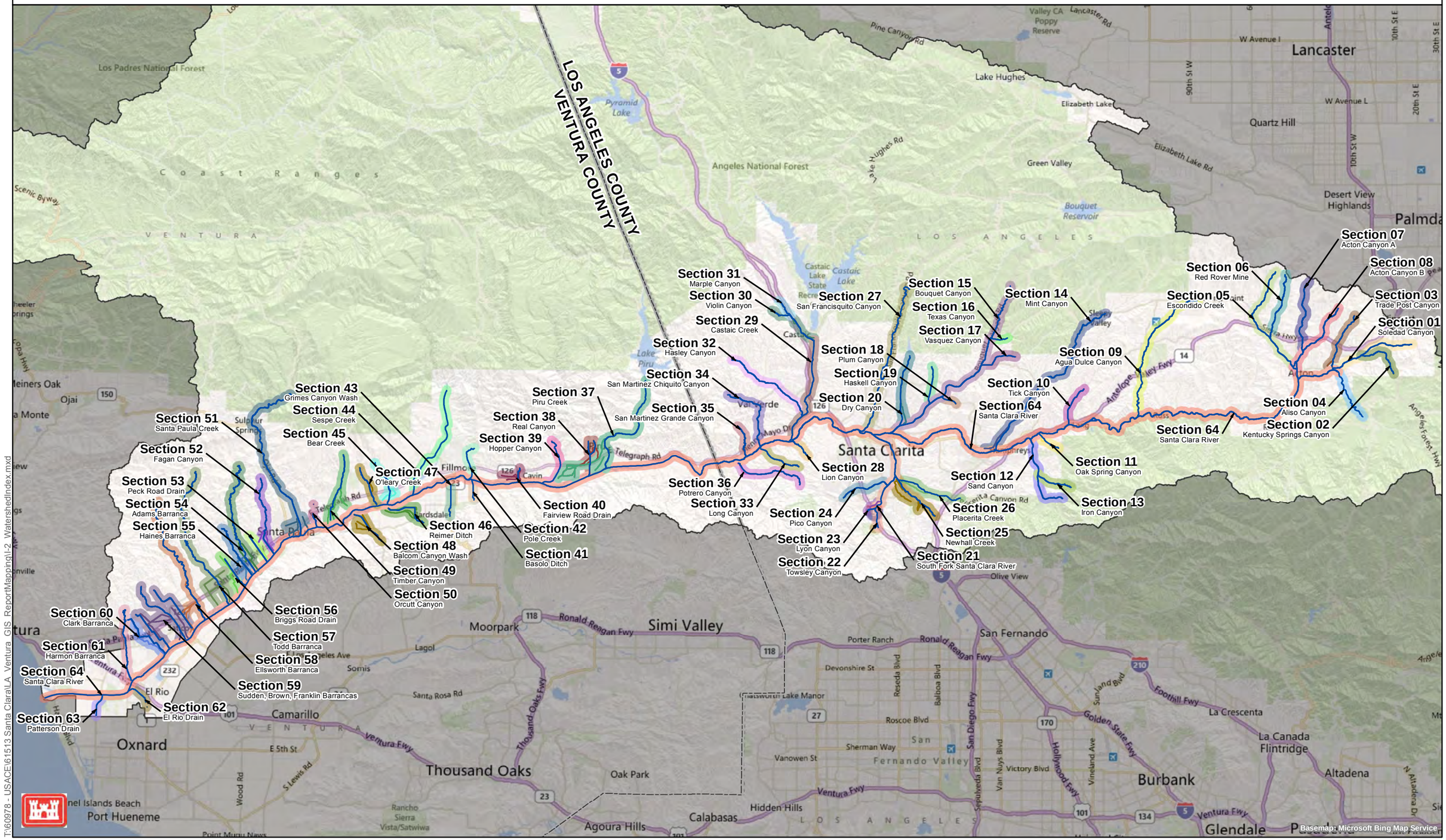

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Figure I-3: Santa Clara River Watershed Hydrology
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5 10 20 Miles

N

Legend

- Concentration Point Locations
- Modeled Reaches
- Watershed Boundary

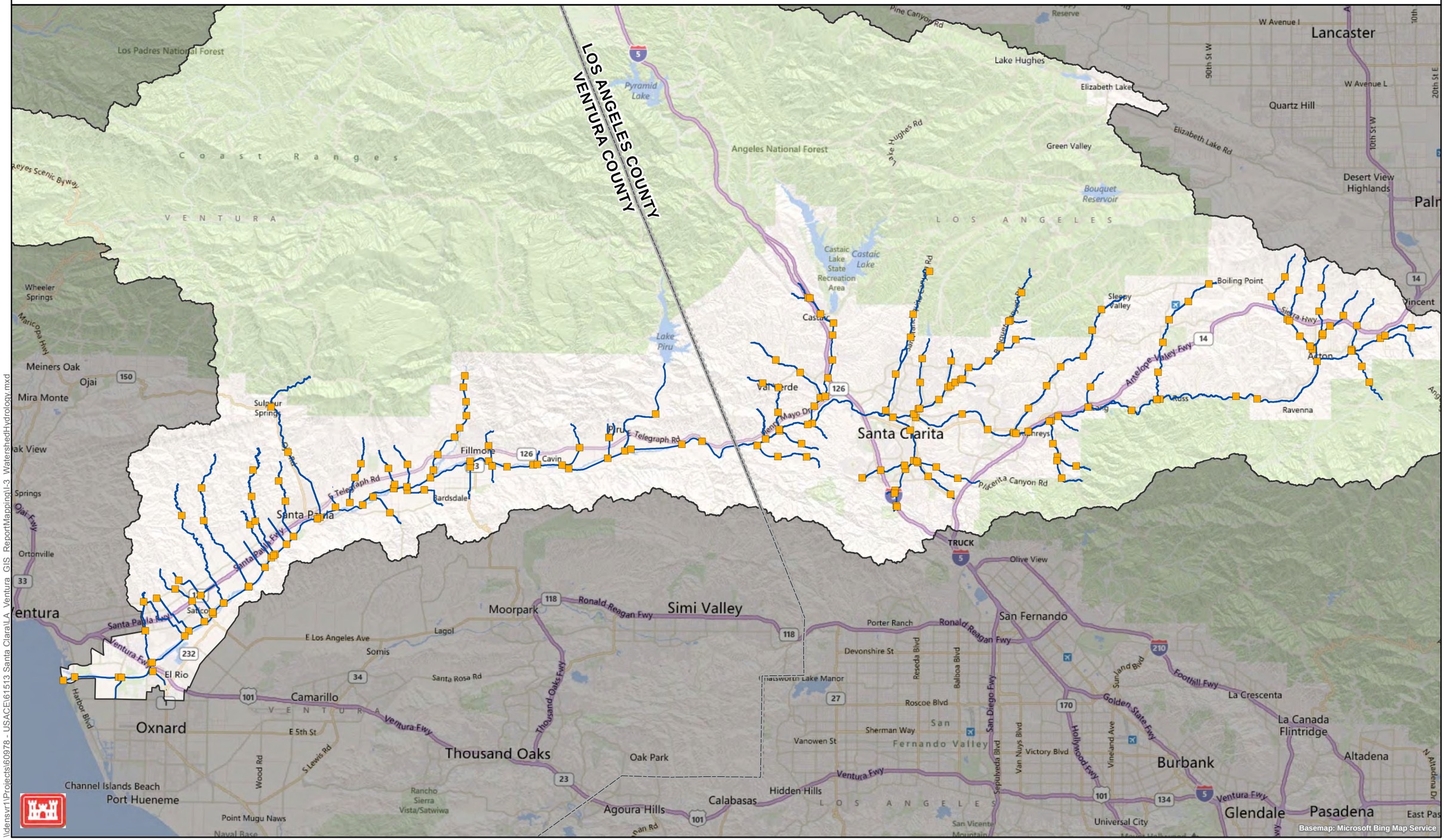

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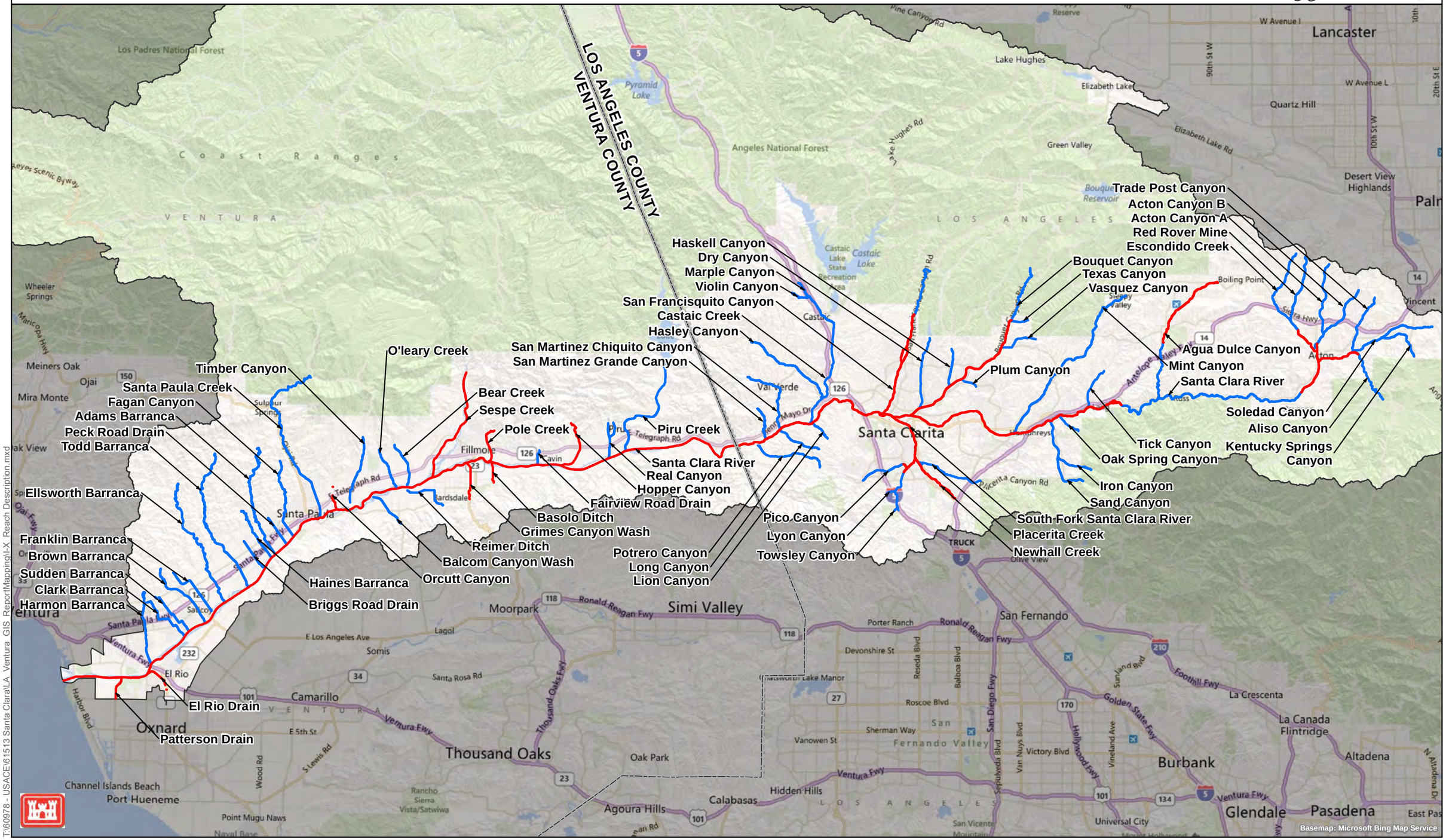
Figure I-4: Santa Clara River Reach Description
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5 10 20 Miles

N

Legend
- FEMA Main Reach
- USACE Main Reach
- Watershed Boundary



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Section 1
Soledad Canyon

1.1 General Description

Soledad Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Soledad Canyon are described in this section.

Soledad Canyon joins the Santa Clara River from the east, located next to Kentucky Springs Canyon at the upstream end of the Santa Clara River Watershed. The study reach extends along the lower three miles of Soledad Canyon. Figure 1-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach is located within light residential areas and bushy open space. The major crossing over Soledad Canyon is Angeles Forest Highway.

1.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in September 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the USACE study reach are summarized in Table 1-1.

Table 1-1
Structures along Soledad Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	174+00	Rockyford Road (dirt road)	Multiple culverts (dip crossing)	2-4' circular CMPs projecting US and DS from embankment, debris accumulation between culverts on US side
2	187+00	Angeles Forest Highway	Single culvert	2.5′ circular CMP with riser on US side, wingwalls

1.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The major features of the sub-reaches are summarized in Table 1-2.

Table 1-2
Sub-reaches along Soledad Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Downstream study limit (Station 12+18) ~ Upstream of Aliso Canyon Road(Station 37+96)	Meandering earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of ranches, farm land and brushy open space
Sub-reach 2 (No structures)	Upstream of Aliso Canyon Road (Station 42+00) ~ Confluence with Kentucky Springs (Station 87+43)	Broad natural channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space
Sub-reach 3 (Structures 1-2)	Confluence with Kentucky Springs (Station 88+75) ~ US study limit (Station 244+08)	Meandering earthen channel, sand/gravel channel bed, brushy main channel, floodplain consisting of brushy open space

1.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 1-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 1-3
Manning's Roughness Values along Soledad Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structures)	Downstream study limit (Station 12+18) ~ Upstream of Aliso Canyon Road (Station 37+96)	0.05	0.04	0.07
Sub-reach 2 (No structures)	Upstream of Aliso Canyon Road (Station 42+00) ~ Confluence with Kentucky Springs (Station 87+43)	0.05	0.04	0.05
Sub-reach 3 (Structures 1-2)	Confluence with Kentucky Springs (Station 88+75) ~ US study limit (Station 244+08)	0.06	0.04	0.06

1.5 Hydrology

Three hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 1-1. The peak discharge rates associated with these locations are summarized in Table 1-4.

Table 1-4
Hydrologic Concentration Points along Soledad Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
186+34	40	130	250	500	780	1,150	1,650	2,550
88+75	80	260	490	970	1,500	2,220	3,180	4,920
0	110	380	710	1,400	2,170	3,210	4,600	7,120

1.6 Hydraulic Model

The Soledad Canyon hydraulic model was developed with 118 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled reach contains two bridges/culverts (see Table 1-1) and six dip crossings (located at Station 14+18, 30+38, 71+20, 93+97, 97+90, and 106+93).

1.7 Boundary Conditions

Normal depth boundary conditions in HEC-RAS were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 244+08 and 240+92) and the two downstream-most cross-sections (Station 14+18 and 12+18) in the hydraulic model. The Soledad Canyon boundary condition slopes are 0.028 and 0.01 at the upstream and downstream ends of the model, respectively.

1.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 1-2. Major flooded areas along Soledad Canyon are summarized for the 100-year and 500-year flood events in Table 1-5.

Table 1-5
Major Flooding along Soledad Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (No structures)	Downstream study limit (Station 12+18) ~ Upstream of Aliso Canyon Road (Station 37+96)	Due to the undefined channel, the floodplain typically extends beyond the channel banks into adjacent open space. Areas where the floodplain extends into residential property/houses include areas around Sta. 15+18 to Sta. 37+96	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 2 (No structures)	Upstream of Aliso Canyon Road (Station 42+00) ~ Confluence with Kentucky Springs (Station 87+43)	The floodplain continuously extends into the left and right overbank area. The inundated area includes open brush	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (Structures 1-2)	Confluence with Kentucky Springs (Station 88+75) ~ US study limit (Station 244+08)	Due to the undefined channel, the floodplain typically extends beyond the channel banks into adjacent open space. Areas where the floodplain extends into residential property/houses include areas around Sta. 101+12, 134+51, 140+90, 166+81, 180+59, 202+84, and Sta. 240+92	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

1.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope is approximately three percent at the upstream end of the study reach, and 1.7 percent downstream. Angeles Forest Highway and Rockyford Road cause backwater conditions and overbank flooding due to insufficient capacity. Additionally, Aliso Canyon Road acts as a natural dam causing backwater and overbank flooding upstream of the dip crossing. The computed flow regime for 52 percent of the cross-sections was supercritical.

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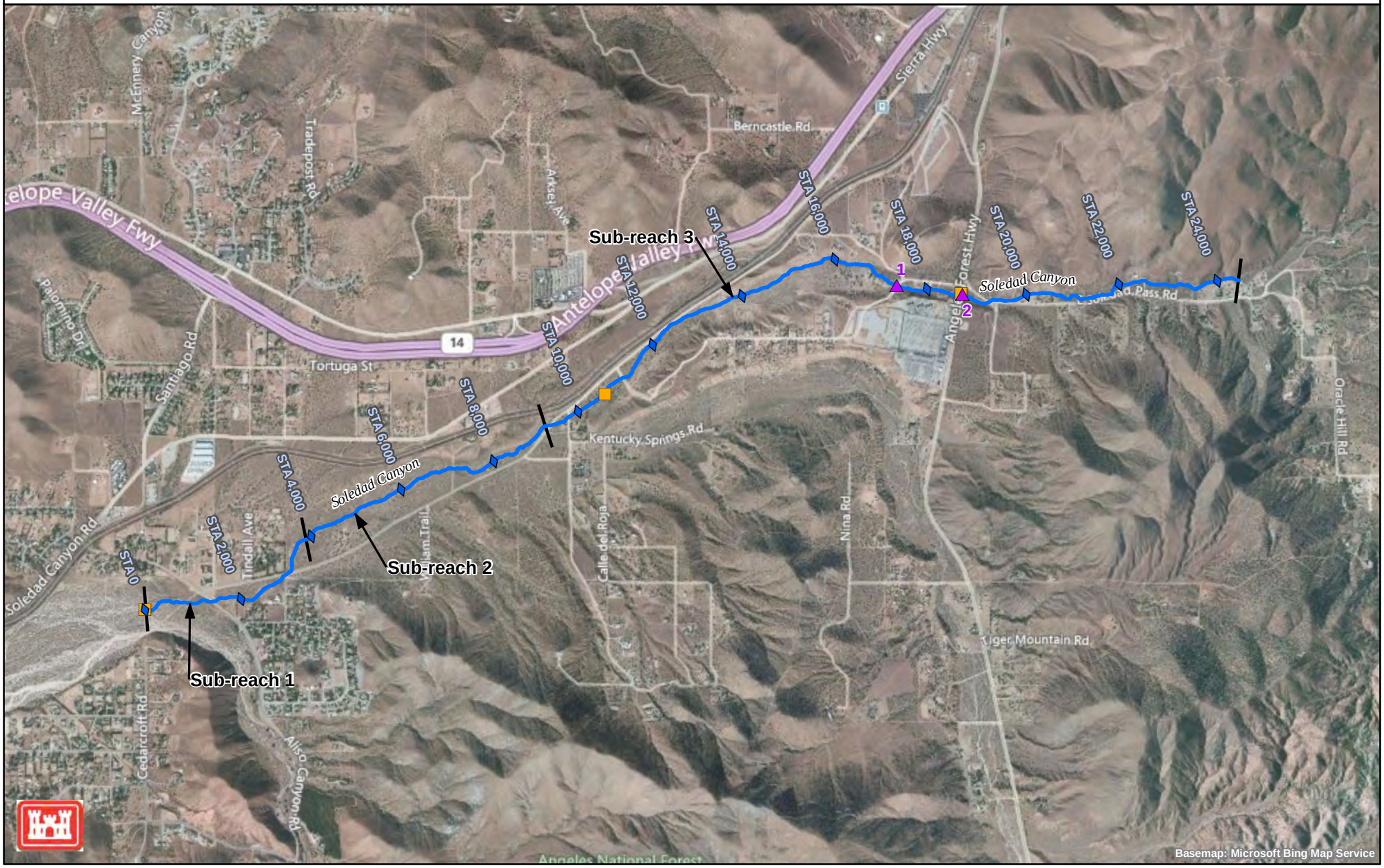
Figure 1-1: Soledad Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach



Basemap: Microsoft Bing Map Service

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Figure 1-2: Soledad Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Section 2
Kentucky Springs Canyon

2.1 General Description

Kentucky Springs Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Kentucky Springs Canyon are described in this section.

Kentucky Springs Canyon joins the Santa Clara River from the east. Kentucky Springs Canyon and Soledad Canyon form the headwaters of the Santa Clara River. The study reach extends along the lower 2.5 miles of Kentucky Springs Canyon. Figure 2-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach is located within an agricultural area and open space. There are no major crossings over Kentucky Springs Canyon.

2.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively. Kentucky Springs Canyon contains no structures with the study reach.

2.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The features of this study reach were relatively consistent, and a single sub-reach was identified. The physical characteristics of the Kentucky Springs Canyon sub-reach are summarized in Table 2-1.

Table 2-1
Sub-reaches along Kentucky Springs Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Confluence with Soledad Canyon (Station 0+80) ~ US study limit (Station 134+95)	Broad undefined channel, sand/gravel channel bed, brushy main channel, floodplain consisting of agriculture and brushy open space

2.4 Manning's Roughness Coefficients

The Manning's roughness values for the study reach are summarized in Table 2-2. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 2-2
Manning's Roughness Values along Kentucky Springs Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1	Confluence with Soledad Canyon (Station 0+80) ~ US study limit (Station 134+95)	0.06	0.04	0.06

2.5 Hydrology

One hydrologic concentration point was provided along the study reach (see the Introduction for the source of the hydrology information). The location of the hydrologic concentration point is shown in Figure 2-1. The peak discharge rate associated with this location is summarized in Table 2-3.

Table 2-3
Hydrologic Concentration Point along Kentucky Springs Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	30	120	220	370	670	990	1,420	2,200

2.6 Hydraulic Model

The Kentucky Springs Canyon hydraulic model was developed with 177 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled study reach is located in an open, undeveloped valley with farmland and open space. The modeled study reach contains two dip crossings located at Station 1+59 and 113+39.

2.7 Boundary Conditions

Normal depth boundary conditions were applied at the upstream and downstream ends of the hydraulic model. These boundary conditions were developed based on the invert slopes computed between the upstream-most cross-sections (Station 134+95and 134+53) and between the downstream-most cross-sections (Station 119 and 80). The boundary condition slopes are 0.037 and 0.026 for the upstream and downstream ends, respectively, of the Kentucky Springs Canyon model.

2.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 2-2. Major flooded areas along Kentucky Springs Canyon are summarized for the 100-year and 500-year flood events in Table 2-4.

Table 2-4
Major Flooding along Kentucky Springs Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1	Confluence with Soledad Canyon (Station 0+80) ~ US study limit (Station 134+95)	Due to the undefined channel the floodplain extends beyond the channel banks into the adjacent open space. The flooded areas include residential property near Sta. 6+51 to Sta. 9+42, and Sta. 83+00 to Sta. 127+69	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

2.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope is approximately three percent throughout the study reach. The computed flow regime for 55 percent of the cross-sections was supercritical.

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Figure 2-1: Kentucky Springs Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 2-2: Kentucky Springs Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 3
Trade Post Canyon

3.1 General Description

Trade Post Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Trade Post Canyon are described in this section.

Trade Post Canyon joins the Santa Clara River from the north, between the locations where Aliso Canyon and Kentucky Springs join the mainstem. The study reach extends 3.1 miles upstream of the confluence with the Santa Clara River and continues to the mouth of this tributary. Figure 3-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach is located within areas of residential and bushy open space except for a 1/2 mile segment which is located within a commercial area. Major crossings over Trade Post Canyon include Soledad Canyon Road, Highway 14 and Sierra Highway.

3.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 3-1.

Table 3-1
Structures along Trade Post Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	15+50	Railroad	Single culvert	3' circular RCP, headwall & wingwalls, US opening buried (6" from the invert)
2	29+00	Soledad Canyon Road	Multiple culverts	2-7'x6' (Span x Rise) concrete box culverts w/ 9" wide pier, headwall & wingwalls
3	65+00	HWY 14	Multiple culverts	2-6' circular Culverts (CMPs US side; RCPs DS side) & 1-8'x4' (Span x Rise) concrete box culverts (could not find US inlet), headwall & wingwalls
4	74+00	Sierra Highway	Buried culvert below retail center & Sierra Hwy	6'x5.75' concrete box culvert, debris grate at DS end, grouted riprap/drop at DS side
5	81+00	Cattle Creek Road	Single culvert	9.67'x6.83' concrete box culvert, headwall & wingwalls, paved apron at US side
6	130+00	Mary Road	Detention basin	Assumed box culvert 8'x5', headwall & wingwalls

3.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The physical characteristics of the Trade Post Canyon sub-reaches are summarized in Table 3-2.

Table 3-2
Sub-reaches along Trade Post Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	Confluence with Soledad Canyon (Station 1+71) ~ Soledad Canyon Road (Station 28+96)	Meandering earthen channel, sand/gravel channel bed, brushy main channel, floodplain consisting of ranches & brushy open space
Sub-reach 2 (Structure 2)	Soledad Canyon Road (Station 29+68) ~ Tortuga Street (Station 52+30)	Meandering earthen channel, sand/gravel channel bed, semi-defined main channel, floodplain consisting of brushy open space & residential area
Sub-reach 3 (Structure 3)	Tortuga Street (Station 54+78) ~ Sierra Highway (Station 68+70)	Meandering earthen channel, sand/gravel channel bed, un- or semi-defined brushy main channel, floodplain consisting of brushy open space
Sub-reach 4 (Structures 4 and 5)	Sierra Highway (Station 75+78) ~ 1,000 ft US of Cattle Creek Road (Station 90+60)	Meandering earthen channel, sand/gravel channel bed, floodplain consisting of commercial & residential areas
Sub-reach 5 (Structures 6)	1,000 ft US of Cattle Creek Road (Station 91+14) ~ US study limit (Station 160+18)	Meandering earthen channel, sand/gravel channel bed, main channel, floodplain consisting of ranches and pasture

3.4 Manning's Roughness Coefficients

The Manning's roughness values for the Trade Post Canyon sub-reaches are summarized in Table 3-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 3-3
Manning's Roughness Values along Trade Post Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	Confluence with Soledad Canyon (Station 1+71) ~ Soledad Canyon Road (Station 28+96)	0.05	0.4	0.05
Sub-reach 2 (Structure 2)	Soledad Canyon Road (Station 29+68) ~ Tortuga Street (Station 52+30)	0.06	0.4	0.06
Sub-reach 3 (Structure 3)	Tortuga Street (Station 54+78) ~ Sierra Highway (Station 68+70)	0.05	0.4	0.05
Sub-reach 4 (Structures 4 to 6)	Sierra Highway (Station 75+78) ~ 1,000 ft US of Cattle Creek Road (Station 90+60)	0.06	0.4	0.06
Sub-reach 5 (Structures 7)	1,000 ft US of Cattle Creek Road (Station 91+14) ~ US study limit (Station 160+18)	0.045	0.4	0.05

3.5 Hydrology

Two hydrologic concentration points were provided along the study reach of Trade Post Canyon (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are show in Figure 3-1. The peak discharge rates associated with these locations are summarized in Table 3-4.

Table 3-4
Hydrologic Concentration Points along Trade Post Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
68+70	10	40	70	130	210	310	440	690
0	30	110	210	400	630	930	1,330	2,060

3.6 Hydraulic Model

The Trade Post Canyon hydraulic model was developed with 273 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled reach contains six bridges/culverts (see Table 3-1), three dip crossings (located at Sta. 45+19, 57+32 and 104+94), and one overflow reach.

3.6.1 Overflow Reaches

Overflow reaches were added to the Trade Post Canyon model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach during extreme events due to limited channel and bridge capacities. An overflow reach was added to the right overbank upstream of the Railroad crossing.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 3-5.

Table 3-5
Maximum Flow in Trade Post Canyon right overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	30	108	188	294	410	562	755	1,113

Overflow Reach Results

Due to limited capacity at the railroad crossing, all flows overtop the main channel and flow along the railroad before continuing downstream towards Soledad Canyon. Nearly all of the flow overtops into the right overbank reach due to minimal capacity of the crossing after accounting for sediment accumulation.

3.7 Boundary Conditions

Normal depth boundary conditions in HEC-RAS were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 160+18 and 159+80) and the two downstream-most cross-sections (Station 5+04 and 1+71) in the hydraulic model. Trade Post Canyon boundary condition slopes are 0.16 and 0.001 at the upstream and downstream ends of the model, respectively.

The normal depth boundary condition for the overflow reaches were used for the upstream boundary based on the invert slopes computed between the upstream-most cross-sections (Station 19+09 and 16+51) and between the downstream-most cross-sections (Stations 8+00 and 1+44) . The overflow boundary condition slopes are 0.02 and 0.01 at the upstream and downstream ends of the model, respectively.

3.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 3-2. Major flooded areas along Trade Post Canyon are summarized for the 100-year and 500-year flood events in Table 3-6.

Table 3-6
Major Flooding along Trade Post Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	Confluence with Soledad Canyon (Station 1+71) ~ Soledad Canyon Road (Station 28+96)	Due to the undefined channel the floodplain extends into the adjacent open space in the left and right overbank areas. Areas where the inundation extends over residential property and parking lots include areas near Sta. 1+71 to Sta. 3+38, 7+72, 16+09 to 19+72. Directly downstream of Sta. 16+09, the flow continuously flows in the left overbank. The flooded areas include several houses, roads and the railroad	Same as the 100-year flood extent with additional flooding extend on the left and right overbanks. Additional flooding occurs between Sta. 6+81 to 13+35
Sub-reach 2 (Structure 2)	Soledad Canyon Road (Station 29+68) ~ Tortuga Street (Station 52+30)	Due to the undefined channel, the floodplain extends into the adjacent open space in the left and right overbank areas. Flooded areas include open space and residential property and roads are near Sta. 38+62, and Sta. 44+34	Same as the 100-year flood extent with additional flooding extend on the left and right overbanks
Sub-reach 3 (Structure 3)	Tortuga Street (Station 54+78) ~ Sierra Highway (Station 68+70)	Due to the undefined channel, the floodplain extends into the adjacent open space in the left and right overbank areas. Flooded areas include open space and residential property and roads are near Sta. 57+87, and Sta. 66+87	Same as the 100-year flood extent with additional flooding extend on the left and right overbanks
Sub-reach 4 (Structures 4 to 6)	Sierra Highway (Station 75+78) ~ 1,000 ft US of Cattle Creek Road (Station 90+60)	Due to the undefined channel, the floodplain extends into the adjacent open space in the left and right overbank areas. Flooded areas include open space and residential property and roads are near Sta. 82+11 to Sta. 89+91	Same as the 100-year flood extent with additional flooding extend on the left and right overbanks. Additional flooded occurs upstream of Sierra Hwy
Sub-reach 5 (Structures 7)	1,000 ft US of Cattle Creek Road (Station 91+14) ~ US study limit (Station 160+18)	Due to the undefined channel, the floodplain extends into the adjacent open space in the left and right overbank areas. Flooded areas include open space and residential property and roads are near Sta. 180+40	Same as the 100-year flood extent with additional flooding extend on the left and right overbanks. Additional flooded occurs downstream of the detention facility

3.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average bed slope ranges from ten percent in the upstream portions of the study reach to 2.8 percent downstream (discluding the three most downstream cross-sections). Conveyance limitations caused flooding under 500-year flood conditions at the Railroad crossing, Sierra Highway and at the detention facility outlet. The computed flow regime for 67 percent of the cross-sections was supercritical.

Figure 3-1: Trade Post Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

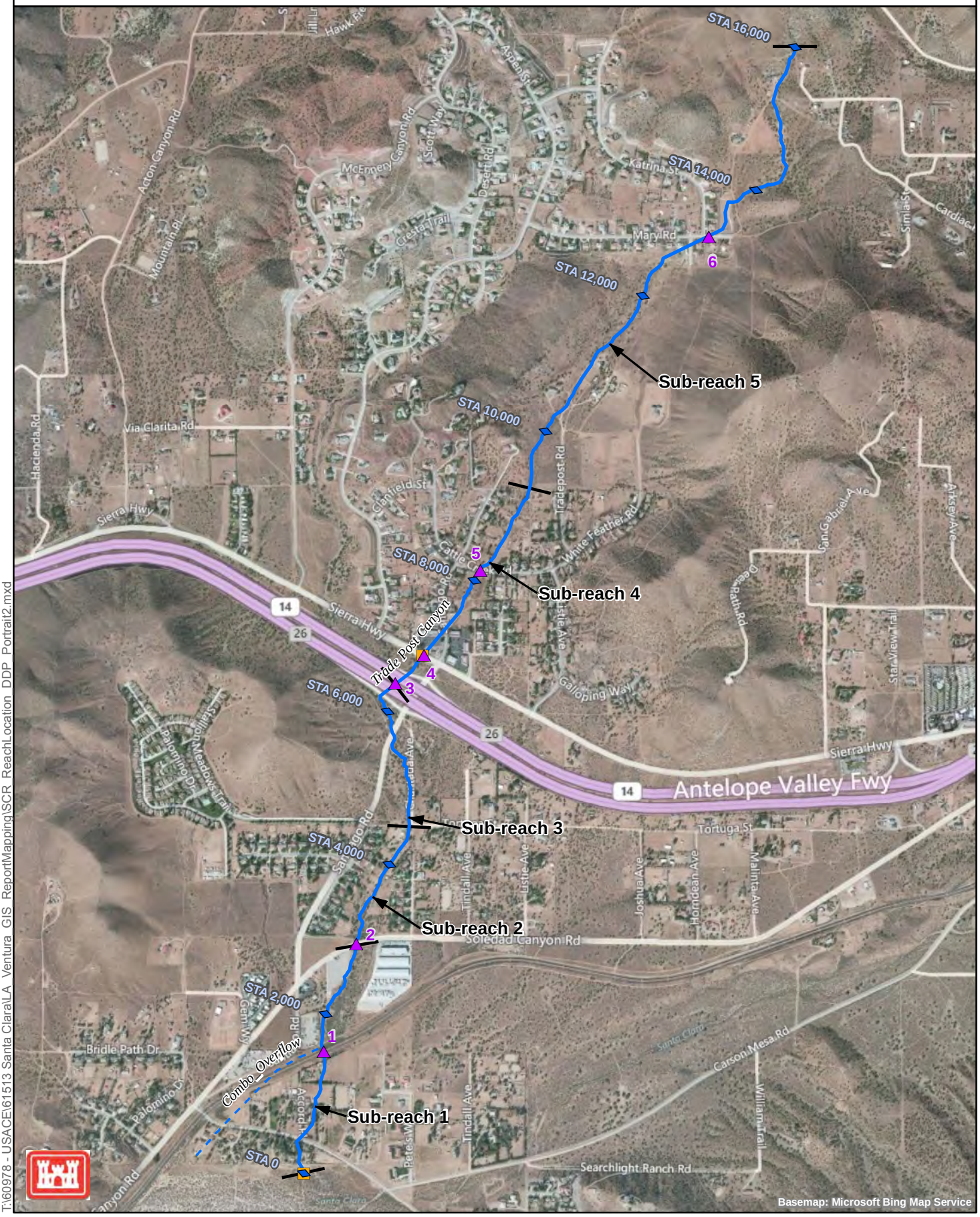

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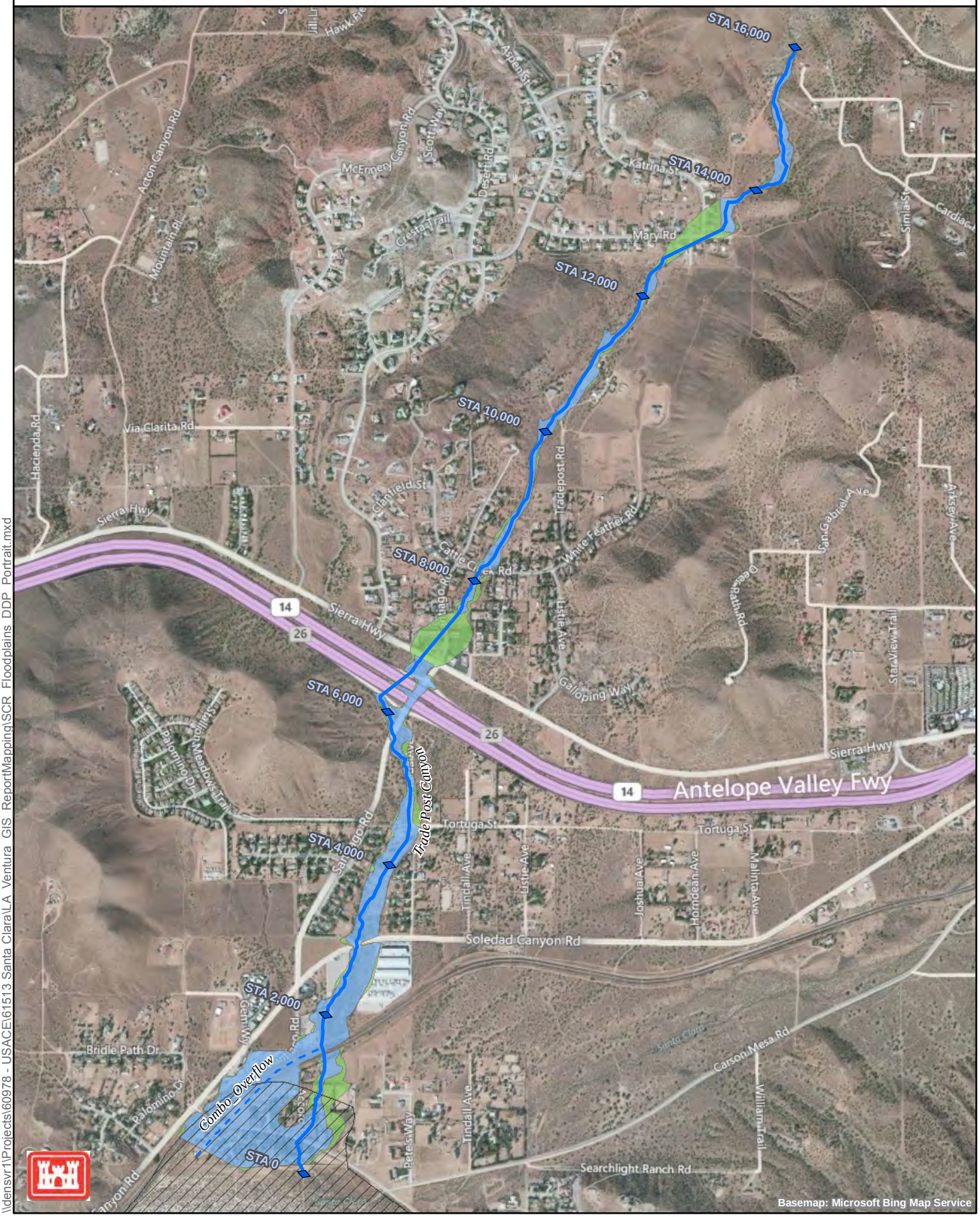
Figure 3-2: Trade Post Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Basemap: Microsoft Bing Map Service

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Section 4
Aliso Canyon

4.1 General Description

Aliso Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Aliso Canyon are described in this section.

Aliso Canyon joins the Santa Clara River from the south, between the locations where Escondido Creek and Trade Post Canyon join the mainstem. The study reach extends from the confluence with the Santa Clara River to a point located 3.4 miles upstream. Figure 4-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach is located within areas of residential and bushy open space. The only major crossing over Aliso Canyon is Aliso Canyon Road.

4.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

The features of the single crossing noted along this reach are summarized in Table 4-1.

Table 4-1
Crossings along Aliso Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	55+00	Aliso Canyon Road	Multiple culverts	5-4′ CMPs projecting US and DS from embankment, some debris at US end

4.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The features of this study reach were relatively consistent, and a single sub-reach was identified. The physical characteristics of the Aliso Canyon study reach are summarized in Table 4-2.

Table 4-2
Sub-reaches along Aliso Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1	SCR confluence (Station 7+24) ~ US study limit (Station 174+56)	Deep canyon channel with steep banks, gravel/boulder channel bed, well-defined main channel, floodplain consisting of brushy open space

4.4 Manning's Roughness Coefficients

The Manning's roughness values for the study reach are summarized in Table 4-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 4-3
Manning's Roughness Values along Aliso Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1	SCR confluence (Station 7+24) ~ US study limit (Station 174+56)	0.065	0.04	0.065

4.5 Hydrology

Three hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 4-1. The peak discharge rates associated with these locations are summarized instable 4-4.

Table 4-4
Hydrologic Concentration Points along Aliso Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
100+74	150	490	930	1,830	2,840	4,210	6,040	9,340
54+07	150	500	940	1,860	2,880	4,270	6,120	9,470
0	160	550	1,030	2,040	3,160	4,680	6,710	10,380

4.6 Hydraulic Model

The Aliso Canyon hydraulic model was developed with 187 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled reach contains a culvert crossing at Aliso Canyon Road (see Table 4-1).

4.7 Boundary Conditions

Normal depth boundary conditions in HEC-RAS were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections

(Station 174+56 and 173+95) and the two downstream-most cross-sections (Station 8+51 and 7+25) in the hydraulic model. Aliso Canyon boundary condition slopes are 0.003 and 0.015 at the upstream and downstream ends of the model, respectively.

4.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 4-2. Major flooded areas along Aliso Canyon are summarized for the 100-year and 500-year flood events in Table 4-5.

Table 4-5
Major Flooding along Aliso Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1	SCR confluence (Station 7+24) ~ US study limit (Station 174+56)	The floodplain is contained in the main channel, with additional flooding into the farmland at Sta.66+25 and encroaching on the residential property near Sta. 61+81	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

4.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The channel bed slope ranges from 2.6 percent upstream to 1.2 percent downstream. The Aliso Canyon Road crossing is a significant obstruction for all discharge frequencies. The computed flow regime for 52 percent of the cross-sections was subcritical.

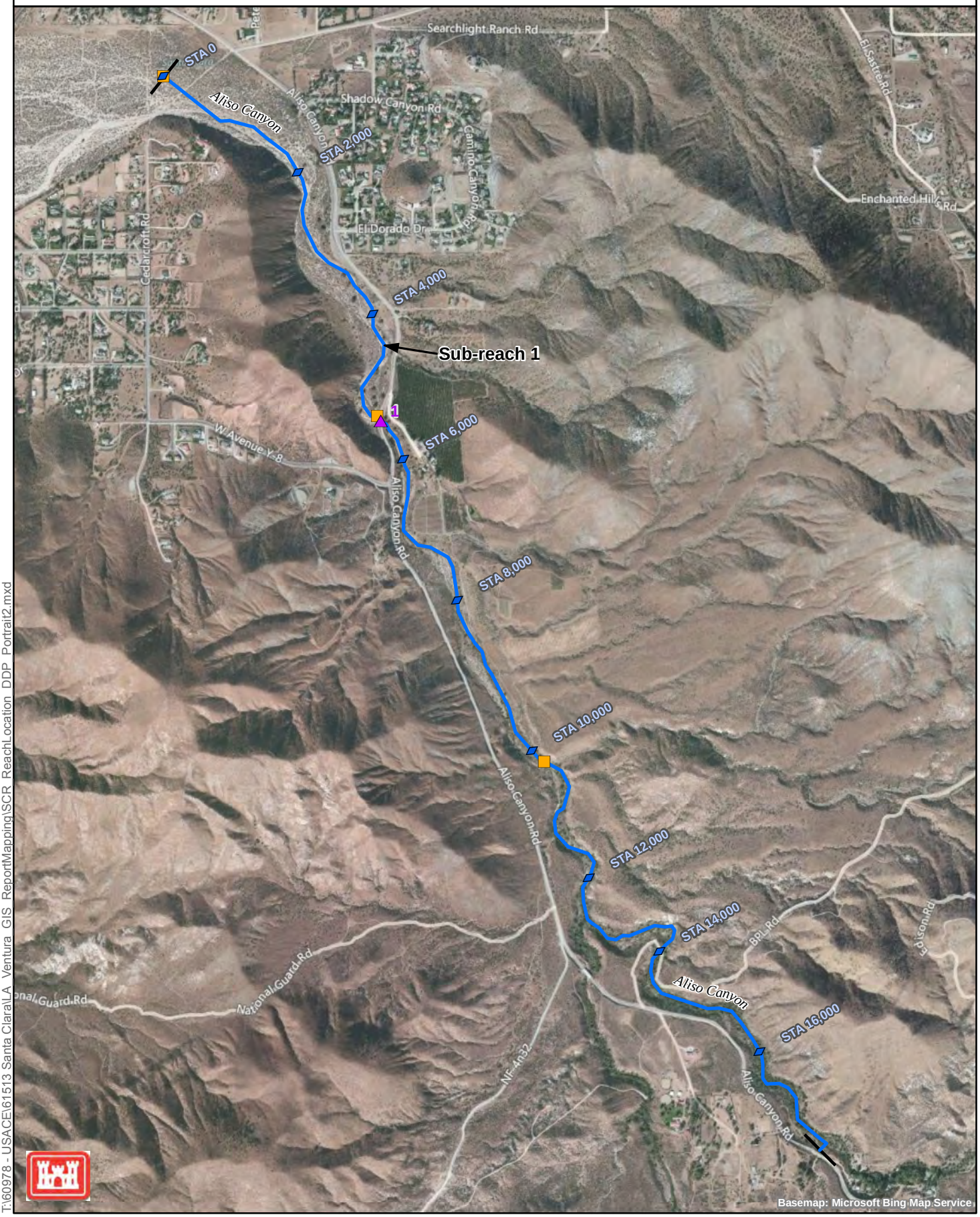
Figure 4-1: Aliso Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach



Basemap: Microsoft Bing Map Service

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Figure 4-2: Aliso Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 5
Escondido Creek

5.1 General Description

The Escondido Creek tributary includes both a USACE and a FEMA reach, as shown in Figure 5-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the Escondido Creek tributary (including both the USACE and FEMA reaches) are summarized in Sections 5.8 and 5.9.

Escondido Creek joins Acton Canyon from the north just upstream of the confluence of Acton Canyon and the Santa Clara River. The USACE study reach extends 4.1 miles along Escondido Creek upstream of the confluence with Red Rover Mine. The FEMA reach begins downstream of the confluence with Red Rover Mine and extends to the confluence with Acton Canyon. Figure 5-1 shows the alignment of the USACE and FEMA study reaches, as well as the structures within USACE reach, and the land use of surrounding areas.

The USACE study reach is located within areas of residential and brushy open space. Major crossings over Escondido Creek include Highway 14 and Sierra Highway.

5.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 5-1.

Table 5-1
Structures along Escondido Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	31+00	Escondido Canyon Road	Single culvert	4' circular CMP, headwall & wingwalls, US side significantly filled with sediment (2′ from the invert)
2	72+00	Ward Road	Single Culvert	3' circular CMP, headwall & wingwalls, concrete apron at DS side
3	79+58	Downstream of Highway 14	Drop Structure	~ 3-foot drop structure
4	80+00	Highway 14	Multiple culverts	2-10'x6' (Span x Rise) concrete box culverts, headwall & wingwalls, US side significantly filled sediment (3′ from the invert), concrete inlet apron at US end, vertical drop at DS side (3′)
5	123+50	Sierra Highway/ Shannan View Road	Single culvert	6'x3.13' (Span x Rise) concrete box culvert, headwall, 1′ drop at DS end
6	197+18	Shannan View Road	Span Bridge	Assumed 1′ deck

5.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The major features of the sub-reaches are summarized in Table 5-2.

Table 5-2
Sub-reaches along Escondido Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1)	Downstream study limit (Station 2+97) ~ confluence between Red River Mine and Escondido Creek (Station 29+60)	Meandering earthen channel, sand/gravel/cobbles channel bed, vegetation cover consisting of shrubs, floodplain consisting of brushy open space
Sub-reach 2 (Structures 2 to 5)	Confluence with Red Rover Mine Canyon (Station 30+41) ~ Sierra Highway (Station 123+13)	Meandering natural channel with thick brush, sand/gravel channel bed, floodplain consisting of brushy open space
Sub-reach 3 (Structures 6)	Sierra Highway (Station123+72) ~ 3,400 ft DS of US study limit (Station 219+97)	Undefined channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space and residential area
Sub-reach 4 (No structures)	3,400 ft DS of US study limit (Station 223+55) ~ US study limit (Station 261+35)	Meandering, shallow undefined channel, sand/gravel channel bed, floodplain consisting of brushy open space

5.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 5-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 5-3
Manning's Roughness Values along Escondido Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1)	Downstream study limit (Station 2+97) ~ confluence between Red River Mine and Escondido Creek (Station 29+60)	0.05	0.044	0.05
Sub-reach 2 (Structures 2 to 5)	Confluence with Red Rover Mine Canyon (Station 30+41) ~ Sierra Highway (Station 123+13)	0.045	0.04	0.06
Sub-reach 3 (Structures 6)	Sierra Highway (Station 123+72) ~ 3,400 ft DS of US study limit (Station 219+97)	0.06	0.04	0.06
Sub-reach 4 (No Structures)	3,400 ft DS of US study limit (Station 223+55) ~ US study limit (Station 261+35)	0.05	0.04	0.05

5.5 Hydrology

Four hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 5-1. A concentration point was not provided at the downstream limit (Station 0) of the USACE study reach. Therefore, the peak discharge associated with the concentration point directly downstream of the downstream study limit was applied at Station 0. The peak discharge rates associated with these locations are summarized in Table 5-4.

Table 5-4
Hydrologic Concentration Points along Escondido Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
187+40	10	50	90	180	280	410	590	910
120+27	30	110	200	400	610	910	1,300	2,020
41+74	50	160	310	610	950	1,410	2,020	3,130
-	70	240	450	890	1,380	2,050	2,940	4,550

5.6 Hydraulic Model

The Escondido Creek hydraulic model was developed with 362 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled reach contains five bridges/culverts, one drop structure (see Table 5-1) and one dip crossings located at Sta. 155+25.

5.6.1 FEMA Reach

FEMA developed the hydraulic model that extends between the downstream limit of the USACE reach to the confluence with Santa Clara River. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

5.7 Boundary Conditions

Normal depth boundary conditions in HEC-RAS were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 261+35 and 258+02) and the two downstream-most cross-sections (Station 4+43 and 2+97) in the hydraulic model. Escondido Creek boundary condition slopes are 0.16 and 0.024 at the upstream and downstream ends of the model, respectively.

5.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 5-2. Major flooded areas along Escondido Creek are summarized for the 100-year and 500-year flood events in Table 5-5.

Table 5-5
Major Flooding along Escondido Creek

Sub-reach	Sub-reach Location	100-year	500-year
USACE Reaches			
Sub-reach 1 (Structures 1)	Downstream study limit (Station 2+97) ~ confluence between Red River Mine and Escondido Creek (Station 29+60)	Flooding extends into the left overbank upstream of Red Rover Mine Road and continues till the end of the study reach	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 2 (Structures 2 to 5)	Confluence with Red Rover Mine Canyon (Station 30+41) ~ Sierra Highway (Station 123+13)	Due to the undefined channel the floodplain extends into adjacent open space. Additional overtopping flow at Highway 14 travels west along the highway until a low point and connects back with the mainstem. Overflow on the left bank at Sta. 51+26 inundates houses until it reaches the confluence with Red Rover Mine Canyon	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (Structures 6)	Sierra Highway (Station 123+72) ~ 3,400 ft DS of US study limit (Station 219+97)	Due to the undefined channel the floodplain extends into adjacent open space. The flooded areas include open space and residential property near Sta. 147+88, 158+90, 165+41, 180+31, 184+70, and Sta. 192+27 to 197+36. Additional flooding occurs upstream of Sierra Highway	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 4 (No Structures)	3,400 ft DS of US study limit (Station 223+55) ~ US study limit (Station 261+35)	Flooding is contained to the mainstem and adjacent open space	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
FEMA Reach			
NA	DS study limit (Station 40) ~ USACE study limit (Station 87+70)	Due to the undefined channel the floodplain extends beyond the channel banks into the left and right overbank areas. The inundated areas include open space, farmland, and residential areas	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

5.9 Profiles

USACE and FEMA channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope ranges from about 16 percent at the upstream end of the study reach to 2.4 percent downstream. Conveyance limitations are apparent at the Escondido Canyon Road, Highway 14, Sierra Highway and Crown Valley Road crossings. The computed flow regime for 64 percent of the cross-sections was supercritical.

Figure 5-1: Escondido Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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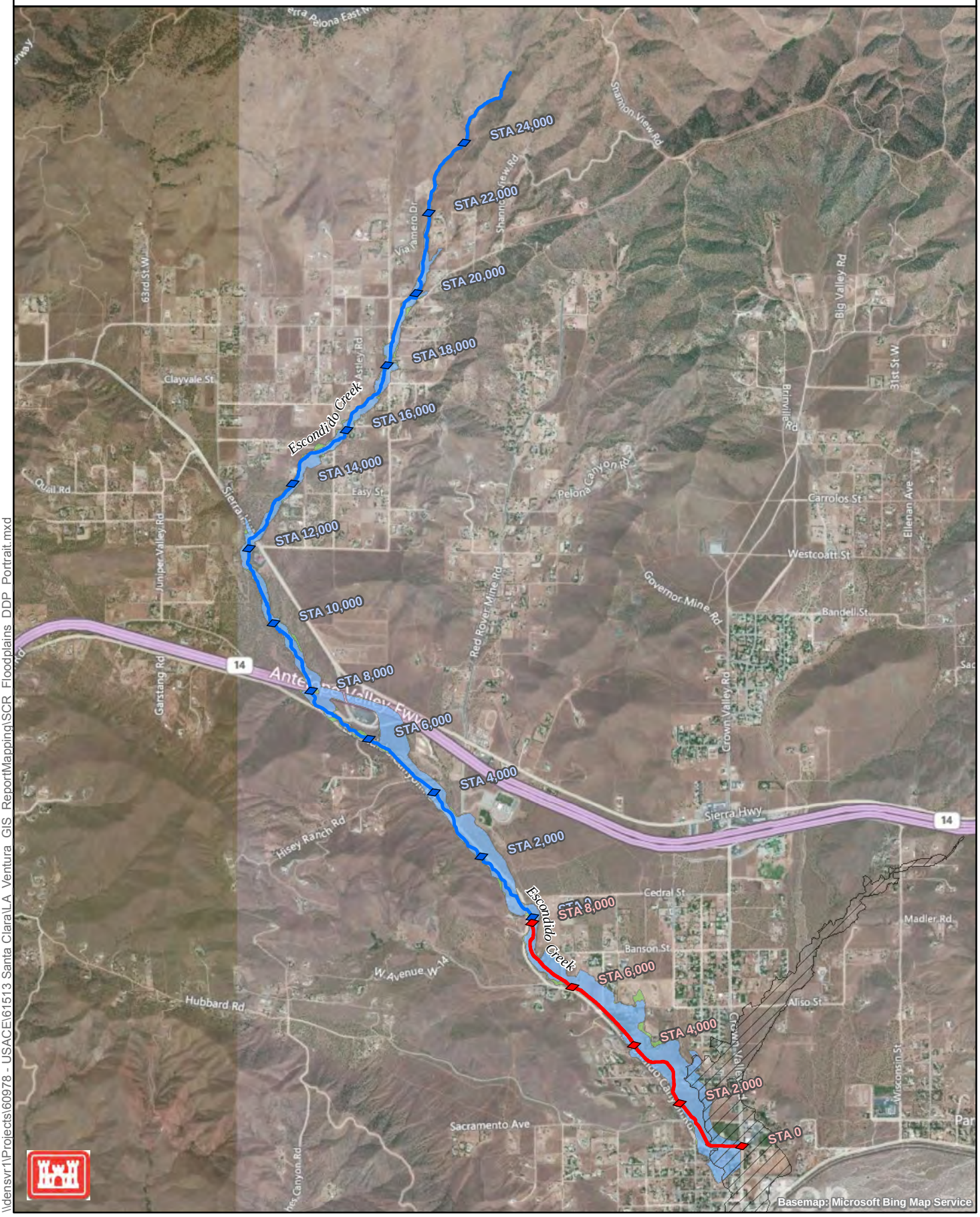
Figure 5-2: Escondido Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 6
Red Rover Mine

6.1 General Description

Red Rover Mine is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Red Rover Mine are described in this section.

Red Rover Mine is a tributary of Escondido Creek, located approximately 2.67 miles upstream of the Escondido Creek and Santa Clara River confluence. The study reach extends 3.3 miles upstream of the confluence with Escondido Creek. Figure 6-1 shows the alignment of the study reach, location of crossings, and land use of surrounding areas.

The study reach is located within areas of residential and brushy open space. Major crossings over Red Rover Mine include Highway 14 and Sierra Highway.

6.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 6-1.

Table 6-1
Crossings along Red Rover Mine (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	15+00	Highway 14	Multiple culverts	3-6'x4.75' (Span x Rise) concrete box culverts, headwall & wingwalls, US side significantly filled sediment (see photos), vertical drop at DS side (42")
2	19+00	Sierra Highway	Single culvert	3'x2' (Span x Rise) concrete box culvert, headwall & wingwalls, outlet invert 22" above channel bottom
3	44+70	Driveway to residence	Multiple culverts	2-1.5' circular concrete culverts, headwall

6.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank

area land use, and degree of channel meandering. The major features of the sub-reaches are summarized in Table 6-2.

Table 6-2
Sub-reaches along Red Rover Mine

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Confluence with Escondido Creek (Station 0+63) ~ Red Rover Mine Road (Station 34+61)	Natural channel with low banks, sand/gravel channel bed, floodplain consisting of brushy open space
Sub-reach 2 (Structure 3)	Red Rover Mine Road (Station 35+21)~ 4,300 ft DS of US study limit (Station 134+50)	Undefined meandering channel, sand/gravel channel bed, brush vegetation cover, floodplain consisting of brushy open space and residential area
Sub-reach 3 (No Structures)	4,300 ft DS of US study limit (Station 135+29) ~ US study limit (Station 186+68)	Narrow, shallow channel, sand/gravel channel bed, brush vegetation cover, floodplain consisting of brushy open space

6.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 6-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 6-3
Manning's Roughness Values along Red Rover Mine

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Confluence with Escondido Creek (Station 0+63) ~ Red Rover Mine Road (Station 34+61)	0.05	0.04	0.05
Sub-reach 2 (Structure 3)	Red Rover Mine Road (Station 35+21)~ 4,300 ft DS of US study limit (Station 134+50)	0.06	0.04	0.06
Sub-reach 3 (No Structures)	4,300 ft DS of US study limit (Station 135+29) ~ US study limit (Station 186+68)	0.05	0.04	0.05

6.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 6-1. The peak discharge rates associated with these locations are summarized in Table 6-4.

Table 6-4
Hydrologic Concentration Points along Red Rover Mine (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
89+52	10	30	60	120	180	270	390	600
0	30	80	160	310	490	720	1,030	1,600

6.6 Hydraulic Model

The Red Rover Mine hydraulic model was developed with 362 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled reach contains three bridges/culverts (see Table 6-1) and two dip crossings at Sta. 35+21, and 24+54.

6.7 Boundary Conditions

Normal depth boundary conditions in HEC-RAS were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 186+68 and 185+39) and the two downstream-most cross-sections (Station 1+08 and 63) in the hydraulic model. Red Rover Mine boundary condition slopes are 0.32 and 0.021 at the upstream and downstream ends of the model, respectively.

6.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 6-2. Major flooded areas along Red Rover Mine are summarized for the 100-year and 500-year flood events in Table 6-5.

Table 6-5
Major Flooding along Red Rover Mine

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Confluence with Escondido Creek (Station 0+63) ~ Red Rover Mine Road (Station 34+61)	Due to the undefined channel the floodplain extends into the left and right overbanks. Flooded areas include open space and residential properties near Sta. 34+33, 26+73, and Sta. 10+97	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 2 (Structure 3)	Red Rover Mine Road (Station 35+21)~ 4,300 ft DS of US study limit (Station 134+50)	Due to the undefined channel the floodplain extends into the left and right overbanks. Flooded areas include open space and residential properties near Sta. 44+02, 51+97 to Sta. 62+21, 64+23, 66+38, 77+16, 82+21 and Sta. 89+00	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (No Structures)	4,300 ft DS of US study limit (Station 135+29) ~ US study limit (Station 186+68)	Due to the undefined channel the floodplain extends into the left and right overbanks. Flooded areas include open space and residential properties near Sta. 150+16	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

6.9 Profiles

Water surface profiles for 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope ranges from approximately 32 percent at the upstream end of the study reach to 2 percent downstream. No major flooding constraints exist within the reach. The predominant flow regime was supercritical.

Figure 6-1: Red Rover Mine Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

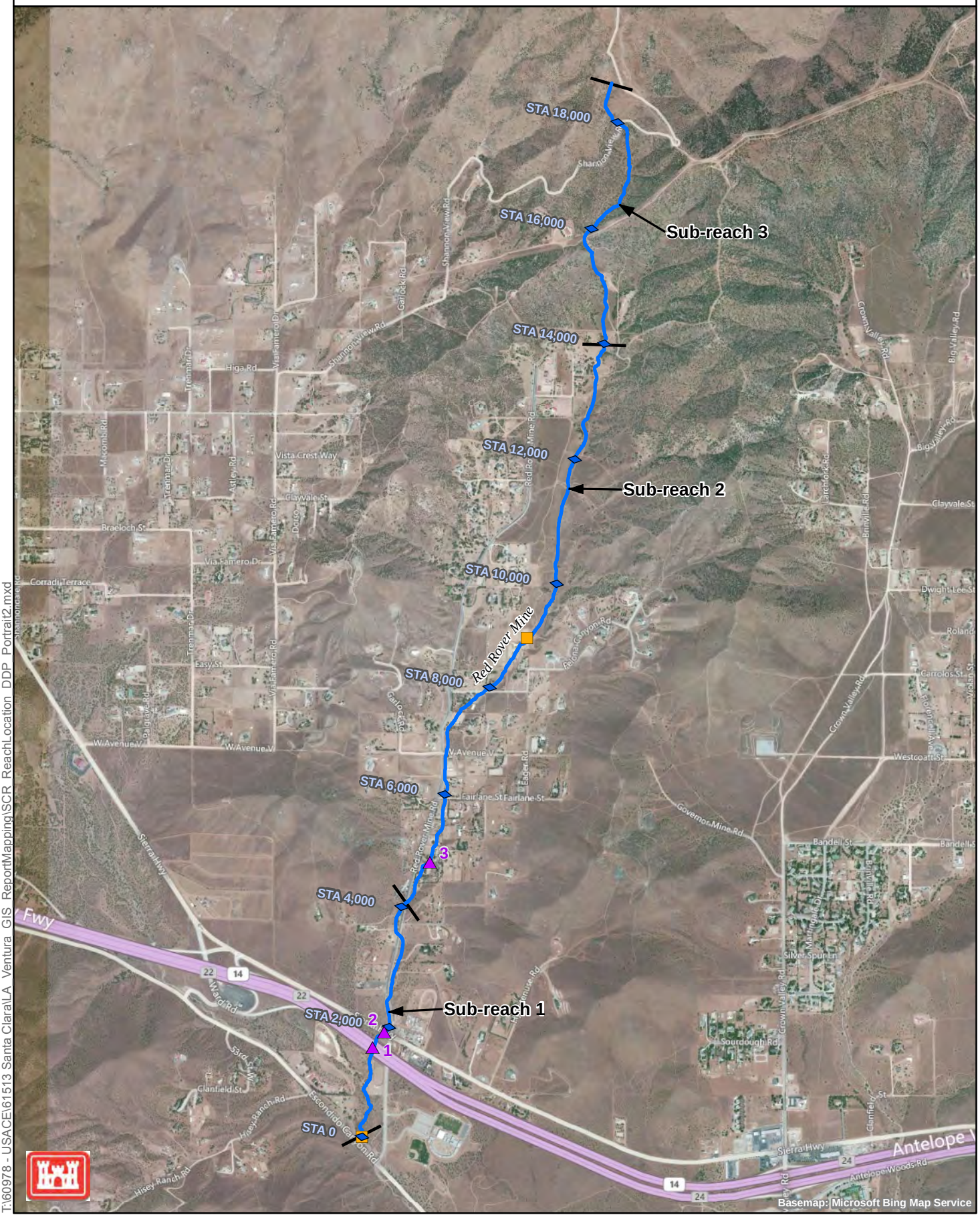

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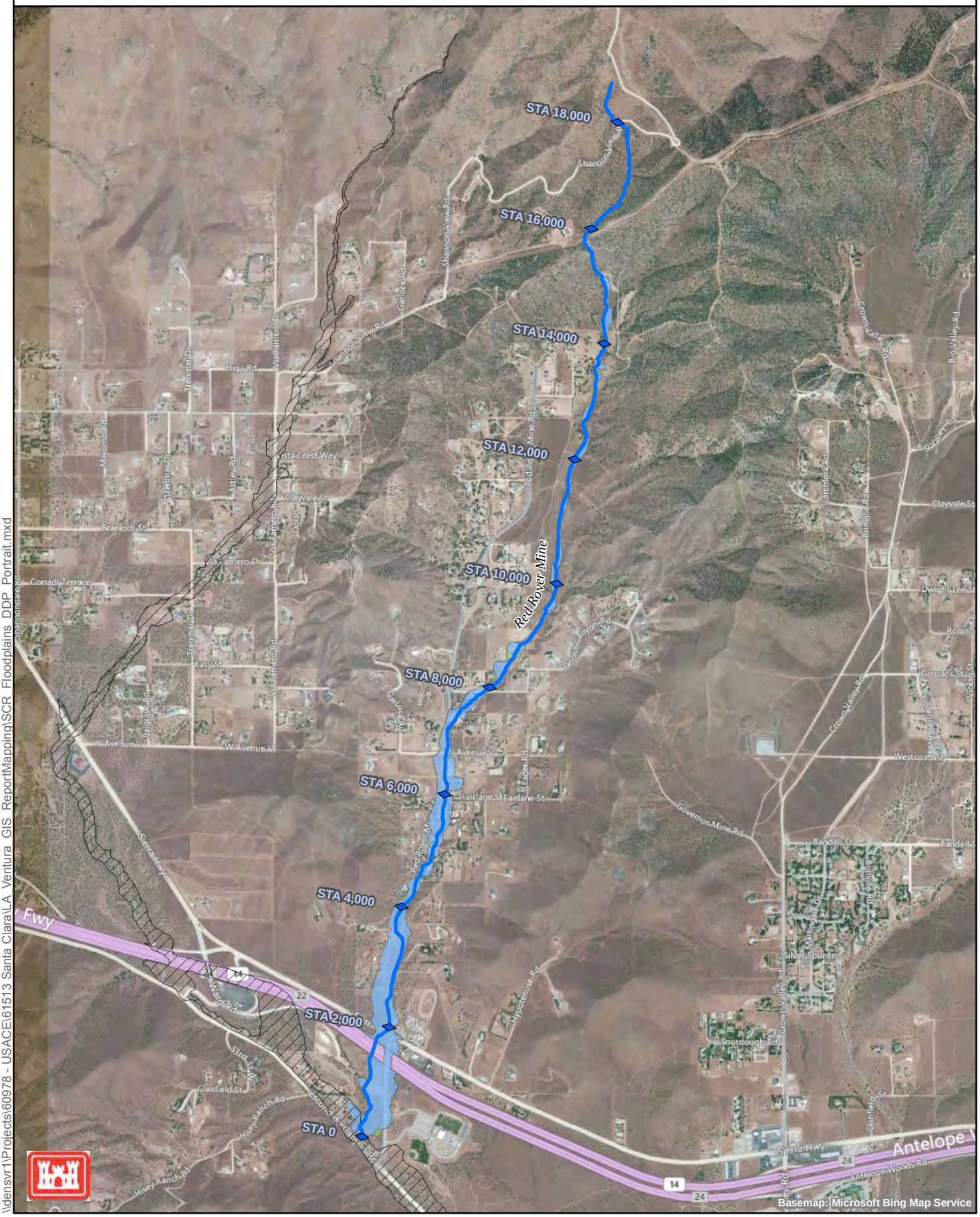
Figure 6-2: Red Rover Mine Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Basemap: Microsoft Bing Map Service

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Section 7
Acton Canyon A

7.1 General Description

Acton Canyon A is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Acton Canyon A are described in this section.

Acton Canyon A is the west headwater stream for Acton Canyon, located approximately 1.4 miles upstream of the Escondido Creek and Acton Canyon confluence. The study reach is the upper 2.6 miles of Acton Canyon A. Figure 7-1 shows the alignment of the study reach, location of crossings, and land use of surrounding areas.

The study reach is located within areas of residential and bushy open space. Major crossings over Acton Canyon A include Highway 14 and Sierra Highway.

7.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 7-1.

Table 7-1
Structures along Acton Canyon A (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	31+39	Downstream of Highway 14	Drop Structure	Riprap drop structure
2	35+20	Antelope Woods Road & Highway 14	Multiple culverts	Culverts passing through Antelope Woods Road and HWY 14, 3-8'x6.83' (Span x Rise) concrete box culverts, headwall & wingwalls, bottom of culverts filled with sediment at US end (4' rise at US end due to sediment), vertical wall drop at DS end (42")
3	37+54	Sierra Highway	Single culvert	6'x6' (Span x Rise) concrete box culvert, headwall
4	90+51	Downstream of Bandell Street	Drop Structure	Grouted riprap drop structure
5	108+05	Downstream of West Coast Road	Drop Structure	Riprap drop structure

7.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The major features of the sub-reaches are summarized in Table 7-2.

Table 7-2
Sub-reaches along Acton Canyon A

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 3)	Confluence with Acton Canyon B (Station 0+57) ~ Beginning of right overbank residential area (Station 43+50)	Broad earthen channel, sand/gravel channel bed, brush vegetation cover, floodplain consisting of brushy open space
Sub-reach 2 (Structures 4 and 5)	Beginning of right overbank residential area (Station 43+72) ~ Dwight Lee Street (Station 16+134)	Undefined channel, sand/gravel channel bed, brush vegetation cover, floodplain consisting of brushy open space and residential area
Sub-reach 3 (No Structures)	Dwight Lee Street (Station 161+66) ~ US study limit (Station 205+99)	Natural meandering channel, sand/gravel channel bed, broad swale, floodplain consisting of brushy open space

7.4 Manning's Roughness Coefficients

The Manning's roughness values for the Acton Canyon A sub-reaches are summarized in Table 7-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 7-3
Manning's Roughness Values along Acton Canyon A

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 3)	Confluence with Acton Canyon B (Station 0+57) ~ Beginning of right overbank residential area (Station 43+50)	0.06	0.04	0.05
Sub-reach 2 (Structures 4 and 5)	Beginning of right overbank residential area (Station 43+72) ~ Dwight Lee Street (Station 16+134)	0.06	0.04	0.06
Sub-reach 3 (No Structures)	Dwight Lee Street (Station 161+66) ~ US study limit (Station 205+99)	0.05	0.04	0.05

7.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Acton Canyon A (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 7-1. The peak discharge rates associated with these locations are summarized in Table 7-4.

Table 7-4
Hydrologic Concentration Points along Acton Canyon A (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
137+79	20	60	110	220	340	510	730	1,130
64+34	30	110	200	400	610	910	1,300	2,020
0	40	130	250	500	770	1,140	1,630	2,530

7.6 Hydraulic Model

The Acton Canyon A hydraulic model was developed with 474 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled channel contains two bridges/culverts, three drop structures (see Table 7-1) and six dip crossings (located at Sta. 161+95, 152+32, 138+33, 122+25, 108+30, and 90+91).

7.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the study reach. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 205+99 and 204+39) and the two downstream-most cross-sections (Station 1+12 and 0+57) in the hydraulic model. Computed boundary condition slopes are 0.15 and 0.036 at the upstream and downstream ends of the model, respectively.

7.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 7-2. Major flooded area along Acton Canyon A are summarized for the 100-year and 500-year flood events in Table 7-5.

Table 7-5
Major Flooding along Acton Canyon A

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 3)	Confluence with Acton Canyon B (Station 0+57) ~ Beginning of right overbank residential area (Station 43+50)	Due to the undefined channel the floodplain extends continuously into the left and right overbanks. The flooded area is mainly brushy open space	Same as the 100-year flood extent except at Highway 14 additional flooding on the right overbank
Sub-reach 2 (Structures 4 and 5)	Beginning of right overbank residential area (Station 43+72) ~ Dwight Lee Street (Station 16+134)	The floodplain extends into the left and right overbanks thought the sub-reach. The flooded area consists of mainly brushy open space with additional flooding upstream of Carrolos Street overtopping a dirt parking lot	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (No Structures)	Dwight Lee Street (Station 161+66) ~ US study limit (Station 205+99)	Due to the undefined channel the floodplain extends into the left and right overbanks overtopping brushy open space	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

7.9 Profiles

Channel and water surface profiles for 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average invert slope ranges from approximately 11 percent at the upstream end of the study reach to 4 percent downstream. Conveyance limitations are evident for the 100-, 200- and 500-year flood conditions. The predominant flow regime was supercritical.

Figure 7-1: Acton Canyon A Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

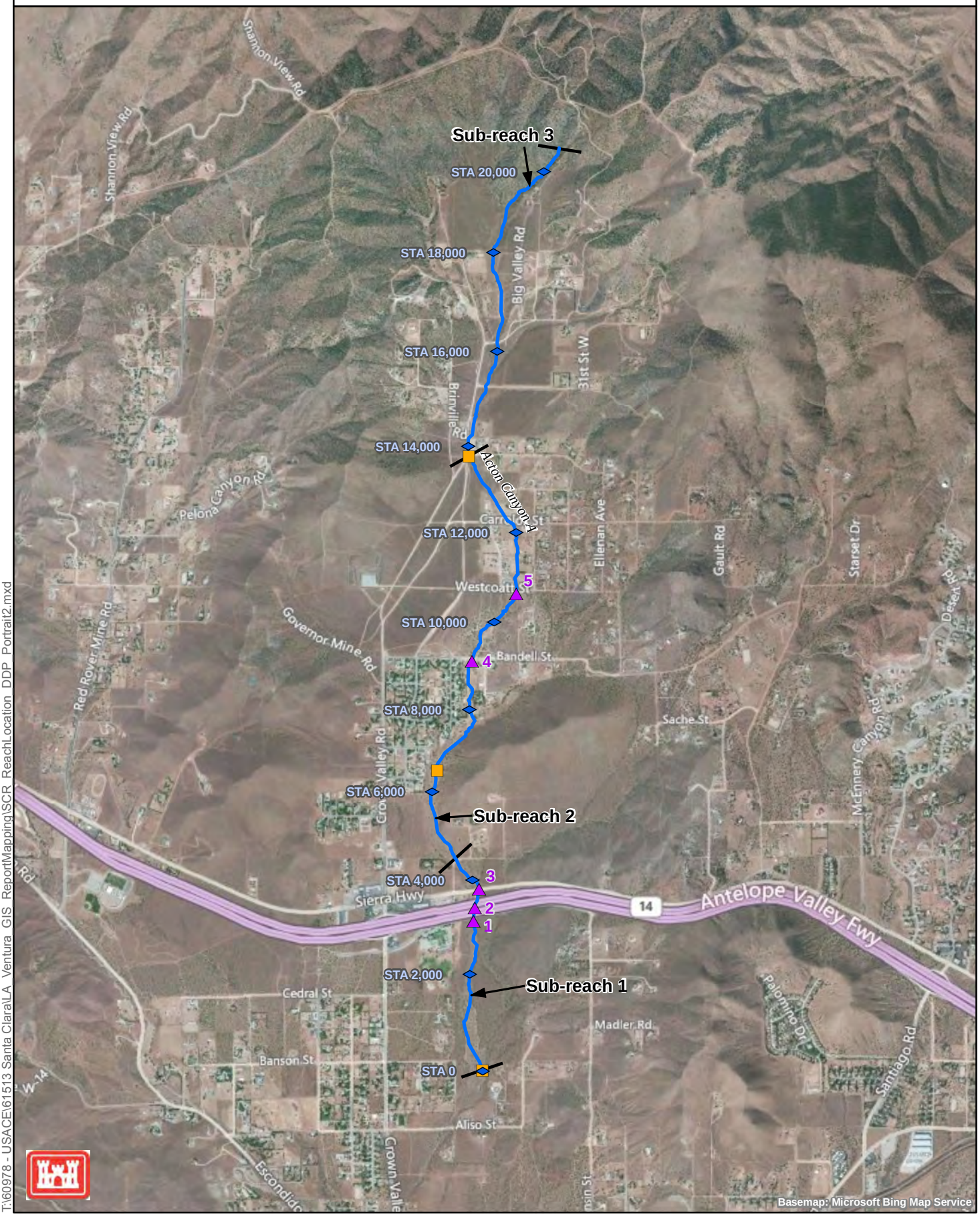

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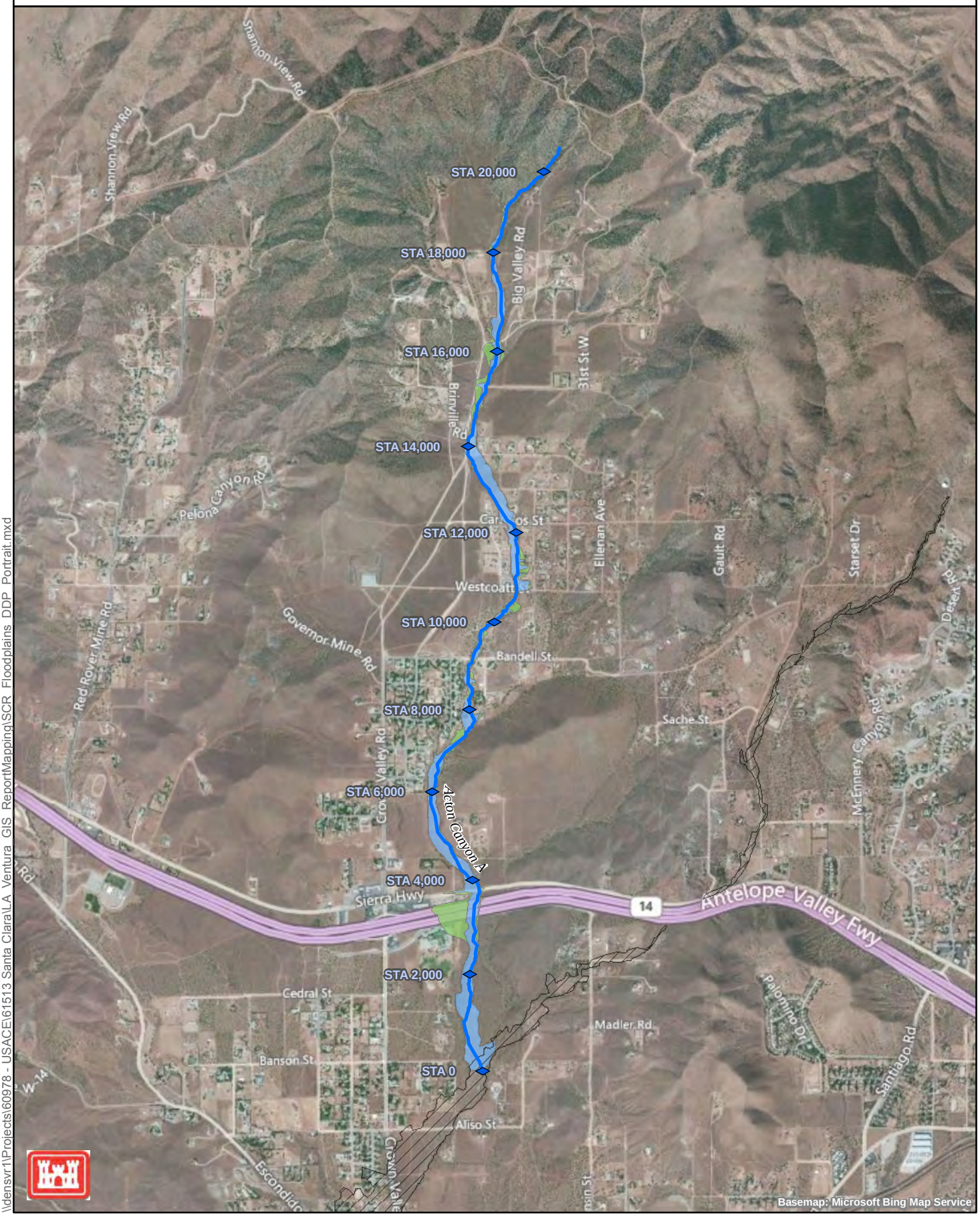
Figure 7-2: Acton Canyon A Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 8
Acton Canyon B

8.1 General Description

The Acton Canyon B tributary includes both a USACE and a FEMA reach, as shown in Figure 8-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for Acton Canyon B (including both the USACE and FEMA reaches) are summarized in Sections 8.8 and 8.9.

Acton Canyon B joins the Santa Clara River from the north downstream of Trade Post Canyon. The USACE reach begins at the confluence with Escondido Creek and extends upstream approximately four miles. The FEMA reach intersects the USACE reach at Crown Valley Road and extends 0.83 miles downstream to the confluence with Santa Clara River. The USACE and FEMA mainstem delineation differs because of the lack of a defined main channel. The mainstem of Acton Canyon B for the USACE reach was delineated based on a reach centerline shapefile provided by Los Angeles County, aerial imagery, and topographic information. USACE and FEMA mainstem reaches were merged together to provide conservative estimates of flood hazard areas along Acton Canyon B. Both of the FEMA and USACE reaches were included in this study and are shown in Figure 8-1. Figure 8-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach is located within areas of residential and bushy open space. Major crossings over Acton Canyon B include Highway 14 and Sierra Highway.

8.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings and culverts along the study reach is summarized in Table 8-1.

Table 8-1
Structures along Acton Canyon B (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	92+00	Adams Street (dirt road)	Single culvert	1-4' circular CMP, headwall
2	95+00	Private road (dirt road)	Single culvert	1-4' circular CMP, headwall
3	110+00	Highway 14 & Sierra Highway	Single culvert	1-8' concrete pipe, headwall

8.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The major features of the sub-reaches are summarized in Table 8-2.

Table 8-2
Sub-reaches along Acton Canyon B

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No Structures)	Downstream study limit (Station 9+11) ~ Confluence with Acton Canyon A (Station 79+76)	Natural earthen channel, sand/gravel channel bed, floodplain consisting of brush open space and farm land
Sub-reach 2 (Structures 1 to 3)	Confluence with Acton Canyon A (Station 80+34) ~ Acton Canyon Road (Station 129+96)	Meandering earthen channel with steep banks, sand/gravel channel bed, incised or well-defined main channel, floodplain consisting of brushy open space
Sub-reach 3 (No Structures)	Acton Canyon Road (Station 130+82) ~ Sache Street (Station 167+80)	Deep canyon channel with steep banks, sand/gravel channel bed, floodplain consisting of brushy open space and light residential area
Sub-reach 4 (No Structures)	Sache Street (Station 168+36) ~ US study limit (Station 215+34)	Meandering earthen channel, sand/gravel channel bed, well defined canyon, floodplain consisting of brushy open space

8.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 8-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 8-3
Manning's Roughness Values along Acton Canyon B

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No Structures)	Downstream study limit (Station 9+11) ~ Confluence with Acton Canyon A (Station 79+76)	0.05	0.046	0.05
Sub-reach 2 (Structures 1 to 3)	Confluence with Acton Canyon A (Station 80+34) ~ Acton Canyon Road (Station 129+96)	0.06	0.04	0.06
Sub-reach 3 (No Structures)	Acton Canyon Road (Station 130+82) ~ Sache Street (Station 167+80)	0.05	0.04	0.06
Sub-reach 4 (No Structures)	Sache Street (Station 168+36) ~ US study limit (Station 215+34)	0.05	0.04	0.05

8.5 Hydrology

Five hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 8-1. The peak discharge rates associated with these locations are summarized in Table 8-4.

Table 8-4
Hydrologic Concentration Points along Acton Canyon B (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
130+82	10	30	50	100	160	230	330	510
81+95	10	40	70	140	220	320	460	710
55+63	10	40	80	160	240	360	520	800
47+59	60	200	370	730	1,130	1,670	2,390	3,700
0	140	480	900	1,770	2,750	4,080	5,850	9,050

8.6 Hydraulic Model

The Acton Canyon B hydraulic model was developed with 187 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled channel contains three bridges/culverts and five dip crossings (located at Sta. 191+86, 168+36, 130+82, 84+74, and 17+54).

8.6.1 FEMA Reach

FEMA developed the hydraulic model that extends from between the downstream limit of the USACE reach to the confluence with Santa Clara River. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

8.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 215+34 and 214+74) and the two downstream-most cross-sections (Station 12+20 and 9+11) in the hydraulic model. Computed boundary condition slopes are 0.1 and 0.023 at the upstream and downstream ends of the model, respectively.

8.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 8-2. Major flooded areas along Acton Canyon B are summarized for the 100-year and 500-year flood events in Table 8-5.

Table 8-5
Major Flooding along Acton Canyon B

Sub-reach	Sub-reach Location	100-year	500-year
USACE Reaches			
Sub-reach 1 (No Structures)	Downstream study limit (Station 9+11) ~ Confluence with Acton Canyon A (Station 79+76)	Due to the undefined channel the floodplain extends into the left and right overbank areas. The flooded areas include brushy open space and residential properties near Sta. 9+11 to 21+35, 41+31, and Sta. 65+90	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 2 (Structures 1 to 3)	Confluence with Acton Canyon A (Station 80+34) ~ Acton Canyon Road (Station 129+96)	Due to the undefined channel the floodplain extends into the left and right overbank areas. The flooded areas include brushy open space and residential properties near Sta. 81+96, 121+28 to Sta. 126+55, 149+56, and Sta. 155+48	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (No Structures)	Acton Canyon Road (Station 130+82) ~ Sache Street (Station 167+80)	Due to the undefined channel the floodplain extends into the left and right overbank areas. The flooded areas include brushy open space	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 4 (No Structures)	Sache Street (Station 168+36) ~ US study limit (Station 215+34)	Due to the undefined channel the floodplain extends into the left and right overbank areas. The flooded areas include brushy open space	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
FEMA Reach			
NA	Confluence with SCR (Station 93+62) ~ USACE downstream study limit (Station 1+33)	Flooding extends into the left and right overbanks. The flooded areas include residential property, brushy open space, farmland and roadways	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

8.9 Profiles

USACE and FEMA channel and water surface profiles for 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope ranges from 10 percent at the upstream end of the study reach to 0.7 percent downstream. Conveyance limitations are evident at Highway 14 and Sierra Highway during the 500-year flood conditions. The computed flow regime for 58 percent of the cross-sections was supercritical.

Figure 8-1: Acton Canyon B Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

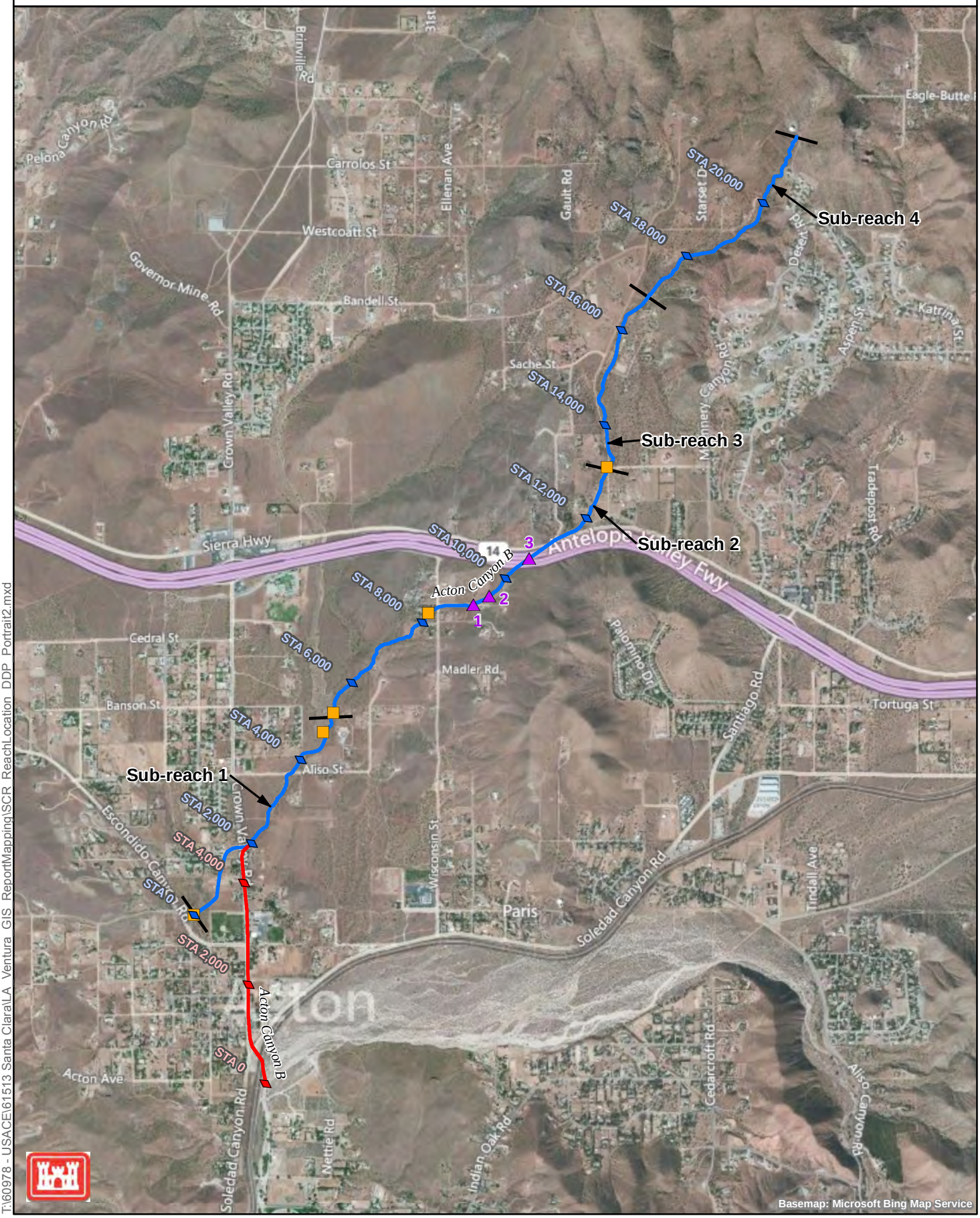

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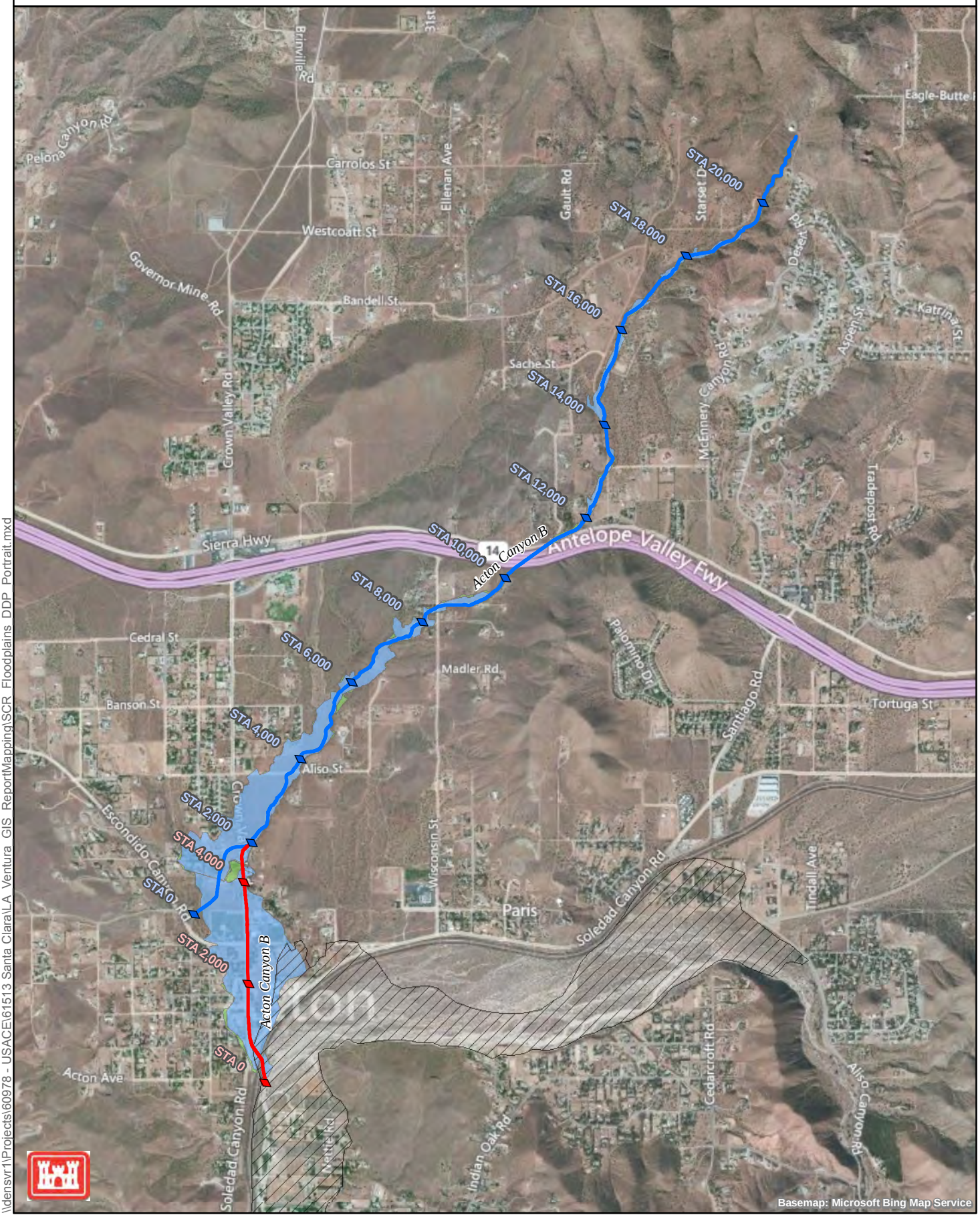
Figure 8-2: Acton Canyon B Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach100-Year Estimated Floodplain



Basemap: Microsoft Bing Map Service

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Section 9
Agua Dulce Canyon

9.1 General Description

The Agua Dulce Canyon tributary includes both a USACE and a FEMA reach, as shown in Figure 9-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the Agua Dulce Canyon tributary (including both the USACE and FEMA reaches) are summarized in Sections 9.8 and 9.9.

Agua Dulce Canyon joins the Santa Clara River from the north, located between Tick Canyon and Escondido Canyon. The USACE reach begins at the confluence with the Santa Clara River and extends approximately 3 miles upstream along Agua Dulce Canyon. The FEMA reach begins at the USACE upstream study limit and extends 4.5 miles further upstream. Figure 9-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach upstream of Highway 14 is surrounded by brushy open space and downstream of Station 140+00 becomes a narrow, shallow valley. Major crossings over Agua Dulce Canyon include the Railroad, Agua Dulce Canyon Road and Highway 14.

9.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 9-1.

Table 9-1
Structures along Agua Dulce Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	4+50	Railroad	Pier bridge	2-pier concrete bridge with 30′x7.3′ (Span x Rise) conveyance area in the middle, no conveyance area outside of piers, 4.2′ deck thickness
2	84+00	Agua Dulce Canyon Road 1	Span bridge	Concrete span bridge with 45′x12.5′ (Span x Rise) conveyance area, 2′ deck thickness
3	125+00	HWY 14	Culvert	1-17′x17′ (Span x Rise) concrete pipe arch culvert, headwall & wingwalls, US large steel debris catcher, 5′ drop at DS side
4	142+50	Agua Dulce Canyon Road 2	Multiple culvert	2-3.5′x2.3′ (Span x Rise) concrete elliptical culverts, headwall, DS concrete slab at outlet

9.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The features of this study reach were relatively consistent, and a single sub-reach was identified. The major features are summarized in Table 9-2.

Table 9-2
Sub-reaches along Agua Dulce Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 4)	Confluence with Santa Clara River (Station 2+45) ~ US study limit (Station 167+00)	Earthen canyon channel with steep banks, sand/gravel channel bed, floodplain consisting of brushy open space

9.4 Manning's Roughness Coefficients

The Manning's roughness values the USACE study reach are summarized in Table 9-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 9-3
Manning's Roughness Values along Agua Dulce Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 4)	Confluence with Santa Clara River (Station 2+45) ~ US study limit (Station 167+00)	0.05	0.04	0.05

9.5 Hydrology

Two hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 9-1. The peak discharge rates associated with these locations are summarized in Table 9-4.

Table 9-4
Hydrologic Concentration Points along Agua Dulce Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
83+76	100	340	650	1,270	1,970	2,920	4,190	6,480
0	110	350	670	1,310	2,030	3,010	4,320	6,680

9.6 Hydraulic Model

The Agua Dulce Canyon hydraulic model was developed with 128 cross-sections to represent varying channel geometry and hydraulic structures along the reach. The modeled reach contains four bridges/culverts (see Table 9-1).

9.6.1 FEMA Reach

FEMA developed the hydraulic model that extends between the upstream USACE study limit to approximately 4.5 miles upstream along Agua Dulce Canyon. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

9.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 167+00 and 165+89) and the two downstream-most cross-sections (Station 2+87 and 2+45) in the hydraulic model. Computed boundary condition slopes are 0.036 and 0.006 at the upstream and downstream ends of the model, respectively

9.8 Flood Boundaries

USACE and FEMA flood boundaries for 500- and 100-year flood events are presented in Figure 9-2. Major flooded areas along Agua Dulce Canyon are summarized for the 100-year and 500-year flood events in Table 9-5.

Table 9-5
Major Flooding along Agua Dulce Canyon

Sub-reach	Sub-reach Location	100-year	500-year
USACE Reaches			
Sub-reach 1 (Structures 1 to 4)	Confluence with Santa Clara River (Station 2+45) ~ US study limit (Station 167+00)	Flooding extends into the left and right overbanks with additional flooding upstream of the Railroad crossing. Flooded areas include brushy open space	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
FEMA Reach			
NA	USACE US study limit (Station 3+20) ~ FEMA US study limit (Station 235+32)	Continuous flooding in the left and right overbank areas. The inundated area includes residential areas, farmland, commercial property and brushy open space	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

9.9 Profiles

USACE and FEMA channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope is approximately three percent upstream of Highway 14 and 1.5 percent downstream. A natural 20-foot drop exists approximately 1,000 feet downstream of Highway 14. The Railroad crossing has inadequate conveyance for all discharge frequencies, blocking flow and increasing overbank flooding upstream.
Escondido Road also has inadequate conveyance under most flooding conditions. There was no predominate flow regime: there was an equal number of supercritical and subcritical cross-sections.

Figure 9-1: Agua Dulce Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 4,000 8,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

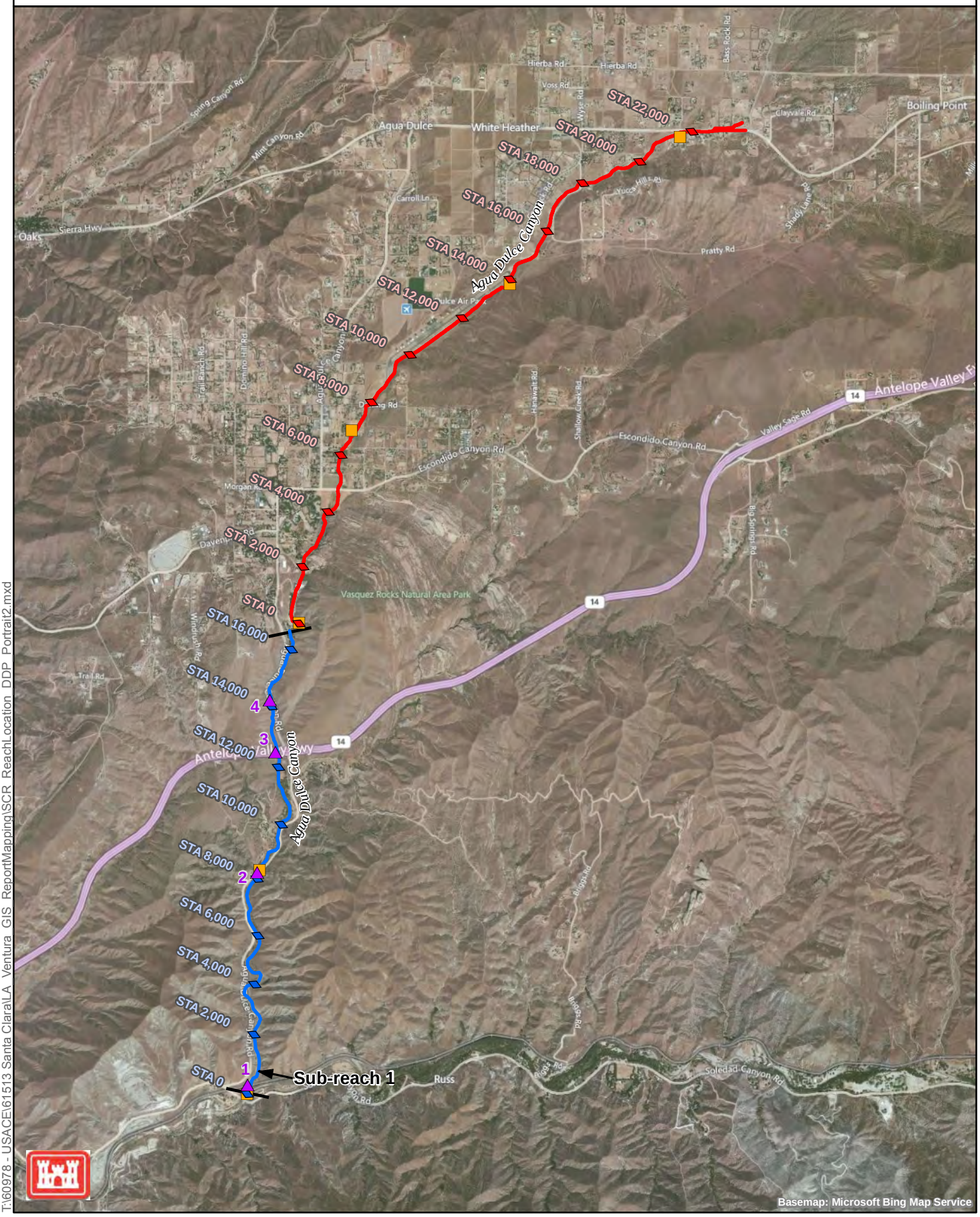

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Figure 9-2: Agua Dulce Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 4,000 8,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 10
Tick Canyon

10.1 General Description

Tick Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Tick Canyon are described in this section.

Tick Canyon joins the Santa Clara River from the north, between the locations where Oak Spring Canyon and Agua Dulce Canyon join the mainstem. The study reach extends along the lower 2.2 miles of Tick Canyon. Figure 10-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The study reach is located within areas of residential and brushy open space. Major crossings over Tick Canyon include Highway 14 and Soledad Canyon Road.

10.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 10-1.

Table 10-1
Structures along Tick Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	6+55	Highway 14	Pier bridge	Concrete span bridge, 2-4′ pier thickness
2	9+10	Frontage Road	Pier bridge	Concrete span bridge with 50′x7.3′ (Span x Rise) box conveyance area, 1.5′ pier thickness, right channel ½ filled with sediment
3	12+57	Soledad Road	Multiple culverts	3-10'x5.8' (Span x Rise) concrete box culverts, headwall & wingwalls, DS side ½ filled with sediment
4	19+65	Begonias Lane	Pier bridge	Concrete bridge with 2-11.8'x7.8′ (Span x Rise) box conveyance areas, headwall, pier nose at US side, abrupt transitions from bridge to trapezoidal channel at US & DS sides
5	45+00	Gandifloras Road	Span bridge	Concrete span bridge with 2- 9.8′x6.8′ (Span x Rise) conveyance areas, pier nose at US side, abrupt transitions from bridge to trapezoidal channel at US & DS sides
6	99+75	Tick Canyon Road	Culvert/dip crossing	1-4.5′ diameter CMP adjacent to earthen dip crossing

10.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The major features of the sub-reaches are summarized in Table 10-2.

Table 10-2
Sub-reaches along Tick Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1 to 3)	Confluence with Santa Clara River (Station 0+81) ~ Soledad Canyon Road (Station 9+58)	Heavy vegetated channel with many trees and dense brush, sand/gravel channel bed, floodplain consisting of brushy open space and commercial area
Sub-reach 2 (Structures 4 and 5)	Soledad Canyon Road (Station 13+56) ~ Grandifloras Road (Station 46+07)	Trapezoidal concrete channel, floodplain consisting of residential property
Sub-reach 3 (No Structures)	Soledad Canyon Road (Station 48+03) ~ 4,000 ft DS of US study limit (Station 64+47)	Trapezoidal concrete channel, floodplain consisting of residential and brushy open space
Sub-reach 4 (Structure 6)	4,000 ft DS of US study limit (Station 66+89) ~ US study limit (Station 110+47)	Broad undefined channel, sand/gravel channel bed, brush vegetation cover, floodplain consisting of brushy open space

10.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 10-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 10-3
Manning's Roughness Values along Tick Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1 to 3)	Confluence with Santa Clara River (Station 0+81) ~ Soledad Canyon Road (Station 9+58)	0.07	0.05	0.07
Sub-reach 2 (Structures 4 and 5)	Soledad Canyon Road (Station 13+56) ~ Grandifloras Road (Station 46+07)	0.13	0.015	0.13
Sub-reach 3 (No Structures)	Soledad Canyon Road (Station 48+03) ~ 4,000 ft DS of US study limit (Station 64+47)	0.06	0.015	0.13
Sub-reach 4 (Structure 6)	4,000 ft DS of US study limit (Station 66+89) ~ US study limit (Station 110+47)	0.05	0.04	0.05

10.5 Hydrology

Two hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 10-1. The peak discharge rates associated with these locations are summarized in Table 10-4.

Table 10-4
Hydrologic Concentration Points along Tick Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
52+82	50	170	320	620	970	1,430	2,050	3,170
0	60	200	380	740	1,150	1,710	2,450	3,790

10.6 Hydraulic Model

The Tick Canyon hydraulic model was developed with 83 cross-sections to represent varying channel geometry and hydraulic structures within the reach. The modeled channel contains six bridges/culverts. .

10.6.1 Channel Improvements

Channel improvements were added to Tick Canyon based on as-built drawings. The improved reach extends from upstream of Soledad Canyon Road (Station 13+56) to upstream of Grandifloras Road (Station 64+47) (reference: County of Los Angeles, *Storm Drain to be constructed in Tract No 26021.* (County of Los Angeles, 1970), County of Los Angeles, *Storm Drain to be constructed in Tract No 25006.* (County of Los Angeles, 1967), and California Department of Transportation Division of Maintenance (CDTDM), *Bridge Inspection Records of Information System (BIRIS). Project No. 53 1549* (CDTDM, 1994)).

The improved channel and culverts have capacity to convey the peak 200-year flood discharge without overtopping.

10.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 110+47 and 109+02) and the two downstream-most cross-sections (Station 1+42 and 81) in the hydraulic model. Computed boundary condition slopes are 0.022 and 0.26 at the upstream and downstream ends of the model, respectively.

10.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 10-2. Major flooded areas along Tick Canyon are summarized for the 100-year and 500-year flood events in Table 10-5.

Table 10-5
Major Flooding along Tick Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1 to 3)	Confluence with Santa Clara River (Station 0+81) ~ Soledad Canyon Road (Station 9+58)	Flooding extends into the left overbank areas upstream of Highway 14. Additional overbank flooding also occurs downstream of Highway 14. The flooded areas include open space and part of Soledad Canyon Road	Same as the 100-year flood extent with additional flooding overtopping Soledad Canyon Road, and extended flooding upstream and downstream of HWY 14
Sub-reach 2 (Structures 4 and 5)	Soledad Canyon Road (Station 13+56) ~ 4,000 ft DS of US study limit (Station 46+07)	Flooding is contained in the main channel	Flooding is contained in the main channel except upstream of Grandifloras Road to approximately 1,500 feet downstream and upstream and downstream of Begonias Lane. Flooded areas include residential property and roads
Sub-reach 3 (No Structures)	Soledad Canyon Road (Station 48+03) ~ 4,000 ft DS of US study limit (Station 64+47)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 4 (Structure 6)	4,000 ft DS of US study limit (Station 66+89) ~ US study limit (Station 110+47)	Flooding is contained in the main channel	Flooding is contained in the main channel

10.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope is approximately two percent along the study reach except for directly upstream of the confluence with the Santa Clara River, where the slope increases to approximately 25 percent. Highway 14, Soledad Canyon Road, Begonias Lane and Grandifloras Road act as significant obstructions to flow under all discharge frequencies. The computed flow regime for 57 percent of the cross-sections was supercritical.

Figure 10-1: Tick Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 10-2: Tick Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Basemap: Microsoft Bing Map Service

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Section 11
Oak Spring Canyon

11.1 General Description

Oak Spring Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Oak Spring Canyon are described in this section.

Oak Spring Canyon joins the Santa Clara River from the south, between the locations where Sand Canyon and Tick Canyon join the mainstem. The study reach extends along the lower 1.4 miles of Oak Springs Canyon, beginning 0.36 miles upstream of Oak Spring Canyon Road (Structure #2). Figure 11-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of residential, agriculture and brushy open space. The upper study limit consists of a golf course which was inaccessible during the field reconnaissance.

11.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 11-1.

Table 11-1
Structures along Oak Spring Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	11+21	Oak Spring Canyon Road / Railroad	Pier bridge & dip crossing	2-pier concrete bridge, 1′ pier thickness, earthen dip crossing under bridge
2	51+58	Oak Spring Canyon Road	Multiple culvert	3-48″ diameter CMPs projecting from bridge embankment

11.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 11-2.

Table 11-2
Sub-reaches along Oak Spring Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	DS study limit (Station 12+32) ~ Whitewater Canyon Road (Station 22+06)	Natural channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space, agriculture and residential areas
Sub-reach 2 (Structure 2)	Whitewater Canyon Road (Station 22+43)~ Oak Spring Canyon Road (Station 50+72)	Meandering channel with undefined channel banks, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space and residential area
Sub-reach 3 (No structures)	Oak Spring Canyon Road (Station 51+64) ~ US study limit (Station 69+05)	Buried CMP culvert, floodplain consisting of recreational area (Golf Course)

11.4 Manning's Roughness Coefficients

The Manning's roughness values for the Oak Spring Canyon sub-reaches are summarized in Table 11-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 11-3
Manning's n Values along Oak Spring Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	DS study limit (Station 12+32) ~ Whitewater Canyon Road (Station 22+06)	0.07	0.04	0.06
Sub-reach 2 (Structure 2)	Whitewater Canyon Road (Station 22+43)~ Oak Spring Canyon Road (Station 50+72)	0.07	0.04	0.05
Sub-reach 3 (No structures)	Oak Spring Canyon Road (Station 51+64) ~ US study limit (Station 69+05)	0.05	0.04	0.05

11.5 Hydrology

One hydrologic concentration point was provided along the Oak Spring Canyon study reach. The location of this hydrologic concentration point is shown in Figure 11-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 11-4.

Table 11-4
Hydrologic Concentration Point along Oak Spring Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	40	130	250	500	770	1,140	1,630	2,530

11.6 Hydraulic Model

The Oak Spring Canyon hydraulic model was developed with 142 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled channel contains two bridges/culverts (see Table 11-1), two dip crossings at Sta. 22+07 and 5+52, and one overflow reach.

11.6.1 Overflow Reaches

An overflow reach was added to the Oak Spring Canyon model to compute the hydraulic characteristic and flooding limits of flows that leave the main channel path. Overtopping into the left overbank occurs under the peak 25-, 50-, 100-, 200- and 500-year flow conditions. The overflow reach begins downstream of Station 27+91 and joins the main channel upstream of the Railroad crossing.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 11-5.

Table 11-5
Maximum Flow in Oak Spring Canyon Left Overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	0	0	0	43	184	438	832	1,538

Overflow Reach Results

Due to limited channel capacity downstream of 23+00, discharge frequencies greater than the 25-year flood overtop into the left overbank. During the 100-year flood approximately 16-percent of peak flow escapes the main channel.

11.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 69+05 and 66+91) and the two downstream-most cross-sections (Station 4+06 and 3+45) in the hydraulic model. Computed boundary condition slopes are 0.02 and 0.03 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were applied at the upstream end of the overflow reach based on the invert slopes computed between the upstream-most cross-sections (Stations 18+69 and 17+01). The invert slope at the upstream boundary is 0.03. At the downstream boundary a return junction was used to reconnect the overflow reach with the main channel.

11.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 11-2. Major flooded areas along Oak Spring Canyon are summarized for the 100-year and 500-year flood events in Table 11-6.

Table 11-6
Major Flooding along Oak Spring Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	DS study limit (Station 12+32) ~ Whitewater Canyon Road (Station 22+06)	Flooding extends into the left and right overbank areas. Flooding on the left overbank inundates residential property and brushy open space. Flooding on the right overbank inundates brush open space	Same as the 100-year flood extent with additional flooding in the left and right overbanks
Sub-reach 2 (Structure 2)	Whitewater Canyon Road (Station 22+43)~ Oak Spring Canyon Road (Station 50+72)	Flooding extends into the left and right overbank continuously. The majority of the flooded area is brushy open space with a residential property inundated near Sta. 22+50	Same as the 100-year flood extent with additional flooding in the left and right overbanks
Sub-reach 3 (No structures)	Oak Spring Canyon Road (Station 51+64) ~ US study limit (Station 69+05)	Flooding is contained in the main channel	Flooded extends into the left and right overbank near Sta. 60+00 and upstream of Oak Spring Canyon Road

11.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average slope of the channel bottom is approximately two percent along the study reach. The Railroad/Oak Spring Canyon Road crossing creates a bottle neck situation causing additional flooding on the left and right overbanks upstream and downstream of the crossing. The computed flow regime for 49 percent of the cross-sections was supercritical.

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Figure 11-1: Oak Spring Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 11-2: Oak Spring Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Section 12
Sand Canyon

12.1 General Description

Sand Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Sand Canyon are described in this section.

Sand Canyon joins the Santa Clara River from the south, between the locations where Mint Canyon and Oak Spring Canyon join the mainstem. The study reach begins upstream of Sand Canyon Road and extends 4.1 miles to the confluence with the Santa Clara River. Figure 12-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located in a residential community with medium tree coverage and undeveloped areas dominated by brush. Major crossings over Sand Canyon include Lost Canyon Road, Railroad Crossing and Alamo Canyon Road.

12.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 12-1.

Table 12-1
Structures along Sand Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	7+22	Lost Canyon Road	Span bridge/Two bridges	5′ rise concrete span bridge, concrete headwall & wingwalls, pier thickness: 3′
2	6+71	Downstream of Railroad	Drop structure	Grouted riprap drop ~ 3-foot drop
3	13+03	Railroad	Pier bridge	5-pier concrete bridge, 2 piers in the main channel & 3 piers on left overbank, 10′ rise in the main channel, deck thickness: 4′, DS drop
4	60+60	Alamo Canyon Road	Span bridge	20′ rise concrete span bridge, deck thickness: 1′
5	158+41	Placerita Canyon Road	Span bridge	12′~15′ rise concrete span bridge, deck thickness: 3′, headwalls

12.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 12-2.

Table 12-2
Sub-reaches along Sand Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 5)	Confluence with SCR (Station 1+85) ~ 1,200 ft DS Sand Canyon Road (Station 162+03)	Earthen channel with brush and trees on channel banks, sand/gravel/cobbles channel bed, floodplain consisting of residential area and medium tree cover
Sub-reach 2 (No Structures)	1,200 ft DS Sand Canyon Road (Station 165+34) ~ US study limit (Station 219+73)	Meandering earthen channel with undefined channel banks, sand/gravel/cobbles channel bed, shrubs/trees vegetation cover, floodplain consisting of brushy open space

12.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 12-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 12-3
Manning's Roughness Values along Sand Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 5)	Confluence with SCR (Station 1+85) ~ 1,200 ft DS Sand Canyon Road (Station 162+03)	0.13	0.04	0.13
Sub-reach 2 (No Structures)	1,200 ft DS Sand Canyon Road (Station 165+34) ~ US study limit (Station 219+73)	0.05	0.04	0.05

12.5 Hydrology

Three hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure12-1. The peak discharge rates associated with these locations are summarized in Table 12-4.

Table 12-4
Hydrologic Concentration Points along Sand Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
155+88	100	340	650	1,270	1,980	2,930	4,200	6,500
108+58	170	580	1,100	2,160	3,350	4,965	7,120	11,010
0	190	640	1,210	2,380	3,700	5,480	7,860	12,150

12.6 Hydraulic Model

The Sand Canyon hydraulic model was developed with 106 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains four bridges/culverts and one drop structure (see Table 12-1), and four dip crossings (located at Sta. 201+09, 91+89, 43+34, and 20+65).

12.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 219+73 and 217+56) and the two downstream-most cross-sections (Station 4+51 and 1+85) in the hydraulic model. Computed boundary condition slopes are 0.04 and 0.02 for upstream and downstream, respectively.

12.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 12-2. Major flooded areas along Sand Canyon are summarized for the 100-year and 500-year flood events in Table 12-5.

Table 12-5
Major Flooding along Sand Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 5)	Confluence with SCR (Station 1+85) ~ 1,200 ft DS Sand Canyon Road (Station 162+03)	Flooding continually flows between the channel and overbank areas due to limiting channel capacity. The flooded area includes brush open space and residential property	Same as the 100-year flood extent with additional flooding on the left and right overbanks between Sta. 61+37 and Sta. 92+29, and downstream of Placerita Canyon Road
Sub-reach 2 (No Structures)	1,200 ft DS Sand Canyon Road (Station 165+34) ~ US study limit (Station 219+73)	Flooding extends into the left and right overbank areas. The flooded areas include brushy open space	Same as the 100-year flood extent with additional flooding in the left and right overbanks

12.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average slope of the channel bottom is approximately two percent along the study reach. Conveyance limitations are apparent under 500-year flood conditions at the following crossings: the railroad crossing, Alamo Canyon Road, and Placerita Canyon Road. The conveyance capacity at the Lost Canyon Road crossing is at about the 50-year flood level. The computed flow regime for 51 percent of the cross-sections was supercritical.

Figure 12-1: Sand Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

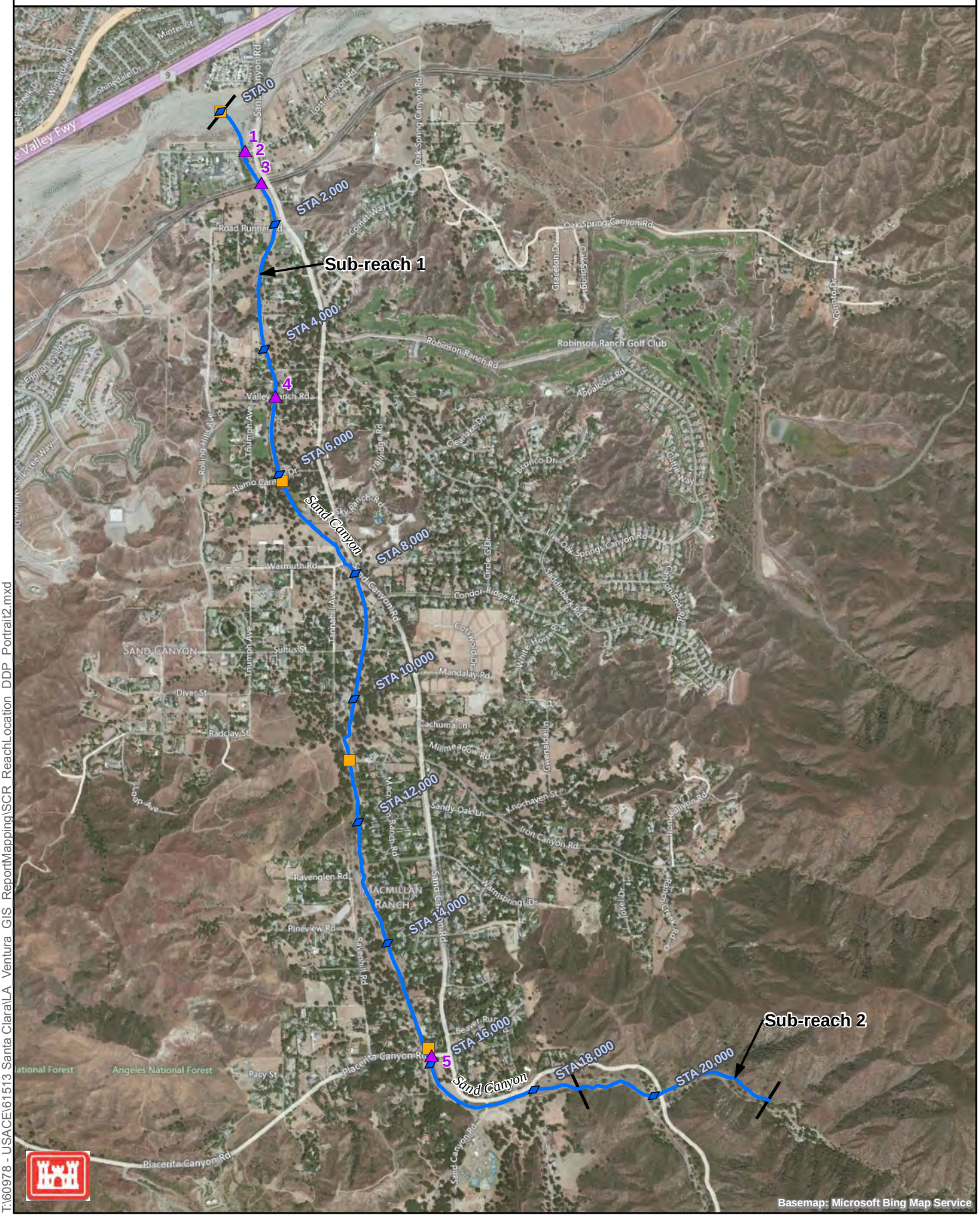

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Figure 12-2: Sand Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach100-Year Estimated Floodplain

Basemap: Microsoft Bing Map Service

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Section 13
Iron Canyon

13.1 General Description

Iron Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Iron Canyon are described in this section.

Iron Canyon is a tributary to Sand Canyon. The study reach begins at the confluence with Sand Canyon and extends 1.9 miles upstream. Figure 13-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within residential areas with medium vegetative cover and areas of brushy open space.

13.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 13-1.

Table 13-1
Structures along Iron Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	15+00	Sand Canyon Road	Span bridge	4′ rise concrete span bridge, pier thickness: 3′
2	59+00	North Iron Canyon Road	Multiple culverts/dip crossing	3-24″ CMPs & Concrete dip crossing with 3′ drop DS

13.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 13-2.

Table 13-2
Sub-reaches along Iron Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Confluence with Sand Canyon (Station 0+90) ~ 1,100 ft US of North Iron Canyon Road (Station 66+50)	Narrow earthen channel with well defined banks, sand/gravel/cobbles channel bed, floodplain consisting of residential area and medium tree cover
Sub-reach 2 (No structures)	1,100 ft US of North Iron Canyon Road (Station 70+33) ~ US study limit (Station 102+82)	Meandering earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space

13.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 13-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 13-3
Manning's Roughness Values along Iron Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Confluence with Sand Canyon (Station 0+90) ~ 1,100 ft US of North Iron Canyon Road (Station 66+50)	0.13	0.04	0.13
Sub-reach 2 (No structures)	1,100 ft US of North Iron Canyon Road (Station 70+33) ~ US study limit (Station 102+82)	0.05	0.04	0.05

13.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 13-1. The peak discharge rates associated with these locations are summarized in Table 13-4.

Table 13-4
Hydrologic Concentration Points along Iron Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
58+06	30	90	160	320	500	740	1,060	1,640
0	30	110	210	410	640	950	1,360	2,110

13.6 Hydraulic Model

The Iron Canyon hydraulic model was developed with 138 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled reach contains two bridges/culverts (see Table 13-1).

13.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 102+82 and 102+57) and the two downstream-most cross-sections (Station 2+51 and 90) in the hydraulic model. Computed boundary condition slopes are 0.08 and 0.02 at the upstream and downstream ends of the model, respectively.

13.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 13-2. Major flooded areas along Iron Canyon are summarized for the 100-year and 500-year flood events in Table 13-5.

Table 13-5
Major Flooding along Iron Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Confluence with Sand Canyon (Station 0+90) ~ 1,100 ft US of North Iron Canyon Road (Station 66+50)	Flooding continuously flows in the left and right overbank areas. Flooded areas include many residential properties along Iron Canyon	Same as the 100-year flood extent with additional flooding in the left and right overbanks especially at Sta. 52+63
Sub-reach 2 (No structures)	1,100 ft US of North Iron Canyon Road (Station 70+33) ~ US study limit (Station 102+82)	Flooding is contained in the main channel except for upstream and downstream of Iron Canyon Road. The flooded areas include residential property and local roads	Same as the 100-year flood extent with additional flooding in the left and right overbanks

13.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slopes range from seven percent in the upstream reach to 1.5 percent near the confluence with Sand Canyon. Major overbank flooding occurs along Iron Canyon due to limited channel capacity; as a result, the bridge structures have minimal impact on the water surface elevations and the floodplains. The predominant flow regime was supercritical.

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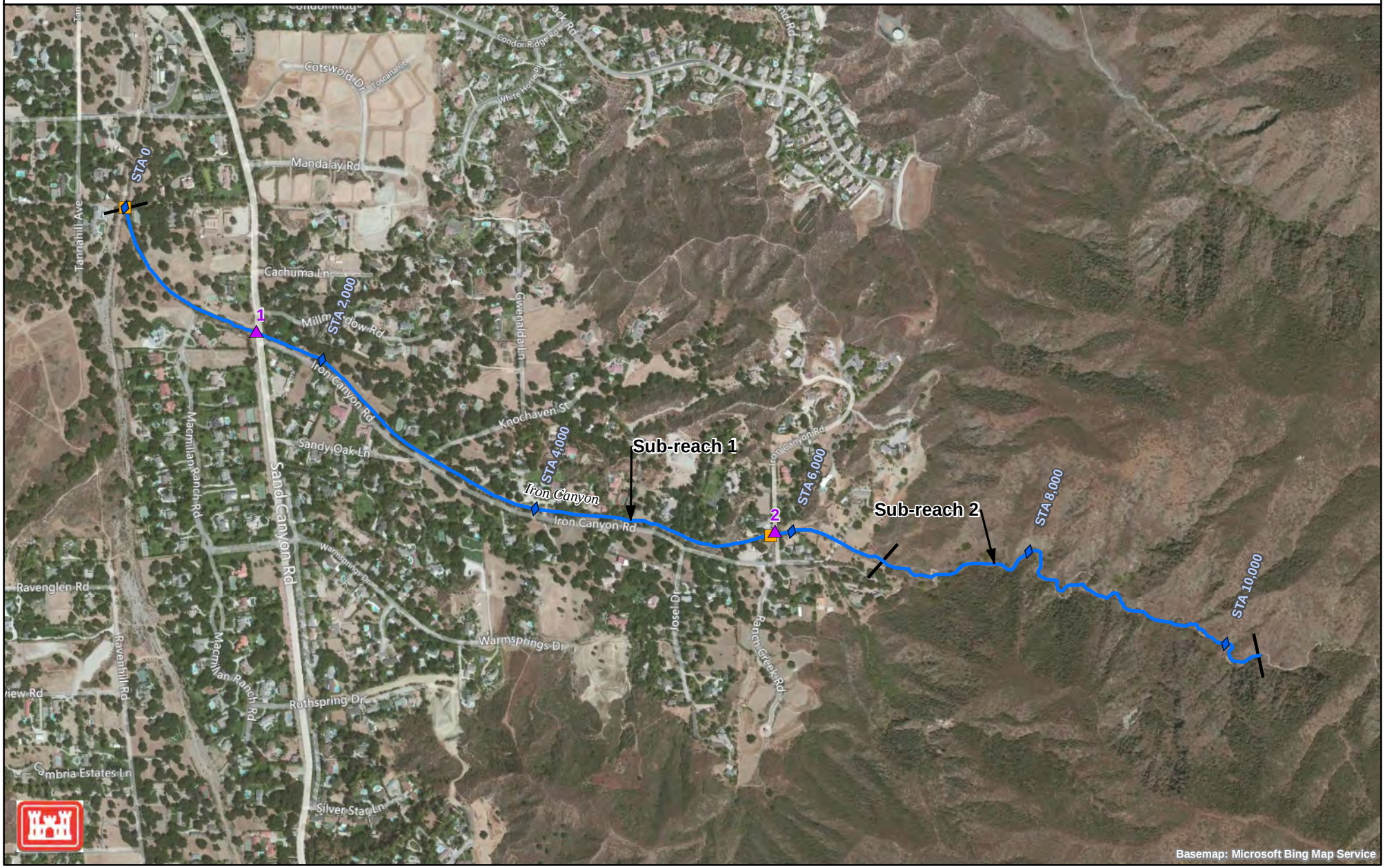
Figure 13-1: Iron Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach



Basemap: Microsoft Bing Map Service

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Figure 13-2: Iron Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 14
Mint Canyon

14.1 General Description

Mint Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Mint Canyon are described in this section.

Mint Canyon joins the Santa Clara River from the north. The Mint Canyon confluence is located between the Bouquet Canyon and Sand Canyon confluences with the mainstem. The study reach begins upstream of Steele Street and extends 9.7 miles to the confluence with the Santa Clara River. Figure 14-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of residential development, commercial use and brushy open space. Major crossings over Mint Canyon include Soledad Canyon Road, Vasquez Canyon Road and Sierra Highway.

14.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 14-1.

Table 14-1
Structures along Mint Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	3+65	Bike/Trail Overcrossing	Span bridge	High arch span bridge, abutment slowing flow on right channel bank
2	13+58	Soledad Canyon Road	Span bridge	45′x12′ (Span x Rise) concrete span bridge, concrete headwall & wingwalls, US banks covered by pole and wire, DS vertical concrete walls
3	30+00	Solamint Road to Scherzinger Lane	Buried culverts	2-17′x12′ (Span x Rise) rectangular concrete culverts, headwall & wingwalls, debris pier nose at US end
4	46+32	Downstream of Adon Ave A	Drop Structure	~ 2-foot wooden drop structure
5	47+28	Downstream of Adon Ave B	Drop Structure	~ 2-foot wooden drop structure
6	48+28	Downstream of Adon Ave C	Drop structure	~ 2-foot wooden drop structure
7	49+89	Adon Avenue	Span bridge	35′ x 5.5′ (Span x Rise) concrete span bridge, concrete headwall & wingwalls, board/steel drop at DS side (1.5′~2′)
8	75+50	Sierra Highway 1	Span bridge	38′x6.5′ (Span x Rise) concrete span bridge, concrete headwall & wingwalls, DS banks covered by pole and wire, US right bank grouted rock, US grouted rock drop (3′~4′)
9	76+66	Upstream of Sierra Highway 1	Drop Structure	Grouted Riprap drop structure
10	131+44	Private Driveway 1	Culvert/Dip	6′x2.25′ (Span x Rise) concrete culvert (low flow) with concrete dip crossing (high flow over driveway), vertical cut earthen banks
11	153+04	Fitch Avenue	Pier bridge	Timber bridge with 1-18′x7′ & 1-18′x10′ (Span x Rise) conveyance areas, 2′ pier width with metal debris nose, 2′ deck thickness
12	193+05	Vasquez Canyon Road	Pier bridge	2-33′x12.5′ (Span x Rise) concrete box conveyance area, 1.5′ pier thickness, wooden wingwalls, pier nose at US side
13	255+68	Sierra Highway 2	Multiple culverts	2-8′x2.5′ (Span x Rise) concrete box culverts, 9″ pier thickness, 21″ deck thickness
14	305+90	Sierra Highway 3	Pier bridge	Concrete bridge with 2-25′x10′ (Span x Rise) conveyance areas, left channel filled with 4′ sediment, US banks consist of large rock riprap, DS right bank consist of guide wall
15	370+54	Sierra Highway 4	Multiple culverts	2-6′x3′ (Span x Rise) concrete box culverts, US left bank rock riprap, right bank concrete blockwall along Sierra HWY, 2′ drop at DS side
16	435+97	Sierra Highway 5	Single culvert	1-8′x4′ (Span x Rise) concrete box culvert, US concrete headwall and wingwalls on right side, DS concrete headwall, 4′ drop at DS side

Table 14-1
Structures along Mint Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
17	443+50	Sierra Highway 6	Single culvert	1-6′x2′ (Span x Rise) concrete box culvert, 2′ drop at DS side
18	455+95	Private Driveway 2	Multiple culverts	Squashed culverts below residential driveways (Not Accessible and not included in the model)
19	469+00	Sierra Highway 7	Single culvert	1-3′x2′ (Span x Rise) elliptical CMP, headwall & wingwalls with concrete bags
20	486+00	Sierra Highway 8	Single culvert	1-4′ diameter CMP, DS ½ filled with sediment, US smooth rock headwall, DS concrete bag headwalls
21	500+00	Abandoned Motor Lodge Road	Single culvert	1-2.75″x4′ (Span x Rise) concrete box culvert, 5′ drop at DS end, concrete headwall & wingwalls
22	501+00	Sierra Highway 9	Multiple culverts	1-3′x2′ (Span x Rise) concrete box culvert and 27″ above are 2-2.5′ diameter CMPs, concrete headwall
23	510+50	Private Driveway 3	Multiple culverts	1-3′diameter & 1-4′ diameter CMPs, US grouted channel, DS earthen rock channel, concrete headwall & wingwalls
24	512+00	Private Driveway 4	Multiple culverts	2-4.5′ diameter & 1-3.5′ diameter CMPs, concrete headwall & wingwalls
25	512+60	Steele Street	Single culvert	1-4′ diameter CMP, 1′ filled with sediment
26	514+50	Private Driveway 5	Multiple culverts	2-4′ diameter CMPs, ½ filled with sediment

14.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 14-2.

Table 14-2
Sub-reaches along Mint Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 3)	Confluence with Santa Clara River (Station 3+20) ~ Solamint Road (Station 49+89)	Rectangular concrete channel, floodplain consisting of residential and commercial land use
Sub-reach 2 (Structures 4 to 11)	Solamint Road (Station 50+02) ~ Fitch Avenue (Station 152+72)	Natural varying channel with light brush, sand/gravel channel bed, floodplain consisting of brushy open space, agriculture and residential area
Sub-reach 3 (Structures 12 to 20)	Fitch Avenue (Station 153+32) ~ Downstream of Sierra Highway 8 (Station 479+63)	Meandering natural channel, sand/gravel channel bed, pines/cottonwoods vegetation cover, floodplain consisting of brushy open space
Sub-reach 4 (Structures 21 to 26)	Downstream of Sierra Highway 8 (Station 481+06) ~ US study limit (Station 515+67)	Shallow, narrow channel, sand/gravel channel bed, floodplain consisting of brushy open space and residential area

14.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 14-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 14-3
Manning's Roughness Values along Mint Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 3)	Confluence with Santa Clara River (Station 3+20) ~ Solamint Road (Station 49+89)	0.13	0.015	0.13
Sub-reach 2 (Structures 4 to 11)	Solamint Road (Station 50+02) ~ Fitch Avenue (Station 152+72)	0.06	0.044	0.06
Sub-reach 3 (Structures 12 to 20)	Fitch Avenue (Station 153+32) ~ Downstream of Sierra Highway 8 (Station 479+63)	0.05	0.044	0.05
Sub-reach 4 (Structures 21 to 26)	Downstream of Sierra Highway 8 (Station 481+06) ~ US study limit (Station 515+67)	0.06	0.039	0.06

14.5 Hydrology

Seven hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). At some concentration points the reported discharge rates are smaller than at concentration points upstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The locations of the hydrologic concentration points are shown in Figure 14-1. The peak discharge rates associated with these locations are summarized in Table 14-4.

Table 14-4
Hydrologic Concentration Points along Mint Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
431+28	130	450	850	1,670	2,590	3,840	5,510	8,520
367+60	150	510	970	1,900	2,950	4,370	6,270	9,690
294+07	150	510	970	1,900	2,950	4,370	6,270	9,690
219+24	150	510	970	1,900	2,950	4,370	6,270	9,690
156+00	150	510	970	1,900	2,950	4,370	6,270	9,690
76+27	150	500	940	1,850	2,880	4,260	6,110	9,450
0	150	500	940	1,850	2,880	4,260	6,110	9,450

14.6 Hydraulic Model

The Mint Canyon hydraulic model was developed with 285 cross-sections to represent varying channel geometry and hydraulic structures within the reach. The modeled reach contains 22 bridges/culverts and four drop structures (see Table 14-1), two dip crossings (located at Sta. 203+08 and 166+37), and one overflow reach. Structure Number 18, Private Driveway crossing, was not included in the model because it was inaccessible and the culverts appeared smashed.

14.6.1 Channel Improvements

Channels improvements were added to Mint Canyon based on as-built drawings. The improved reach extends from the confluence with Santa Clara River to Solamint Road (Station 30+00) (references: County of Los Angeles Environment Department Division, *Storm Drain Plans in Tract No. 42504 P. D* (City of Los Angeles, 1985), Los Angeles County Flood Control District (LACFCD), *Mint Canyon Santa Clara River to Adon Avenue.* (LACFCD, 1970), Los Angeles Department of Public Works (LADPW), *Sierra Highway over Mint Canyon Channel* (LADPW, 1985), and Los Angeles County Department Design Division Structures Section, *Soledad Canyon Road over Mint Canyon Channel* (Los Angeles County, 1985)).

The improved channel and culverts have sufficient capacity to convey the 200-year storm event without overtopping. The improved channel capacity without culvert

limitations, based on normal depth calculations, is 10,000 cfs, which is greater than the estimated peak discharge of the 500-year storm event.

14.6.2 Overflow Reaches

An overflow reach was added to Mint Canyon to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach due to limited channel and culvert capacity. The overflow reach begins downstream of Sierra Highway (Structure #8) and follows along Sierra Highway towards the Santa Clara River.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 14-5.

Table 14-5
Maximum Flow in Mint Canyon right overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
SierraSplit (right)	0	0	0	114	856	1,400	2,520	4,340

14.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 515+67 and 515+21) and the two downstream-most cross-sections (Station 4+82 and 3+20) in the hydraulic model. Computed boundary condition slopes are 0.027 and 0.003 at the upstream and downstream ends of the model, respectively.

The normal depth boundary conditions for the overflow reach were developed based on the invert slopes computed between the upstream-most cross-sections (Stations 90+38 and 89+35) and between the downstream-most cross-sections (Stations 7+05 and 2+44). The upstream and downstream slopes at the boundaries of the overflow reach are 0.02 and 0.002, respectively.

14.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 14-2. Major flooded areas along Mint Canyon are summarized for the 100-year and 500-year flood events in Table 14-6.

Table 14-6
Major Flooding along Mint Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 3)	Confluence with Santa Clara River (Station 3+20) ~ Solamint Road (Station 49+89)	The floodplain extends into the right overbank downstream of Sierra Highway and into the left overbank up to the adjacent local streets. The floodplain inundates commercial and residential property. Additionally, the Sierra Highway flow downstream follows a natural depression parallel to the SCR flowing west	Same as the 100-year flood extent with additional flooding on the left and right overbanks
Sub-reach 2 (Structures 4 to 11)	Solamint Road (Station 50+02) ~ Fitch Avenue (Station 152+72)	Flooding extends into the left and right overbank inundating residential areas, commercial and industrial property and Sierra Highway	Same as the 100-year flood extent with additional flooding on the left and right overbanks. Specifically, between Sta. 134+61 to Sta. 120+54
Sub-reach 3 (Structures 12 to 20)	Fitch Avenue (Station 153+32) ~ Downstream of Sierra HWY 8 (Station 479+63)	Flooding extends into the left and right overbank inundating adjacent residential areas, the Highway, and brushy open space	Same as the 100-year flood extent with additional flooding on the left and right overbanks. Specifically, upstream and downstream of Vasquez Canyon
Sub-reach 4 (Structures 21 to 26)	Downstream of Sierra HWY 8 (Station 481+06) ~ US study limit (Station 515+67)	Flooding extends into the left and right overbank inundating adjacent residential areas	Same as the 100-year flood extent with additional flooding on the left and right overbanks

14.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from 1.6 percent in the upstream reaches to 0.4 percent downstream. The computed flow regime for 64 percent of the cross-sections was subcritical.

Figure 14-1: Mint Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

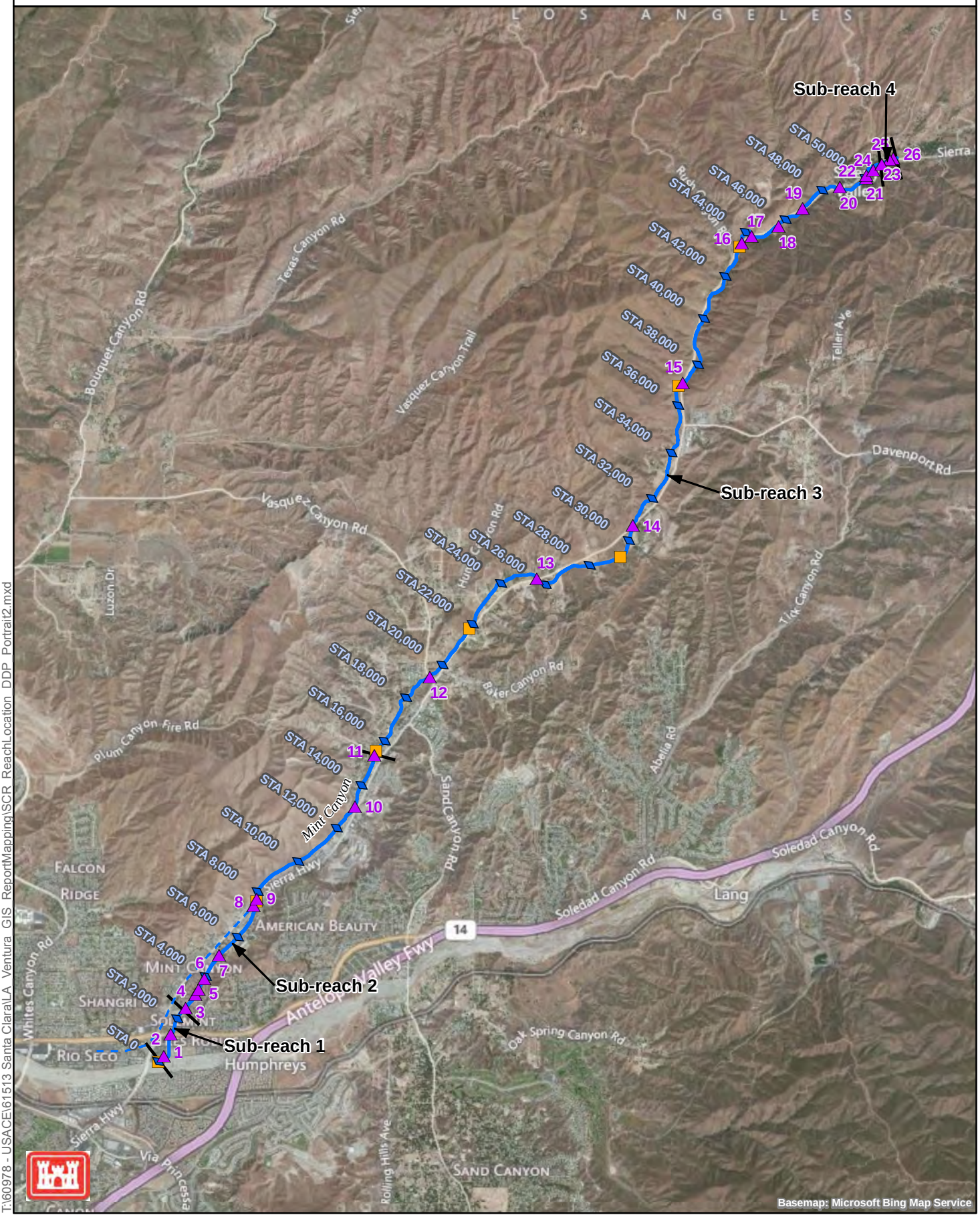

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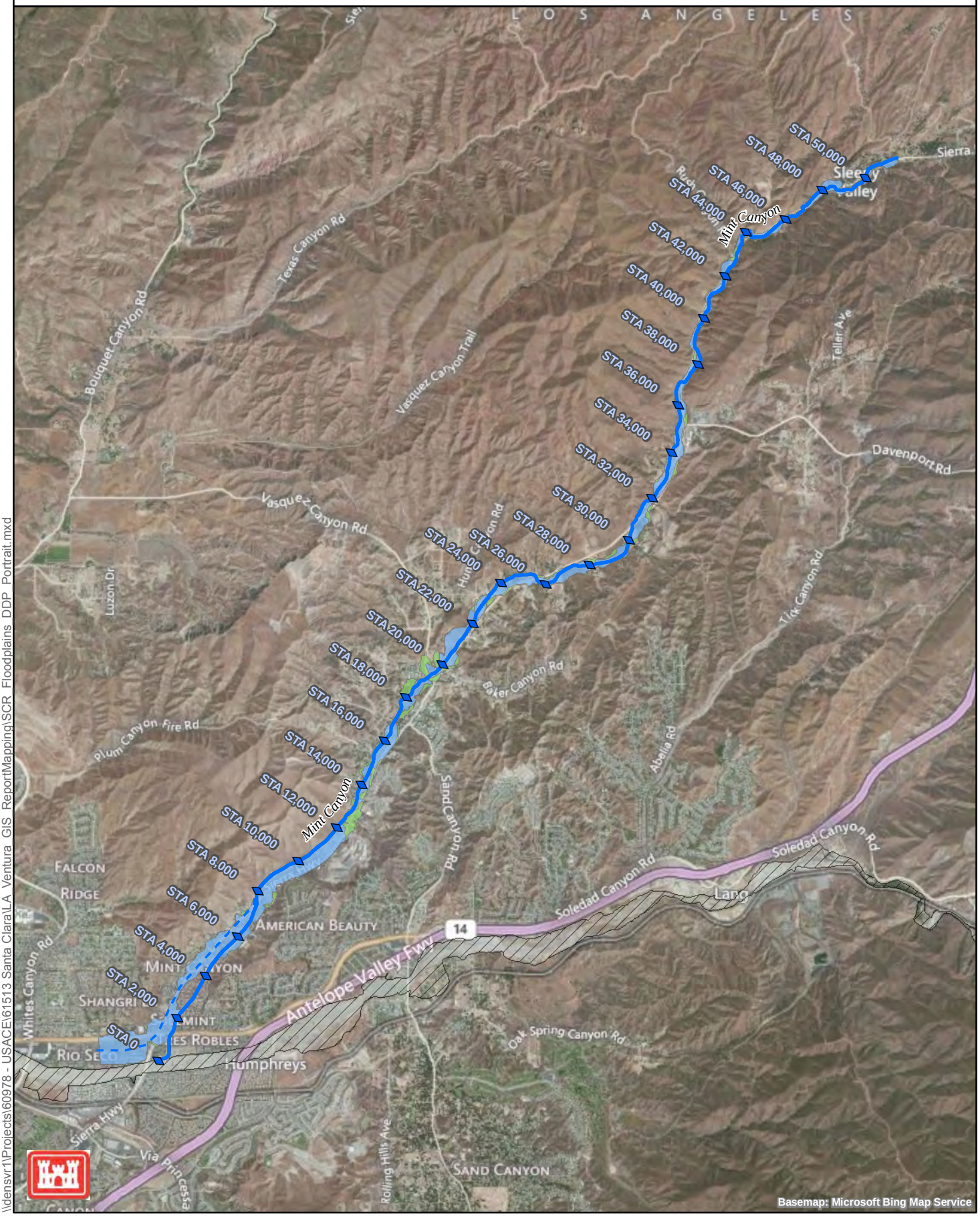
Figure 14-2: Mint Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach100-Year Estimated Floodplain



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Section 15
Bouquet Canyon

15.1 General Description

The Bouquet Canyon tributary includes both a USACE and a FEMA reach, as shown in Figure 15-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the Bouquet Canyon tributary (including both the USACE and FEMA reaches) are summarized in Sections 2.8 and 2.9.

Bouquet Canyon joins the Santa Clara River from the north, between the locations where South Fork Santa Clara River and Mint Canyon join the mainstem. The USACE study reach extends 2.9 miles upstream of the Texas Canyon confluence. The FEMA reach extends from the downstream end of the USACE reach to the Santa Clara River confluence. Figure 15-1 shows the alignment of the study reach, location of structures, and land use of surrounding areas.

The USACE study reach is located within areas of residential development and brushy open space. The only major crossing over Bouquet Canyon in the USACE reach is Bouquet Canyon Road, which crosses the river twice.

15.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 15-1.

Table 15-1
Structures along Bouquet Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	69+76	Bouquet Canyon Road 1	Single culvert	1-CMP, US side smashed (1~2 ft tall), very minor flow capacity, DS head & wingwalls. Modeled as a dip crossing
2	37+26	Bouquet Canyon Road 2	Single culvert	Completely filled CMP, driveway now used as dip crossing, DS drop 4′. Modeled as a dip crossing

15.3 Sub-reaches

The physical characteristics along the USACE reach were analyzed including the main channel geometry, bed material, overbank area land use, and degree of channel meandering. The general features along this reach were somewhat uniform, so only a single sub-reach was identified. The major features of the sub-reach are summarized in Table 15-2.

Table 15-2
Sub-reaches along Bouquet Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	DS study limit (Station 2+28) ~ US study limit (Station 174+30)	Meandering vegetated channel, sand/gravel channel bed, oaks/willows/burnt trees vegetation cover, floodplain consisting of brushy open space in valley

15.4 Manning's Roughness Coefficients

The Manning's roughness values for the USACE study reach are summarized in Table 15-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 15-3
Manning's Roughness Values along Bouquet Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	DS study limit (Station 2+28) ~ US study limit (Station 174+30)	0.05	0.04	0.05

15.5 Hydrology

Bouquet Canyon has one hydrologic concentration point along the USACE study reach (see the Introduction for the source of the hydrology information). The location of the hydrologic concentration point is shown in Figure 15-1. The peak discharge rates associated with this location are summarized in Table 15-4.

Table 15-4
Hydrologic Concentration Point for Bouquet Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
91+28	140	450	860	1,680	2,610	3,870	5,550	8,580
0	150	490	920	1,820	2,820	4,180	5,990	9,270

15.6 Hydraulic Model

The Bouquet Canyon hydraulic model was developed with 142 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains two smashed structures which are represented by dip crossings, located at Sta. 69+77 and 37+26 within the model.

15.6.1 FEMA Reach

FEMA developed the hydraulic model that extends from the mouth of Bouquet Canyon at the Santa Clara River upstream to the confluence with Texas Canyon. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

15.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 174+30 and 173+39) and the two downstream-most cross-sections (Station 3+73 and 2+28) in the hydraulic model. Computed boundary condition slopes are 0.05 and 0.02 at the upstream and downstream ends of the model, respectively.

15.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 15-2. Major flooded areas along Bouquet Canyon are summarized for the 100-year and 500-year flood events in Table 15-5.

Table 15-5
Major Flooding along Bouquet Canyon

Sub-reach	Sub-reach Location	100-year	500-year
USACE Reach			
Sub-reach 1 (Structures 1 and 2)	DS study limit (Station 2+28) ~ US study limit (Station 174+30)	Flooding continuously extends into the left and right overbank overtopping Bouquet Canyon Road. Additionally, the floodplain extends into residential areas and open space near Sta.36+57 to Sta. 41+29, 59+29 to Sta. 61+61, and Sta. 76+76 to Sta. 80+83	Same as the 100-year flood extent with additional flooding on the left and right overbanks
FEMA Reach			
NA	Confluence with SCR (Station 1+67) ~ USACE US study limit (Station 408+95)	Flooding extends into the left and right overbank continuously until the improved channel begins at Sta. 205+33	Flooding extends into the left and right overbank areas continuously until the improved channel begins at Sta. 205+33. The floodplain extends beyond the banks of the improved channel at Sta. 203+81 to Sta. 196+39, 152+50 to Sta. 70+16, and Sta. 56+75 to Sta. 23+85. The flooded areas include residential areas, roadways and open space

15.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from three percent in the upstream reaches to 1.5 percent downstream. The computed flow regime for 55 percent of the cross-sections was supercritical.

Figure 15-1: Bouquet Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

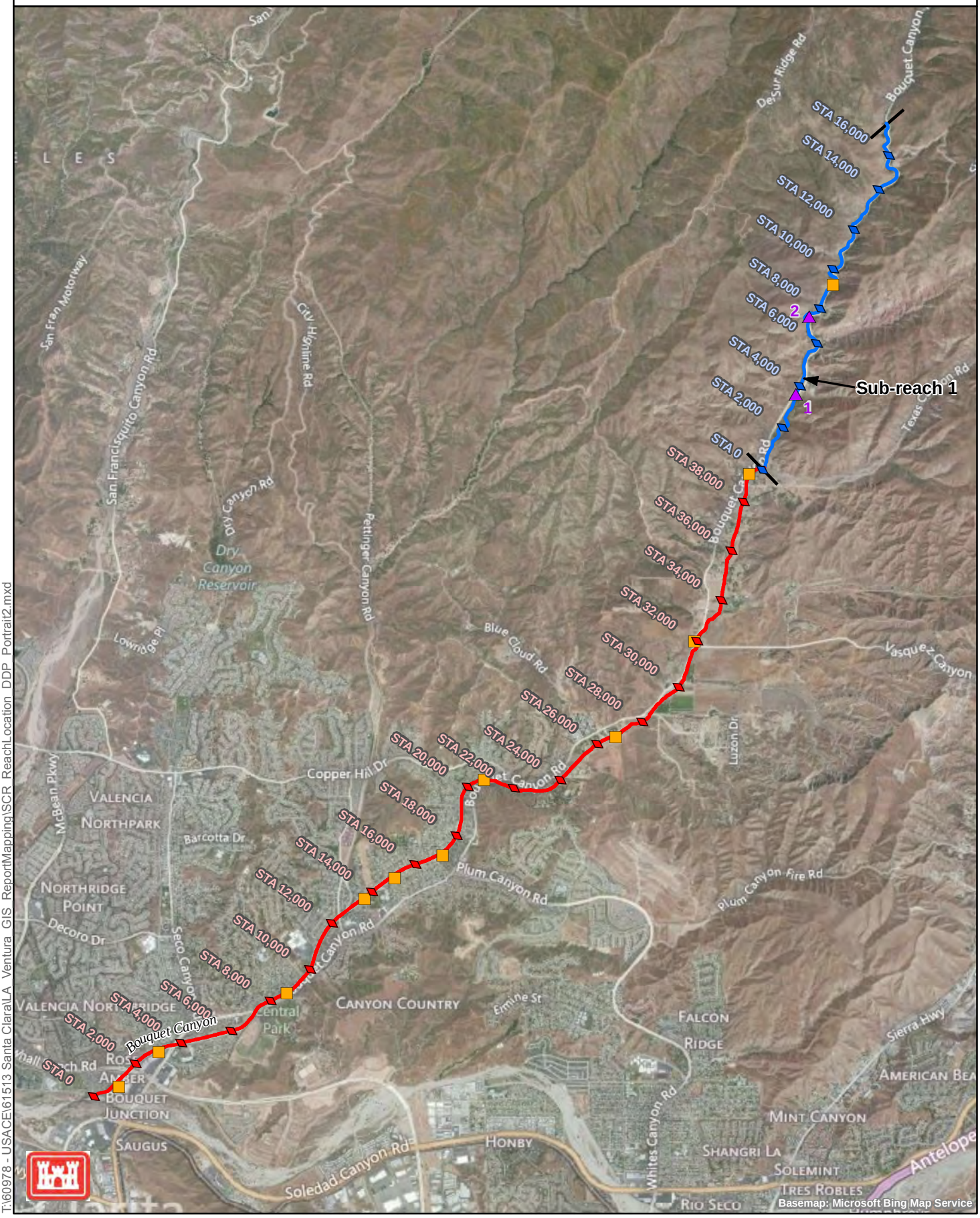

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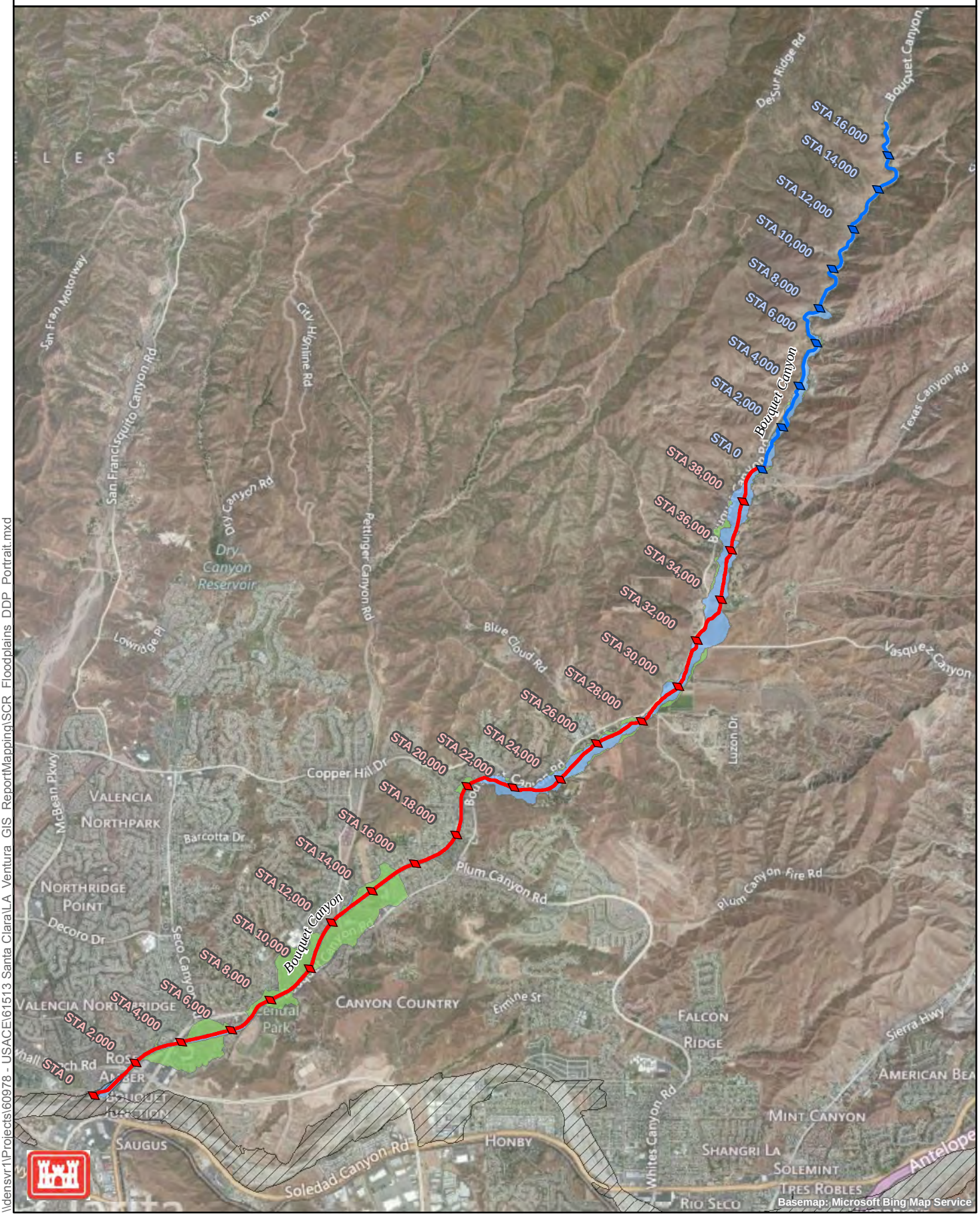
Figure 15-2: Bouquet Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach100-Year Estimated Floodplain



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Section 16
Texas Canyon

16.1 General Description

Texas Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Texas Canyon are described in this section.

Texas Canyon is a tributary of Bouquet Canyon, located upstream of the Vasquez Canyon and Bouquet Canyon confluence. The study reach begins at the confluence with Bouquet Canyon and continues one mile upstream. Figure 16-1 shows the alignment of the study reach and the surrounding land use.

The study reach is located within agriculture areas, ranches and brushy open space. There are no major crossings over Texas Canyon.

16.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively. There were no structures noted along the study reach.

16.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 16-1.

Table 16-1
Sub-reaches along Texas Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Confluence with Bouquet Canyon (Station 0+42) ~ 1,100 ft US of confluence (Station 9+11)	Undefined earthen channel with shallow banks, sand/gravel channel bed, floodplain consisting of agriculture, ranches and brushy open space
Sub-reach 2 (No structures)	1,100 ft US of confluence (Station 10+81) ~ 2,400 ft US of confluence (Station 21+12)	Narrow defined channel that appears to be dredged, sand/gravel channel bed, floodplain consisting of brushy open space and agriculture
Sub-reach 3 (No structures)	2,400 ft US of confluence (Station 23+15) ~ US study limit (Station 45+03)	Wide braided channel, sand/gravel channel bed, floodplain consisting of brushy open space

16.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 16-2. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 16-2
Manning's Roughness Values along Texas Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structures)	Confluence with Bouquet Canyon (Station 0+42) ~ 1,100 ft US of confluence (Station 9+11)	0.06	0.04	0.06
Sub-reach 2 (No structures)	1,100 ft US of confluence (Station 10+81) ~ 2,400 ft US of confluence (Station 21+12)	0.05	0.04	0.05
Sub-reach 3 (No structures)	2,400 ft US of confluence (Station 23+15) ~ US study limit (Station 45+03)	0.05	0.046	0.05

16.5 Hydrology

Texas Canyon has one hydrologic concentration point along the study reach (see the Introduction for the source of the hydrology information). The location of the hydrologic concentration point is shown in Figure 16-1. The peak discharge rates associated with this location are summarized in Table 16-3.

Table 16-3
Hydrologic Concentration Point for Texas Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
45+04	120	410	780	1,530	2,380	3,520	5,050	7,810

16.6 Hydraulic Model

The HEC-RAS model for Texas Canyon was developed with 34 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains no bridges, culverts or dip crossings.

16.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most

cross-sections (Station 45+03 and 42+23) and the two downstream-most cross-sections (Station 1+71 and 42) in the hydraulic model. Computed boundary condition slopes are 0.03 and 0.023 at the upstream and downstream ends of the model, respectively.

16.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 16-2. Major flooded areas along Texas Canyon are summarized for the 100-year and 500-year flood events in Table 16-4.

Table 16-4
Major Flooding along Texas Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (No structures)	Confluence with Bouquet Canyon (Station 0+42) ~ 1,100 ft US of confluence (Station 9+11)	Flooding extends into the left and right overbank areas. The flooded areas include brushy open space and residential properties	Same as the 100-year flood with wider flood extents on the left and right overbank
Sub-reach 2 (No structures)	1,100 ft US of confluence (Station 10+81) ~ 2,400 ft US of confluence (Station 21+12)	Flooding extends into the left overbank directly downstream of cross-section Sta. 15+03. The flooded areas include brushy open space and residential properties	Same as the 100-year flood except the 500-year flood extends into the left overbank farther upstream at cross-section Sta. 21+13. The flooded areas include brushy open space and residential property and houses
Sub-reach 3 (No structures	2,400 ft US of confluence (Station 23+15) ~ US study limit (Station 45+03)	Flooding is contained in the main channel	Same as the 100-year flood with wider flood extents on the left and right overbank

16.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slopes range from about two percent in the upstream reaches of the model to 0.8 percent downstream. The computed flow regime for 53 percent of the cross-sections was subcritical.

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Figure 16-1: Texas Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 500 1,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

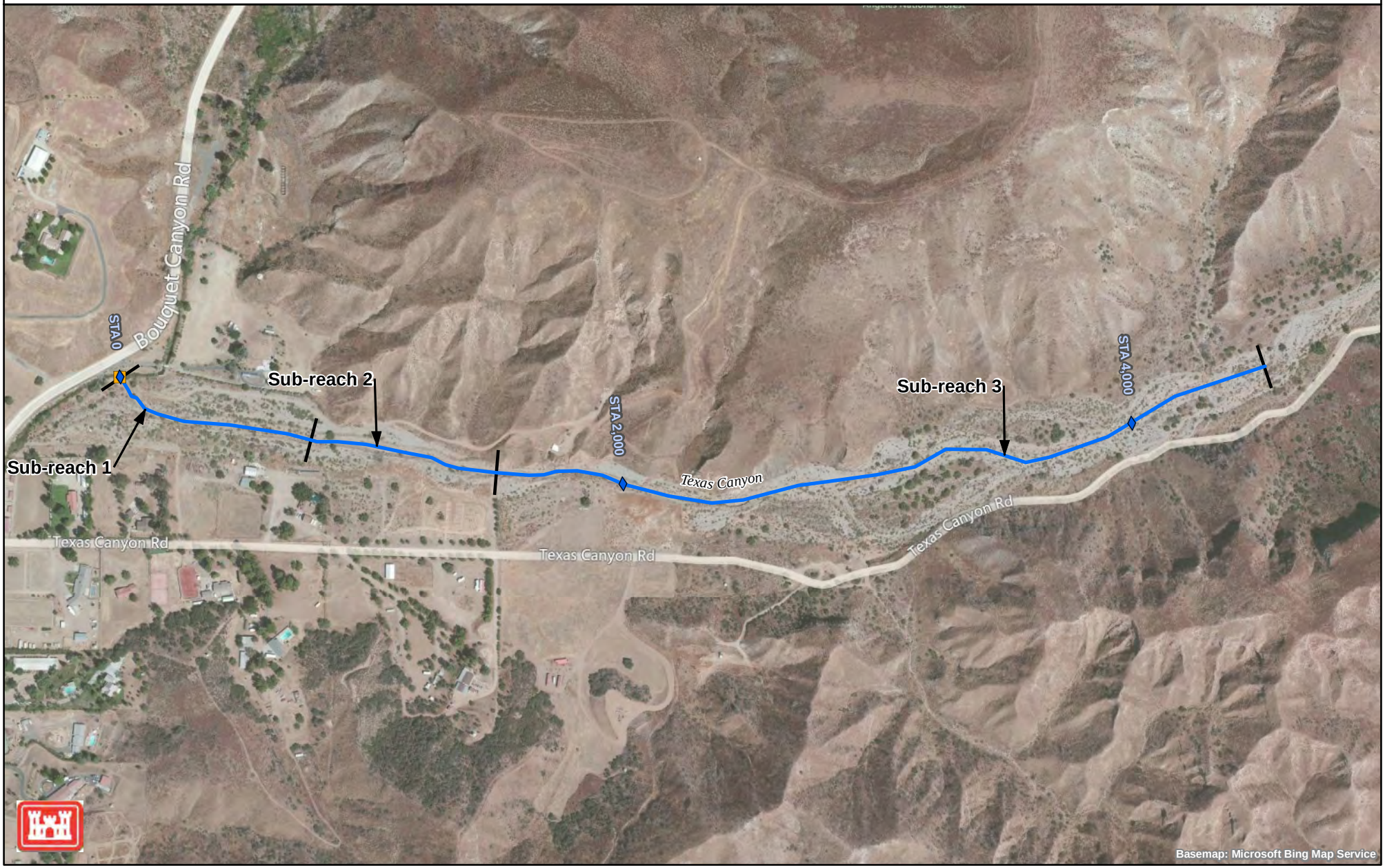

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Figure 16-2: Texas Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 500 1,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 17
Vasquez Canyon

17.1 General Description

Vasquez Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Vasquez Canyon are described in this section.

Vasquez Canyon is one of several tributaries to Bouquet Canyon. Vasquez Canyon flows into Bouquet Canyon between the locations of the Plum Canyon and Texas Canyon confluences with Bouquet Canyon. The study reach begins at the confluence with Bouquet Canyon and extends upstream 1.9 miles. Figure 17-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of brushy open space and agriculture. There are no major crossings over Vasquez Canyon.

17.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

There were no structures noted along the study reach during the field reconnaissance.

17.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The physical characteristics of the Vasquez Canyon sub-reaches are summarized in Table 17-1.

Table 17-1
Sub-reaches along Vasquez Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Confluence with Bouquet Canyon (Station 36+11) ~ 2,100 ft US of confluence (Station 20+21)	Narrow earthen channel with vertical banks, DS pole and wire on right channel bank, sand/gravel channel bed, floodplain consisting of brushy open space and agriculture
Sub-reach 2 (No structures)	2,100 ft US of confluence (Station 22+99) ~ US study limit (Station 104+13)	Undefined channel, sand/gravel channel bed, light brush vegetation cover, floodplain consisting of brushy open space and residential area

17.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 17-2. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 17-2
Manning's Roughness Values along Vasquez Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structures)	Confluence with Bouquet Canyon (Station 36+11) ~ 2,100 ft US of confluence (Station 20+21)	0.06	0.035	0.05
Sub-reach 2 (No structures)	2,100 ft US of confluence (Station 22+99) ~ US study limit (Station 104+13)	0.05	0.044	0.05

17.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 17-1. The peak discharge rates associated with these locations are summarized in Table 17-3.

Table 17-3
Hydrologic Concentration Points along Vasquez Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
51+69	40	130	250	490	760	1,120	1,610	2,480
0	50	170	310	620	960	1,420	2,040	3,150

17.6 Hydraulic Model

The Vasquez Canyon hydraulic model was developed with 81 cross-sections to represent the varying channel geometry and the hydraulic structures located along the study reach. The modeled reach contains one dip crossing located at Sta. 28+06.

17.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 104+13 and 101+34) and the two downstream-most cross-sections (Station 10+01 and 9+34) in the hydraulic model. Computed boundary condition slopes are 0.026 and 0.024 at the upstream and downstream ends of the model, respectively.

17.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 17-2. Major flooded areas along Vasquez Canyon are summarized for the 100-year and 500-year flood events in Table 17-4.

Table 17-4
Major Flooding along Vasquez Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (No structures)	Confluence with Bouquet Canyon (Station 36+11) ~ 2,100 ft US of confluence (Station 20+21)	Flooding extends into the left overbank directly downstream of the Vasquez Canyon dip crossing and continues until the confluence with Bouquet Canyon. Also, flooding occurs directly upstream of Vasquez Canyon Road on the right overbank and continues until the confluence. The flood areas include brushy open space and local roads	Same as the 100-year flood with additional extended limits on the left and right overbank
Sub-reach 2 (No structures)	2,100 ft US of confluence (Station 22+99) ~ US study limit (Station 104+13)	Flooding extends into the left and right overbank continuously for the entire reach. The flooded areas include residential property between Sta.43+32 to Sta. 44+49, and brushy open space	Same as the 100-year flood with additional extended limits on the left and right overbank

17.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 2.6 percent along the study reach. The computed flow regime for 52 percent of the cross-sections was subcritical.

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Figure 17-1: Vasquez Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

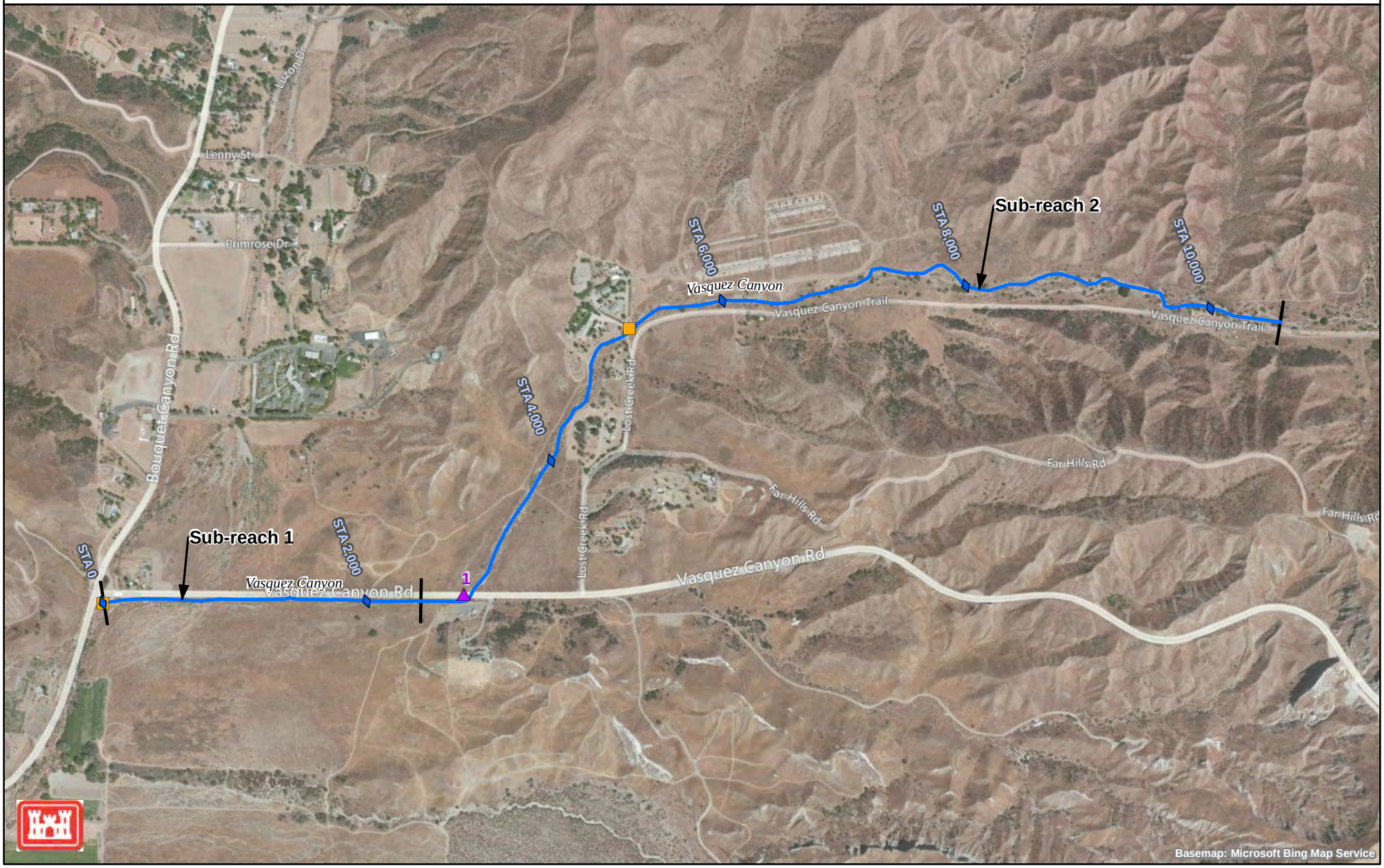

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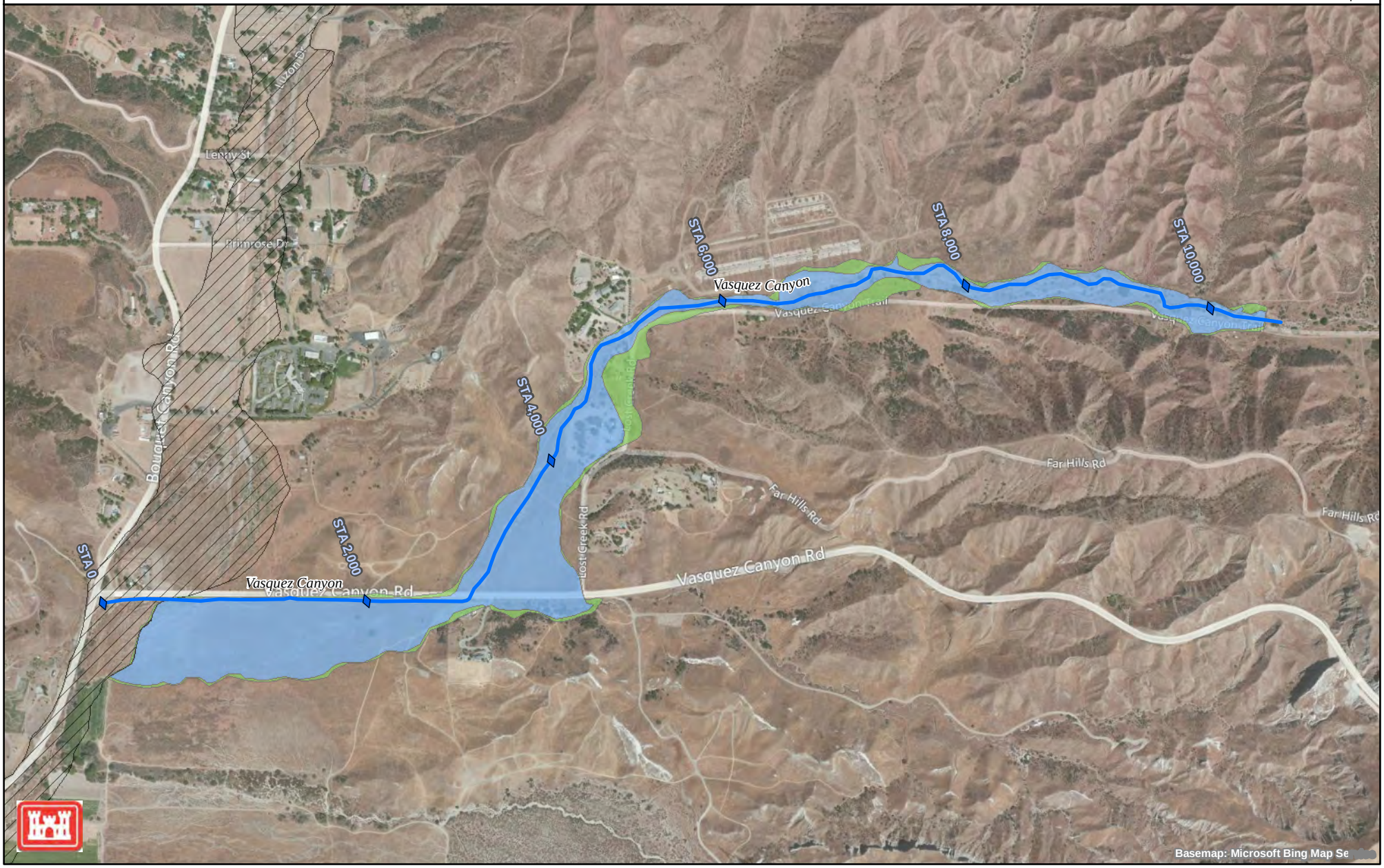
Figure 17-2: Vasquez Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 18
Plum Canyon

18.1 General Description

Plum Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Plum Canyon are described in this section.

Plum Canyon is a tributary of Bouquet Canyon. Plum Canyon joins Bouquet Canyon between the locations of the Haskell Canyon and Vasquez Canyon confluences with Bouquet Canyon. The study reach begins at the confluence with Bouquet Canyon and extends 1.1 miles upstream. Figure 18-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located along Plum Canyon Road in a dense residential area. The only major crossing along the study reach is Bouquet Canyon Road.

18.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and drop structures along the study reach is summarized in Table 18-1.

Table 18-1
Structures along Plum Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	9+49	Bouquet Canyon Road	Span bridge	Concrete span bridge with 19.67'x9'58" (Span x Rise) box conveyance area, wrapped concrete transitions, 1-10" pier with debris nose only at US side
2	25+02	Rodgers Drive	Pier bridge	2-10'x7' (Span x Rise) concrete box conveyance area with wrapped concrete transitions, 1-8" pier, debris nose at US side
3	NA	Debris Basin	Buried culvert inlet	Not incorporated into the hydraulic model

18.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The features of this study reach were relatively consistent, and a single sub-reach was identified. The physical characteristics of the Plum Canyon sub-reach are summarized in Table 18-2.

Table 18-2
Sub-reaches along Plum Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Confluence with Bouquet Canyon (Station 1+19) ~ US study limit (Station 41+70)	Trapezoidal concrete channel, floodplain consisting of residential area and open brushy space

18.4 Manning's Roughness Coefficients

The Manning's roughness values for the single Plum Canyon sub-reach are summarized in Table 18-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 18-3
Manning's Roughness Values along Plum Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Confluence with Bouquet Canyon (Station 1+19) ~ US study limit (Station 41+70)	0.13	0.015	0.13

18.5 Hydrology

One hydrologic concentration point was provided along the study reach of Plum Canyon (see the Introduction for the source of the hydrology information). The location of this hydrologic concentration point is shown in Figure 18-1. The peak discharge rates associated with this location are summarized in Table 18-4.

Table 18-4
Hydrologic Concentration Point for Plum Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	40	130	240	470	730	1,080	1,550	2,400

18.6 Hydraulic Model

The Plum Canyon hydraulic model was developed with 26 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains two bridges/culverts.

18.6.1 Channel Improvements

Channel improvements were added to Plum Canyon based on as-built drawings. The improved reach begins at the confluence with Bouquet Canyon and extends to the upstream study limit. (reference: County of Los Angeles (COLA) California, *Storm Drain Plans in Plum Canyon Channel PD No. 1540* (COLA, 1979)).

The improved channel and culverts have capacity to convey the 500-year storm event without overtopping.

18.6.2 Bridge Structures

Initial HEC-RAS model results indicated that pressure flow would occur at both the Rogers Drive and Bouquet Canyon bridge structures under certain flood events. HEC-RAS often has difficulty with bridge computations in supercritical flow reaches. To check the reasonableness of the initial results, the models were re-run with modified soffit elevations for the bridge structures to determine the sensitivity of the results to this parameter. The models were also re-run with- and without the pressure flow computation option selected. The results of these sensitivity analyses indicated that the flow through both structures would likely remain supercritical through each of these structures, even under peak 500-year flood conditions, and the pressure flow conditions defaulted to by the model were erroneous. In the final models, the computation options and/or soffit geometries were adjusted to force the correct (supercritical) condition.

18.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 41+70 and 39+24) and the two downstream-most cross-sections (Station 3+71 and 1+19) in the hydraulic model. Computed boundary condition slopes are 0.035 and 0.027 at the upstream and downstream ends of the model, respectively.

18.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 18-2. Major flooded areas along Plum Canyon are summarized for the 100-year and 500-year flood events in Table 18-5.

Table 18-5
Major Flooding along Plum Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Confluence with Bouquet Canyon (Station 1+19) ~ US study limit (Station 41+70)	Flooding is contained in the main channel	Flooding is contained in the main channel

18.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope of the study reach is approximately 2.5 percent, except for directly upstream of Bouquet Canyon Road where the channel has a six-foot drop. The predominant flow regime throughout the model was supercritical.

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Figure 18-1: Plum Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 500 1,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 18-2: Plum Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 500 1,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Section 19
Haskell Canyon

19.1 General Description

Haskell Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Haskell Canyon are described in this section.

Haskell Canyon is a tributary to Bouquet Canyon, located approximately 2.5 miles upstream of the confluence of Bouquet Canyon with the Santa Clara River. The study reach begins at the Bouquet Canyon confluence and extends 1.5 miles upstream. Figure 19-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located in areas of mixed use, including residential development and open space dominated by heavy brush. The major crossings over Haskell Canyon are Copper Hill Road and Ridgegrove Drive.

19.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 19-1.

Table 19-1
Structures along Haskell Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	10+00	Ridgegrove Drive	Span Bridge	Span bridge is approximately 14.5 feet from channel invert, with large drop from grade change immediately upstream
2	55+00	Copper Hill Road	Bridge	2-pier bridge with debris noses and rectangular section through the bridge

19.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 19-2.

Table 19-2
Sub-reaches along Haskell Canyon

Sub-reach	Sub-Reach Location	Description
Sub-reach 1 (Structure 1)	Confluence with Bouquet Canyon (Station 4+39) ~ Ridgegrove Drive (Station 9+87)	Curved trapezoidal fully lined concrete channel, floodplain consisting of heavy residential area and brush
Sub-reach 2 (Structure 2)	Ridgegrove Drive (Station 10+60) ~ 1,720 ft US from Copper Hill Drive (Station 56+05)	Straight trapezoidal fully lined concrete channel, floodplain consisting of residential homes and brushy open space
Sub-reach 3 (No structures)	1,720 ft US from Copper Hill Drive (Station 59+54) ~ 1,720 ft US from Copper Hill Drive (Station 70+89)	Straight trapezoidal soft bottom channel with concrete-lined banks with extremely dense, overgrown vegetation (mainly willows) inside the channel, overbank floodplain consisting of residential neighborhoods
Sub-reach 4 (No structures)	1,720 ft US from Copper Hill Drive (Station 72+07) ~ U/S study limit (Station 101+31)	Broad vegetated earthen channel, sand/gravel channel bed, floodplain consisting of some residential and mostly brushy open space in valley

19.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study channel are summarized in Table 19-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 19-3
Manning's Roughness Values along Haskell Canyon

Sub-reach	Sub-Reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	Confluence with Bouquet Canyon (Station 4+39) ~ Ridgegrove Drive (Station 9+87)	0.13	0.015	0.13
Sub-reach 2 (Structure 2)	Ridgegrove Drive (Station 10+60) ~ 1,720 ft US from Copper Hill Drive (Station 56+05)	0.05	0.015	0.13
Sub-reach 3 (No structures)	1,720 ft US from Copper Hill Drive (Station 59+54) ~ 1,720 ft US from Copper Hill Drive (Station 70+89)	0.05	0.10	0.13
Sub-reach 4 (No structures)	1,720 ft US from Copper Hill Drive (Station 72+07) ~ U/S end of improved channel (Station 101+31)	0.05	0.046	0.05

19.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 19-1. The peak discharge rates associated with these locations are summarized in Table 19-4.

Table 19-4
Hydrologic Concentration Points along Haskell Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
69+27	110	360	680	1,330	2,070	3,060	4,390	6,790
0	120	390	730	1,440	2,240	3,320	4,760	7,360

19.6 Hydraulic Model

The Haskell Canyon hydraulic model was developed with 67 cross-sections to represent the varying channel geometry and hydraulic structures along the study reach. The modeled reach contains two bridges/culverts.

19.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 101+31 and 100+00) and the two downstream-most cross-sections (Station 5+86 and 4+39) in the hydraulic model. Computed boundary condition slopes are 0.016 and 0.004 for at the upstream and downstream ends of the model, respectively.

19.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 19-2. Major flooded areas along Haskell Canyon are summarized for the 100-year and 500-year flood events in Table 19-5.

Table 19-5
Major Flooding along Haskell Canyon

Sub-reach	Sub-Reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	Confluence with Bouquet Canyon (Station 4+39) ~ Ridgegrove Drive (Station 9+87)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 2 (Structure 2)	Ridgegrove Drive (Station 10+60) ~ 1,720 ft US from Copper Hill Drive (Station 56+05)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 3 (No structures)	1,720 ft US from Copper Hill Drive (Station 59+54) ~ 1,720 ft US from Copper Hill Drive (Station 70+89)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 3 (No structures)	1,720 ft US from Copper Hill Drive (Station 59+54) ~ 1,720 ft US from Copper Hill Drive (Station 70+89)	Flooding is contained in the main channel	Flooding is contained in the main channel

19.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately one percent along the study reach, except for directly upstream of Carson Mesa Road where the channel slope steepens to three percent. The predominant flow regime was supercritical.

Figure 19-1: Haskell Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

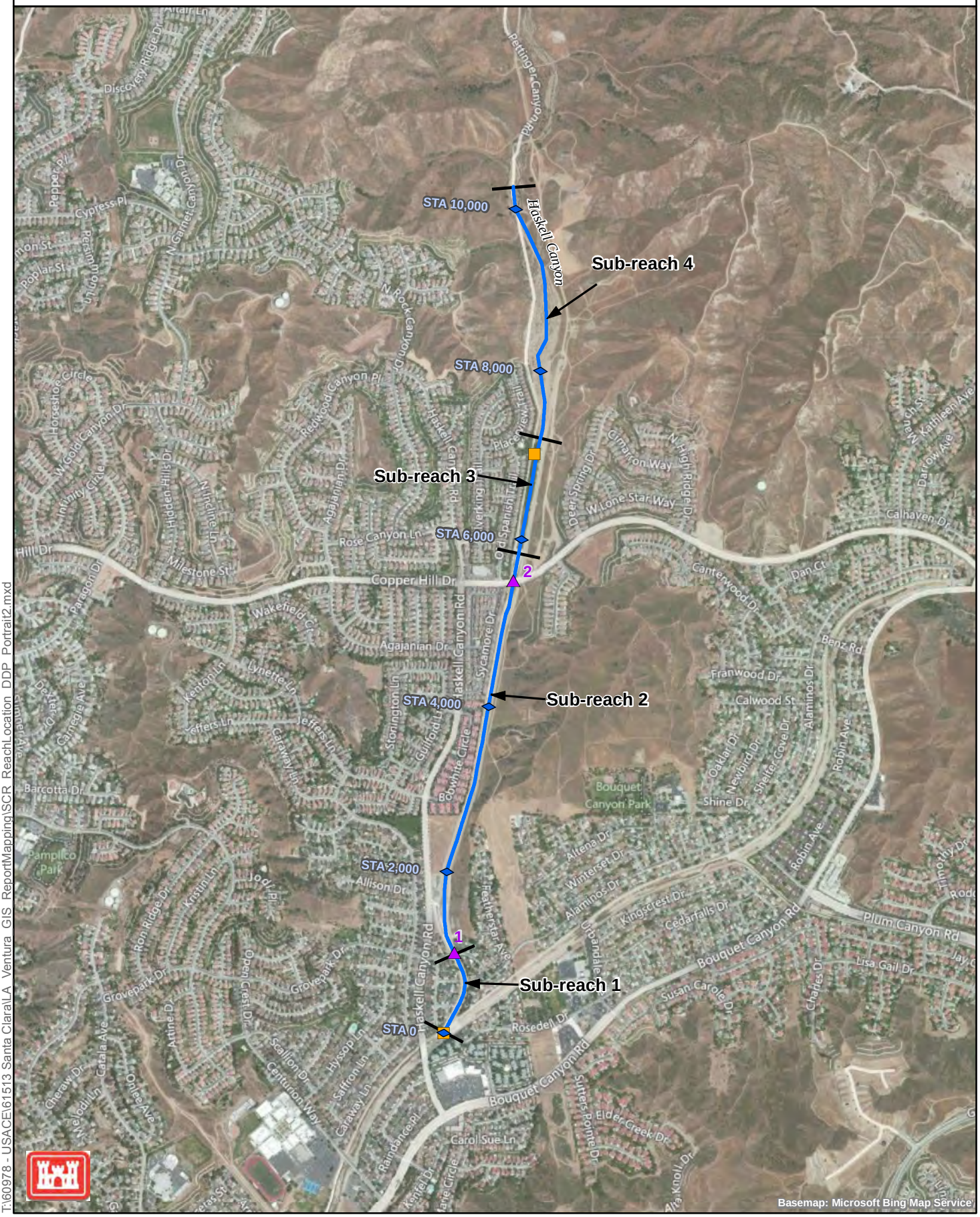

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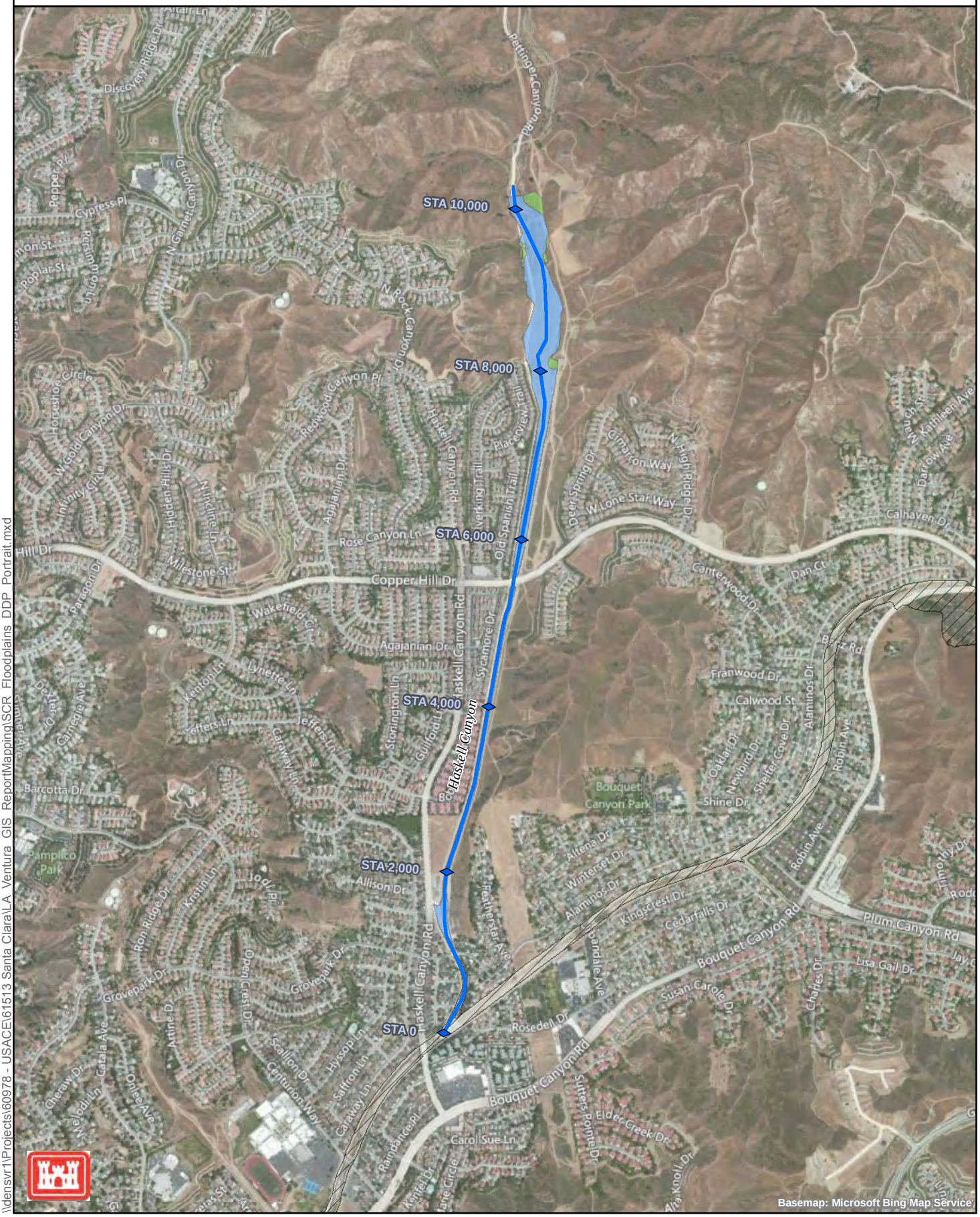
Figure 19-2: Haskell Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 20
Dry Canyon

20.1 General Description

Dry Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Dry Canyon are described in this section.

Dry Canyon is a tributary to Bouquet Canyon, located approximately 0.5 miles upstream of the confluence of Bouquet Canyon with the Santa Clara River. The study reach begins at the Bouquet Canyon confluence and extends four miles upstream. Figure 20-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located in a dense residential neighborhood with improved channels and numerous bridge crossings.

20.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 20-1.

Table 20-1
Structures along Dry Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	12+89	Festividad Drive	Span bridge	Concrete span bridge with 10′x12′ (Bottom Width x Rise) trapezoidal conveyance area
2	26+71	Garzota Drive	Span bridge	Concrete span bridge with 10′x11′ (Bottom Width x Rise) trapezoidal conveyance area
3	47+98	Decoro Drive	Span bridge	Concrete span bridge with 10′x10′ (Bottom Width x Rise) trapezoidal conveyance area
4	77+74	Pamplico Drive	Span bridge	Concrete span bridge with 10′x11.5′ (Bottom Width x Rise) trapezoidal conveyance area
5	99+13	Tupelo Ridge Drive	Span bridge	Concrete span bridge with 10′x11.5′ (Bottom Width x Rise) trapezoidal conveyance area
6	110+00	Copper Hill Drive	Span bridge	Concrete span bridge with 14.5′x10′ (Span x Rise) box conveyance area, wrapped concrete transitions
7	125+01	Banyan Place	Span bridge	Concrete span bridge with 18′x10′ (Span x Rise) box conveyance area, wrapped concrete transitions
8	152+50	Tamarack Lane	Span bridge	Concrete span bridge with 18′x10′ (Span x Rise) box conveyance area, wrapped concrete transitions
9	161+14	Boxwood Lane	Span bridge	Concrete span bridge with 18′x10′ (Span x Rise) box conveyance area, wrapped concrete transitions

20.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. Two sub-reaches was identified along the study reach. The physical characteristics of the Dry Canyon sub-reaches are summarized in Table 20-2.

Table 20-2
Sub-reaches along Dry Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 9)	Confluence with Bouquet Canyon (Station 2+69) ~ End of improved channel (Station 174+57)	Trapezoidal concrete channel, floodplain consisting of residential area
Sub-reach 2 (No Structures)	End of improved channel (Station 177+31) ~ US study limit (Station 191+34)	Natural earthen channel, sand/gravel channel bed, floodplain consisting of some residential and mostly open brushy space in valley

20.4 Manning's Roughness Coefficients

The Manning's roughness values for the Dry Canyon sub-reaches are summarized in Table 20-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 20-3
Manning's Roughness Values along Dry Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 9)	Confluence with Bouquet Canyon (Station 2+69) ~ End of improved channel (Station 174+57)	0.13	0.015	0.13
Sub-reach 2 (No Structures)	End of improved channel (Station 177+31) ~ US study limit (Station 191+34)	0.05	0.045	0.05

20.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Dry Canyon (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 20-1. The peak discharge rates associated with these locations are summarized in Table 20-4.

Table 20-4
Hydrologic Concentration Points along Dry Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
131+60	90	290	550	1,070	1,670	2,470	3,540	5,480
70+65	100	330	620	1,220	1,890	2,800	4,020	6,210
0	110	370	700	1,380	2,140	3,170	4,550	7,030

20.6 Hydraulic Model

The Dry Canyon hydraulic model was developed with 108 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains an upstream debris basin and nine bridges/culverts (see Table 20.1). The debris basin geometry was included in the model, but the model does not account for the potential flow attenuation within the basin.

20.6.1 Channel Improvements

Channel improvements were added to Dry Canyon based on as-built drawings. The improved reach begins at the confluence with the Santa Clara River and extends to Copper Hill Drive (reference: Los Angeles County Flood Control District (LACFCD). *Project No 9103 Line B Unit 1 No. 470-9103D2.1* (LACFCD, 1973), County of Los Angeles (COLA). *Storm Drain Plans in Tract No 29999, PD No. 928* (COLA, 1969)).

The improved channel and culverts have capacity to convey the 500-year storm event without overtopping.

20.6.2 Bridge Structures

Initial HEC-RAS model results indicated that pressure flow would occur at several of the modeled bridge structures under certain flood events. HEC-RAS often has difficulty with bridge computations in supercritical flow reaches. To check the reasonableness of the initial results, the bridge structures for the Tupelo Ridge Drive, Decoro Drive, Garzota Drive and Festividad Drive crossings (all clear span structures) were removed from the hydraulic model to compute the water surface elevations through the unobstructed reaches. Each of the bridges were reviewed after running the model to determine if the calculated water surface elevation upstream of the bridge structure was lower than the low chord deck elevation. If the computed water surface elevation upstream of the bridge was lower than the low chord deck elevation, then the bridge was completely removed from the model. If the water surface elevation computed was higher than the low chord deck elevation, then the bridge was added back into the model and the solution was re-computed.

20.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the study reach. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 191+37 and 189+21) and the two downstream-most cross-sections (Station 5+60 and 2+69) in the hydraulic model. Computed boundary condition slopes are 0.006 and 0.03 for upstream and downstream, respectively.

20.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 20-2. Major flooded areas along Dry Canyon are summarized for the different flood events in Table 20-5.

Table 20-5
Major Flooding along Dry Canyon

Sub-reach	Sub-Reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 9)	Confluence with Bouquet Canyon (Station 2+69) ~ End of improved channel (Station 174+57)	Flooding is contained in the main channel; except for upstream of Copper Hill Drive where the floodplain extends into the left overbank area. The flooded area is commercial landuse	Same flooding as the 100-year flood extent with additional flooding on the left and right overbank upstream of Copper Hill Drive, Banyan Place, Boxwood Lane, and Tamarack Lane. The inundation areas include residential neighborhoods
Sub-reach 2 (No Structures)	End of improved channel (Station 177+31) ~ US study limit (Station 191+34)	Flooding extends onto the left and right overbanks inundating the open space and the Dry Canyon dirt road	Same flooding as the 100-year flood with additional flooding on the left and right overbanks

20.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 1.5 percent along the study reach, except for directly upstream of the confluence with Santa Clara River where the slope steepens to three percent. Copper Hill Drive, Banyan Place, Tamarack Lane and Boxwood Lane cause local flooding upstream of each crossing. The predominant flow regime was supercritical.

Figure 20-1: Dry Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

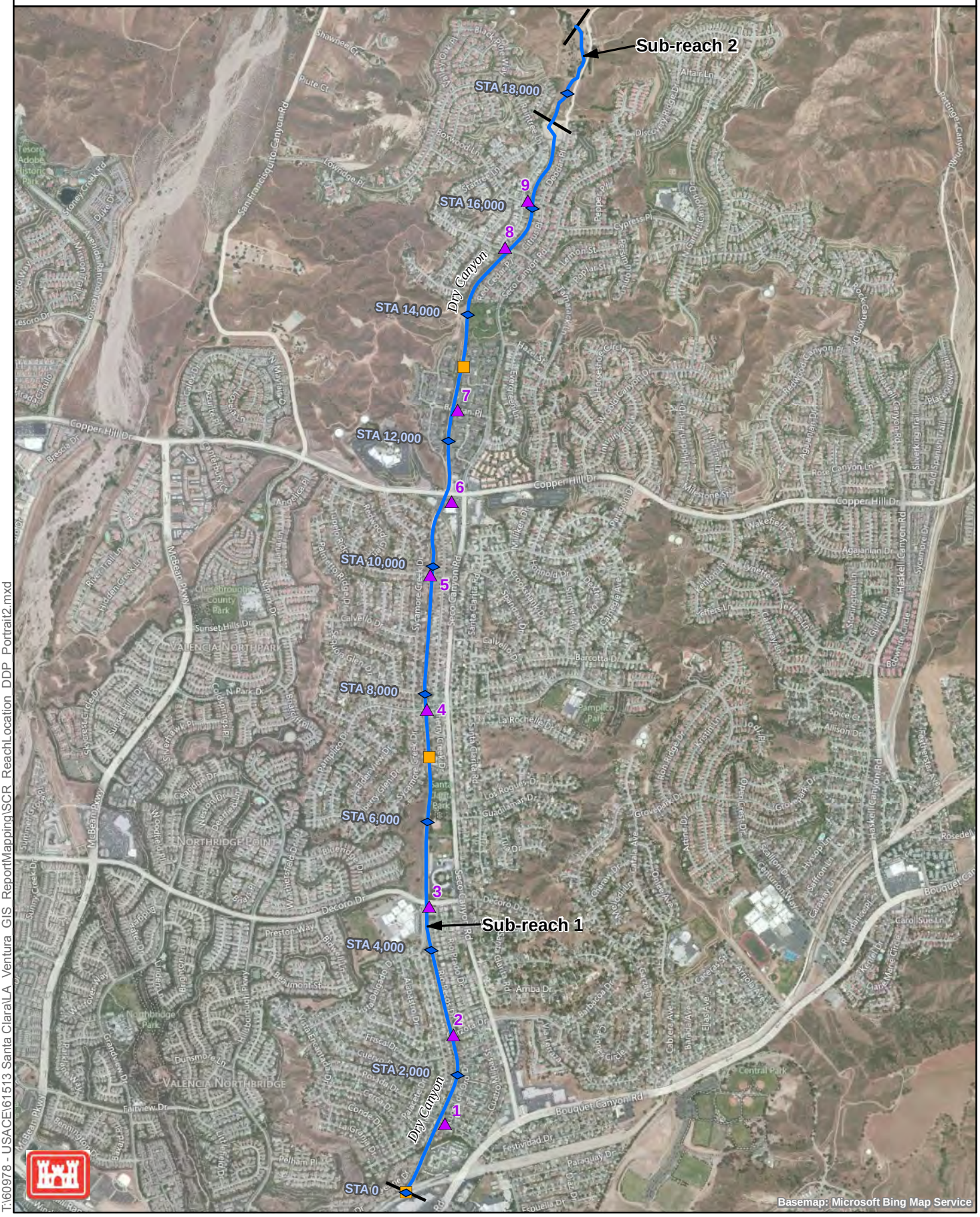

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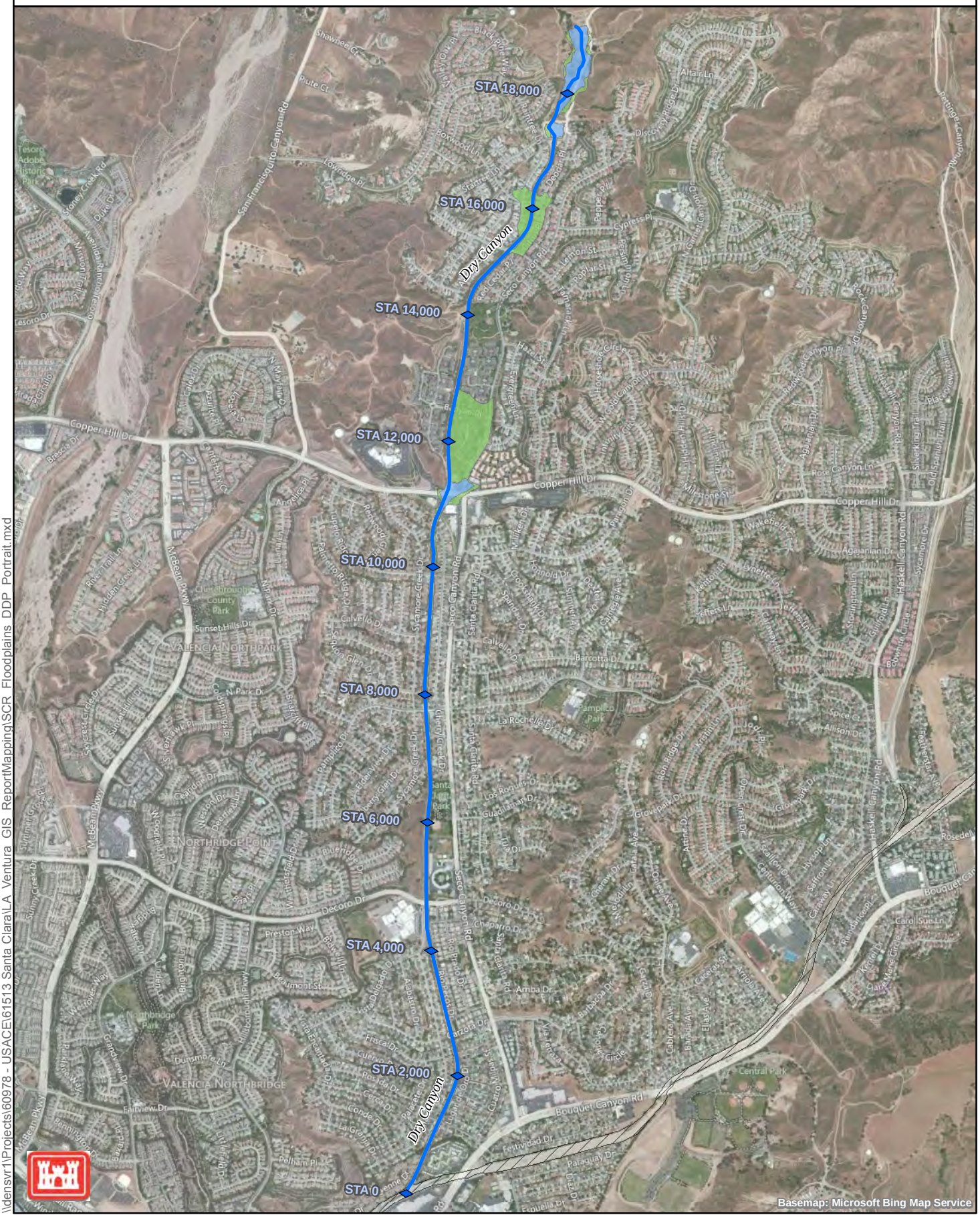
Figure 20-2: Dry Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-yea Estimated Floodplain
- 500-yea Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 21
South Fork Santa Clara River

21.1 General Description

The South Fork Santa Clara River tributary includes both a USACE and a FEMA reach, as shown in Figure 21-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the South Fork Santa Clara River tributary (including both the USACE and FEMA reaches) are summarized in Sections 2.8 and 2.9.

South Fork Santa Clara River joins the Santa Clara River from the south, between the locations where San Francisquito Canyon and Bouquet Canyon join the mainstem. The USACE reach begins upstream of Calgrove Boulevard and extends downstream 2.1 miles to a point just prior the confluence with the Pico Canyon. The FEMA reach begins at the downstream USACE limit and continues to the confluence with the Santa Clara River. Figure 21-1 shows the extents of the USACE and FEMA study reaches, as well as the locations of structures within the USACE reach, and the land use of the surrounding areas.

The USACE study reach is located within dense residential areas and brushy open space. Major crossings over South Fork Santa Clara River in this reach include Atwood Boulevard, Powell Drive & Everett Drive, De Wolfe Road, Old Wiley Canyon Road, Wiley Road, Calgrove Boulevard and Interstate-5.

21.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures within the USACE study reach is summarized in Table 21-1.

Table 21-1
Structures along South Fork SCR (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	2+37 (US XS)	Engineered drop structure	Drop structure	~ 1-foot drop
2	11+70 (US XS)	Engineered drop structure	Drop structure	~ 1-foot drop
3	19+11 (US XS)	Engineered drop structure	Drop structure	~ 3-foot drop
4	22+25	Lyons Avenue	Multiple Culverts	2- 15.75′x15′ (Span x Rise) Rectangular concrete culverts, headwall & wingwalls, baffle blocks at DS side
5	39+62	Powell Drive & Everett Drive	Single Culvert	20′ Rise rectangular concrete culvert, curved, headwall & wingwalls
6	42+59	Atwood Boulevard	Span Bridge	Concrete span bridge with 12′x25′ (Span x Rise) conveyance, deck thickness: 6′
7	46+27	De Wolfe Road	Span Bridge	Concrete span bridge with 12′x25′ (Span x Rise) conveyance, deck thickness: 6′
8	55+00	Old Wiley Canyon Road	Span Bridge	Concrete span bridge with 12′x25′ (Span x Rise) conveyance, deck thickness: 6′
9	60+56	Wiley Canyon Road	Span Bridge	Concrete span bridge with 12′x25′ (Span x Rise) conveyance, deck thickness: 6′
10	87+11	Interstate-5	Multiple Culverts	3-12′x8′ (Span x Rise) Concrete box culvert, headwall & wingwalls, elongated pier shape, 2′ deck thickness, sediment on bottom
11	97+00	Calgrove Boulevard	Multiple Culverts	3-12′x10′ (Span x Rise) Concrete box culverts, headwall & wingwalls, elongated pier shape, 2′ deck thickness

21.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 21-2.

Table 21-2
Sub-reaches along South Fork Santa Clara River

Sub-Reach	Sub-Reach Location	Description
Sub-Reach 1 (Structures 1 to 5)	DS study limit (Station 0+19) ~ Powell Drive & Everett Drive (Station 38+12)	Trapezoidal channel with concrete lined banks, sand/gravel channel bed, floodplain consisting of residential area
Sub-Reach 2 (Structures 5 to 9)	Powell Dr & Everett Drive (Station 40+79) ~ Wiley Canyon Road (Station 58+84)	Rectangular concrete channel, floodplain consisting of residential area and brushy open space
Sub-Reach 3 (Structures 10 to 11)	Wiley Canyon Road (Station 62+07) ~ US study limit (Station 110+76)	Undefined earthen channel, sand/gravel/cobbles channel bed, shrubs/trees vegetation cover, floodplain consisting of brushy open space and farmland

21.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 21-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 21-3
Manning's Roughness Values along South Fork Santa Clara River

Sub-Reach	Sub-Reach Location	Left Overbank	Main Channel	Right Overbank
Sub-Reach 1 (Structures 1 to 5)	DS study limit (Station 0+19) ~ Powell Drive & Everett Drive (Station 38+12)	0.13	0.025	0.13
Sub-Reach 2 (Structures 5 to 9)	Powell Drive & Everett Drive (Station 40+79) ~ Wiley Canyon Road (Station 58+84)	0.05	0.015	0.13
Sub-Reach 3 (Structures 10 to 11)	Wiley Canyon Road (Station 62+07) ~ US study limit (Station 110+76)	0.05	0.04	0.05

21.5 Hydrology

Three hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 21-1. The peak discharge rates associated with these locations are summarized in Table 21-4.

Table 21-4
Hydrologic Concentration Points along South Fork Santa Clara River (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
97+86	140	480	900	1,770	2,740	4,060	5,820	9,010
62+87	170	580	1,100	2,160	3,350	4,960	7,110	11,000
0	190	630	1,190	2,350	3,650	5,400	7,740	11,980

21.6 Hydraulic Model

The hydraulic model for the USACE reach of the South Fork Santa Clara River was developed using 121 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains eight bridges/culverts and three drop structures (see Table 21-1), two dip crossings (located at Sta. 2+37 and 11+71), and three overflow reaches.

21.6.1 Channel Improvements

Channel improvements were added to the South Fork Santa Clara River model based on as-built drawings. The improved reach extends from upstream of Wiley Canyon Road (Station 64+60) to Lyons Avenue (Station 22+67) (reference: Los Angeles County Flood Control District (LACFCD), *Santa Clara River - South Fork Lyons Avenue to Wiley Canyon & Lyon Canyon. Channel Reinforced Concrete Channel* (LACFCD, 1986)).

The improved channel and culverts have capacity to convey the peak discharge of the 50-year storm event without overtopping. The improved channel capacity without culvert limitations, based on normal depth calculations, is 12,060 cfs, which is greater than the estimated peak discharge of the 500-year storm event.

21.6.2 Overflow Reaches

Overflow reaches were added to the South Fork Santa Clara River model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach during extreme events due to limited channel and bridge capacities. Overflow reaches were added along the left and right overbank areas upstream of Wiley Canyon Road and into the right overbank area downstream of the Powell Drive and Everett Drive crossings.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 21-5. The summarized flows in the table below are different than the initial discharges, and reflect the quantities expected to escape the main channel.

Table 21-5
Maximum Flow in South Fork Santa Clara River left overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	0	0	0	0	0	0	190	1,494
Overflow (right upstream)	0	0	0	0	0	262	1,898	4,273
Overflow (right downstream)	0	0	0	0	0	0	0	2,028

Overflow Reach Results

Due to limited bridge/culvert capacity at I-5, the higher frequencies overtop the main channel upstream of the I-5 structure. Approximately, 50-percent of flow overtops into the right overbank and , 16-percent overtops into the left overflow reach. Below the I-5, 40-percent of flow overtops into the right overbank downstream of the Powell Drive and Everett Drive crossings.

21.6.3 FEMA Reach

FEMA developed the hydraulic model that extends from between the downstream limit of the USACE reach to the confluence with Santa Clara River. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

21.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 110+76 and 109+01) and the two downstream-most cross-sections (Station 1+93 and 19) in the hydraulic model. Computed boundary condition slopes are 0.026 and 0.01 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were applied at the boundaries of the overflow reaches, based on the invert slopes computed between the upstream-most cross-sections. The upstream right overflow reach upstream boundary condition slope is 0.01 (Station 12+04 and 10+48) and the left overflow reach upstream boundary condition slope is 0.02 (Station 22+72 and 21+25). At the downstream ends of the overflow models upstream, return junctions were used to connect the overflow reaches with the mainstem. For the downstream right overflow reach, the invert slope at the upstream boundary is 0.011 (Station 48+06 and 45+28) and the invert slope at the downstream boundary is 0.003 (Station 1+73 and 1+28).

21.8 Flood Boundaries

USACE and FEMA flood boundaries for 500- and 100-year flood events are presented in Figure 21-2a and 21-2b. Major flooded areas along South Fork Santa Clara River are summarized for the 100-year and 500-year flood events in Table 21-6.

Table 21-6
Major Flooding along South Fork Santa Clara River

Sub-Reach	Sub-Reach Location	100-year	500-year
USACE Reaches			
Sub-Reach 1 (Structures 1 to 5)	DS study limit (Station 0+19) ~ Powell Drive & Everett Drive (Station 38+12)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-Reach 2 (Structures 5 to 9)	Powell Drive & Everett Drive (Station 40+79) ~ Wiley Canyon Road (Station 58+84)	Flooding is contained in the main channel	Flooding continuously flows in the left and right overbank from downstream of Wiley Canyon Road to upstream of Lyons Avenue. The flooded areas include open space, highways and residential areas
Sub-Reach 3 (Structures 10 to 11)	Wiley Canyon Road (Station 62+07) ~ US study limit (Station 110+76)	Flooding is contained in the main channel until the Calgrove Boulevard crossing where flooding extends into the left and right overbanks. Flooding also extends into the right overbank at the I-5 crossing where it flows under I-5 into the overflow reach prior to reconnecting into the main channel downstream of I-5. Directly downstream of I-5 the floodplain extends into the left overbank all the way to the highway. The flood areas include open space, highways, with some encroachment into residential areas	Same as the 100-year flooding, with additional overflow on the left bank upstream of I-5. The floodplain extends along I-5, overtops I-5 then reconnects with the main channel. Additional overtopping also occurs upstream of Wiley Road. The flooded areas include open space, highways and residential areas
FEMA Reach			
NA	Confluence with SCR (Station 6+65) ~ USACE DS study limit (Station 219+22)	Flooding is contained in the main channel except between Sta. 148+02 and Sta. 157+15	Flooding extends beyond the main channel from Sta. 67+29 to Sta. 71+99 (right), Sta. 118+42 to Sta. 164+92 (right and left), and Sta. 167+10 to Sta. 180+56 (right)

21.9 Profiles

USACE and FEMA reach water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 1.5 percent, except for at the confluence with the Santa Clara River where the study reach flattens to about 0.4 percent. The 100-year, 200-year and 500-year flood all overtop Calgrove Boulevard, Old Wiley Road,

De Wolfe Road, and Atwood Boulevard. Conveyance limitations are very evident for all of the bridge locations under 500-year flood conditions. I-5 and Calgrove Boulevard were the only structures that caused additional flooding under 100-year flood conditions. The predominant flow regime is supercritical.

Figure 21-1: South Fork Santa Clara River Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 21-2 (Index): South Fork Santa Clara River Floodplain Map (1 of 3)

Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

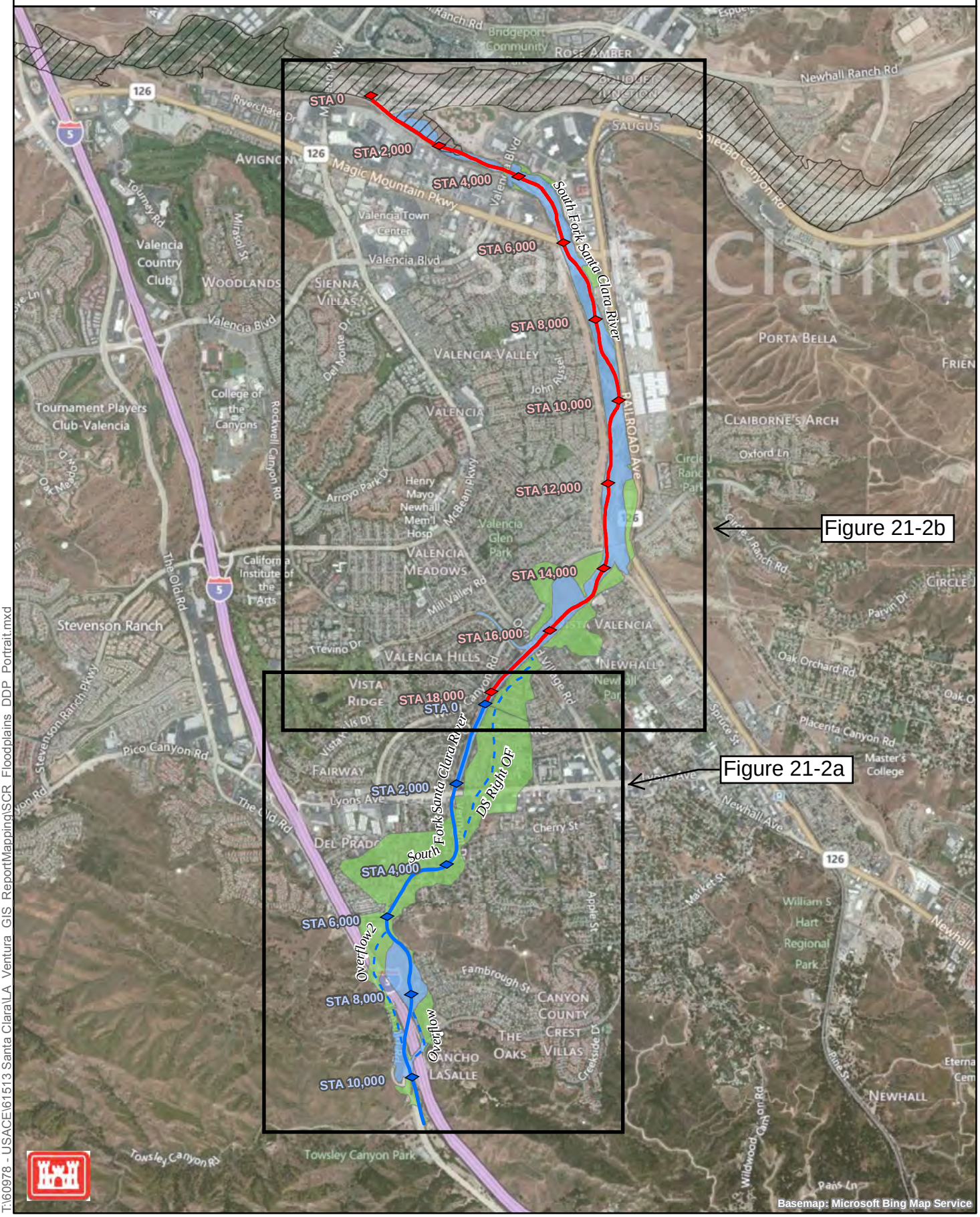

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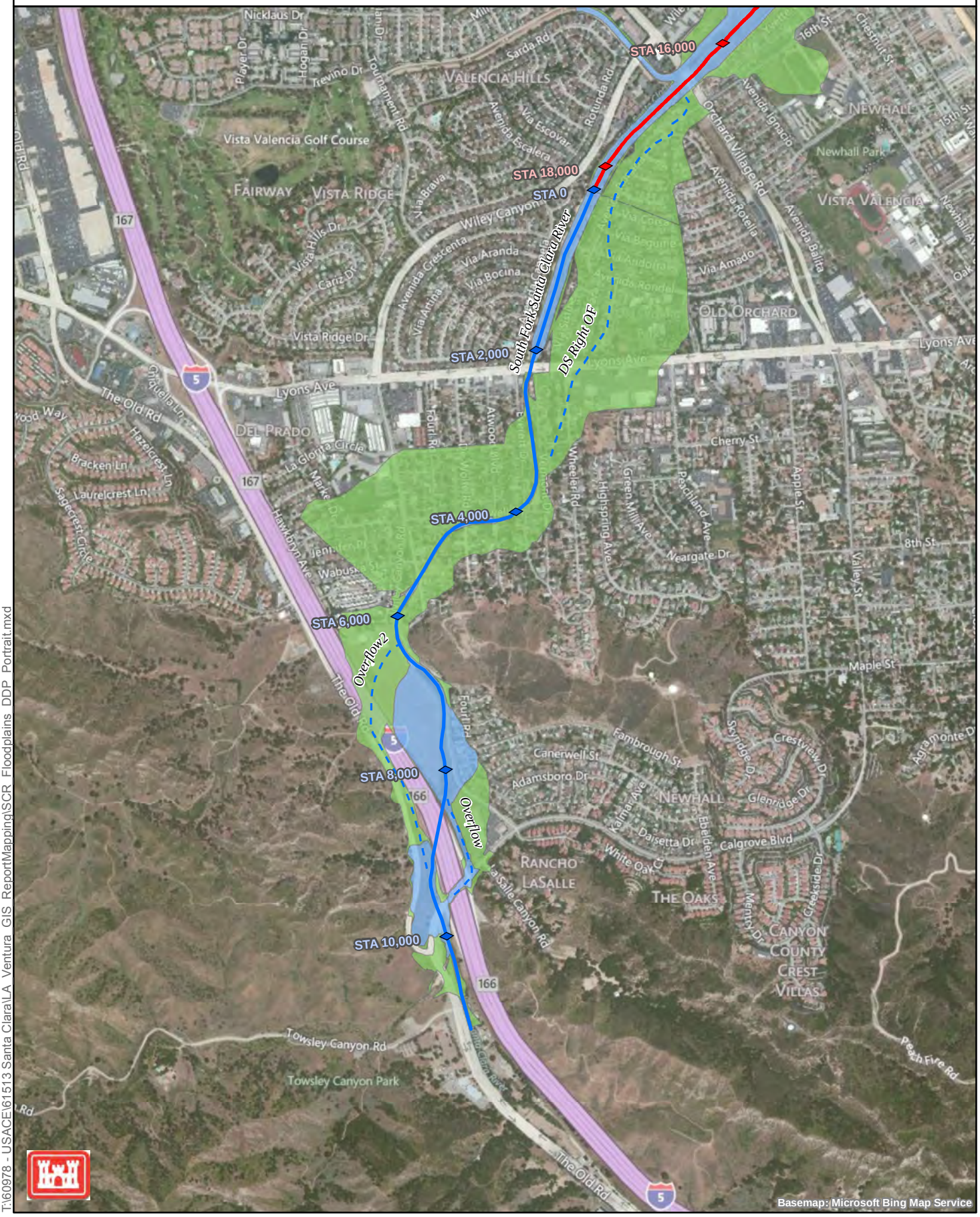
Figure 21-2a: South Fork Santa Clara River Floodplain Map (2 of 3)
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Basemap: Microsoft Bing Map Service

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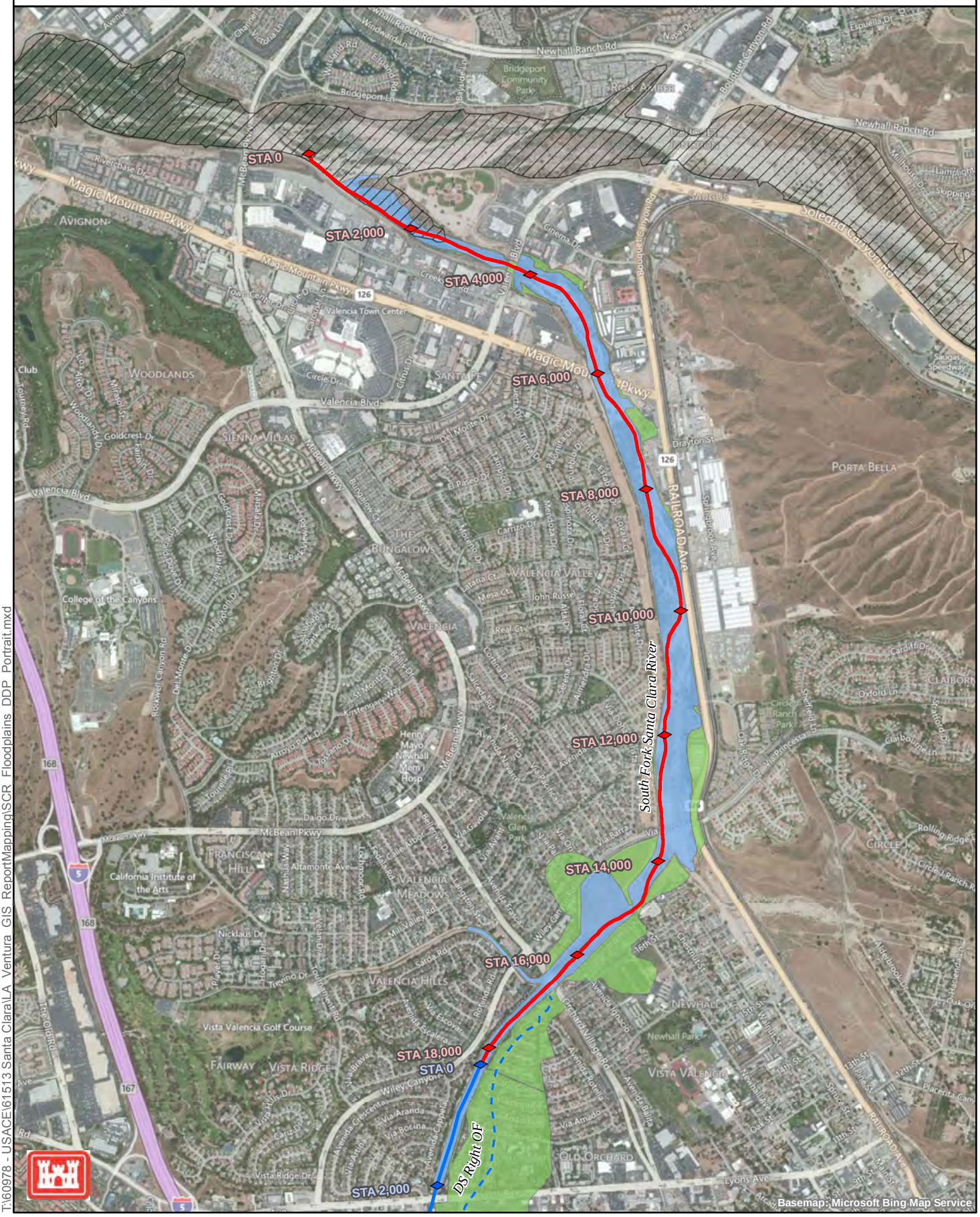
Figure 21-2b: South Fork Santa Clara River Floodplain Map (3 of 3)
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 22
Towsley Canyon

22.1 General Description

Tick Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Tick Canyon are described in this section.

Towsley Canyon is a tributary of the South Fork Santa Clara River, located approximately 0.77 miles upstream of the confluence of Lyon Canyon with the South Fork Santa Clara River. The study reach begins at the Towsley Canyon confluence with South Fork Santa Clara River and extends 0.4 miles upstream. Figure 22-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach merges with the South Fork Santa Clara River immediately downstream of Interstate-5. The area is dominated by brushy open space with a few residential structures. The only major crossing over Towsley Canyon is The Old Road.

22.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

The characteristics of the single structure identified along Towsley Canyon are summarized in Table 22-1.

Table 22-1
Structures along Towsley Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	5+97	The Old Road	Multiple culverts	2-12'x10' (Span x Rise) Concrete box culverts, headwall & wingwalls, trapezoidal XS at US side, rectangular XS at DS side, deck thickness: 2'

22.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The limits and major characteristics of the Towsley Canyon sub-reaches are summarized in Table 22-2.

Table 22-2
Sub-reaches along Towsley Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Confluence with South Fork SCR (Station 4+20) ~ The Old Road (Station 5+19)	Rectangular concrete channel, floodplain consisting of brushy open space
Sub-reach 2 (Structure 1)	The Old Road (Station 6+40) ~ US study limit (Station 17+10)	Narrow earthen channel, sand/gravel/cobble channel bed, floodplain consisting of brushy open space and sparse residential areas

22.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study channel are summarized in Table 22-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 22-3
Manning's Roughness Values along Towsley Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structures)	Confluence with South Fork SCR (Station 4+20) ~ The Old Road (Station 5+19)	0.045	0.015	0.045
Sub-reach 2 (Structure 1)	The Old Road (Station 6+40) ~ US study limit (Station 17+10)	0.05	0.035	0.06

22.5 Hydrology

One hydrologic concentration point was provided along the study reach (see the Introduction for the source of the hydrology information). The location of the hydrologic concentration point is shown in Figure 22-1. The peak discharge rates associated with this location are summarized in Table 22-4.

Table 22-4
Hydrologic Concentration Point along Towsley Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	100	330	630	1,230	1,910	2,830	4,060	6,280

22.6 Hydraulic Model

The Towsley Canyon hydraulic model was developed with nine cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains one bridge/culvert.

22.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 17+10 and 14+22) and the two downstream-most cross-sections (Station 5+19 and 4+20) in the hydraulic model. Computed boundary condition slopes are 0.032 and 0.011 at the upstream and downstream ends of the model, respectively.

22.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 22-2. Major flooded areas along Towsley Canyon are summarized for the 100-year and 500-year flood events in Table 22-5.

Table 22-5
Major Flooding along Towsley Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (No structures)	Confluence with South Fork SCR (Station 4+20) ~ The Old Road (Station 5+19)	Flooding is contained in the main channel	Flooding extends into the left and right overbank areas. The flooding inundates open space, the highway and residential areas
Sub-reach 2 (Structure 1)	The Old Road (Station 6+40) ~ US study limit (Station 17+10)	Flooding is contained in the main channel	Same flooding as the 100-year flood, with additional flooding on the left upstream of the Old Road crossing. The flooded areas included open space

22.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately two percent along the study reach, except for directly upstream of The Old Road where the channel drops approximately three-feet. The Old Road crossing is a significant obstruction for all discharge frequencies examined. The computed flow regime for 50 percent of the cross-sections was supercritical.

Figure 22-1: Towsley Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 300 600
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 22-2: Towsley Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 300 600
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 23
Lyon Canyon

23.1 General Description

Lyon Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Lyon Canyon are described in this section.

Lyon Canyon joins the South Fork Santa Clara River from the west, located between Pico Canyon and Towsley Canyon. The study reach begins at the confluence of Lyon Canyon with South Fork Santa Clara River and extends 0.8 miles upstream. Figure 23-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of residential development and brushy open space. Major crossings over Lyon Canyon include Wiley Canyon Road, the Old Road and I-5.

23.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 23-1.

Table 23-1
Structures along Lyon Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	2+16	Wiley Canyon Road	Single culvert	Rectangular concrete box culvert, headwall & wingwalls
2	12+64	The Old Road/I-5	Multiple culverts	2-8′x3.8′ (Span x Rise) concrete box culvert, headwall & wingwalls, right culvert filled with sediment ~13″

23.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank

area land use, and degree of channel meandering. The physical characteristics of the Lyon Canyon sub-reaches are summarized in Table 23-2.

Table 23-2
Sub-reaches along Lyon Canyon

Sub-reach	Sub-reach	Description
Sub-reach 1 (Structure 1)	DS study limit (Station 0+ 41) ~ Old Road/I-5 (Station 10+37)	Trapezoidal channel with concrete lined banks, sand/gravel channel bed, floodplain consisting of residential area
Sub-reach 2 (No Structures)	Old Road/I-5 (Station 14+57) ~ 400 ft US of Old Road (Station 14+57)	Earthen channel, sand/gravel channel bed, floodplain consisting of brushy open space and residential area
Sub-reach 3 (No Structures)	400 ft US of Old Road (Station 14+90) ~ US study limit (Station 26+85)	Narrow meandering channel, sand/gravel/cobbles channel bed, brush/trees vegetation cover, floodplain consisting of brushy open space

23.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study channel are summarized in Table 23-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 23-3
Manning's Roughness Values along Lyon Canyon

Sub-reach	Sub-reach	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	DS study limit (Station 0+41) ~ Old Road/I-5 (Station 10+37)	0.13	0.025	0.13
Sub-reach 2 (No Structures)	Old Road/I-5 (Station 14+57) ~ 400 ft US of Old Road (Station 14+57)	0.13	0.04	0.05
Sub-reach 3 (No Structures)	400 ft US of Old Road (Station 14+90) ~ US study limit (Station 26+85)	0.05	0.04	0.05

23.5 Hydrology

One hydrologic concentration point was provided along the study reach (see the Introduction for the source of the hydrology information). The location of this hydrologic concentration point is shown in Figure 23-1. The peak discharge rates associated with this location are summarized in Table 23-4.

Table 23-4
Hydrologic Concentration Point for Lyon Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	20	80	150	300	470	690	990	1,530

23.6 Hydraulic Model

The Lyon Canyon hydraulic model was developed with 48 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains two bridges/culverts (see Table 23-1) and one overflow reach.

23.6.1 Overflow Reaches

An overflow reach was added to the Lyon Canyon model to compute the hydraulic characteristics and flooding limits of flow that leaves the main channel path. Overtopping occurs along the study reach during extreme events due to limited channel and bridge capacities. The overflow reach is located at The Old Road and flows northeast towards the South Fork Santa Clara River.

Overflow Reach Discharges

The overflow discharges for the Lyon Canyon model were calculated using a different methodology than was used for other overflow reaches developed in this study, due to the overtopping occurring at the bridge structure of The Old Road (instead of upstream of the bridge structure as was typical in other study reaches). The topography indicates that flows which overtop the road are redirected along a new path, rather than rejoining the main channel downstream. The quantity of overtopping flow computed by the hydraulic model was manually removed from the mainstem flow and added to the overflow reach, for each event where overflow was computed. (The manual method was used because the HEC-RAS split flow routines will not allow lateral flows at bridge structures). The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 23-5.

Table 23-5
Maximum Flow in Lyon Canyon Left Overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	0	0	0	0	0	0	247	779

23.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 26+85 and 24+38) and the two downstream-most cross-sections

(Station 70 and 41) in the hydraulic model. Computed boundary condition slopes are 0.022 and 0.085 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used for the overflow reach, using bottom slopes between the two upstream-most cross-sections (Station 37+08 and 35+89) and the two downstream-most cross-sections (Station 4+08 and 2+25) of this model component. Computed boundary condition slopes are 0.002 and 0.012 at the upstream and downstream ends of the overflow reach, respectively.

23.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 23-2. Major flooded areas along Lyon Canyon are summarized for the 100-year and 500-year flood events in Table 23-6.

Table 23-6
Major Flooding along Lyon Canyon

Sub-reach	Sub-reach	100-year	500-year
Sub-reach 1 (Structure 1)	DS study limit (Station 0+41) ~ Old Road/I-5 (Station 10+37)	Flooding is contained in the main channel, except for upstream and downstream of Wiley Canyon Road. The flooding upstream extends into the left overbank while the flooding downstream extends into the right overbank. The flooded areas include residential property and local streets	Same as the 100-year flood extend with additional flooding on the left and right overbanks
Sub-reach 2 (No structures)	Old Road/I-5 (Station 14+57) ~ 400 ft US of Old Road (Station 14+57)	Flooding overtops and backwaters upstream of The Old Road. The flooding areas include open space and residential property	Flooding overtops and backwaters upstream of The Old Road. The floodplain extends into the left overbank and follows a natural depression flooding residential properties before joining the mainstem of the South Fork Santa Clara River
Sub-reach 3 (No Structures)	400 ft US of Old Road (Station 14+90) ~ US study limit (Station 26+85)	Flooding is contained in the main channel	Flooding is contained in the main channel, except for a couple areas where the floodplain extends into the left overbank. The flooding areas includes brushy open space

23.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The channel bed slope ranges from one percent upstream to 0.6 percent downstream. Conveyance limitations are apparent at the Old Road and I-5 crossings. The predominant flow regime was supercritical.

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Figure 23-1: Lyon Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

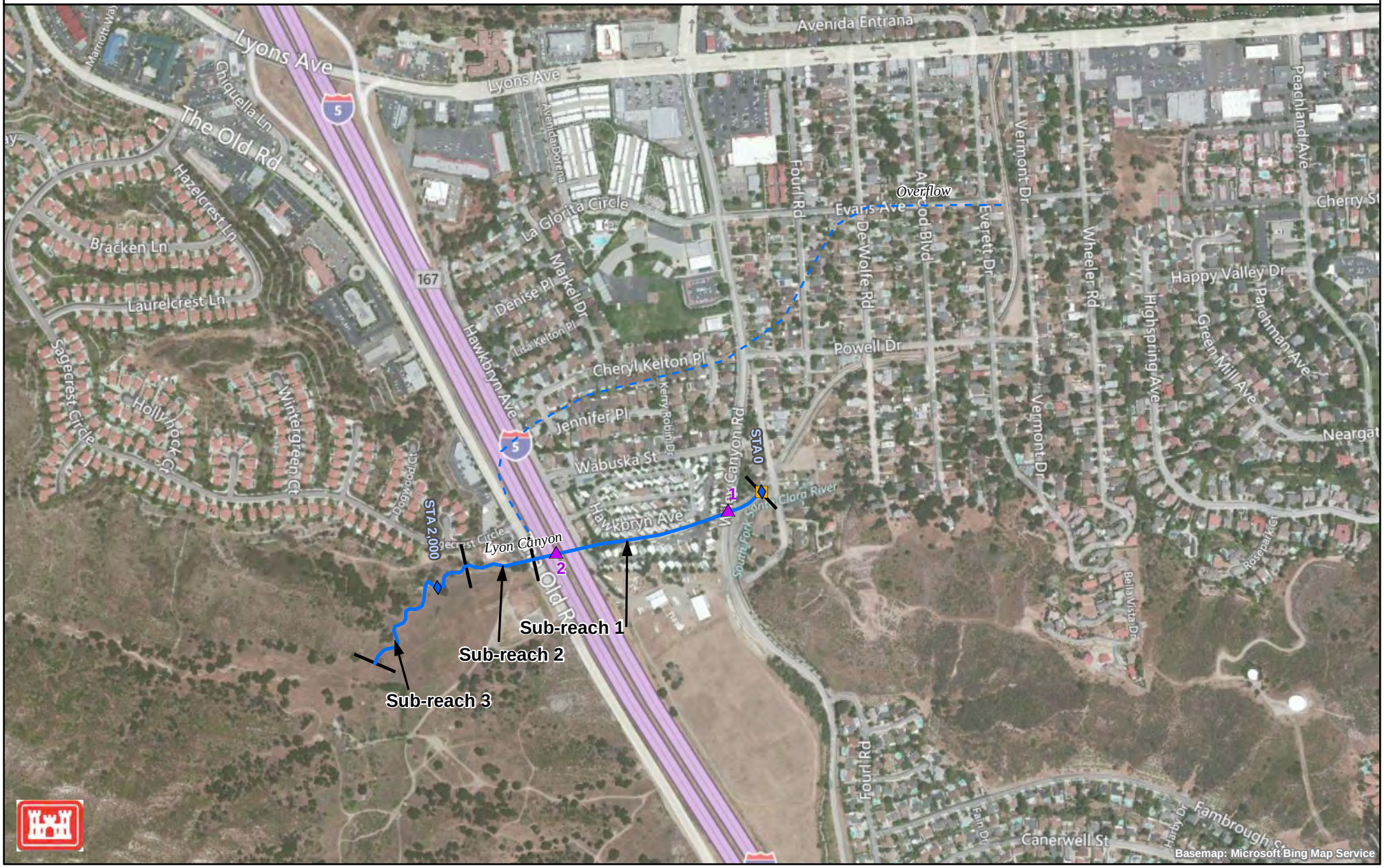

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Figure 23-2: Lyon Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Section 24
Pico Canyon

24.1 General Description

The Pico Canyon tributary includes both a USACE and a FEMA reach, as shown in Figure 24-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the Pico Canyon tributary (including both the USACE and FEMA reaches) are summarized in Sections 2.8 and 2.9.

Pico Canyon joins the South Fork Santa Clara River from the west. The USACE study reach begins 0.3 miles upstream of the Pico Canyon confluence with the South Fork Santa Clara River and extends 2.3 miles upstream. The FEMA study reach extends from the downstream end of the USACE study reach to the confluence with the South Fork Santa Clara River. Figure 24-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of dense residential development, recreational use and brushy open space. Major crossings over Pico Canyon include Tournament Road, I-5, and The Old Road.

24.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the USACE reach is summarized in Table 24-1.

Table 24-1
Structures along Pico Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	2+16	Engineered drop structure	Drop structure	~ 2 foot drop
2	10+11	Engineered drop structure	Drop structure	~ 4 foot drop
3	14+84	Engineered drop structure	Drop structure	~ 3 foot drop
3	20+04	Engineered drop structure	Drop structure	~ 3 foot drop
5	24+83	Engineered drop structure	Drop structure	~ 4 foot drop
6	25+28	Tournament Road	Span bridge	Concrete span bridge, drop structure at DS side, concrete pan at US side
7	60+79	I-5	Span bridge	Concrete span bridge, located immediate DS of a long culvert
8	61+92	The Old Road	Multiple culverts	4-Concrete box culverts, headwall & wingwalls, US end of a long culvert
9	71+61	Debris basin	Debris basin	Baffle blocks at DS side slope
10	115+79	Stevenson Ranch Road	Multiple culverts	4-Concrete box culverts, headwall & wingwalls

24.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 24-2.

Table 24-2
Sub-reaches along Pico Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 6)	DS study limit (Station 0+52) ~ Tournament Road (Station 24+83)	Trapezoidal channel with concrete lined banks, silt/clay channel bed, floodplain consisting of residential area
Sub-reach 2 (Structure 7)	Tournament Road (Station 25+72) ~ I-5 (Station 60+12)	Narrow, meandering earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of a golf course
Sub-reach 3 (Structures 8 to 10)	I-5 (Station 61+30) ~ Stevenson Ranch Parkway (Station 115+25)	Trapezoidal channel with concrete lined banks, silt/clay channel bed, and floodplain consisting of residential area
Sub-reach 4 (No structures)	Stevenson Ranch Parkway (Station 116+69) ~ US Study limit (Station 119+28)	Straight earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of open space

24.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE reach are summarized in Table 24-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 24-3
Manning's Roughness Values along Pico Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach1 (Structures 1 to 6)	DS study limit (Station 0+52) ~ Tournament Road (Station24+83)	0.13	0.03	0.13
Sub-reach 2 (Structure 7)	Tournament Road (Station25+72) ~ I-5 (Station 60+12)	0.04	0.04	0.04
Sub-reach 3 (Structures 8 to 10)	I-5 (Station 61+30) ~ Stevenson Ranch Parkway (Station 115+25)	0.13	0.03	0.13
Sub-reach 4 (No structures)	Stevenson Ranch Parkway (Station 116+69) ~ US Study limit (Station 119+28)	0.05	0.04	0.05

24.5 Hydrology

Three hydrologic concentration points were provided along the USACE reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 24-1. The peak discharge rates associated with these locations are summarized in Table 24-4.

Table 24-4
Hydrologic Concentration Points along Pico Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
113+48	40	120	230	450	700	1,040	1,490	2,310
59+54	60	210	390	770	1,190	1,770	2,540	3,930
0	70	220	420	830	1,290	1,910	2,740	4,240

24.6 Hydraulic Model

The Pico Canyon hydraulic model was developed with 67 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains an upstream debris/detention facility, four bridges/culverts and five drop structures (see Table 24-1), and one dip crossing (located at Sta. 93+53).

The debris/detention facility geometry was included in the hydraulic model, but the model does not account for potential flow attenuation within the facility.

24.6.1 FEMA Reach

FEMA developed the hydraulic model that extends from the confluence with Santa Clara River to the downstream limit of the USACE reach. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

24.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 119+28 and 117+05) and the two downstream-most cross-sections (Station 2+16 and 52) in the hydraulic model. Computed boundary condition slopes are 0.02 and 0.024 at the upstream and downstream ends of the model, respectively.

24.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 24-2. Flooding conditions along Pico Canyon are summarized for the 100-year and 500-year flood events in Table 24-5. The computations indicate that flood flows are contained within the lined channel throughout the length of both the USACE and FEMA reaches, for all events examined.

Table 24-5
Major Flooding along Pico Canyon

Sub-reach	Sub-reach Location	100-year	500-year
USACE Reaches			
Sub-reach 1 (Structures 1 to 6)	DS study limit (Station 0+52) ~ Tournament Road (Station 24+83)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 2 (Structure 7)	Tournament Road (Station 25+72) ~ I-5 (Station 60+12)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 3 (Structures 8 to 10)	I-5 (Station 61+30) ~ Stevenson Ranch Parkway (Station 115+25)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 4 (No structures)	Stevenson Ranch Parkway (Station 116+69) ~ US Study limit (Station 119+28)	Flooding is contained in the main channel	Flooding is contained in the main channel
FEMA Reach			
NA	Confluence with South Fork SCR ~ USACE DS study limit	Flooding is contained in the main channel	Flooding is contained in the main channel

24.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately one percent between the upstream and downstream study limits. Pico Canyon has five drop structures at the downstream study limit and a 40-foot vertical spillway downstream of the debris basin. The computed flow regime for 55 percent of the cross-sections was subcritical.

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Figure 24-1: Pico Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

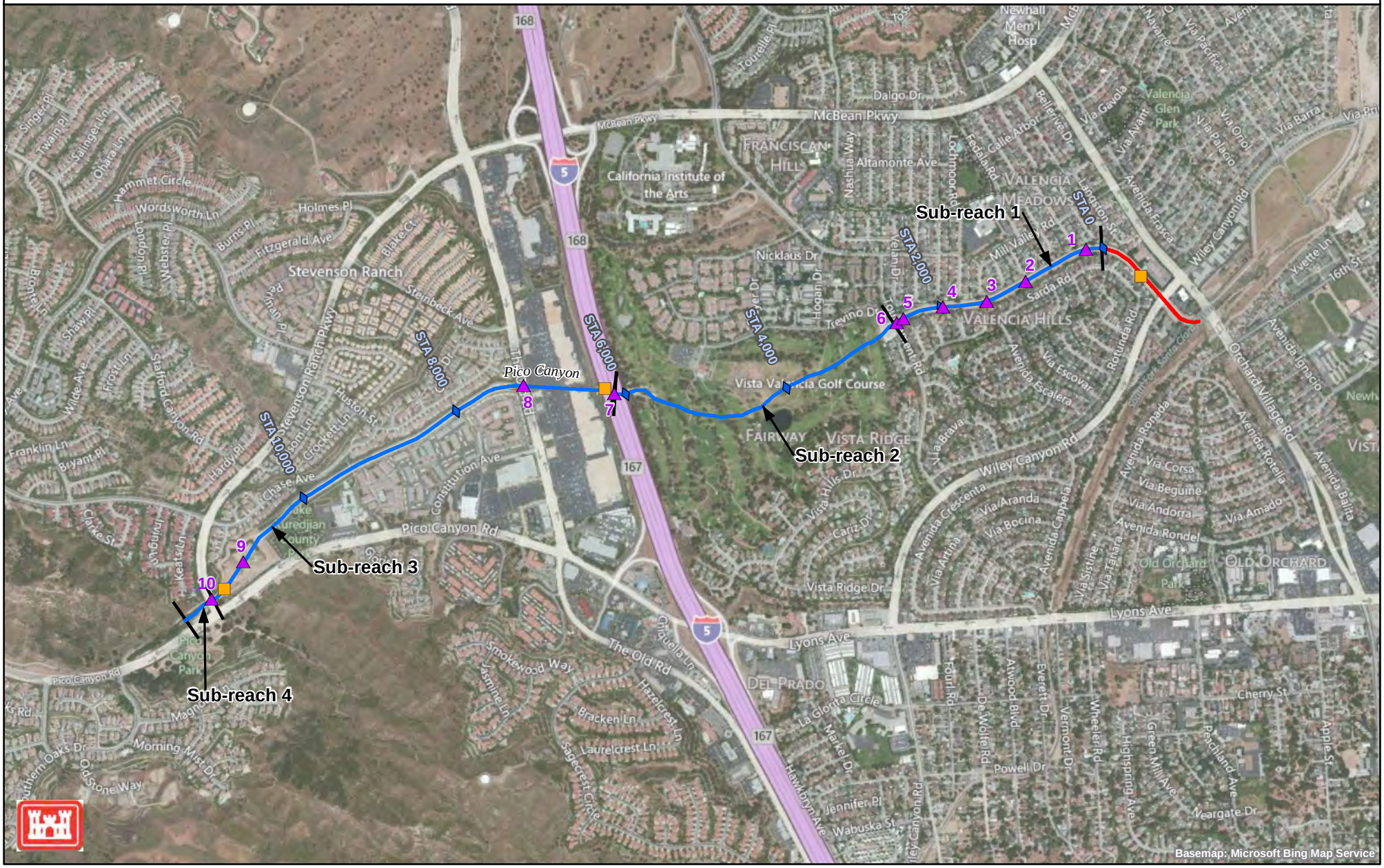

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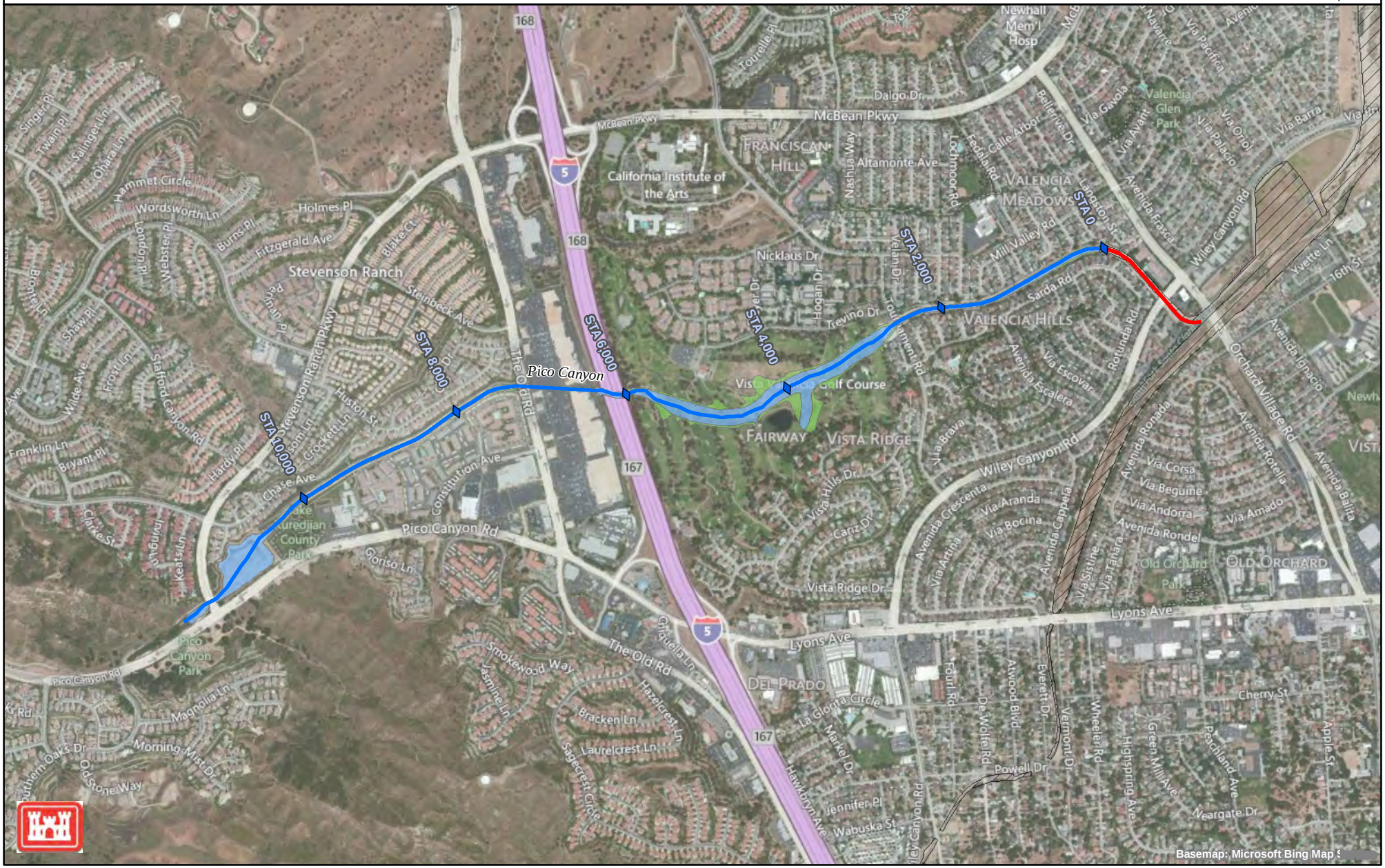
Figure 24-2: Pico Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 25
Newhall Creek

25.1 General Description

Newhall Creek is a FEMA study reach that joins the South Fork Santa Clara River from the southeast. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Newhall Creek. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

25.2 Hydraulic Model

FEMA developed the hydraulic model extending approximately three miles from the upstream limits to the confluence with the South Fork Santa Clara River (see Figure 25-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

25.3 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 25-2. Major flooded areas along Newhall Creek are summarized for the 100-year and 500-year flood events in Table 25-1.

Table 25-1
Major Flooding along Newhall Creek

Sub-Reach	100-year	500-year
DS study limit (Station 0+84) ~ Railroad crossing (Station 52+55)	Flooding is contained in the main channel until Sta. 19+05 where the floodplain extends into the right overbank inundating several residential properties. The left overflow reach runs along Newhall Avenue causing flooding to several residential, commercial, and public properties	Same as the 100-year extent with additional flooding on the left and right overbanks
Railroad crossing (Station 52+93) ~ US study limit	Flooding extends into the right overbank (inundating residential properties) until Sta. 152+10 where the overflow joins the main channel for the remaining sub-reach. Additional overflow from the south, joins the main channel near Sta. 95+00, causes flooding for several industrial and commercial properties	Same as the 100-year extent except for upstream and downstream of the Railroad crossing the floodplain extends into the left and right overbanks. The flooded areas include commercial, industrial and residential property

25.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 1.1 percent. In general, overflows occur due to limited channel capacity. The predominant flow regime is subcritical.

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Figure 25-1: Newhall Creek Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

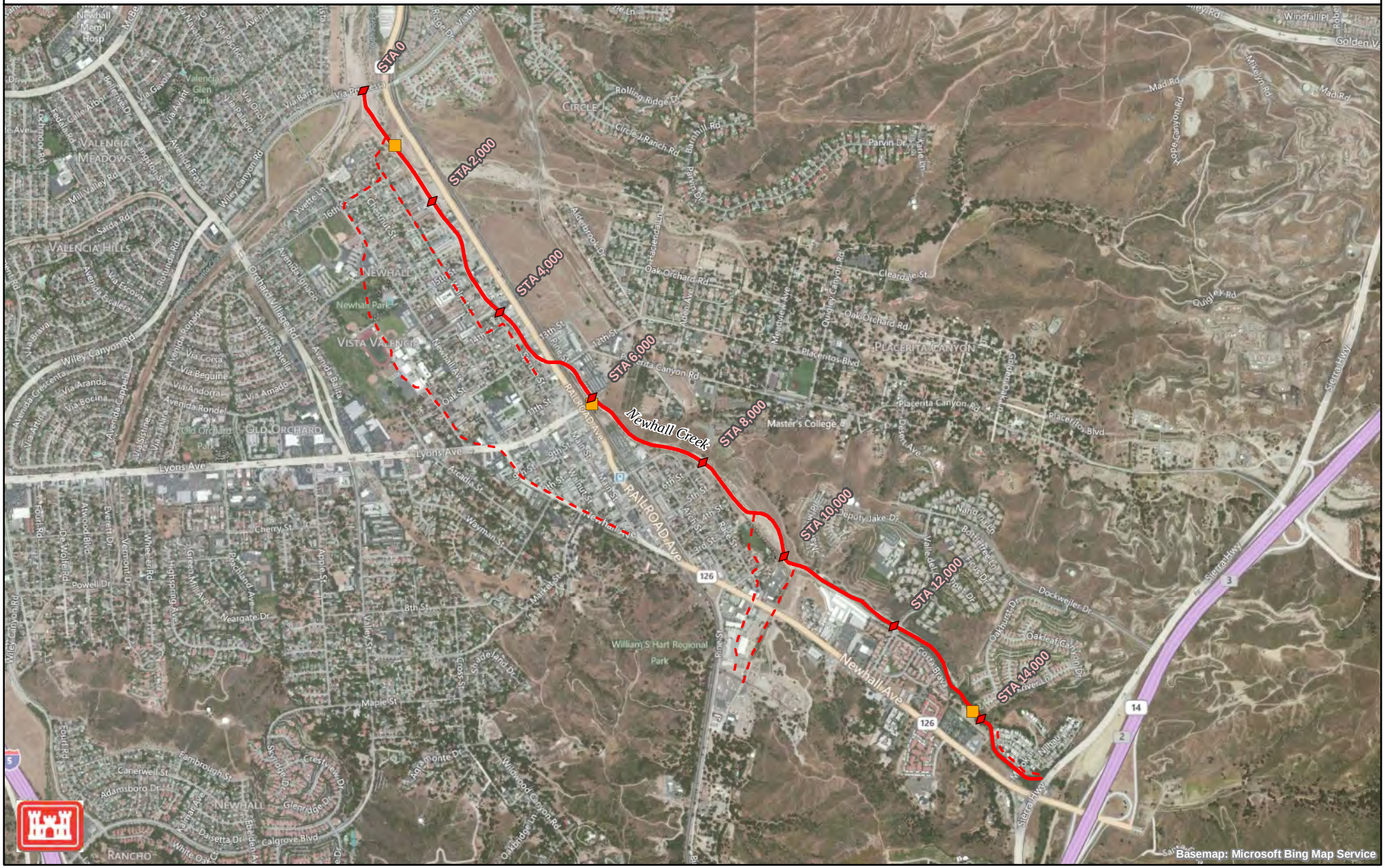

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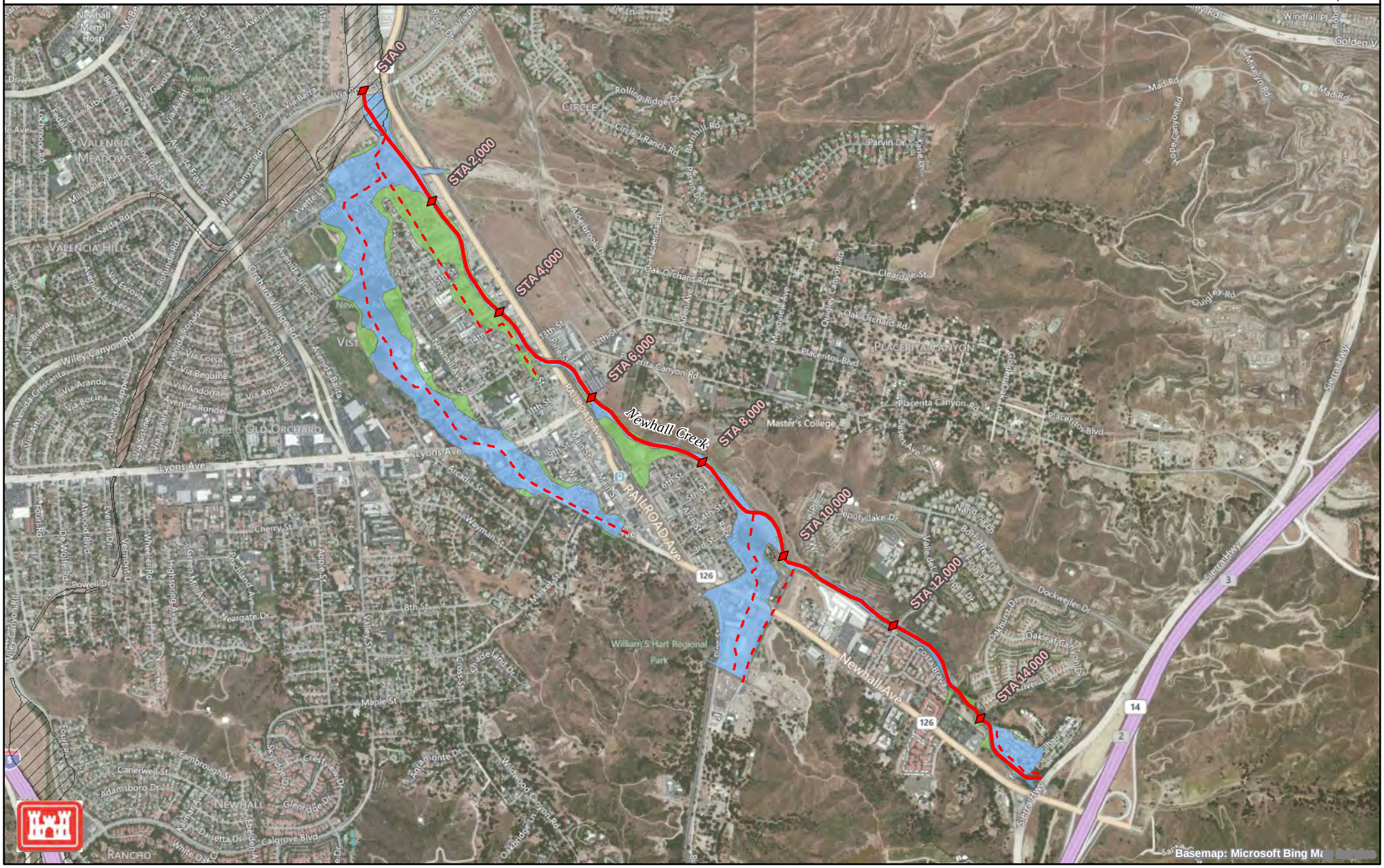
Figure 25-2: Newhall Creek Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 26
Placerita Creek

26.1 General Description

Placerita Creek is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Placerita Creek are described in this section.

Placerita Creek is a tributary of Newhall Creek. Newhall Creek joins the South Fork Santa Clara River from the southeast. The study reach begins at the confluence Placerita Creek with Newhall Creek and extends 3.4 miles upstream. Figure 26-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of residential development and brushy open space. Major crossings over Placerita Creek include San Fernando Road, Hacienda Lane, Sierra Highway, and Highway 14.

26.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 26-1.

Table 26-1
Structures along Placerita Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	2+79	San Fernando Road	Pier bridge	2-pier concrete bridge, elongated pier shape, pier thickness: 1.5′
2	3+79	Railroad	Pier bridge	6.5′ rise 3-pier concrete bridge, deck thickness: 4.5′
3	38+10	Hacienda Lane	Pier bridge	2-pier concrete bridge
4	38+49	Upstream of Hacienda Lane	Drop structure	~ 6 foot drop
5	150+00	Sierra Highway	Single culvert	1-20′ diameter CMP, sediment on invert of culvert
6	150+00	Highway 14	Span bridge	Sierra Highway and HWY 14 were combined in the HEC-RAS model

26.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 26-2.

Table 26-2
Sub-reaches along Placerita Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	DS study limit (Station 5+69) ~ 1,500 ft US of DS study limit (Station 29+64)	Broad natural channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space and farmland
Sub-reach 2 (Structures 3 and 4)	1,500 ft US of DS study limit (Station 33+64) ~ US of Choke Cherry Lane (Station 111+62)	Earthen channel, sand/gravel/cobbles channel bed, trees/brush vegetation cover, floodplain consisting of residential area
Sub-reach 3 (No structures)	US of Choke Cherry Lane (Station 114+37) ~ HWY 14 (Station 147+03)	Narrow earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space and residential area
Sub-reach 4 (Structures 5 and 6)	HWY 14 (Station 155+08) ~ US study limit (Station 179+66)	Meandering earthen channel, sand/gravel/cobbles channel bed, shrubs/brush vegetations cover, floodplain consisting of brushy open space

26.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study channel are summarized in Table 26-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 26-3
Manning's Roughness Values along Placerita Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	DS study limit (Station 5+69) ~ 1,500 ft US of DS study limit (Station 29+64)	0.05	0.04	0.05
Sub-reach 2 (Structures 3 and 4)	1,500 ft US of DS study limit (Station 33+64) ~ US of Choke Cherry Lane (Station 111+62)	0.13	0.04	0.13
Sub-reach 3 (No structures)	US of Choke Cherry Lane (Station 114+37) ~ HWY 14 (Station 147+03)	0.08	0.04	0.08
Sub-reach 4 (Structures 5 and 6)	HWY 14 (Station 155+08) ~ US study limit (Station 179+66)	0.05	0.04	0.05

26.5 Hydrology

Three hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 26-1. The peak discharge rates associated with these locations are summarized in Table 26-4.

Table 26-4
Hydrologic Concentration Points along Placerita Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
114+38	60	210	390	770	1,190	1,770	2,540	3,930
48+54	80	260	490	960	1,490	2,210	3,170	4,900
0	80	270	520	1,020	1,580	2,340	3,360	5,190

26.6 Hydraulic Model

The Placerita Creek hydraulic model was developed with 105 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled reach contains five bridges/culverts and one drop structure (see Table 26-1), five dip crossings (located at Sta. 62+97, 70+56, 93+58, 100+86, and 108+03), and an overflow reach.

A lateral weir was added at River Station 7+02 upstream of the Railroad crossing to account for the right overflow during the 500-year and 200-year floods. The overflow continues along the railroad and eventually flows into the South Fork Santa Clara River. An overflow reach was not added to the model downstream of this weir due to the minimal distance between the overflow location and the South Fork Santa Clara River. However, the 500-year floodplain boundary was extended north based on the estimated flow path.

26.6.1 Overflow Reaches

An overflow reach was added to the Placerita Creek model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the left bank of the study reach due to limited channel capacity. The overflow reach begins downstream of Oak Creek Avenue and continues downstream till joining back to the mainstem just prior to the Railroad crossing. An existing culvert that passes under the Railroad on the left overbank was ignored, due to its limited capacity (as judged through examination of the local topography).

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 26-5.

Table 26-5
Maximum Flow in Placerita Creek Left Overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	0	0	0	0	185	713	1,320	2,804

26.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 179+66 and 178+04) and the two downstream-most cross-sections (Station 2+17 and 1+36) in the hydraulic model. Computed boundary condition slopes are 0.013 and 0.015 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also applied at the upstream end of the overflow reach, based on the invert slopes computed between the upstream-most cross-sections (Station 73+75 and 69+05). The computed slope at upstream end of the overflow reach is 0.01. At the downstream end of the overflow reach, a junction was used to reconnect the overflow reach with the main channel. .

26.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 26-2. Major flooded areas along Placerita Creek are summarized for the 100-year and 500-year flood events in Table 26-6.

Table 26-6
Major Flooding along Placerita Creek

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	DS study limit (Station 5+69) ~ 1,500 ft US of DS study limit (Station 29+64)	Flooding extends into the left and right overbank areas. The flooded area includes residential property and open space	Additional flooding on the left and right overbank areas
Sub-reach 2 (Structures 3 and 4)	1,500 ft US of DS study limit (Station 33+64) ~ US of Choke Cherry Lane (Station 111+62)	Flooding extends into the left overbank at Sta. 85+22 due to limited channel capacity. Flooding continuously flows in the left overbank flooding residential property	Additional flooding occurs on the left and right overbank. Specifically, upstream and downstream of Oak Creek Avenue on the right overbank
Sub-reach 3 (No structures)	US of Choke Cherry Lane (Station 114+37) ~ HWY 14 (Station 147+03)	Flooding is contained in the main channel except for local flooding upstream of Choke Cherry Lane and Sally Road. Flooded areas include residential property and open space	Additional flooding on the right and left overbank upstream and downstream of Choke Cherry Lane and Sally Road. Inundated areas include residential property, open space, and treatment facilities located adjacent to the reach
Sub-reach 4 (Structures 5 and 6)	HWY 14 (Station 155+08) ~ US study limit (Station 179+66)	Flooding is contained in the main channel	Same as the 100-year flood extend, with additional flooding on the left overbank. Inundated areas include brushy open space

26.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 1.3 percent between the upstream and downstream study limits. Conveyance limitations are apparent at the Railroad crossing. The predominant flow regime was subcritical.

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Figure 26-1: Placerita Creek Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

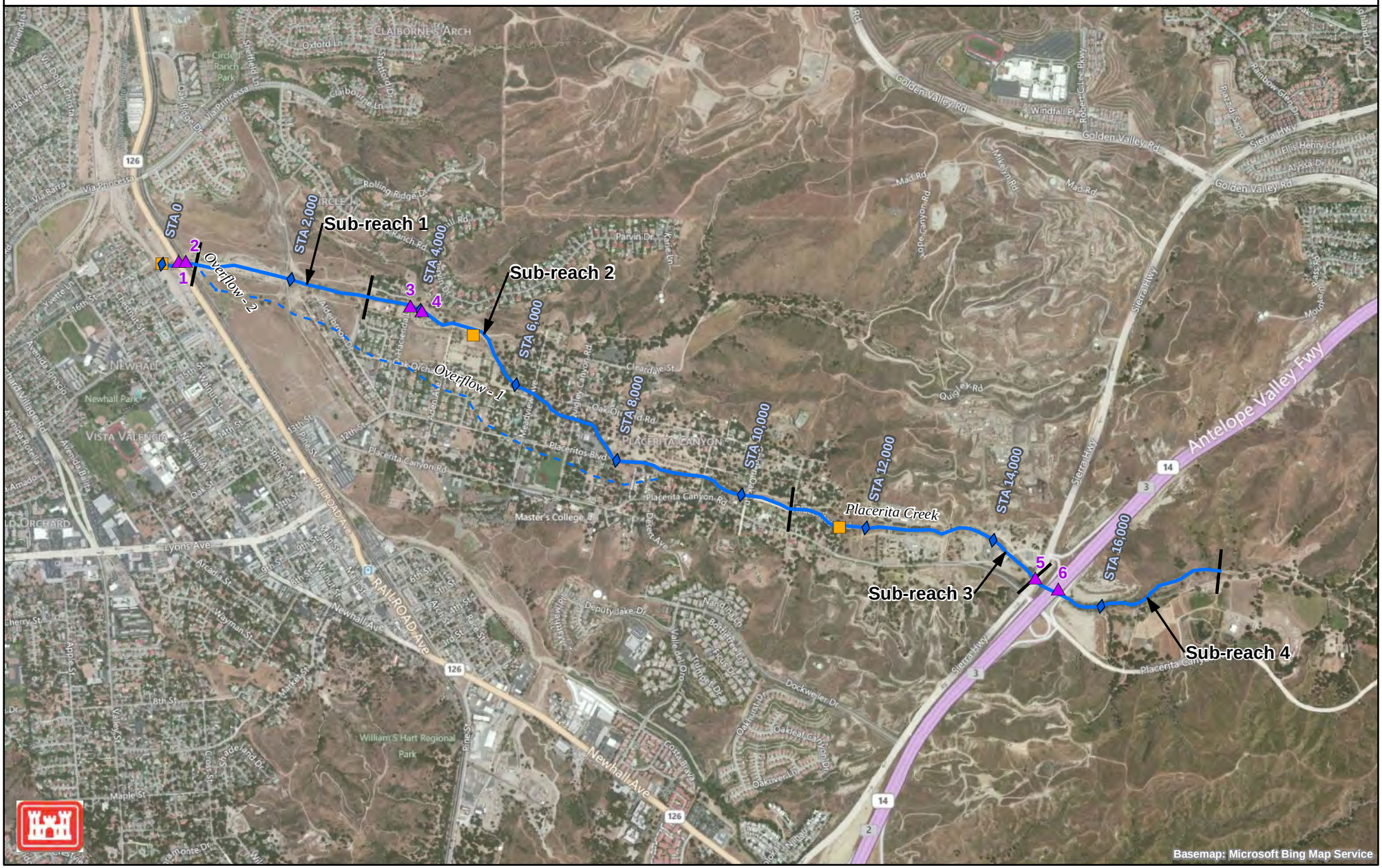

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Figure 26-2: Placerita Creek Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 27
San Francisquito Canyon

27.1 General Description

The San Francisquito Canyon tributary includes both a USACE and a FEMA reach, as shown in Figure 27-1. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the San Francisquito Canyon tributary (including both the USACE and FEMA reaches) are summarized in Sections 2.8 and 2.9.

San Francisquito Canyon joins the Santa Clara River from the north, between the locations where Lion Canyon and South Fork Santa Clara River join the mainstem. The FEMA study reach begins at the confluence of San Francisquito Canyon with the Santa Clara River and extends upstream 6.4 miles. The USACE study reach begins at the upstream end of the FEMA reach and extends an additional three miles. Figure 27-1 shows the alignment of the USACE study reach, the locations of structures, and the land use of surrounding areas.

The USACE study reach is located within areas of brushy open space and some residential development. The only major crossing over the USACE reach of San Francisquito Canyon is San Francisquito Canyon Road.

27.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and drop structures along the USACE reach is summarized in Table 27-1.

Table 27-1
Structures along San Francisquito Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	150+51	San Francisquito Canyon Road	Pier bridge	1 pier bridge (circular pier shape), pier thickness: 2′, pier height: 8′, deck thickness: 2.5′, skewed to the flow

27.3 Sub-reaches

The variation in physical characteristics along the USACE reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters

evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The limits and major physical characteristics of the USACE San Francisquito sub-reaches are summarized in Table 27-2.

Table 27-2
Sub-reaches along San Francisquito Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structure)	DS study limit (Station 0+43) ~ San Francisquito Canyon Road (Station 150+02)	Irregular, broad, meandering channel with low undefined banks, sand/gravel/cobbles channel bed, cottonwood/arundo vegetation cover, floodplain consisting of brushy open space, agriculture and residential
Sub-reach 2 (Structure 1)	San Francisquito Canyon Road (Station 150+97) ~ US study limit (Station 154+97)	Steep canyon channel with thick vegetation, sand/gravel channel bed, brush/willows/arundo vegetation cover, floodplain consisting of brushy open space and residential area

27.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 27-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 27-3
Manning's Roughness Values along San Francisquito Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structure)	DS study limit (Station 0+43) ~ San Francisquito Canyon Road (Station 150+02)	0.06	0.05	0.06
Sub-reach 2 (Structure 1)	San Francisquito Canyon Road (Station 150+97) ~ US study limit (Station 154+97)	0.05	0.08	0.05

27.5 Hydrology

One hydrologic concentration point was provided along the USACE study reach (see the Introduction for the source of the hydrology information). The location of this hydrologic concentration point is shown in Figure 27-1. The peak discharge rates associated with this location are summarized in Table 27-4.

Table 27-4
Hydrologic Concentration Point for San Francisquito Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	500	1,680	3,170	6,250	9,690	14,360	20,590	31,850

27.6 Hydraulic Model

The San Francisquito Canyon hydraulic model for the USACE study reach was developed with 75 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains one bridge/culvert (see Table 27-1) and two dip crossings (located at Sta. 67+57 and 9+45).

27.6.1 FEMA Reach

FEMA developed the hydraulic model extending from the confluence with the Santa Clara River to the downstream limit of the USACE reach. The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

27.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 154+97 and 154+53) and the two downstream-most cross-sections (Station 193 and 19) in the hydraulic model. Computed boundary condition slopes are 0.023 and 0.009 at the upstream and downstream ends of the model, respectively.

27.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 27-2. Major flooded areas along San Francisquito Canyon are summarized for the 100-year and 500-year flood events in Table 27-5.

Table 27-5
Major Flooding along San Francisquito Canyon

Sub-reach	Sub-reach Location	100-year	500-year
USACE Reaches			
Sub-reach 1 (No structure)	DS study limit (Station 0+43) ~ San Francisquito Canyon Road (Station 150+02)	Flooding is contained in the main channel, except near Sta. 13+46 15+72, 26+08, 34+29, and Sta. 38+02. The flooded areas include the San Francisquito Canyon Road, open space and dirt parking lots	Same flooding occurs as the 100-year, with additional flooding extending in the left and right overbanks especially at the downstream study limit
Sub-reach 2 (Structure 1)	San Francisquito Canyon Road (Station 150+97) ~ US study limit (Station 154+97)	Flooding is contained in the main channel	Flooding is contained in the main channel; with additional flooding at San Francisquito Canyon Road on the left and right overbanks. The flooding areas include open space and Highways
FEMA Reach			
	Confluence with SCR ~ USACE DS study limit	Upstream of Copper Hill Drive the floodplain extends into the left and right overbanks, inundating open space and farmland. Downstream of Copper Hill Drive, the floodplain is contained in the main channel	Same flooding occurs as the 100-year, with additional flooding extending in the left and right overbanks

27.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, 2-year flood events are presented in Appendix D. The average channel bed slope ranges from 1.2 percent in the upstream reaches to 0.8 percent downstream. The predominant flow regime throughout the study reach was subcritical.

Figure 27-1: San Francisquito Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 27-2: San Francisquito Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 28
Lion Canyon

28.1 General Description

Lion Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Lion Canyon are described in this section.

Lion Canyon joins the Santa Clara River from the south, between the locations where San Martinez Chiquito Canyon and Castaic Creek join the mainstem. The study reach begins at the confluence of Lion Canyon with the Santa Clara River and extends 1.2 miles upstream. Figure 28-1 shows the alignment of the study reach, and the land use of the surrounding areas. The study reach is located within areas of brushy open space and farmland.

28.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. The Potrero Canyon study reach upstream of the confluence with Santa Clara River was inaccessible during the field reconnaissance. Some information regarding the confluence conditions is presented in the photographs and field notes provided in Appendix A and B, respectively. Geometries of bridges and culverts within the study reach were estimated based on the LIDAR data and aerials. The characteristics of the single crossing noted along the study reach are summarized in Table 28-1.

Table 28-1
Structures along Lion Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	24+00	Private Road	Single Culvert	Assumed 2′ concrete culvert, headwall.

28.3 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The features of this study reach were relatively consistent, and a single sub-reach was identified. The physical characteristics of the Lion Canyon sub-reach are summarized in Table 28-2.

Table 28-2
Sub-reaches along Lion Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1	DS study limit (Station 0+52) ~ US study limit (Station 65+18)	Natural channel, sand/gravel/cobbles channel bed, undefined channel banks, trees/brush vegetation cover, floodplain consisting of brushy open space, vegetation and farmland

28.4 Manning's Roughness Coefficients

The Manning's roughness values for the single Potrero Canyon sub-reach are summarized in Table 28-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 28-3
Manning's Roughness Values along Lion Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1	DS study limit (Station 0+52) ~ US study limit (Station 65+18)	0.05	0.044	0.05

28.5 Hydrology

One hydrologic concentration point was provided along the study reach (see the Introduction for the source of the hydrology information). The location of this hydrologic concentration point is shown in Figure 28-1. The peak discharge rates associated with this location are summarized in Table 28-4.

Table 28-4
Hydrologic Concentration Point for Lion Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
65+19	10	20	50	90	140	210	300	470

28.6 Hydraulic Model

The Lion Canyon hydraulic model was developed with 159 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains one bridge/culvert (see Table 28-1).

28.7 Boundary Conditions

Normal depth boundary conditions were applied at the upstream and downstream ends of the hydraulic model. These boundary conditions were developed based on the invert slopes computed between the upstream-most cross-sections

(Stations 65+18 and 64+76) and between the downstream-most cross-sections (Stations 87 and 52). The boundary condition slope is 0.04 at both the upstream and downstream ends of the model.

28.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 28-2. Major flooded areas along Lion Canyon are summarized for the 100-year and 500-year flood events in Table 28-5.

Table 28-5
Major Flooding along Lion Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1	DS study limit (Station 0+52) ~ US study limit (Station 65+18)	Flooding is contained in the main channel	Flooding is contained in the main channel

28.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately four percent between the upstream and downstream study limits. The study reach contains two natural drops: one at the bridge structure (12-foot drop), and one upstream of the confluence with the Santa Clara River (10-foot drop). The predominant flow regime was supercritical.

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Figure 28-1: Lion Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 28-2: Lion Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 29
Castaic Creek

29.1 General Description

Castaic Creek is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Castaic Creek are described in this section.

Castaic Creek joins the Santa Clara River from the north, between the locations where San Martinez Chiquito Canyon and Lion Canyon join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 5.5 miles upstream to Tapia Canyon Road. Figure 29-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The study reach is located within areas of residential development, agricultural use and brushy open space. Major crossings over Castaic Creek include Highway 126, Commerce Center Drive, Old Road, I-5 and Tapia Canyon Road.

29.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 29-1.

Table 29-1
Structures along Castaic Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	40+00	Highway 126	Pier bridge	Concrete pier bridge, 5 piers, US channel banks near bridge are riprap
2	80+00	Commerce Center Drive	Pier bridge	Concrete pier bridge, 5 piers
3	149+00	Old Road	Pier bridge	Concrete pier bridge, pier thickness: 1′4″
4	151+00	I-5	Pier bridge	Concrete pier bridge, under retrofit construction
5	265+00	Tapia Canyon Road	Multiple culverts	3-8.5′ diam. CMPs projecting from bridge embankment

29.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 29-2.

Table 29-2
Sub-reaches along Castaic Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	Confluence with Santa Clara River (Station 6+15) ~ Highway 126 (Station 38+00)	Wide braided channel, sand/gravel channel bed, shrubs vegetation cover, floodplain consisting of brushy open space and agriculture
Sub-reach 2 (Structure 2)	Highway 126 (Station 41+19)~ 2,500 ft DS of I-5 (Station 122+74)	Broad braided channel, sand/gravel/cobbles channel bed, willows/trees vegetation cover, floodplain consisting of brushy open space, commercial and agriculture
Sub-reach 3 (Structures 3 to 5)	2,500 ft DS of I-5 (Station 126+48) ~ Tapia Canyon Road (Station 264+84)	Clear broad earthen channel, sand/gravel/cobbles channel bed, trees/shrubs vegetation cover, floodplain consisting of brushy open space, agriculture and residential
Sub-reach 4 (No structures)	Tapia Canyon Road (Station 266+10) ~ US study limit (Station 297+50)	Wide earthen channel, sand/gravel/cobbles channel bed, shrubs vegetation cover, floodplain consisting of brushy open space and agriculture

29.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study channel are summarized in Table 29-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 29-3
Manning's Roughness Values along Castaic Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	Confluence with Santa Clara River (Station 6+15) ~ Highway 126 (Station 38+00)	0.07	0.05	0.06
Sub-reach 2 (Structure 2)	Highway 126 (Station 41+19)~ 2,500 ft DS of I-5 (Station 122+74)	0.07	0.05	0.07
Sub-reach 3 (Structures 3 to 5)	2,500 ft DS of I-5 (Station 126+48) ~ Tapia Canyon Road (Station 264+84)	0.045	0.05	0.045
Sub-reach 4 (No structures)	Tapia Canyon Road (Station 266+10) ~ US study limit (Station 297+50)	0.05	0.05	0.05

29.5 Hydrology

Six hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). At some concentration points the reported discharge rates are smaller than at concentration points upstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The locations of the provided hydrologic concentration points along the study reach are shown in Figure 29-1. The peak discharge rates associated with these locations are summarized in Table 29-4.

Table 29-4
Hydrologic Concentration Points along Castaic Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
264+82	410	1380	2610	5,150	7,990	11,830	16,960	26,240
199+25	490	1650	3120	6,150	9,540	14,130	20,260	31,340
152+45	510	1690	3200	6,300	9,770	14,480	20,760	32,120
95+34	510	1700	3220	6,330	9,830	14,560	20,880	32,290
55+37	490	1640	3100	6,100	9,460	14,017	20,100	31,090
17+58	490	1650	3120	6,130	9,520	14,100	20,220	31,270
0	410	1380	2610	5,150	7,990	11,830	16,960	26,240

29.6 Hydraulic Model

The Castaic Creek hydraulic model was developed with 97 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The model included five bridges/culverts (see Table 29-1).

29.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 297+50 and 294+61) and the two downstream-most cross-sections (Station 10+12 and 6+15) in the hydraulic model. Computed boundary condition slopes are 0.01 and 0.008 at the upstream and downstream ends of the model, respectively.

29.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 29-2. Major flooding along Castaic Creek is summarized for the 100-year and 500-year flood events in Table 29-5.

Table 29-5
Major Flooding along Castaic Creek

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	Confluence with Santa Clara River (Station 6+15) ~ Highway 126 (Station 38+00)	Flooding is contained in the main channel	Same flooding occurs as the 100-year; with additional flooding in the main channel
Sub-reach 2 (Structure 2)	Highway 126 (Station 41+19)~ 2,500 ft DS of I-5 (Station 122+74)	Flooding is contained in the main channel	Same flooding occurs as the 100-year; with additional flooding on the left overbank upstream of Commerce Center Drive
Sub-reach 3 (Structures 3 to 5)	2,500 ft DS of I-5 (Station 126+48) ~ Tapia Canyon Road (Station 264+84)	Flooding is mostly contained in the main channel, except at near Sta. 180+26, 207+97, 225+79, 231+74 and directly downstream of I-5 and The Old Road on the left bank. The flooded areas include farm land adjacent and open space	Same flooding occurs as the 100-year; with additional flooding on the left overbank upstream of I-5 and continuous overtopping on the right overbank. The flooded areas include farm land
Sub-reach 4 (No structures)	Tapia Canyon Road (Station 266+10) ~ US study limit (Station 297+50)	Flooding is contained in the main channel, with additional flooding directly upstream of Tapia Canyon Road	Additional flooding upstream of Tapia Canyon Road

29.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 0.6 percent along the study reach. Tapia Canyon crossing is a significant obstruction for all discharge frequencies examined. Conveyance limitations are evident at all of the bridge locations under 500-year flood conditions, except for The Old Road. The predominant flow regime was subcritical.

Figure 29-1: Castaic Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

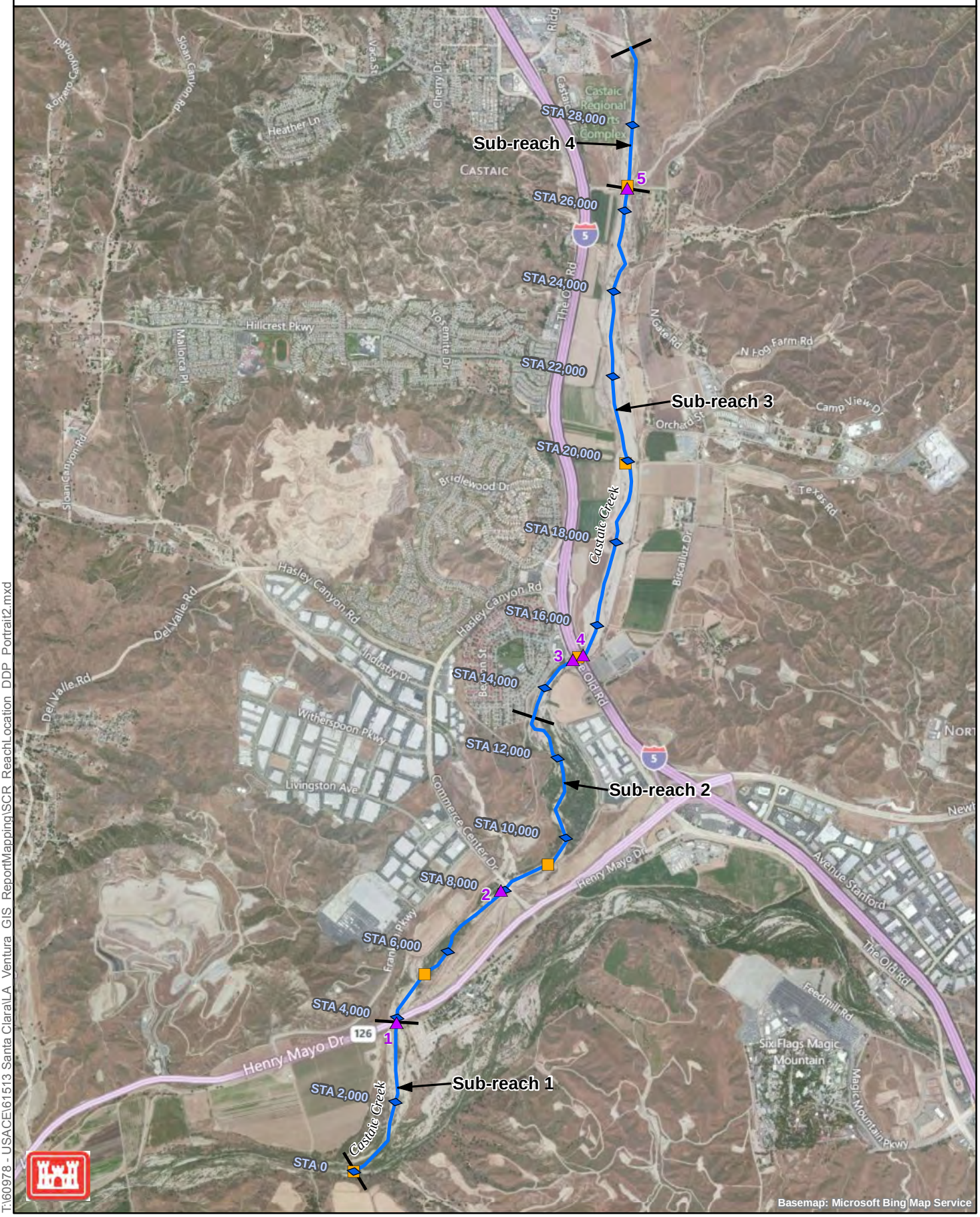

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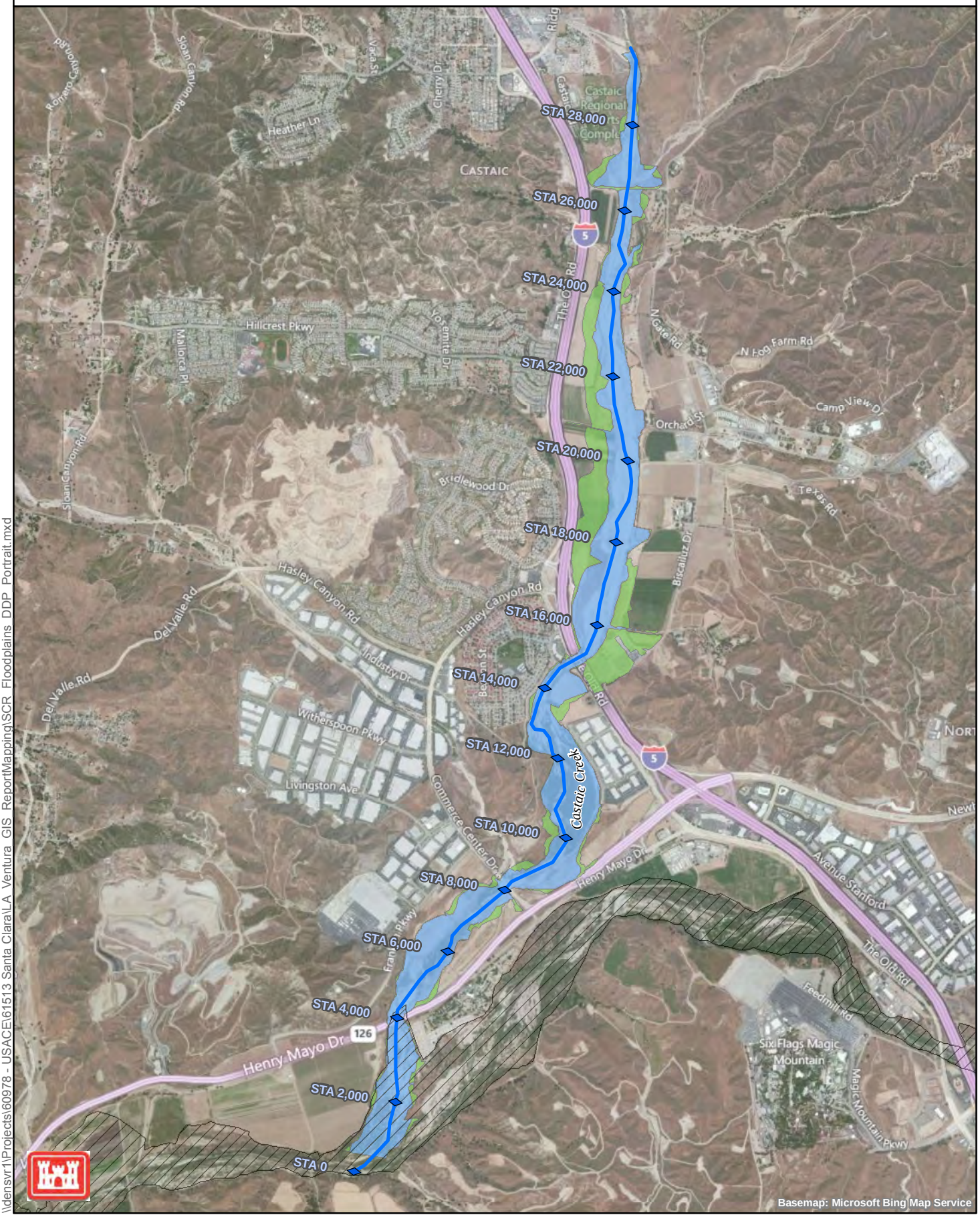
Figure 29-2: Castaic Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 30
Violin Canyon

30.1 General Description

Violin Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Violin Canyon are described in this section.

Violin Canyon is a tributary of Castaic Creek, located upstream of the Hasley Canyon and Castaic Creek confluence. The study reach begins at the confluence of Violin Canyon with Castaic Creek and extends 2.8 upstream. Figure 30-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The extent of the reach designated "Violin Canyon" in this report is different than that used in the hydrology report. The hydrology report shows Violin Canyon extending to the confluence with Marple Canyon (with Marple Canyon confluencing with Castaic Creek), whereas this study shows Violin Canyon extending to confluence with Castaic Creek (with Marple Canyon as an upstream tributary). The naming convention used in this report follows the normal convention, with the reach name of the channel downstream of a confluence being that of the more significant water course. Following this convention, Marple Canyon ends at the confluence with Violin Canyon, and the combined reach between this confluence and Castaic Creek continues as Violin Canyon.

The upstream study reach is located within brushy open space. Downstream of Sierra Oak Trial the channel is surrounded by commercial and residential areas. Major crossings over Violin Canyon include Interstate-5 and The Old Road.

30.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 30-1.

Table 30-1
Structures along Violin Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	21+00	Ridge Route	Span bridge	Concrete span bridge, rectangular concrete channel
2	31+88	Private Road	Span bridge	Concrete span bridge perched higher than channel, rectangular concrete channel
3	43+07	Lake Hughs Road	Span bridge	Concrete span bridge, trapezoidal concrete channel US, rectangular concrete channel DS
4	79+49	Interstate-5 South bound	Culvert	1-22′ corrugated metal pipe, earthen channel downstream and concrete lined channel upstream
5	98+22	Castaic Road	Pier bridge	Concrete pier bridge, DS trapezoidal concrete channel, US concrete channel bed and channel banks consisting of pole and wire
6	99+88	Interstate-5 North bound	Pier bridge	Concrete pier bridge, concrete channel bed and channel banks consisting of pole and wire channel
7	101+53	Old Road	Pier bridge	Concrete pier bridge with debris nose, left channel 21′x8′9″ (Span x Rise), right channel 20′x8′9″ (Span x Rise), trapezoidal concrete channel
8	110+49	Sierra Oak Trail	Multiple culverts	3-21′9″x10′8″ (Span x Rise) concrete box culvert, DS trapezoidal concrete channel, US earthen channel

30.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 30-2.

Table 30-2
Sub-reaches along Violin Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Confluence with Castaic Creek (Station 5+23) ~ 1,000 ft DS of Ridge Route (Station 16+82)	Wide braided channel, sand/gravel channel bed, shrubs vegetation cover, floodplain consisting of brushy open space, commercial and agriculture
Sub-reach 2 (Structures 1 to 4)	1,000 ft DS of Ridge Route (Station 19+19) ~ 1,300 ft DS of I-5 South bound (Station 49+62)	Rectangular concrete channel, floodplain consisting of brushy open space, commercial, residential and agriculture
Sub-reach 3 (Structure 5)	1,300 ft DS of I-5 South bound (Station 53+38) ~ I-5 North bound (Station 75+87)	Natural vegetated channel, shrubs/trees vegetation cover, floodplain consisting of brushy open space, residential
Sub-reach 4 (Structures 6 to 8)	I-5 North bound (Station 83+55) ~ Sierra Oak Trail (Station 111+24)	Trapezoidal and rectangular concrete channel, floodplain consisting of brushy open space and residential
Sub-reach 5 (No structures)	Sierra Oak Trail (Station 113+26) ~ US study limit (Station 148+65)	Braided earthen channel, sand/cobbles channel bed, brush vegetation cover, floodplain consisting of brushy open space

30.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 30-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 30-3
Manning's Roughness Values along Violin Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structures)	Confluence with Castaic Creek (Station 5+23) ~ 1,000 ft DS of Ridge Route (Station 16+82)	0.06	0.04	0.06
Sub-reach 2 (Structures 1 to 4)	1,000 ft DS of Ridge Route (Station 19+19) ~ 1,300 ft DS of I-5 South bound (Station 49+62)	0.13	0.015	0.13
Sub-reach 3 (Structure 5)	1,300 ft DS of I-5 South bound (Station 53+38) ~ I-5 North bound (Station 75+87)	0.05	0.02	0.1
Sub-reach 4 (Structures 6 to 8)	I-5 North bound (Station 83+55) ~ Sierra Oak Trail (Station 111+24)	0.13	0.015	0.13
Sub-reach 5 (No structures)	Sierra Oak Trail (Station 113+26) ~ US study limit (Station 148+65)	0.05	0.04	0.05

30.5 Hydrology

Three hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 30-1. The peak discharge rates associated with these locations are summarized in Table 30-4.

Table 30-4
Hydrologic Concentration Points along Violin Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
93+41	70	230	440	860	1,340	1,980	2,840	4,390
42+38	120	400	760	1,490	2,320	3,430	4,920	7,610
0	130	450	840	1,660	2,570	3,810	5,460	8,450

30.6 Hydraulic Model

The Violin Canyon hydraulic model was developed with 82 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled channel contains eight bridges/culverts (see Table 30-1) and one overflow reach.

30.6.1 Channel Improvements

Channel improvements were added to Violin Canyon based on as-built drawings. The improved reach extends from just upstream of the confluence with Castaic Creek to the upstream limit of Sub-reach 2. (reference: California Department of Transportation Division of Maintenance (DTDM), *Bridge Inspection Records Information System (BIRIS). Project No. 53 2014L* (DTDM, 1967), Los Angeles Flood Control District (LAFCD), *Violin Canyon Channel* (LAFCD, 1986), and County of Los Angeles (CLA) *Land Development Division* (CLA, 1997)).

The improved channel and culverts have the capacity to convey up to the 200-year storm event without overtopping. Overflows occur upstream of the South Bound I-5 crossing under peak 500-year flow conditions.

30.6.2 Overflow Reaches

An overflow reach was added to the Violin Canyon model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach during extreme events due to limited channel and bridge capacities upstream of I-5.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 30-5.

Table 30-5
Maximum Flow in Violin Canyon Left Overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Right_OF 1 (right)	0	0	0	0	0	0	0	847

30.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 148+65 and 146+52) and the two downstream-most cross-sections (Station 6+01 and 5+23) in the hydraulic model. Computed boundary condition slopes are 0.03 and 0.014 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were applied at the upstream boundary of the overflow reach, based on the invert slope computed between the upstream-most cross-sections. The right upstream boundary condition slope is 0.02 (Station 19+05 and 18+79). The downstream boundary condition used a return junction to connect the overflow reach with the mainstem.

30.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 30-2. Major flooded areas along Violin Canyon are summarized for the 100-year and 500-year flood events in Table 30-6.

Table 30-6
Major Flooding along Violin Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (No structures)	Confluence with Castaic Creek (Station 5+23) ~ 1,000 ft DS of Ridge Route (Station 16+82)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 2 (Structures 1 to 4)	1,000 ft DS of Ridge Route (Station 19+19) ~ 1,300 ft DS of I-5 South bound (Station 49+62)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 3 (Structure 5)	1,300 ft DS of I-5 South bound (Station 53+38) ~ I-5 North bound (Station 75+87)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 4 (Structures 6 to 8)	I-5 North bound (Station 83+55) ~ Sierra Oak Trail (Station 111+24)	Flooding is contained in the main channel	Flooding extends into the right overbank upstream of I-5 South due to insufficient capacity for the 500-year flood. The right overflow travels along Castaic Road and connects back into the main channel downstream of the underpass. The flooded areas include parking lots, roadways and commercial buildings
Sub-reach 5 (No structures)	Sierra Oak Trail (Station 113+26) ~ US study limit (Station 148+65)	Flooding is contained in the main channel	Flooding is contained in the main channel

30.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from 1.5 to 3 percent along the study reach. Conveyance limitations are evident at the I-5 South Bound crossing under peak 500-yr flow conditions. Flows that overtop the channel upstream of I-5 follow Castaic Road under I-5 South and rejoin the main channel directly downstream of the underpass. The predominant flow regime was supercritical.

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Figure 30-1: Violin Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

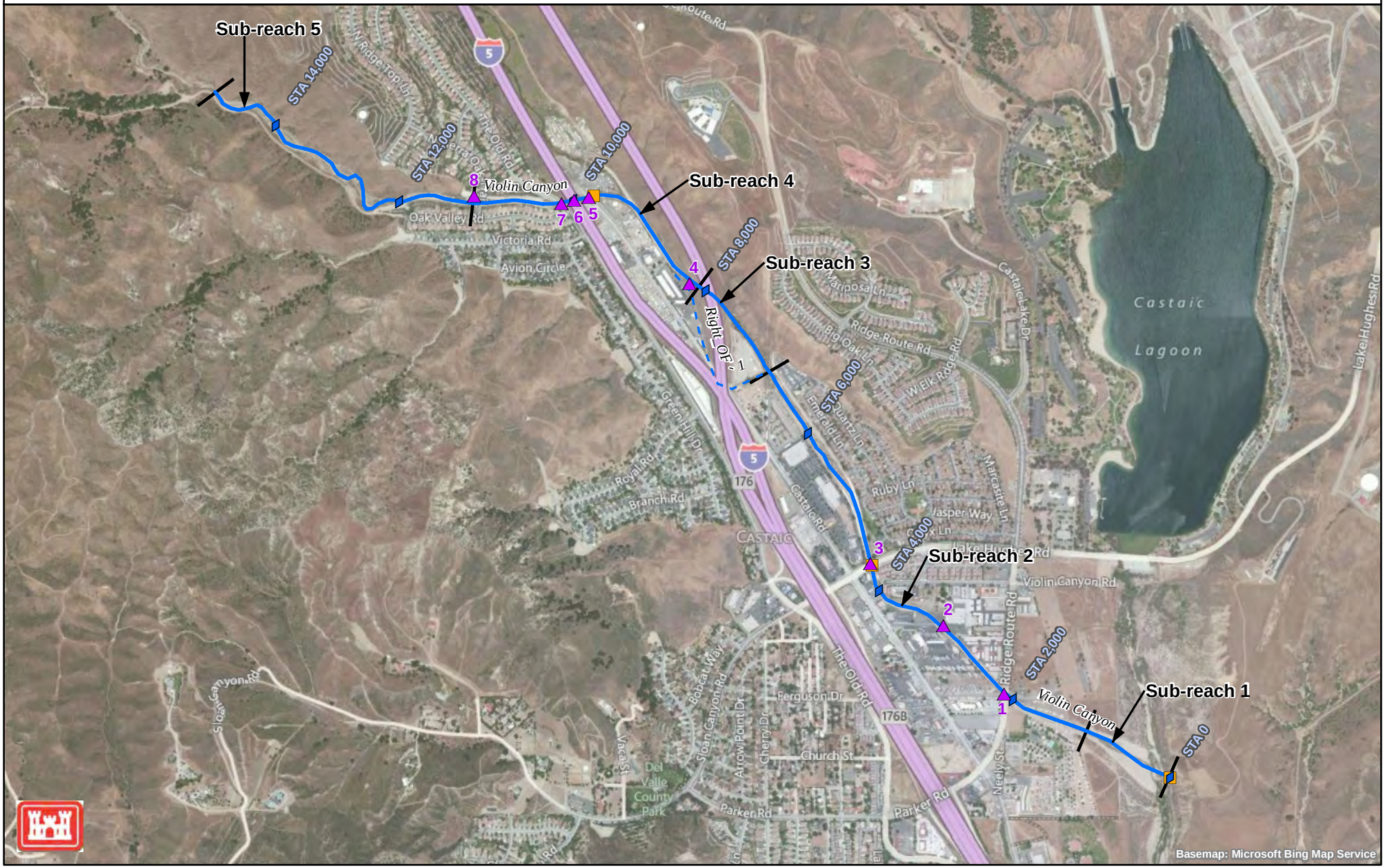

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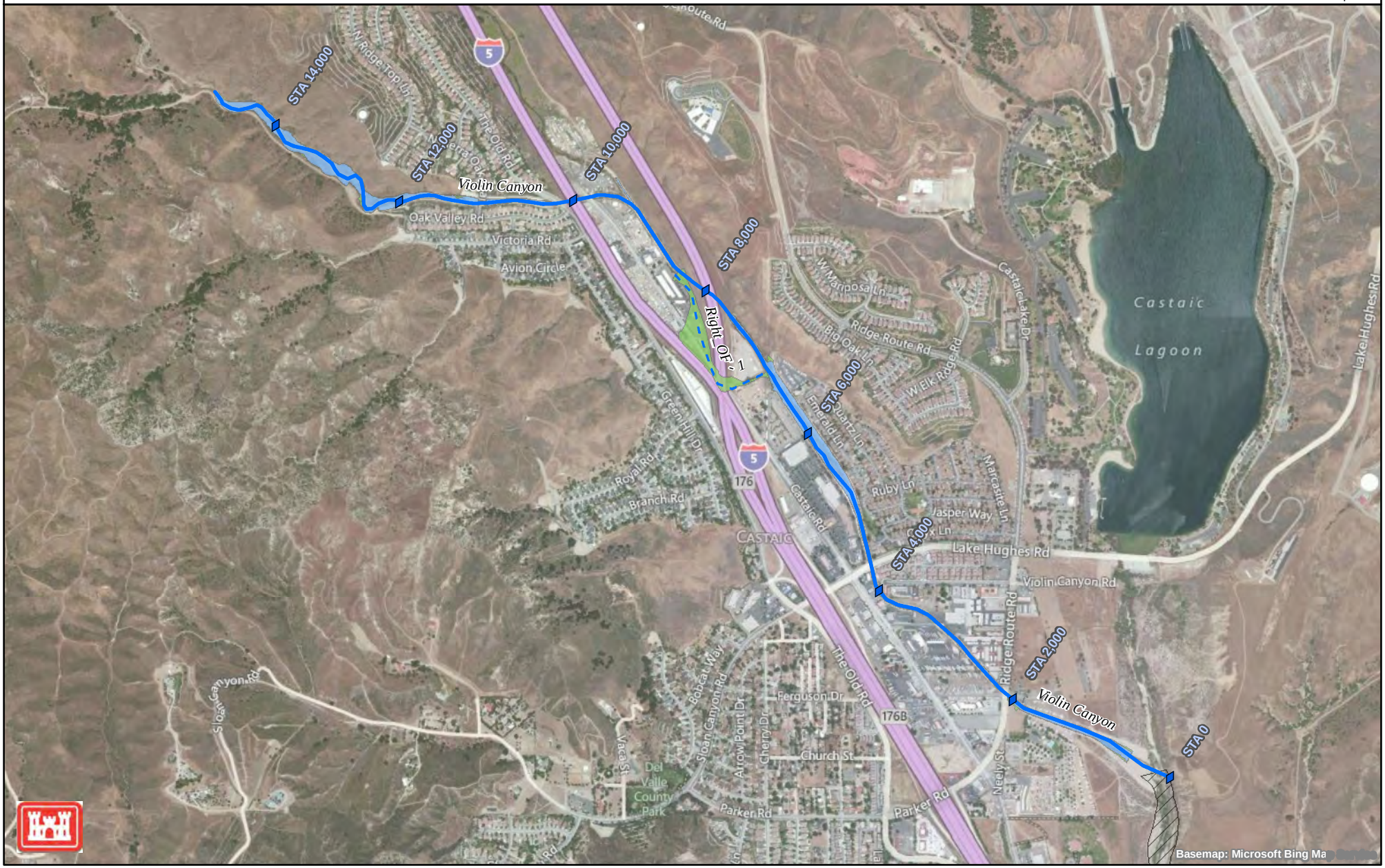
Figure 30-2: Violin Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Section 31
Marple Canyon

31.1 General Description

Marple Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Marple Canyon are described in this section.

Marple Canyon is a tributary to Violin Canyon. The study reach begins at the confluence with Violin Canyon and extends one mile upstream along Marple Canyon. Figure 31-1 shows the alignment of the study reach, and the land use of surrounding areas.

The extent of the reach designated "Marple Canyon" in this report is different than that used in the hydrology report. The hydrology report shows Marple Canyon extending to the confluence with Castaic Creek (with Violin Canyon as an upstream tributary), whereas this study shows Violin Canyon extending to confluence with Castaic Creek (with Marple Canyon as an upstream tributary). The naming convention used in this report follows the normal convention, with the reach name of the channel downstream of a confluence being that of the more significant water course. Following this convention, Marple Canyon ends at the confluence with Violin Canyon, and the combined reach between this confluence and Castaic Creek continues as Violin Canyon.

The study reach is located between the northern and southern lanes of Interstate 5, within areas of industrial use and brushy open space.

31.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. The Marple Canyon study reach upstream of the confluence with Violin Canyon was inaccessible during the field reconnaissance. Some information regarding the surrounding land use is provided in the field notes in Appendix B. Geometries of structures within the study reach were estimated based on the LIDAR data and aerials. Information regarding the single crossing noted along the study reach is summarized in Table 31-1.

Table 31-1
Structures along Marple Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	7+50	Private Road	Single Culvert	Assumed 2.5′ concrete culvert, headwall

31.2 Sub-reaches

The variation in physical characteristics along the study reach was evaluated, and sub-reaches were identified based on common characteristics. The parameters evaluated included the main channel geometry, bed material composition, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 31-2.

Table 31-2
Sub-reaches along Marple Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (No structures)	Confluence with Violin Canyon (Station 1+42) ~ 500 ft US of confluence (Station 6+86)	Concrete channel, floodplain consisting of industrial property and brushy open space
Sub-reach 2 (Structure 1)	500 ft US of confluence (Station 7+35) ~ US of Private Road (Station 13+54)	Earthen sand/gravel channel bed, floodplain consisting of brushy open space and industrial property
Sub-reach 2 (No structures)	US of Private Road (Station 16+05) ~ US study reach (Station 53+76)	Earthen sand/gravel channel bed, floodplain consisting of brushy open space

31.3 Manning's Roughness Coefficients

The Manning's roughness values for Marple Canyon sub-reaches are summarized in Table 31-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 31-3
Manning's Roughness Values along Marple Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (No structures)	Confluence with Violin Canyon (Station 1+42) ~ 500 ft US of confluence (Station 6+86)	0.05	0.015	0.1
Sub-reach 2 (Structure 1)	500 ft US of confluence (Station 7+35) ~ US of Private Road (Station 13+54)	0.1	0.04	0.05
Sub-reach 2 (No structures)	US of Private Road (Station 16+05) ~ US study reach (Station 53+76)	0.05	0.04	0.05

31.4 Hydrology

One hydrologic concentration point was provided along the Marple Canyon study reach. The location of this hydrologic concentration point is shown in Figure 31-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 31-4.

Table 31-4
Hydrologic Concentration Point for Marple Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	30	110	200	400	610	910	1,300	2,020

31.5 Hydraulic Model

The Marple Canyon hydraulic model was developed with 39 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled reach contains one bridge/culvert (see Table 31-1).

31.6 Boundary Conditions

Normal depth boundary conditions in the hydraulic model were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 53+76 and 51+37) and the two downstream-most cross-sections (Station 4+27and 1+42) in the hydraulic model. The Marple Canyon boundary condition slopes are 0.014 and 0.012 at the upstream and downstream ends of the model, respectively.

31.7 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 31-2. Major flooded areas along Marple Canyon are summarized for the 100-year and 500-year flood events in Table 31-5.

Table 31-5
Major Flooding along Marple Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (No structures)	Confluence with Violin Canyon (Station 1+42) ~ 500 ft US of confluence (Station 6+86)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 2 (Structure 1)	500 ft US of confluence (Station 7+35) ~ US of Private Road (Station 13+54)	Flooding is contained in the main channel; except for upstream of the Private Road where flooding extends into the overbanks flooding parking lots and industrial property	Same flooding occurs as the 100-year, with additional flooding extending in the left and right overbanks
Sub-reach 2 (No structures)	US of Private Road (Station 16+05) ~ US study reach (Station 53+76)	Flooding is contained in the main channel	Same flooding occurs as the 100-year, with additional flooding extending in the left and right overbanks

31.8 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average slope of the channel bottom is approximately 1.3 percent along the study reach. The Private Road crossing was blocked in the hydraulic model to account for sediment and debris accumulation; therefore, all flows overtop the bridge causing local flooding upstream of the bridge structure. The predominant flow regime was subcritical.

Figure 31-1: Marple Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 500 1,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 31-2: Marple Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 500 1,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 32
Hasley Canyon

32.1 General Description

Hasley Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Hasley Canyon are described in this section.

Hasley Canyon is one of the tributaries of Castaic Creek, located downstream of the Violin Canyon and Castaic Creek confluence. The study reach begins at the confluence with Castaic Creek and extends 4.8 miles upstream past Burtwood Drive. Figure 32-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

The upstream study reach is located in an urbanized neighborhood while the downstream study reach consists of mostly commercial property. The middle portion of the study reach contains a few residences, but is mainly surrounded by brushy open space. Major crossings over Hasley Canyon include Commerce Center Drive and Romero Road.

32.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in September 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and drop structures along the study reach is summarized in Table 32-1.

Table 32-1
Structures along Hasley Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	2+00	Commerce Center Drive 1	Pier bridge	Concrete pier bridge, 5 piers
2	41+07	Downstream of Commerce Center Drive 2	Drop structure	~ 4 foot drop
3	49+26	Commerce Center Drive 2	Pier bridge	Concrete pier bridge, 1 pier
4	51+41	Between Commerce Center Drive and Dell Valle Road (Drop Structure 1)	Drop structure	~ 4 foot drop
5	54+39	Between Commerce Center Drive and Dell Valle Road (Drop Structure 2)	Drop structure	~ 5 foot drop
6	57+39	Between Commerce Center Drive and Dell Valle Road (Drop Structure 3)	Drop structure	~ 5 foot drop
7	64+65	Between Commerce Center Drive and Dell Valle Road (Drop Structure 4)	Drop structure	~ 6 foot drop
8	67+54	Between Commerce Center Drive and Dell Valle Road (Drop Structure 5)	Drop structure	~ 6 foot drop
9	70+54	Between Commerce Center Drive and Dell Valle Road (Drop Structure 6)	Drop structure	~ 3 foot drop
10	103+53	Between Commerce Center Drive and Dell Valle Road (Downstream of Dell Valle Road)	Drop structure	~ 4 foot drop
11	177+87	Downstream of Romero Road	Drop structure	~ 9 foot drop
12	178+00	Romero Road	Pier bridge	Concrete pier bridge, 4 piers,12′x8′ (Span x Rise) concrete channels
13	233+80	Gilmore Road	Multiple culverts	US 1-4′2″′ diam. cast iron pipe, DS 1-3′ diam. 1-2′ diam. cast iron pipes, headwall & wingwalls
14	244+00	Burlwood Drive	Multiple culverts	2-7′x4′ (Span x Rise) concrete pipe arch, headwall & wingwalls

32.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 32-2.

Table 32-2
Sub-reaches along Hasley Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	Confluence with Castaic Creek (Station 0+74) ~ 1,050 ft DS of Commerce Center Drive (Station 30+63)	Broad braided earthen channel with accumulated sediment buildup, sand/gravel/cobbles channel bed, shrubs/trees vegetation cover, floodplain consisting of commercial and brushy open space
Sub-reach 2 (Structures 2 to 9)	1,050 ft DS of Commerce Center Drive (Station 33+44) ~ 4,200 ft US of Commerce Center Drive (Station 57+99)	Narrow channel with concrete lined channel banks, sand /cobbles channel bed, shrubs vegetation cover, floodplain consisting of commercial, residential and brushy open space
Sub-reach 3 (Structure 10)	4,200 ft US of Commerce Center Drive (Station 60+65) ~ 1,500 ft DS Romero Road (Station 92+51)	Braided earthen channel with evidence of sediment erosion on channel bed, sand/gravel channel bed, floodplain consisting of brushy open space
Sub-reach 4 (Structures 11 and 12)	1,500 ft DS Romero Road (Station 96+06) ~ 4,000 ft US Romero Road (Station 186+57)	Natural narrow channel, sand/cobbles channel bed, trees/shrubs vegetation cover, floodplain consisting of brushy open space and residential
Sub-reach 5 (Structure 13 and 14)	4,000 ft US Romero Road (Station 192+58)~ US study limit (Station 259+68)	Meandering earthen channel, sand/gravel/cobbles channel bed, oaks/shrubs vegetation cover, floodplain consisting of brushy open space and residential

32.4 Manning's Roughness Coefficients

The Manning's roughness values for Hasley Canyon sub-reaches are summarized in Table 32-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 32-3
Manning's Roughness Values along Hasley Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	Confluence with Castaic Creek (Station 0+74) ~ 1,050 ft DS of Commerce Center Drive (Station 30+63)	0.05	0.04	0.10
Sub-reach 2 (Structures 2 to 9)	1,050 ft DS of Commerce Center Drive (Station 33+44) ~ 4,200 ft US of Commerce Center Drive (Station 57+99)	0.10	0.025	0.10
Sub-reach 3 (Structure 10)	4,200 ft US of Commerce Center Drive (Station 60+65) ~ 1,500 ft DS Romero Road (Station 92+51)	0.1	0.04	0.05
Sub-reach 4 (Structures 11 and 12)	1,500 ft DS Romero Road (Station 96+06) ~ 4,000 ft US Romero Road (Station 186+57)	0.05	0.04	0.05
Sub-reach 5 (Structure 13 and 14)	4,000 ft US Romero Road (Station 192+58)~ US study limit (Station 259+68)	0.08	0.04	0.05

32.5 Hydrology

Three hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 32-1. The peak discharge rates associated with these locations are summarized in Table 32-4.

Table 32-4
Hydrologic Concentration Points along Hasley Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
171+33	40	120	220	440	680	1,006	1,440	2,230
92+51	50	180	330	650	1,010	1,503	2,160	3,330
0	60	190	360	710	1,110	1,640	2,350	3,640

32.6 Hydraulic Model

The Hasley Canyon hydraulic model was developed with 225 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled reach contains five bridges/culverts and nine drop structures (see Table 32-1), and one dip crossing (located at Station 104+00).

32.7 Boundary Conditions

Normal depth boundary conditions in hydraulic model were used at the upstream and downstream locations. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 259+68 and 258+76) and the two downstream-most cross-sections (Station 2+32 and 0+74) in the hydraulic model. The Hasley Canyon boundary condition slopes are 0.038 and 0.019 at the upstream and downstream ends of the model, respectively.

32.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 32-2. Major flooded areas along Hasley Canyon are summarized for the 100-year and 500-year flood events in Table 32-5.

Table 32-5
Major Flooding along Hasley Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	Confluence with Castaic Creek (Station 0+74) ~ 1,050 ft DS of Commerce Center Drive (Station 30+63)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 2 (Structures 2 to 9)	1,050 ft DS of Commerce Center Drive (Station 33+44) ~ 4,200 ft US of Commerce Center Drive (Station 57+99)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 3 (Structure 10)	4,200 ft US of Commerce Center Drive (Station 60+65) ~ 1,500 ft DS Romero Road (Station 92+51)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 4 (Structures 11 and 12)	1,500 ft DS Romero Road (Station 96+06) ~ 4,000 ft US Romero Road (Station 186+57)	Flooding extends outside of the main channel directly upstream of Del Valle Road. The flooded areas include residential property and a treatment facility	Same flooding occurs as the 100-year; with additional extended flooding in the left and right overbanks
Sub-reach 5 (Structure 13 and 14)	4,000 ft US Romero Road (Station 192+58)~ US study limit (Station 259+68)	Flooding extends into the left and right overbank areas near Sta. 199+09, 207+05, and Sta. 251+10. The flooded areas include open space and residential property	Same flooding occurs as the 100-year; with additional flooding upstream of Romero Road inundating a parking lot on the right overbank

32.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average slope of the channel bed along the study reach is approximately 2.4 percent. A 20-foot drop is located downstream of Commerce Center Drive 2 crossing where the channel transitions from a section with concrete lined banks to a natural earthen channel. Conveyance limitations are apparent at Gilmore Road and Burlwood Drive crossings. The computed flow regime for 59 percent of the cross-sections was supercritical.

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Figure 32-1: Hasley Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

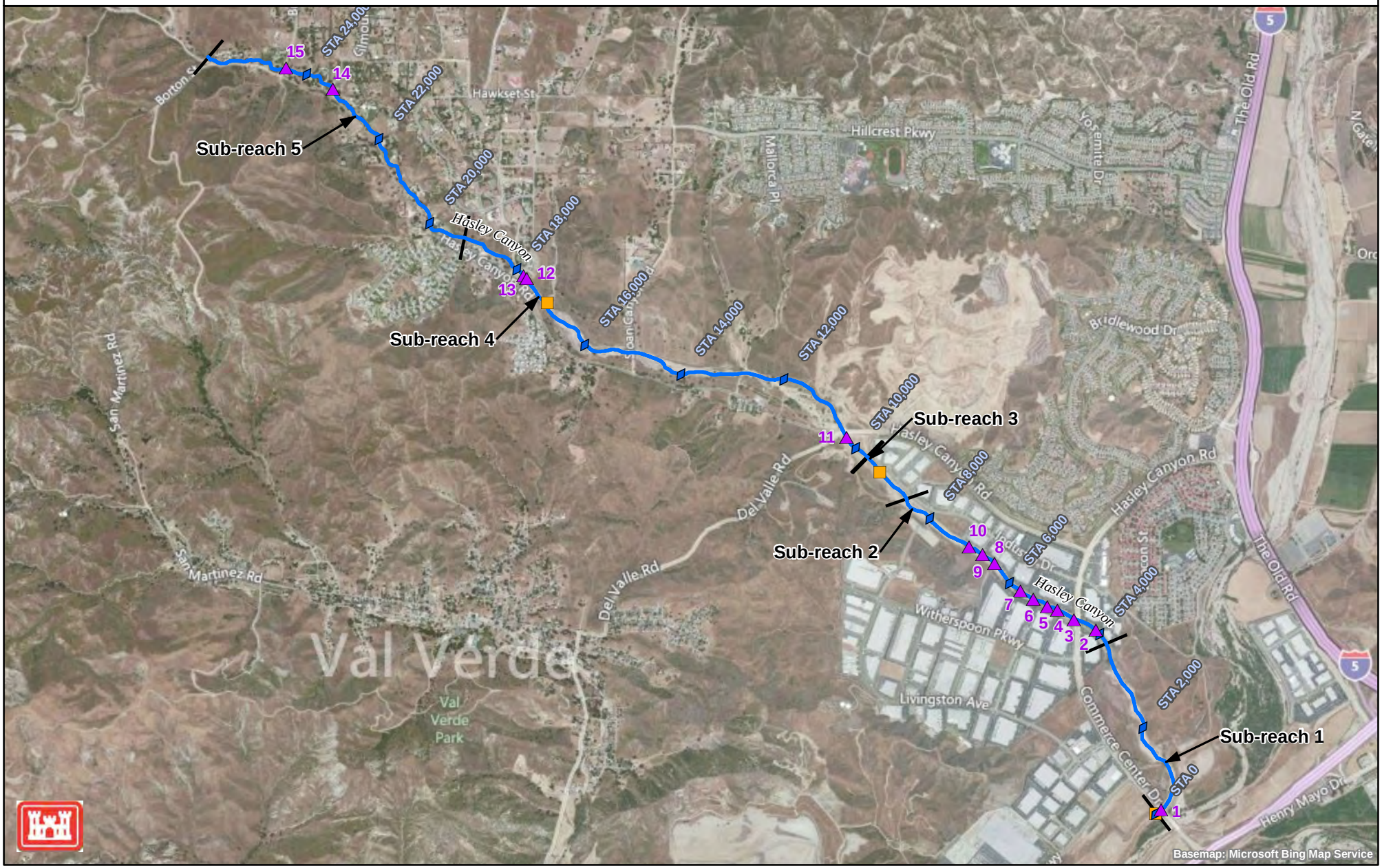

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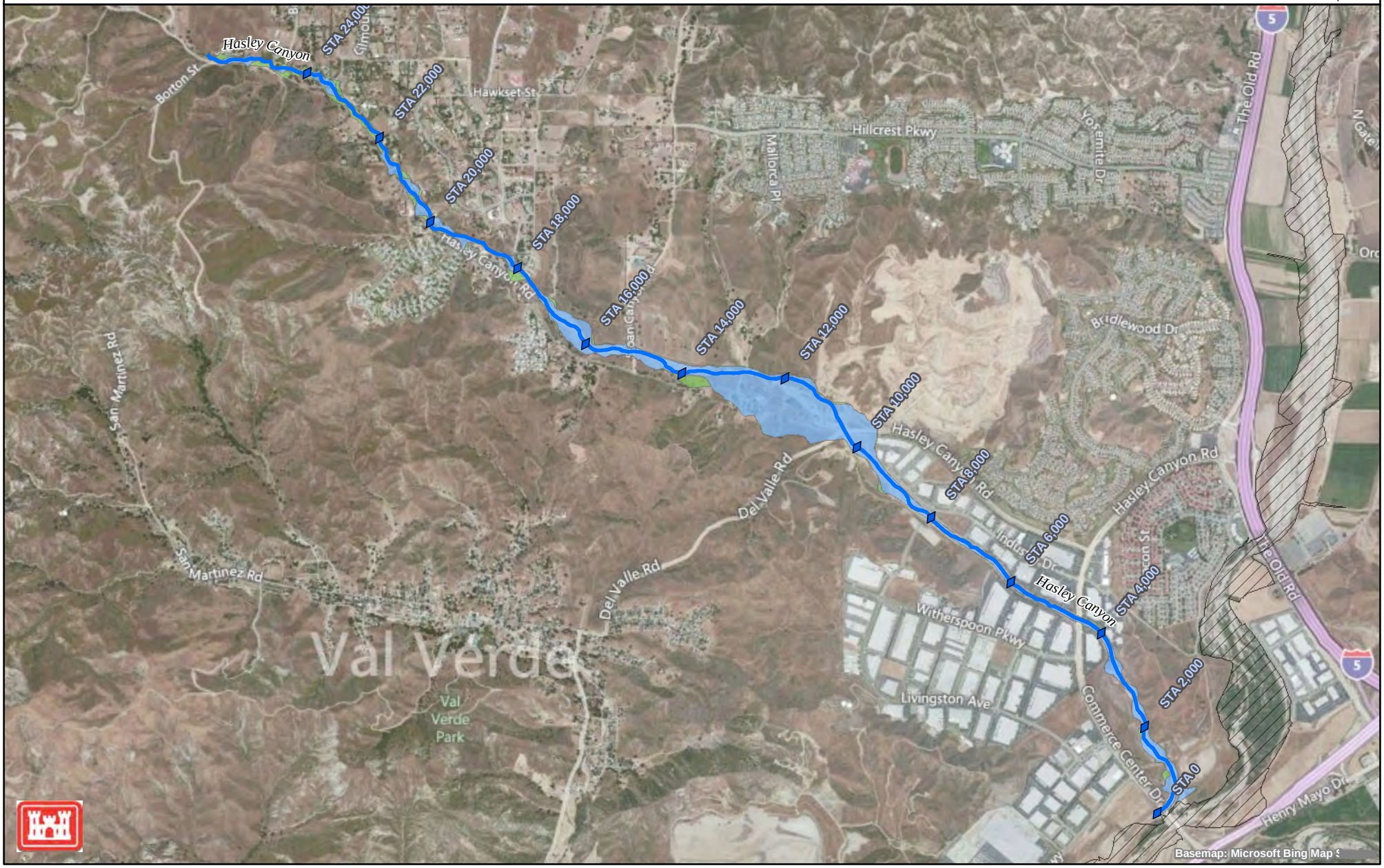
Figure 32-2: Hasley Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Section 33
Long Canyon

33.1 General Description

Long Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Long Canyon are described in this section.

Long Canyon joins the Santa Clara River from the south, between the locations where San Martinez Grande Canyon and San Martinez Chiquito Canyon join the mainstem. The study reach begins at the confluence with Santa Clara River and extends 2.4 miles upstream. Figure 33-1 shows the alignment of the study reach, and the land use of surrounding areas. The upstream section of the study reach is located in a valley dominated by brushy open space, with some agricultural areas. Properties along the downstream section of the study reach are predominantly farm land.

33.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. The Long Canyon study reach upstream of the confluence with Santa Clara River was inaccessible during the field reconnaissance. Some information regarding the confluence conditions is presented in the photographs and field notes provided in Appendix A and B, respectively. Geometries of structures within the study reach were estimated based on the LIDAR data and aerials. Information regarding the single crossing noted along the study reach is summarized in Table 33-1.

Table 33-1
Structures along Long Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	13+00	Private Road	Single Culvert	Assumed 6′ concrete culvert, headwall

33.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 33-2.

Table 33-2
Sub-reaches along Long Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	DS study limit (Station 2+99) ~ 1,000 ft US of DS study limit (Station 12+79)	Wide braided earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of farm land
Sub-reach 2 (No structures)	1,000 ft US of DS study limit (Station 13+23) ~ US study limit (Station 124+83)	Meandering earthen channel, sand/gravel/cobbles channel bed, floodplain consisting of farm land and brushy open space

33.4 Manning's Roughness Coefficients

The Manning's roughness values for Long Canyon sub-reaches are summarized in Table 33-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 33-3
Manning's Roughness Values along Long Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	DS study limit (Station 2+99) ~ 1,000 ft US of DS study limit (Station 12+79)	0.045	0.044	0.045
Sub-reach 2 (No structures)	1,000 ft US of DS study limit (Station 13+23) ~ US study limit (Station 124+83)	0.05	0.044	0.05

33.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 33-1. The peak discharge rates associated with these locations are summarized in Table 33-4.

Table 33-4
Hydrologic Concentration Points along Long Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
71+11	10	20	40	70	110	170	240	380
0	10	30	60	110	180	260	370	580

33.6 Hydraulic Model

The Long Canyon hydraulic model was developed with 240 cross-sections to represent the varying channel geometry and hydraulic structures located along the

reach. The model contains a meandering earthen channel with one bridge/culvert (see Table 33-1) and three dip crossings (located at Sta. 109+28, 82+94, and 56+42).

The cross-sections downstream of the Private Dirt Road are perched above the surrounding farmland. The hydraulic cross-sections drawn across the farmland were drawn extremely dog-legged to be perpendicular to the overbank flow. Due to the close proximity of the farmland with the Santa Clara River and the fact that this area is also included in the Santa Clara River 100- and 500-year floodplain, overflow reaches were not added.

33.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the study reach. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 124+83 and 124+55) and the two downstream-most cross-sections (Station 3+09 and 2+99) in the hydraulic model. Computed boundary condition slopes are 0.034 and 0.068 at the upstream and downstream ends of the model, respectively.

33.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 33-2. Major flooded areas along Long Canyon are summarized for the 100-year and 500-year flood events in Table 33-5.

Table 33-5
Major Flooding along Long Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	DS study limit (Station 2+99) ~ 1,000 ft US of DS study limit (Station 2+79)	Flooding extends into the left overbank directly upstream of the Private Road. Additionally, flooding extends into the left and right overbank areas downstream of the Private Road due to perched channel conditions. The flooded areas include farm land and open space	Same flooding occurs as the 100-year; with additional extended flooding in the left and right overbanks
Sub-reach 1 (No structures)	1,000 ft US of DS study limit (Station 13+23) ~ US study limit (Station124+83)	Flooding is contained in the main channel	Flooding is contained in the main channel

33.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is relatively steep at approximately three percent along the study reach. Conveyance limitations are apparent for the Private Road crossing under 50-year and higher flooding conditions. The computed flow regime for 55 percent of the cross-sections was supercritical.

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Figure 33-1: Long Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 33-2: Long Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 34
San Martinez Chiquito Canyon

34.1 General Description

San Martinez Chiquito Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of San Martinez Chiquito Canyon are described in this section.

San Martinez Chiquito Canyon joins the Santa Clara River from the north, between the locations where Long Canyon and Hasley Canyon join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends four miles upstream. Figure 34-1 shows the alignment of the study reach, the locations of the structures, and the land use of surrounding areas.

Areas adjacent to the upstream segment of the study reach are mostly farmland. The downstream segment of the study reach is surrounded by an urbanized area including residential and commercial land use. Major crossings over San Martinez Canyon include Railroad, Highway 126, Chiquito Canyon Road, Park Avenue, San Martinez Road and Delwood Street.

34.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 34-1.

Table 34-1
Structures along San Martinez Chiquito Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	12+06	Railroad	Pier bridge	Timber pier bridge, pier thickness: 1′4″, deck thickness: 2′4″, pier to pier distance: 15, Large oak tree growing in the middle of channel
2	15+00	HWY 126	Multiple culverts	3-14′x4′~6′ (Span x Rise), concrete box culvert, elongated pier shape, US filled with sediment and debris~2′-4′, riprap at DS channel banks
3	18+00	Old Road	Single culvert	1-20′x13′ (Span x Rise) elevated concrete arch, headwall & wingwalls
4	37+00	Chiquito Canyon Road 1	Pier bridge	Concrete pier bridge, triangular pier shape nose: 1′, deck thickness: 2′, Right channel filled with sediment ~1.7′, channel is broad with undefined channel banks
5	95+14	Downstream of Madison Avenue (drop structure 1)	Drop structure	~ 3 foot drop
6	110+51	Downstream of Madison Avenue (drop structure 2)	Drop structure	~ 3 foot drop
7	114+40	Downstream of Taylor Street	Drop structure	~ 4 foot drop
8	122+00	Chiquito Canyon Road 2	Span bridge	1-27′x5′4″ (Span x Rise) concrete span bridge, deck thickness: 18″, concrete lined chute US, earthen line chute DS, US channel banks and DS left channel bank consist of pole and wire
9	143+10	Wooden Foot Bridge	Span bridge	Timber arch ~ 11′4″ (Rise), deck thickness: 19″, left channel bank consist of pole and wire, earthen right channel bank
10	145+27	Downstream of Park Avenue	Drop structure	~ 3 2-foot drops
11	145+50	Park Avenue	Multiple culverts	2-4.5′ diam. & 1-6′ diam. circular concrete pipe, 2 DS drop structures: 1′4″ concrete drop & 2′9″ steel drop, earthen channel upstream. Downstream right channel banks consist of pole and wire, earthen left channel bank downstream
12	172+00	San Martinez Road 1	Span bridge	1-18 ′x3′10″ (Span x Rise) concrete span bridge, earthen conveyance area, deck thickness: 27″, wingwalls
13	191+00	Verdale Avenue	Single culvert	1-10′8″x 2′4″ (Span x Rise) concrete box culvert, deck thickness: 27″, US inlet concrete lined channel
14	202+00	Delwood Street	Multiple culverts	2-9′x6′9″ (Span x Rise) concrete box culvert, pier thickness:9″, DS drop structure ~ 4′, wingwalls
15	209+00	San Martinez Road 2	Span bridge	1-17′x5′3″ (Span x Rise) concrete span bridge, deck thickness: 23″

34.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 34-2.

Table 34-2
Sub-reaches along San Martinez Chiquito Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 8)	Confluence with Santa Clara River (Station 2+20) ~ Chiquito Canyon Road (Station 121+83)	Wide braided channel, sand/gravel/cobbles channel bed, shallow undefined banks, floodplain consisting of brushy open space, agriculture and residential
Sub-reach 2 (Structures 9 to 11)	Chiquito Canyon (Station 122+92) ~ Kensington Road (Station 203+01)	Natural channel with vertical earthen banks, sand/gravel/cobbles channel bed, oaks/willows vegetation cover, floodplain consisting of brushy open space and residential
Sub-reach 3 (Structures 12 to 14)	Kensington Road (Station 201+78) ~ Delwood Street (Station 208+44)	Open earthen channel, sand/gravel/cobbles channel bed, oaks/willows vegetation cover, floodplain consisting of brushy open space and residential
Sub-reach 4 (Structure 15)	Delwood Street (Station 209+19) ~ US study limit (Station 210+98)	Earthen channel, sand/gravel/cobbles channel bed, shrubs/willows/trees vegetation cover, floodplain consisting of brushy open space and residential

34.4 Manning's Roughness Coefficients

The Manning's roughness values for the San Martinez Chiquito Canyon sub-reaches are summarized in Table 34-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 34-3
Manning's Roughness Values along San Martinez Chiquito Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 8)	Confluence with Santa Clara River (Station 2+20) ~ Chiquito Canyon Road (Station 121+83)	0.06	0.04	0.06
Sub-reach 2 (Structures 9 to 11)	Chiquito Canyon (Station 122+92) ~ Kensington Road (Station 203+01)	0.1	0.04	0.7
Sub-reach 3 (Structures 12 to 14)	Kensington Road (Station 201+78) ~ Delwood Street (Station 208+44)	0.1	0.04	0.05
Sub-reach 4 (Structure 15)	Delwood Street (Station 209+19) ~ US study limit (Station 210+98)	0.05	0.04	0.05

34.5 Hydrology

Four hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 34-1. The peak discharge rates associated with these locations are summarized in Table 34-4.

Table 34-4
Hydrologic Concentration Points along San Martinez Chiquito Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
159+15	20	60	110	210	330	491	700	1,090
118+25	20	80	150	300	460	681	980	1,510
46+82	30	100	190	360	570	838	1,200	1,860
0	30	110	200	390	610	901	1,290	2,000

34.6 Hydraulic Model

The San Martinez Chiquito Canyon hydraulic model was developed with 148 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The model contains a meandering earthen channel with eleven bridges/culverts and four drop structures (see Table 34-1), and four dip crossings (located at cross-section 95+14, 110+51, 114+40, and 165+80).

34.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 210+98 and 209+72) and the two downstream-most cross-sections (Station 6+33 and 2+20) in the hydraulic model. Computed boundary condition slopes are 0.035 and 0.022 at the upstream and downstream ends of the model, respectively.

34.8 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 34-2. Major flooded areas along San Martinez Chiquito Canyon are summarized for the 100-year and 500-year flood events in Table 34-5.

Table 34-5
Major Flooding along San Martinez Chiquito Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 8)	Confluence with Santa Clara River (Station 2+20) ~ Chiquito Canyon Road (Station 121+83)	Flooding is mostly contained in the main channel except upstream of Madison Avenue. The flooded areas include brushy open space	Same flooding occurs as the 100-year; with additional extended flooding in the left and right overbanks between Stat 100+00 and 120+00
Sub-reach 2 (Structures 9 to 11)	Chiquito Canyon (Station 122+92) ~ Kensington Road (Station 203+01)	Flooding is contained in the main channel, except between cross-sections Sta. 193+85 to Sta. 189+91 where the floodplain extends into the left overbank inundating residential property	Flooding extends into the overbank areas upstream of several bridges/culverts including Delwood Street, Park Avenue, Chiquito Canyon Road 2, Harding Avenue, and Madison Street. The flooded areas include residential property
Sub-reach 3 (Structures 12 to 14)	Kensington Road (Station 201+78) ~ Delwood Street (Station 208+44)	Flooding is contained in the main channel	Flooding extends into the left and right overbank areas upstream and downstream of San Martinez Road 1 and Delwood Street
Sub-reach 4 (Structure 15)	Delwood Street (Station 209+19) ~ US study limit (Station 210+98)	Flooding is contained in the main channel	Same flooding occurs as the 100-year; with additional extended flooding in the left and right overbanks

34.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 2.5 percent along the study reach. Conveyance limitations are apparent at Chiquito Canyon Road, Park Avenue, San Martinez, Verdale Avenue, and Delwood Street crossings under the 200- and 500-year flood conditions. The computed flow regime for 57 percent of the cross-sections was supercritical.

Figure 34-1: San Martinez Chiquito Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

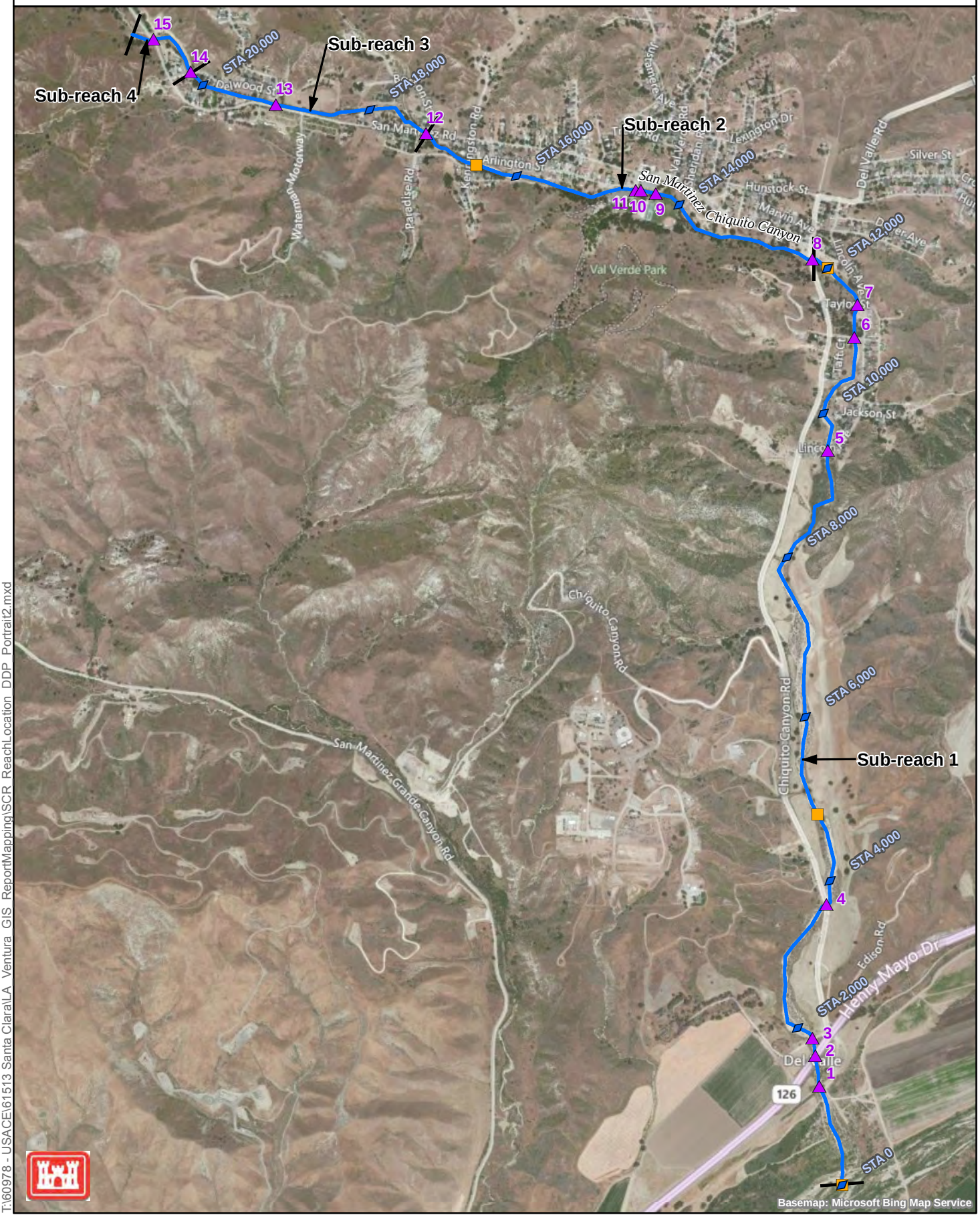

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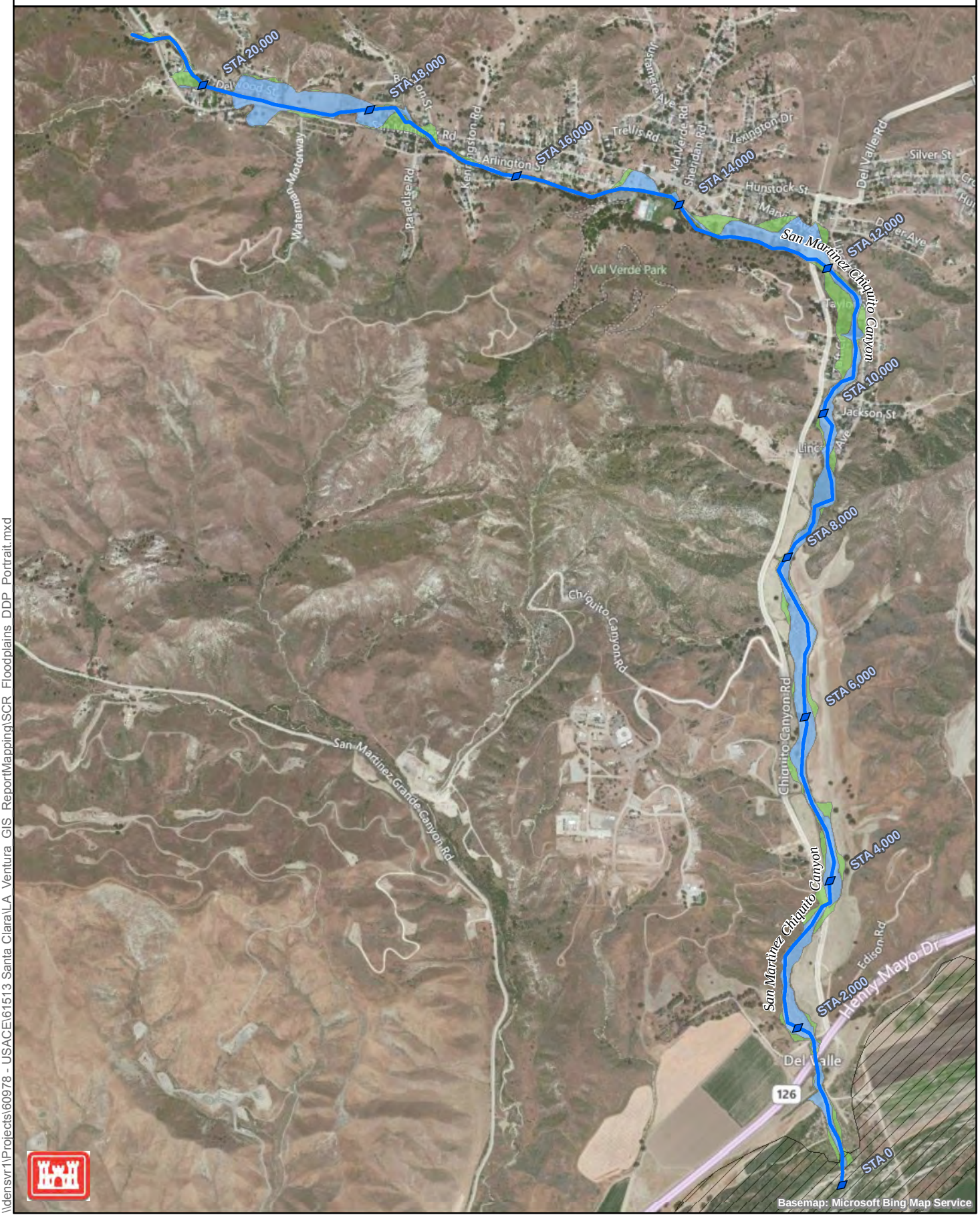
Figure 34-2: San Martinez Chiquito Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Basemap: Microsoft Bing Map Service

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Section 35
San Martinez Grande Canyon

35.1 General Description

San Martinez Grande Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of San Martinez Grande Canyon are described in this section.

San Martinez Grande Canyon joins the Santa Clara River from the north, between the locations where Potrero Canyon and Long Canyon join the mainstem. The study reach begins at the confluence with Santa Clara River and extends 2.2 miles upstream. Figure 35-1 shows the alignment of the study reach, the locations of the crossings, and the land use of surrounding areas.

The upstream study reach is located in a valley with mostly brushy open space along both banks. The downstream study reach is surrounded mostly by farm land. The only major crossing over San Martinez Grande Canyon is Highway 126.

35.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 35-1.

Table 35-1
Structures along San Martinez Grande Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	11+68	Highway 126	Pier bridge	1-pier bridge (group of piers in a row), deck thickness: 4′, US bank protected by riprap
2	93+73	Unnamed Dirt Road	Single culvert	RCP, almost filled with sediment (1′ rise)

35.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 35-2.

Table 35-2
Sub-reaches along San Martinez Grande Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1 and 2)	DS study limit (Station 9+21) ~ Unnamed Dirt Road (Station 15+33)	Heavy vegetated natural channel, sand/gravel channel bed, floodplain consisting of farm land
Sub-reach 2 (No structures)	Unnamed Dirt Road (Station 16+94) ~ US study limit (Station 104+99)	Meandering earthen channel, sand/gravel/cobbles channel bed, thick vegetation cover, floodplain consisting of brushy open space

35.4 Manning's Roughness Coefficients

The Manning's roughness values for the San Martinez Grande Canyon sub-reaches are summarized in Table 35-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 35-3
Manning's Roughness Values along San Martinez Grande Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1 and 2)	DS study limit (Station 9+21) ~ Unnamed Dirt Road (Station 15+33)	0.07	0.044	0.07
Sub-reach 2 (No structures)	Unnamed Dirt Road (Station 16+94) ~ US study limit (Station 104+99)	0.06	0.044	0.06

35.5 Hydrology

One hydrologic concentration point was provided along the San Martinez Grande Canyon study reach. The location of this hydrologic concentration point is shown in Figure 35-2. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 35-4.

Table 35-4
Hydrologic Concentration Point for San Martinez Grande Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
105+00	30	100	200	390	600	895	1,280	1,990

35.6 Hydraulic Model

The San Martinez Grande Canyon hydraulic model was developed with 121 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The model contains a meandering earthen channel with two bridges/culverts (see Table 35-1), and one dip crossing (located at cross-section17+19).

35.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 104+99 and 100+92) and the two downstream-most cross-sections (Station 9+49 and 9+21) in the hydraulic model. Computed boundary condition slopes are 0.024 and 0.021 at the upstream and downstream ends of the model, respectively.

35.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 35-2. Major flooded areas along San Martinez Grande Canyon are summarized for the 100-year and 500-year flood events in Table 35-5.

Table 35-5
Major Flooding along San Martinez Grande Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1 and 2)	DS study limit (Station 9+21) ~ Unnamed Dirt Road (Station 15+33)	Flooding is contained within the main channel	Flooding is contained within the main channel
Sub-reach 2 (No structures)	Unnamed Dirt Road (Station 16+94) ~ US study limit (Station 104+99)	Flooding is contained in the main channel; except for directly upstream of the Unnamed Dirt Road. Upstream of the road flooding extends into the left overbank encroaching onto the existing treatment facility	Same flooding occurs as the 100-year; with additional flooding extending into the left and right overbanks

35.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately two percent along the study reach. The Unnamed Dirt Road crossing is a significant obstruction for all discharge frequencies. The computed flow regime for 68 percent of the cross-sections was subcritical.

Figure 35-1: San Martinez Grande Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 35-2: San Martinez Grande Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 36
Potrero Canyon

36.1 General Description

Potrero Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Potrero Canyon are described in this section.

Potrero Canyon joins the Santa Clara River from the south, immediately downstream of the confluence with San Martinez Grande Canyon. The study reach begins at the confluence with the Santa Clara River and extends 4.3 miles upstream. Figure 36-1 shows the alignment of the study reach, and the land use of the surrounding areas. The study reach is located within a rural watershed with brushy open space and farm land uses along the channel.

36.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. The Potrero Canyon study reach upstream of the confluence with the Santa Clara River was inaccessible during the field reconnaissance. Some information regarding the confluence conditions is presented in the photographs and field notes provided in Appendix A and B, respectively. Geometries of bridges and culverts within the study reach were estimated based on the LIDAR data and aerials. Information regarding the structures noted along the study reach is summarized in Table 36-1.

Table 36-1
Structures along Potrero Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	11+00	Private Road A	Single Culvert	Assumed 5′ dia. concrete culvert, headwall
2	113+00	Private Road B	Single Culvert	Assumed 2.5′ dia. concrete culvert, headwall
3	115+00	Private Road C	Single Culvert	Assumed 2.5′ dia. concrete culvert, headwall
4	128+00	Private Road D	Single Culvert	Assumed 2′ dia. concrete culvert, headwall
5	197+00	Private Road E	Single Culvert	Assumed 2′ dia. concrete culvert, headwall
6	206+00	Private Road F	Single Culvert	Assumed 2′ dia. concrete culvert, headwall

36.3 Sub-reaches

The physical characteristics along the study reach were analyzed including the main channel geometry, bed material, overbank area land use, and degree of channel meandering. The general features along this reach were somewhat uniform, so only a single sub-reach was identified. The limits and major features of the study reach are summarized in Table 36-2.

Table 36-2
Sub-reaches along Potrero Canyon

Sub-Reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1-6)	DS study limit (Station 1+66) ~ US study limit (Station 209+54)	Meandering earthen channel, sand/gravel/cobbles channel bed, shrubs/trees vegetation cover, floodplain consisting of brushy open space and farm land

36.4 Manning's Roughness Coefficients

The Manning's roughness values for Potrero Canyon study reach are summarized in Table 36-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 36-3
Manning's Roughness Values along Potrero Canyon

Sub-Reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1-6)	DS study limit (Station 1+66) ~ US study limit (Station 209+54)	0.05	0.044	0.05

36.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Potrero Canyon (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 36-1. The peak discharge rates associated with these locations are summarized in Table 36-4.

Table 36-4
Hydrologic Concentration Points along Potrero Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
150+28	10	40	80	170	260	380	540	840
64+19	60	190	360	700	1,090	1,620	2,320	3,590
0	70	230	430	840	1,300	1,930	2,770	4,280

36.6 Hydraulic Model

The Potrero Canyon hydraulic model was developed using 282 cross-sections to represent the varying channel geometry and hydraulic structures along the study reach. The modeled tributary is located in an open, undeveloped valley with a few plant/mining facilities located adjacent to the tributary. The main channel has a meandering earthen bed that flows through six bridges/culverts (see Table 36-1) and six dip crossings (located at Station 67+50, 70+83, 73+22, 158+78, 176+78, and 202+33).

36.6.1 Overflow Reaches

In many areas of the model the higher magnitude flows were computed to exceed the capacity of the main channel. In most of these areas, the flow is contained within the left and/or right overbanks, and continues to parallel the main channel flow path. Beginning at cross-section 58+04, however, overtopping flows are expected to follow an independent path. An overflow reach was developed to simulate the hydraulics and floodplain associated with this overtopping flow.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 36-5.

Table 36-5
Maximum Flow in Potrero Canyon Left Overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	0	46	199	553	950	1,659	2,483	3,528

Overflow Reach Results

Due to perched conditions and limited main channel capacity, a majority of flow (approximately 85 percent) overtops the main channel between cross-sections 58+04 and 20+33.

36.7 Boundary Conditions

Normal depth boundary conditions were applied at the upstream and downstream ends of the hydraulic model. These boundary conditions were developed based on the invert slopes computed between the upstream-most cross-sections (Stations 209+54 and 209+01) and between the downstream-most cross-sections (Stations 4+82 and 1+66). The boundary condition slopes are 0.013 and 0.007 for the upstream and downstream ends, respectively, of the Potrero model.

The normal depth boundary conditions for the overflow reach were developed based on the invert slopes computed between the upstream-most cross-sections (Stations 58+25 and 53+71) and between the downstream-most cross-sections

(Stations 451 and 170). The upstream and downstream slopes at the boundaries of the overflow reach are 0.02 and 0.02, respectively.

36.8 Flood Boundaries

Flood boundaries for 500- and 100-year flood events are presented in Figure 36-2. Major flooded areas along Potrero Canyon are summarized for the 100-year and 500-year flood events in Table 36-6.

Table 36-6
Major Flooding along Potrero Canyon

Sub-Reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1-6)	DS study limit (Station 1+66) ~ US study limit (Station 209+54)	Flooding extends in and out of the main channel and overbank areas throughout the reach. The flooded area includes open space and residential property	Same flooding occurs as the 100-year; with additional flooding extending into the left overflow reach

36.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The slope of the study reach upstream of cross-section 28+48 is relatively constant at 0.019. Downstream of cross-section 28+48 the channel drops approximately 100 feet to the confluence with the Santa Clara River, with a local slope of about four percent. The predominant flow regime throughout the model was supercritical.

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Figure 36-1: Potrero Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 36-2: Potrero Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Section 37
Piru Creek

37.1 General Description

Piru Creek is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Mint Canyon are described in this section.

Piru Creek joins the Santa Clara River from the north, located east of Real/Warring Canyon. The study reach begins at the confluence with the Santa Clara River and extends six miles upstream. Figure 37-1 shows the alignment of the study reach, the locations of structures, and the land use of surrounding areas.

Most of the study reach is located within areas of agricultural use. Major crossings over Piru Creek include Center Street and Highway 126 (Telegraph Road).

37.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 37-1.

Table 37-1
Structures along Piru Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	45+00	Highway 126	Bridge	16 piers, as-built drawings will be used for detailed information, large boulders & grout on left bank at US side, debris at US side of piers
2	68+10	Center Street_old	Bridge (closed)	3 truss bridges supported by 2 piers between them (see photos in Appendix 24a), pipe crossing at US end hanging lower than lower deck elevation
3	68+90	Center Street_new	Bridge	4 piers, semi-circular alignment, grouted rock on right bank beneath the bridge
4	73+00	Railroad	Bridge	2 truss bridges supported by 1 pier between them (see photos in Appendix 24a), skewed to the flow, pipe crossing at US end (2-1' pipes) hanging 1' lower than lower deck elevation, approximate height from lower chord of bridge deck to underpass on left bank: 19'
5	203+77	Hoiser Canyon Road_A	Bridge	2 piers, skewed to the flow, grouted rock on both banks at US & DS
6	240+27	Hoiser Canyon Road_B	Multiple culverts	6-13.8'x12' (Span x Rise) concrete box culverts, culverts acting as a drop structure (invert of culverts higher than DS channel bed elevation), big scour pool & sand bars at DS side

Note: the Hoiser Canyon Road is located at the upstream study boundary

37.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 37-2.

Table 37-2
Sub-reaches along Piru Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 11+52) ~ Highway 126 (Station 43+65)	Wide braided channel, sand/gravel/cobble channel bed, brush & trees on both banks, floodplain consisting of agricultural area
Sub-reach 2 (Structures 2 to 6)	Highway 126 (Station 46+53) ~ US study boundary (Station 310+64)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, brush & trees on both banks, floodplain consisting of natural mountain area

37.4 Manning's Roughness Coefficients

Manning's roughness values for the Piru Creek sub-reaches are summarized in Table 37-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 37-3
Manning's Roughness Values along Piru Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station 11+52) ~ Highway 126 (Station 43+65)	0.055	0.035	0.060
Sub-reach 2 (Structures 2 to 6)	Highway 126 (Station 46+53) ~ US study boundary (Station 310+64)	0.070	0.045	0.070

37.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). At the downstream concentration point the reported discharge rates are smaller than those provided for concentration point upstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The locations of the hydrologic concentration points are shown in Figure 37-1. The provided peak discharge rates associated with these locations are summarized in Table 37-4.

Table 37-4
Hydrologic Concentration Points along Piru Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	1,779	5,918	10,768	19,892	29,222	41,100	55,280	80,227

37.6 Hydraulic Model

The Piru Creek hydraulic model was developed with 188 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled reach contains six bridges/culverts (see Table 37-1) and two overflow reaches.

37.6.1 Overflow Reaches

Overflow reaches were added to the Piru Creek model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs upstream of the Railroad crossing and upstream Highway 126 due to capacity limitations at these locations. Overflows at both locations occur along the right overbank.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 37-5.

Table 37-5
Maximum Flows for the Piru Creek Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Right_OF1	1	0	0	0	156	1,052	5,854	13,721	31,341
Right_OF2	1	0	0	0	77	587	4,033	11,045	25,957

37.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 310+64 and 308+14) and the two downstream-most cross-sections (Station 15+85 and 11+52) in the hydraulic model. Computed boundary condition slopes are 0.1 and 0.002 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used for the overflow reaches based on the invert slopes computed between the upstream-most cross-sections and downstream-most cross-sections. The computed boundary condition slopes for the upstream overflow reach are 0.004 (Station 77+74 and 76+05) and 0.014 (Station 4+95 and 2+58), at the upstream and downstream ends, respectively, of this reach. The computed boundary condition slopes for the downstream overflow reach are 0.018 (Station 40+20 and 35+58) and 0.007 (Station 16+10 and 10+06), at its upstream and downstream ends, respectively.

37.8 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 37-2. Major flooded areas along Piru Creek are summarized for the 100-year and 500-year flood events in Table 37-6.

Table 37-6
Major Flooding along Piru Creek

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station 11+52) ~ Highway 126 (Station 43+65)	Flooding extends into the left and right overbanks continuously until draining to the Santa Clara River	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structures 2 to 6)	Highway 126 (Station 46+53) ~ US study boundary (Station 310+64)	Flooding is contained to the adjacent open space along the main channel, except between Sta. 211+46 to Sta. 203+27 where flooding inundates adjacent residential property	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks. Additional flooding at Sta. 143+12 to Sta. 85+74, 173+00 to Sta. 161+53, 272+21 to Sta. 247+26

37.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 0.7 percent, except at the upstream drop below the existing reservoir where the slope is approximately 12 percent. Channel capacity limitations are evident along the study reach. The Railroad crossing is a significant obstruction. The predominant flow regime for the channel was subcritical.

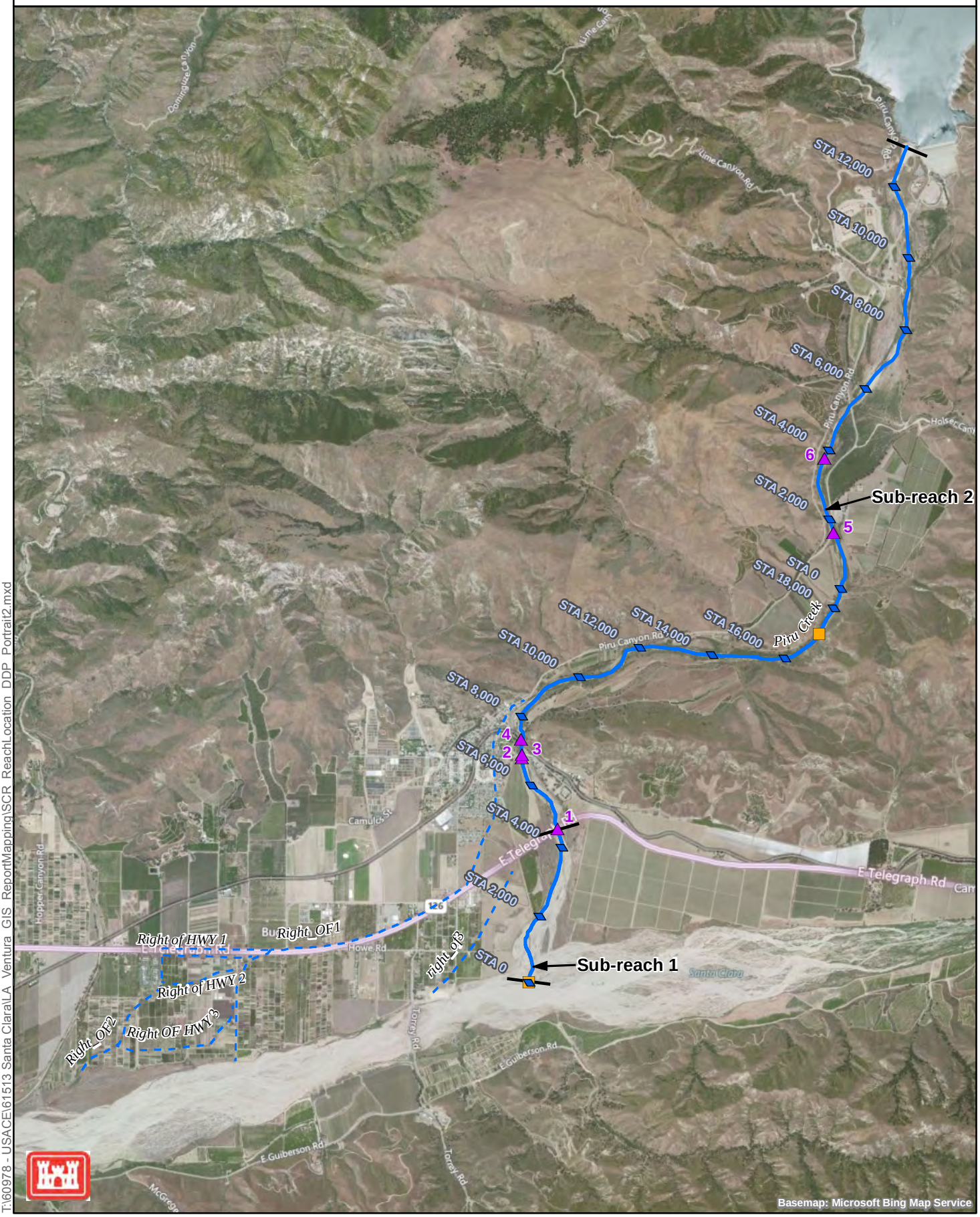
Figure 37-1: Piru Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,500 7,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach



Basemap: Microsoft Bing Map Service

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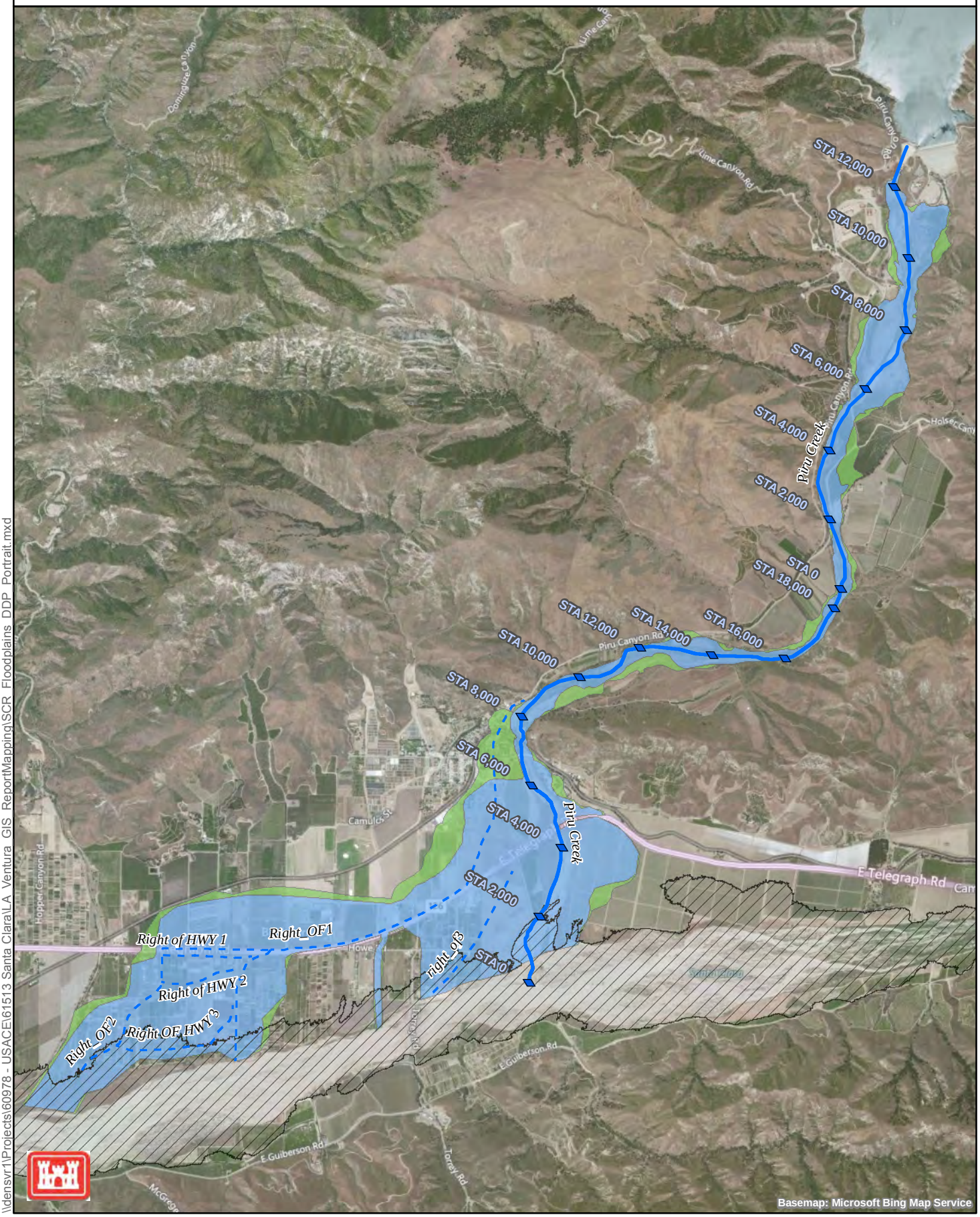
Figure 37-2: Piru Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,500 7,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 38
Real/Warring Canyon

38.1 General Description

Real/Warring Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Real Canyon are described in this section.

Real/Warring Canyon joins the Santa Clara River from the north, located between Edwards Canyon and Piru Creek. Real/Warring Canyon is composed of two branches, Real Canyon (west branch) and Warring Canyon (east branch). The study reach includes both branches, and extends approximately 1.7 miles from upstream of Highway 126 to the confluence with the Santa Clara River. The total length of the study reach, including both the east and west branches, is 2.6 miles. At the upstream end of each branch (Real Canyon and Warring Canyon) there is a debris basin. Figure 38-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural with some industrial and residential. The residential area is concentrated along the east overbank of Warring Canyon.

38.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 38-1.

Table 38-1
Structures along Real/Warring Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	29+00	Howe Road	Span Bridge	16'x 6' Span bridge with rectangular concrete channel both upstream and downstream of crossing
2	33+60	Highway 126	Span Bridge	14'x 6' Span bridge with rectangular concrete channel
3	36+54	Unnamed crossing 23D	Span Bridge	10" concrete slab over crossing upstream of HWY 126
4	37+60	Unnamed crossing 23E	Span Bridge	10" concrete slab over crossing
5	38+60	Unnamed crossing 23F	Span Bridge	10" concrete slab over crossing
6	42+10	Pacific Avenue	Span Bridge	10" concrete slab used as a road crossing
7 west	55+50	Railroad Crossing	Rectangular Culvert	Real Canyon channel splits into two separate channels downstream of the Railroad. 7'x 4' Rectangular concrete culvert on the west branch
8 west	64+10	Camulos Street	Rectangular Culvert	8'x 4.5' rectangular concrete culvert upstream of crossing and 8' x 4' rectangular concrete culvert downstream of crossing on the west branch. There is a steep entrance at the upstream side of culvert and concrete baffles downstream of culvert
9 west	82+90	Center Street	Span Bridge	7'x 5' span bridge with concrete channels upstream of crossing and 15' x 7' span bridge with concrete channels downstream of crossing on the west branch. The upstream channel is very narrow, but the channel expands under the bridge
10 east	1+90	Unnamed crossing 23J	Span Bridge	12'x 6' Span bridge with rectangular concrete channels
11 east	24+07	Downstream of Camulos Street	Drop Structure	~ 2 foot drop
12 east	24+20	Camulos Street	Span Bridge	9'x 6' Span Bridge with concrete channels showing erosion upstream of this crossing
13 east	32+80	Center Street	Span Bridge	Span bridge with upstream concrete trapezoidal channel and downstream earthen channel with grouted boulders; there is a large drop downstream of this crossing

Notes: Descriptions with dimensions provide width by length;
~ denotes an approximation, crossing could not be accesses from that side.

38.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 38-2.

Table 38-2
Sub-reaches along Real Canyon

Sub-reach 1	Sub-reach 1	Description
Sub-reach 1 (Structure 1)	Santa Clara River confluence (Station 10+08) ~ Howe Road (Station 28+70)	Improved trapezoidal earthen channel; ranch and cattle feed on the west, agriculture on the east; not much vegetation along the banks, some small shrubs at the confluence with the SCR; silt, sand, and gravel bed material; primarily citrus landuse
Sub-reach 2 (Structures 2 to 7)	Howe Road (Station 29+17) ~ the Railroad (Station 55+79)	Concrete rectangular channel with some sediment in the bottom of the channel; primarily citrus landuse
Sub-reach 3 (Structure 8)	The Railroad (Station 56+52)~ Camulos Street Real (west branch) (Station 63+87)	Earthen trapezoidal channel with erodible sandy material upstream of the Railroad crossing; grouted rock toe on the east and west banks upstream of the Railroad; primarily citrus landuse in the west overbank; nursery and transition landuse in the east overbank
Sub-reach 4 (Structure 9)	Camulos Street west branch (Station 64+28) ~ US study limit Real (west branch) (Station 92+75)	Trapezoidal and rectangular concrete channel with evidence of erosion and high velocity flow; primarily citrus landuse in the west overbank; nursery and transition landuse in the east overbank
Sub-reach 5 (Structures 10 and 11)	the Railroad (Station 00+37) ~ Camulos Street Warring (east branch) (Station 24+07)	Rectangular concrete channel with evidence of erosion and high velocity flow; citrus and residential in east overbank; nursery and transition landuse in west overbank
Sub-reach 6 (Structure 12)	Camulos Street (Station 24+48) ~ Center Street Warring (east branch) (Station 32+52)	Grouted concrete trapezoid channel ~100' upstream of Camulos Street to the next drop structure; grouted boulder toe on the east and west banks downstream of Camulos Street; large drop at the downstream end of the Center Street crossing; citrus and residential in east overbank; nursery and transition landuse in west overbank
Sub-reach 7 (No structures)	Center Street east branch (Station 33+19) ~ Upstream of Center Street Warring (east branch) (Station 45+19)	Concrete rectangular channel; primarily citrus landuse

38.4 Manning's Roughness Coefficients

Manning's roughness values for the Real/Warring Canyon sub-reaches are summarized in Table 38-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 38-3
Manning's Roughness Values along Real/Warring Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	Santa Clara River confluence (Station 10+08) ~ Howe Road (Station 28+70)	0.075	0.015	0.075
Sub-reach 2 (Structures 2 to 7)	Howe Road (Station 29+17) ~ the Railroad (Station 55+79)	0.075	0.015	0.075
Sub-reach 3 (Structure 8)	The Railroad (Station 56+52)~ Camulos Street Real (west branch) (Station 63+87)	0.070	0.030	0.070
Sub-reach 4 (Structure 9)	Camulos Street west branch (Station 64+28) ~ US study limit Real (west branch) (Station 92+75)	0.070	0.015	0.070
Sub-reach 5 (Structures 10 and 11)	the Railroad (Station 00+37) ~ Camulos Street Warring (east branch) (Station 24+07)	0.130	0.015	0.070
Sub-reach 6 (Structure 12)	Camulos Street (Station 24+48) ~ Center Street Warring (east ranch) (Station 32+52)	0.130	0.035	0.070
Sub-reach 7 (No structures)	Center Street east branch (Station 33+19) ~ Upstream of Center Street Warring (east branch) (Station 45+19)	0.070	0.015	0.070

38.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Real/Warring Canyon (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 38-1. The peak discharge rates associated with these locations are summarized in Table 38-4.

Table 38-4
Hydrologic Concentration Points along Real/Warring Canyon (cfs)

Tributary	River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Real Canyon (west)	53+65	25	82	149	275	405	569	765	1,111
Real Canyon (west)	0	128	426	776	1,433	2,105	2,960	3,981	5,778
Warring Canyon (east)	37	105	348	634	1,171	1,721	2,420	3,255	4,724

38.6 Hydraulic Model

The Real/Warring Canyon hydraulic model was developed with two tributaries (East and West) and 253 cross-sections to represent the varying channel geometry and hydraulic structures along the study reach. The modeled channel contains twelve bridges/culverts (see Table 38-1), and ten overflow reaches.

38.6.1 Channel Improvements

Channel improvements were added to Real/Warring Canyon based on as-built drawings. The improved reach extends from the confluence with Santa Clara River to upstream of the Railroad crossing on the west branch, and further upstream on the west branch between Center Street and the upstream study limit. An improved reach on the east branch extends from the Railroad crossing to downstream of Camulos Street. (references: County of Ventura Department of Public Works Ventura County Flood Control District. *Real Wash Debris Dam and Channel from Center Street 1684 feet Northerly* (Ventura County Public Works, 1983). County of Ventura Department of Public Works Ventura County Flood Control District. *Real-Warring Channel Improvements from Santa Clara River to 300 feet North of S.P.R.R.* (Ventura County Public Works, 1973).

The improved channel and culverts on the west branch have approximately 25-year flood capacity. The improved channel and culverts on the east branch have approximately 10-year flood capacity.

38.6.2 Overflow Reaches

Ten different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. The different overflow reaches for Real/Warring Canyon are summarized in Table 38-5.

Table 38-5
Overflow Reaches for Real/Warring Canyon

Overflow River	Reach	Description of location
HWY 126 Under Pass	1	Underpass for flow along the North side of Highway 126 to cross the highway and travel south towards Santa Clara River
RealEastLeftSplit	1	Upstream of Camulos Street crossing on the left overbank of the East branch, conveys flows South across the railroad towards Highway 126 where it reconnects to the main channel
RealEastRightSplit	1,2	Upstream of Camulos Street crossing on the right overbank of the East branch, conveys flows adjacent to the main channel and reconnects upstream of the Railroad crossing
RealWestLeftSpt	1	Overflow on the left overbank due to limited channel conveyance starting at Sta. 74+99 on West branch, conveys flows towards East branch
RealWestRght	1	Overflow on the right overbank due to limited channel conveyance starting at Sta. 72+59 on West branch, conveys flows parallel to the main channel and reconnects upstream of Camulos Road crossing
RealWestRghtSpt1	1,2A,2B,3,4,5	Upstream of Pacific Avenue crossing on the right overbank, conveys flows southwest, along Highway 126, and under highway towards Santa Clara River
RealWestRghtSpt2	1	Upstream of Unnamed Crossing 23F on the right overbank, conveys flows southwest and connects with RealWestRightSplit1
RightofHWY 1	1	Overflow from HWY126UnderPass overflow river due to channel capacity limitations and perched conditions, connects with RealWestRghtSpt1
RightofHWY 2	1	Overflow from HWY126UnderPass overflow river due to channel capacity limitations and perched conditions, connects with RealWestRghtSpt1
RightofHWY 3	1	Overflow from HWY126UnderPass overflow river due to channel capacity limitations and perched conditions, connects with RealWestRghtSpt1

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 38-6.

Table 38-6
Maximum Flows for the Real/Warring Canyon Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
HWY126UnderPass	1	30	30	30	494	1,125	1,854	3,047	3,979
RealEastLeftSplit	1	0	0	25	84	204	429	747	1,415
RealEastRightSplit	1	0	0	25	84	188	349	571	1,066
RealEastRightSplit	2	0	0	25	84	204	429	747	1,415
RealWestLeftSpt	1	0	0	0	323	718	1,352	2,492	3,302
RealWestRght	1	0	0	0	10	16	43	87	174
RealWestRghtSpt1	1	0	0	0	482	1,101	1,951	1,975	4,748
RealWestRghtSpt1	2A	0	0	0	484	1,128	1,948	3,399	4,738
RealWestRghtSpt1	2B	0	0	0	0	13	105	362	768
RealWestRghtSpt1	3	0	0	0	1	27	146	454	866
RealWestRghtSpt1	4	0	0	0	450	1,054	1,964	3,398	3,148
RealWestRghtSpt1	5	0	0	0	440	1,048	1,970	3,397	4,180
RealWestRghtSpt2	1	0	0	0	398	606	753	1,434	1,249
RightofHWY 1	1	0	0	0	10	10	10	10	47
RightofHWY 2	1	0	0	0	450	995	1,864	3,046	2,348
RightofHWY 3	1	0	0	0	9	60	21	9	1,047

38.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections of both branches (Real Canyon - Stations 92+75 and 90+13, Warring Canyon – Stations 45+19 and 42+94) and the two downstream-most cross-sections of Real Canyon (Stations 10+36 and 10+08) in the hydraulic model. Computed boundary condition slopes are 0.052 (Real Canyon) and 0.05 (Warring Canyon) at the upstream ends of these branches, and 0.007 at the downstream end of Real Canyon. A junction was used to join Warring Canyon to Real Canyon.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction was not used). The boundary condition slopes used for the different overflow reaches is summarized in Table 38-7.

Table 38-7
Boundary Condition Slopes for the Overflow Reaches of Real/Warring Canyon

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
HWY126UnderPass	1	Junction return	0.011
RealEastLeftSplit	1	0.039	Junction return
RealEastRightSplit	1,2	0.039	Junction return
RealWestLeftSpt	1	0.048	Junction return
RealWestRght	1	0.046	Junction return
RealWestRghtSpt1	1,2A,2B,3,4,5	0.008	0.004
RealWestRghtSpt2	1	0.013	Junction return
RightofHWY 1	1	0.013	Junction return
RightofHWY 2	1	0.01	Junction return
RightofHWY 3	1	0.007	Junction return

38.8 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 38-2. Major flooded areas along Real/Warring Canyon are summarized for the 100-year and 500-year flood events in Table 38-8.

Table 38-8
Major Flooding along Real/Warring Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	Santa Clara River confluence (Station 10+08) ~ Howe Road (Station 28+70)	Flooding is contained in the main channel	Flooding is contained in the main channel
Sub-reach 2 (Structures 2 to 7)	Howe Road (Station 29+17) ~ the Railroad (Station 55+79)	Flooding occurs in the far right overbank area due to overtopping at Highway 126. The overbank flow continues flow southwest towards Hooper Canyon	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 3 (Structure 8)	The Railroad (Station 56+52)~ Camulos Street Real (west branch) (Station 63+87)	Flooding extends into the left overbank and continues towards the East Branch. The flooded areas include farmland and detention ponds	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 4 (Structure 9)	Camulos Street west branch (Station 64+28) ~ US study limit Real (west branch) (Station 92+75)	Flooding is contained in the main channel until Sta. 74+99 where flooding extends into the right overbank area but reconnects upstream of Camulos Street. The flooded areas include open space	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 5 (Structures 10 and 11)	the Railroad (Station 00+37) ~ Camulos Street Warring (east branch) (Station 24+07)	Flooding extends into the left and right overbank areas. The left overbank flooding continues across the railroad to Highway 126, where the right overbank flooding continues to the confluence with the East and West Branch	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 6 (Structure 12)	Camulos Street (Station 24+48) ~ Center Street Warring (east branch) (Station 32+52)	Flooding extends into the left and right overbank areas upstream of Camulos Street. Flooded areas include open space	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 7(No structures)	Center Street east branch (Station 33+19) ~ Upstream of Center Street Warring (east branch) (Station 45+19)	Flooding extends into the left and right overbank areas upstream of Center Street. Flooded areas include open space	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks

38.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The channel bed slope along Real Canyon (west branch) ranges from four percent upstream to 0.8 percent downstream. The channel bed slope on Warring Canyon (east branch) ranges between four percent upstream to one percent downstream. Conveyance structures that are significant conveyance obstructions along Real Canyon include Center Street, Camulos Street, Railroad crossing, Highway 126, Pacific Avenue, Unnamed Crossing 23F, 23E and 23D. The predominant flow regime for the model was supercritical.

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Figure 38-1: Real Canyon Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

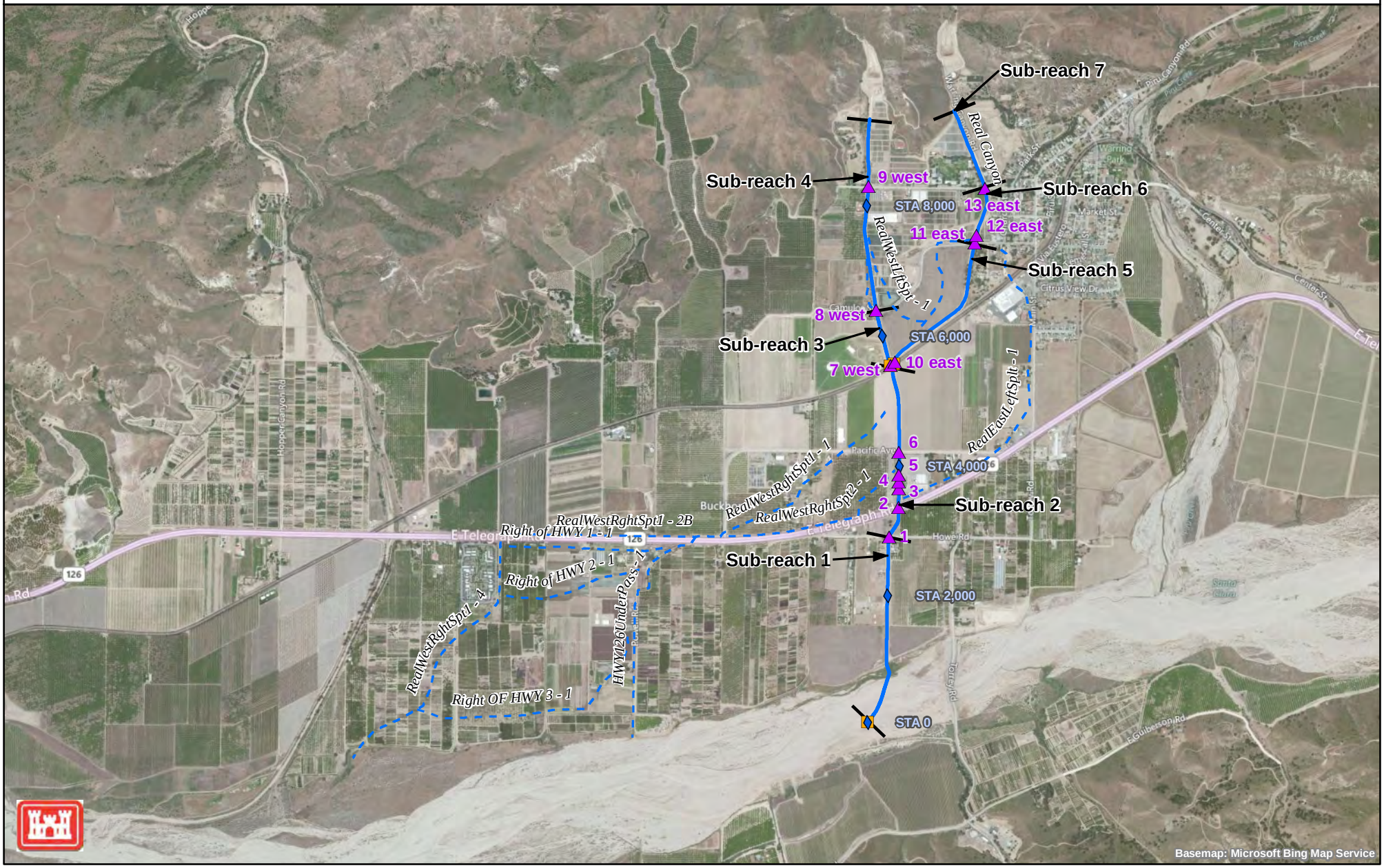

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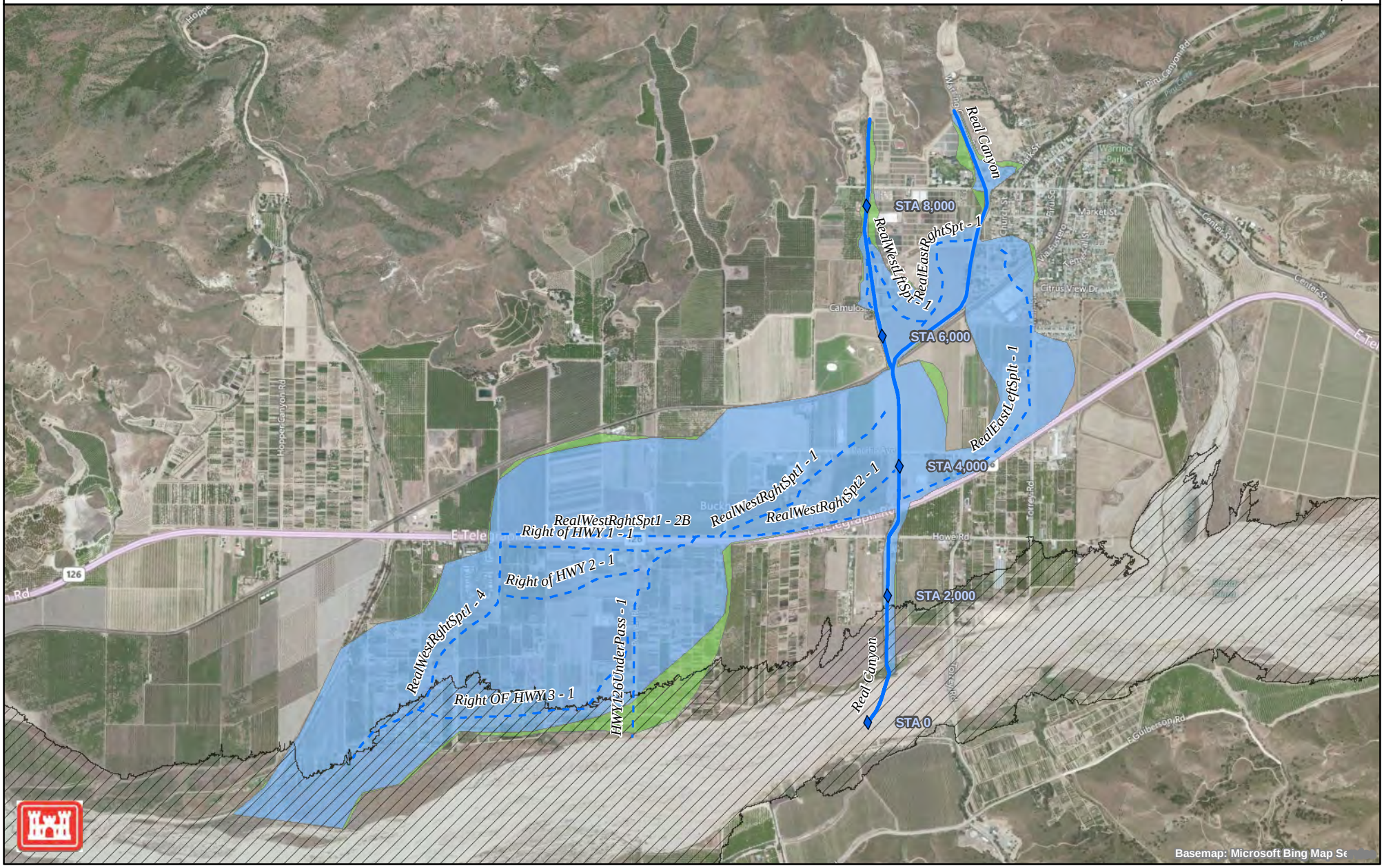
Figure 38-2: Real Canyon Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



Section 39
Hopper Canyon

39.1 General Description

Hopper Canyon is a FEMA study reach that joins the Santa Clara River from the south, between the locations where Real/Warring Canyon and Fairview Road Drain join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Hopper Canyon. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

39.2 Hydraulic Model

FEMA developed the hydraulic model extending approximately three miles from the upstream limits to the confluence with the Santa Clara River (see Figure 39-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

39.3 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 39-2. Major flooded areas along Hopper Canyon are summarized for the 100-year and 50-year flood events in Table 39-1.

Table 39-1
Major Flooding along Hopper Canyon

Sub-Reach	100-year	500-year
DS study limit (Station 32+80) ~ US study limit (Station 151+04)	Flooding is contained in the main channel until Sta. 115+63, where the floodplain extends into the left and right overbank areas continuously until the confluence with the Santa Clara River	Same as the 100-year extent with additional flooding on the left and right overbanks

39.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slopes ranges from 1.5 percent upstream to 0.7 percent near the confluence with Santa Clara River. The Railroad crossing is a significant obstruction for all discharge frequencies examined. The predominant flow regime is subcritical.

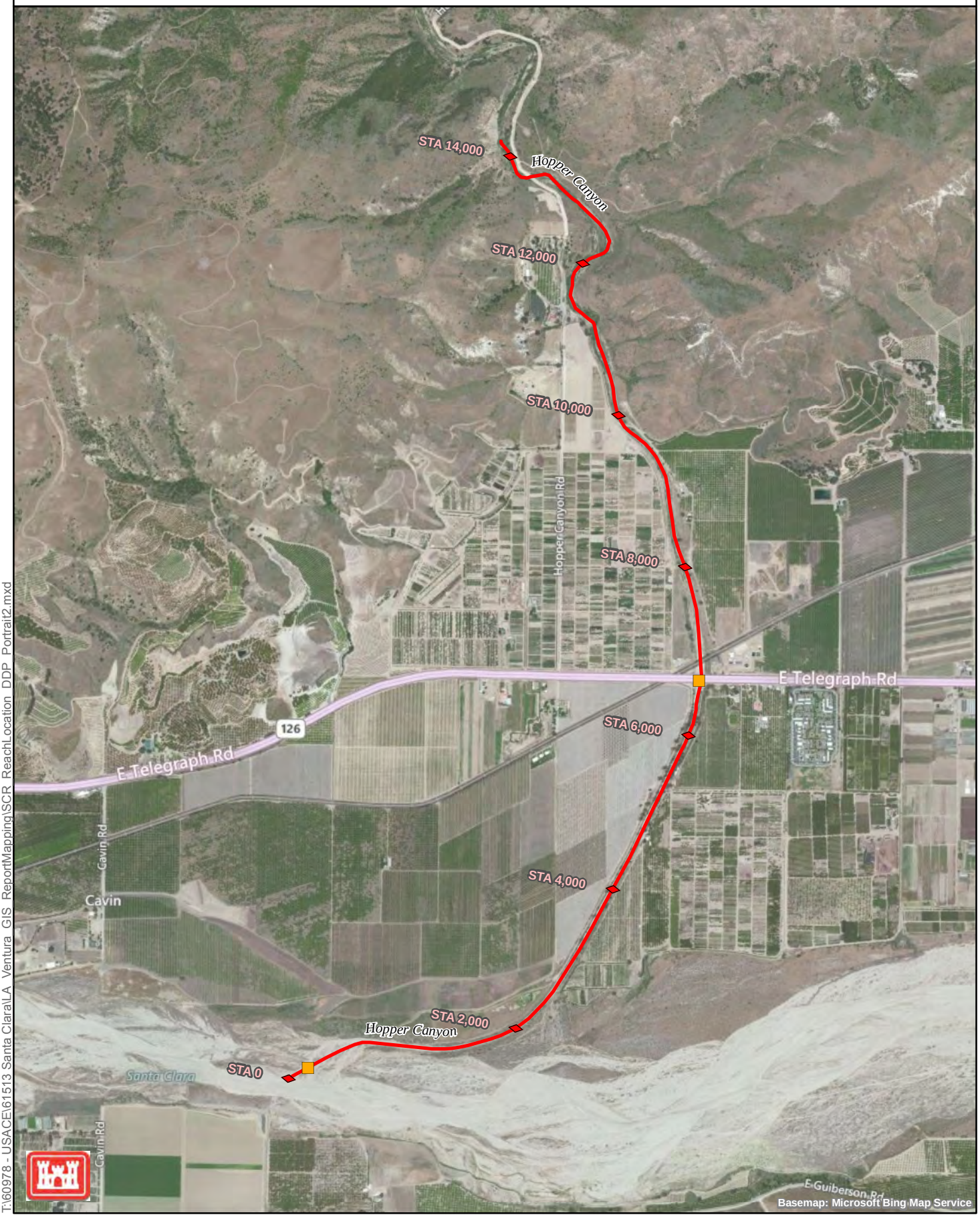
Figure 39-1: Hopper Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach



Basemap: Microsoft Bing Map Service

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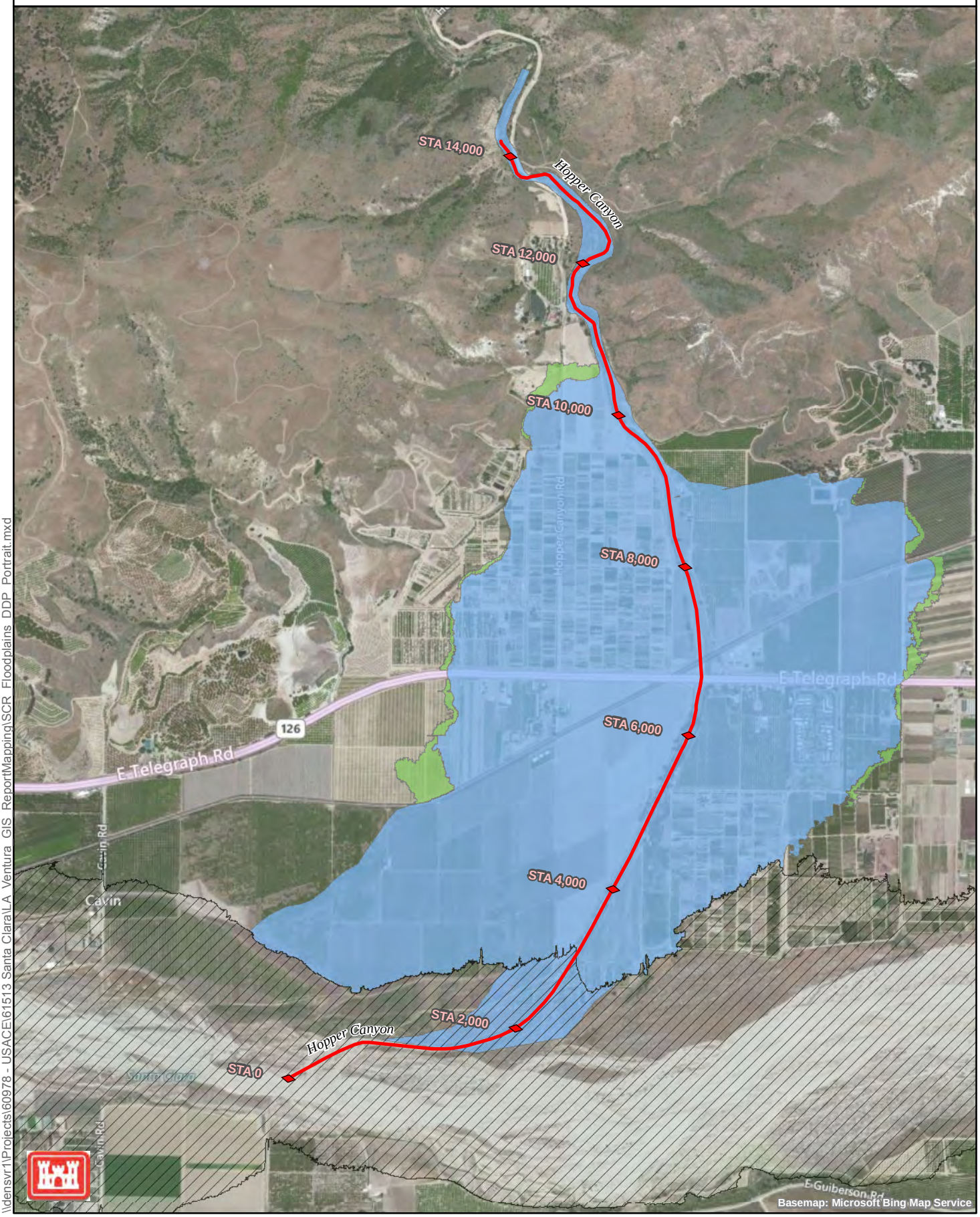
Figure 39-2: Hopper Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 40
Fairview Road Drain

40.1 General Description

Fairview Road Drain is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Fairview Road Drain are described in this section.

Fairview Road Drain joins the Santa Clara River from the north, located between Pole Creek and Calvin Road Drain. The study reach extends along 0.8 miles, from upstream of Highway 126 to the confluence with the Santa Clara River. Figure 40-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

40.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures along the study reach is summarized in Table 40-1.

Table 40-1
Structures along Fairview Road Drain (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	12+80	Unnamed Access Road 21A	Circular Culvert	4' diameter culvert ~ 10' downstream of the railroad bridge with some sedimentation; 44" from invert to top of culvert for conveyance
2	13+20	Railroad bridge	Span Bridge	13'x7' steel and concrete span bridge with vertical timber abutments
3	30+70	Highway 126	Circular culvert	6' diameter circular concrete culvert
4	34+20	Unnamed Access Road 21B	Span bridge	8'x4.5' conveyance area

Notes:
Descriptions with dimensions provide width by length;
~ denotes an approximation, crossing could not be accesses from that side.

40.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 40-2.

Table 40-2
Sub-reaches along Fairview Road Drain

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 9+04) ~ the Railroad bridge (Station 12+89)	Erodible sandy bed material; shrubs and brush along banks; wide channel; nursery in east overbank, citrus in west overbank
Sub-reach 2 (Structure 3)	The Railroad bridge (Station 13+29) ~ Highway 126 (Station 30+15)	Erodible sandy bed material; dense shrubs and brush along banks; citrus landuse in both overbanks
Sub-reach 3 (Structure 4)	Highway 126 (Station 31+45) ~Upstream of Highway 126 (Station 39+38)	Rectangular concrete channel with ~1' drops every ~10'; some sand and gravel in the bottom of the concrete channel; primarily citrus landuse in both overbanks

40.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the study reach are summarized in Table 40-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 40-3
Manning's Roughness Values along Fairview Road Drain

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 9+04) ~ the Railroad bridge (Station 12+89)	0.060	0.035	0.065
Sub-reach 2 (Structure 3)	The Railroad bridge (Station 13+29) ~ Highway 126 (Station 30+15)	0.065	0.040	0.065
Sub-reach 3 (Structure 4)	Highway 126 (Station 31+45) ~Upstream of Highway 126 (Station 39+38)	0.065	0.015	0.065

40.5 Hydrology

One hydrologic concentration point was provided along the Fairview Road Drain study reach. The location of this hydrologic concentration point is shown in Figure 40-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 40-4.

Table 40-4
Hydrologic Concentration Point for Fairview Road Drain (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	58	192	348	644	946	1,330	1,789	2,596

40.6 Hydraulic Model

The Fairview Road Drain hydraulic model was developed with 160 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains four bridges/culverts (see Table 40-1), and four overflow reaches.

40.6.1 Overflow Reaches

Four different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbank along of the study reach. The different overflow reaches for Fairview Road Drain are summarized in Table 40-5.

Table 40-5
Overflow Reaches for Fairview Road Drain

Overflow River	Reach	Description of location
LeftSplit	1	Overflow from the left overbank upstream and downstream of Highway 126, flows south towards the Santa Clara River
RightSplitUS	1,2	Upstream of Railroad crossing on the right overbank, to convey flow along the north side of the Railroad crossing
RightSplit2	1	Overflow from RightSplitUS river on the right, flows southwest and reconnects with RightSplitUS
RightSplit1	1	Downstream of Railroad crossing on the right overbank to convey overflow from the main channel and RightSplitUS (Railroad ditch overflow)

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 40-6.

Table 40-6
Maximum Flows in Fairview Road Drain Overflow Reaches (cfs)

River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
LeftSplit	1	0	0	0	20	22	89	239	467
RightSplitUS	1	0	0	0	0	170	370	549	820
RightSplitUS	2	0	0	0	0	170	370	549	913
RightSplit2	1	0	0	0	0	0	0	0	95
RightSplit1	1	0	0	0	0	170	403	641	1,103

40.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 39+38 and 37+50) and the two downstream-most cross-sections (Station 9+28 and 9+04) in the hydraulic model. Computed boundary condition slopes are 0.05 and 0.056 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction return was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 40-7.

Table 40-7
Boundary Condition slopes for the overflow reaches of Fairview Road Drain

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
LeftSplit	1	0.077	0.001
RightSplit	1	0.056	0.001
RightSplit2	1	0.06	Junction return
RightSplit2	1,2	0.05	0.004

40.8 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 40-2. Major flooded areas along Fairview Road Drain are summarized for the 100-year and 500-year flood events in Table 40-8.

Table 40-8
Major Flooding along Fairview Road Drain

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 9+04) ~ the Railroad bridge (Station 12+89)	Flooding extends into the left and right overbanks continuously until draining to the Santa Clara River. Additional flow continues to flow along the north ditch of the Railroad	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structure 3)	The Railroad bridge (Station 13+29) ~ Highway 126 (Station 30+15)	Flooding extends into the left and right overbanks continuously until draining to the Santa Clara River	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 3 (Structure 4)	Highway 126 (Station 31+45) ~Upstream of Highway 126 (Station 39+38)	Flooding is contained in the main channel except upstream of Highway 126 flooding extends into the left and right overbanks	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks

40.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope of the study reach is approximately five percent. Structures that limit the flood conveyance capacity of Fairview Road Drain include Highway 126, the Railroad crossing, and Unnamed Dirt Road (#1). The predominant flow regime for the channel was supercritical.

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Figure 40-1: Fairview Road Drain Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

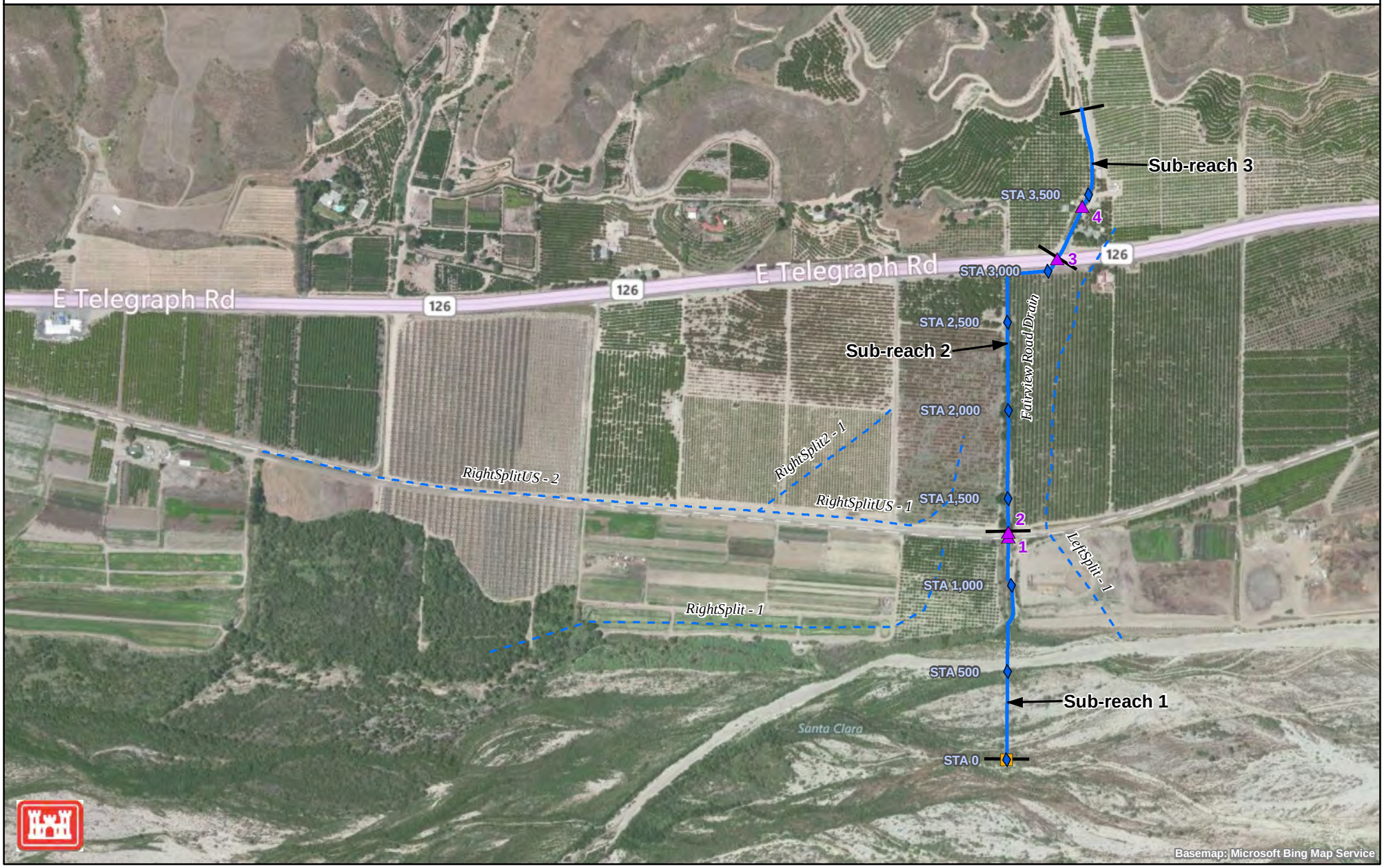

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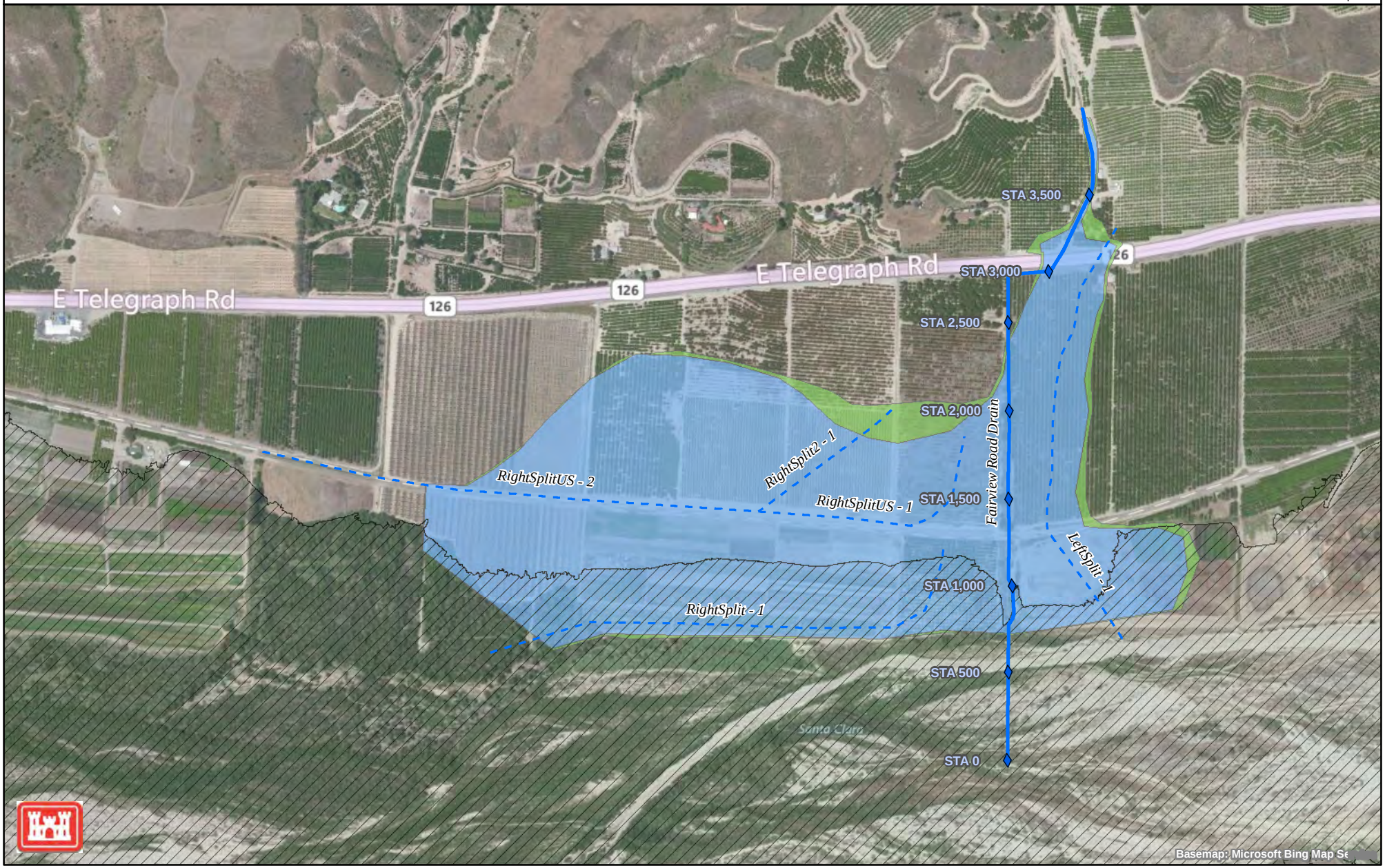
Figure 40-2: Fairview Road Drain Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 750 1,500 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 41
Basolo Ditch

41.1 General Description

Basolo Ditch is a FEMA study reach that joins the Santa Clara River from the south, between the locations where Fairview Road Drain and Pole Creek join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Basolo Ditch. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

41.2 Hydraulic Model

FEMA developed the hydraulic of the study reach, which begins at the confluence with the Santa Clara River and extends approximately one mile upstream (see Figure 41-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

41.3 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 41-2**.** Major flooded areas along Basolo Ditch are summarized for the 100-year and 500-year flood events in Table 41-1.

Table 41-1
Major Flooding along Basolo Ditch

Sub-Reach	100-year	500-year
DS study limit (Station 10+23) ~ US study limit (Station 34+63)	Flooding is contained in the main channel until West Guiberson Road where the floodplain extends into the left and right overbank areas. The flooded areas include a farm and farmland	Same as the 100-year extent with additional flooding on the left and right overbanks

41.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from two percent upstream to 0.1 percent near the confluence with Santa Clara River. Channel capacity limitations are evident along the study reach. The predominant flow regime is subcritical.

Figure 41-1: Basolo Ditch Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 750 1,500
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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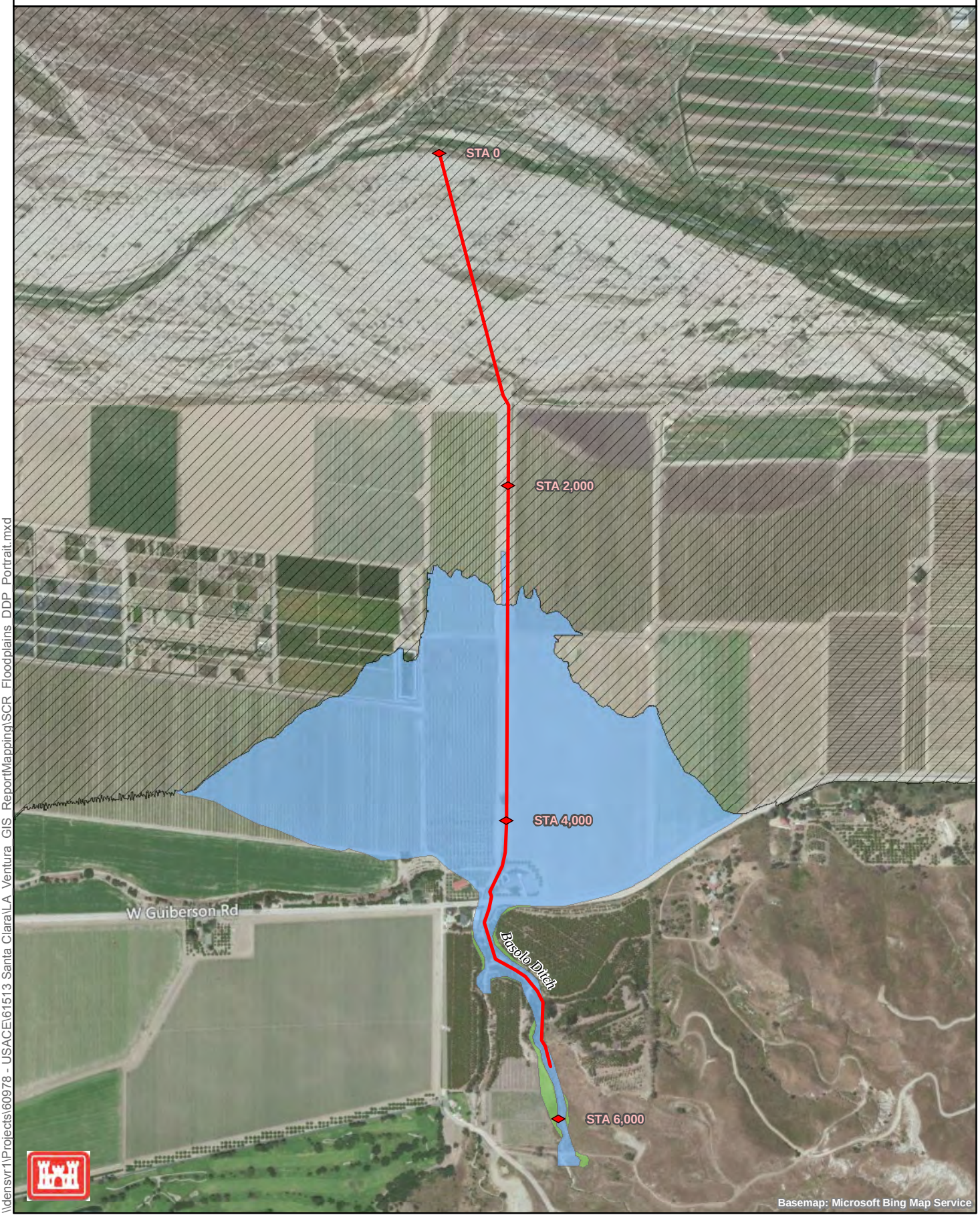
Figure 41-2: Basolo Ditch Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 750 1,500
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 42
Pole Creek

42.1 General Description

Pole Creek is a FEMA study reach that joins the Santa Clara River from the north, between the locations where Basolo Ditch and Grimes Canyon Wash join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Pole Creek. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

42.2 Hydraulic Model

FEMA developed the hydraulic model of the study reach, which begins at the confluence with the Santa Clara River and extends upstream approximately two miles (see Figure 42-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

42.3 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 42-2. Major flooded areas along Pole Creek are summarized for the 100-year and 500-year flood events in Table 42-1.

Table 42-1
Major Flooding along Pole Creek

Sub-Reach	100-year	500-year
DS study limit (Station 14+06) ~ US study limit (Station 107+99)	Flooding is contained in the main channel until Sta. 80+00, where the floodplain extends into the left overbank. Additionally, upstream of Highway 126 the floodplain extends into the left and right overbank areas continuously until the confluence with the Santa Clara River	Same as the 100-year extent with additional flooding on the left and right overbanks especially between Sta. 50+00 to Sta. 80+00

42.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from three percent upstream to 0.7 percent near the confluence with Santa Clara River. Channel capacity limitations are evident along the study reach. The Highway 126 crossing is a significant obstruction. The predominant flow regime is subcritical.

Figure 42-1: Pole Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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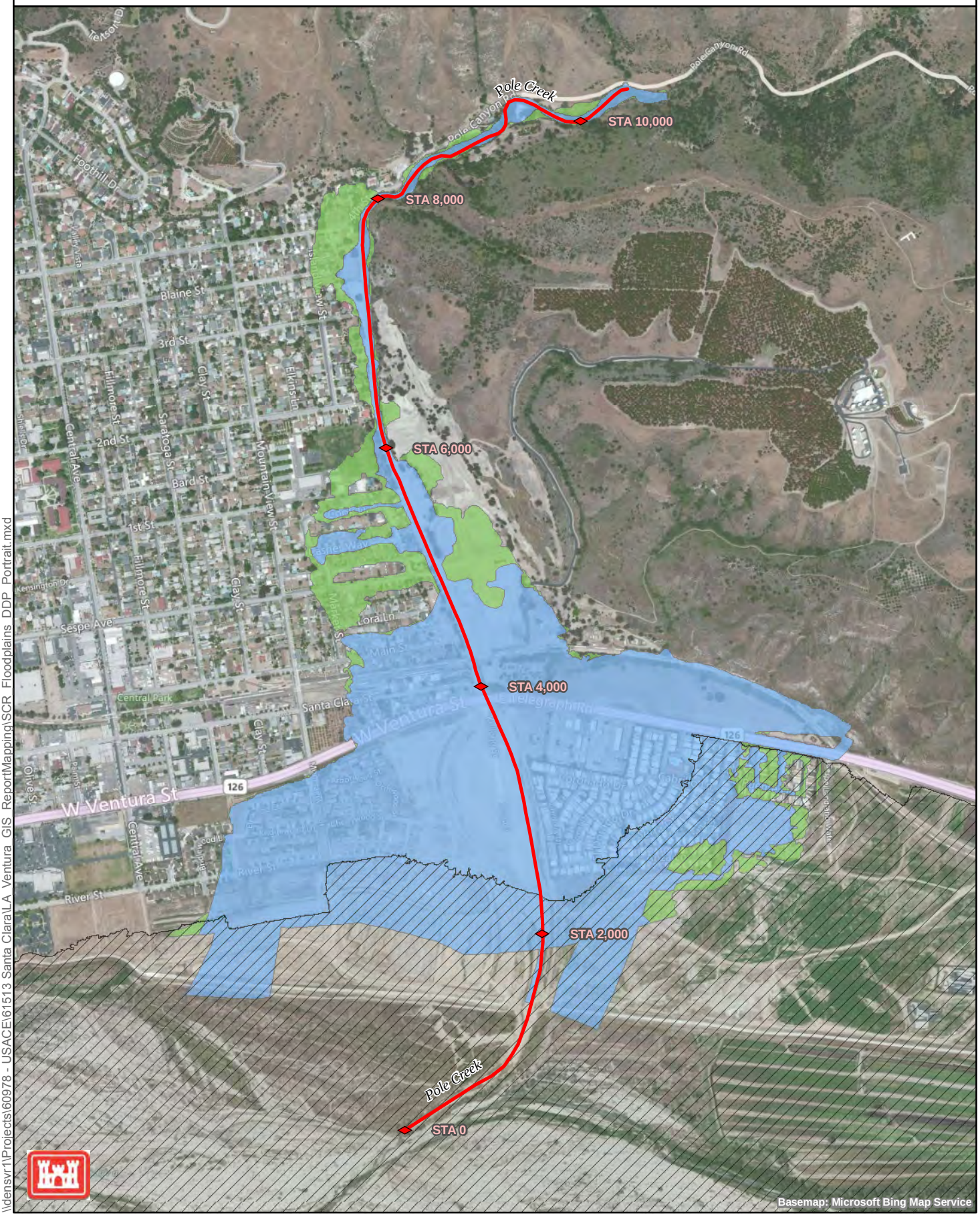
Figure 42-2: Pole Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 43
Grimes Canyon Wash

43.1 General Description

Grimes Canyon Wash is a FEMA study reach that joins the Santa Clara River from the south, between the locations where Pole Creek and Sespe Creek join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Grimes Canyon Wash. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

43.2 Hydraulic Model

FEMA developed the hydraulic model of the study reach, which begins at the confluence with the Santa Clara River and extends upstream approximately two miles (see Figure 43-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

43.3 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 43-2. Major flooded areas along Grimes Canyon Wash are summarized for the 100-year and 500-year flood events in Table 43-1.

Table 43-1
Major Flooding along Grimes Canyon Wash

Sub-Reach	100-year	500-year
DS study limit (Station 40+19) ~ US study limit (Station 112+88)	Flooding extends into the left and right overbank areas continuously until the confluence with the Santa Clara River	Same as the 100-year extent with additional flooding on the left and right overbanks

43.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from 2.4 percent upstream to 0.7 percent near the confluence with Santa Clara River. Channel capacity limitations are evident along the study reach. The predominant flow regime is subcritical.

Figure 43-1: Grimes Canyon Wash Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 43-2: Grimes Canyon Wash Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Basemap: Microsoft Bing Map Service

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Section 44
Sespe Creek

44.1 General Description

Sespe Creek is a FEMA study reach that joins the Santa Clara River from the north, between the locations where Grimes Canyon Wash and Bear Creek join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Sespe Creek. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

44.2 Hydraulic Model

FEMA developed the hydraulic model of the study reach, which begins at the confluence with the Santa Clara River and extends upstream approximately six miles (see Figure 44-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

44.3 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 44-2. Major flooded areas along Sespe Creek are summarized for the 100-year and 500-year flood events in Table 44-1.

Table 44-1
Major Flooding along Sespe Creek

Sub-Reach	100-year	500-year
DS study limit (Station 18+77) ~ US study limit (Station 332+72)	Flooding extends into the left and right overbank areas continuously until the confluence with the Santa Clara River. The flooded areas include farmland, industrial, commercial and residential property	Same as the 100-year extent with additional flooding on the left and right overbanks

44.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from one percent upstream to 0.65 percent near the confluence with Santa Clara River. Channel capacity limitations are evident along the study reach. Highway 126, the Old Telegraph Road and the Railroad crossing are obstructions during the 500-year flooding conditions. The predominant flow regime is subcritical.

Figure 44-1: Sespe Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 4,000 8,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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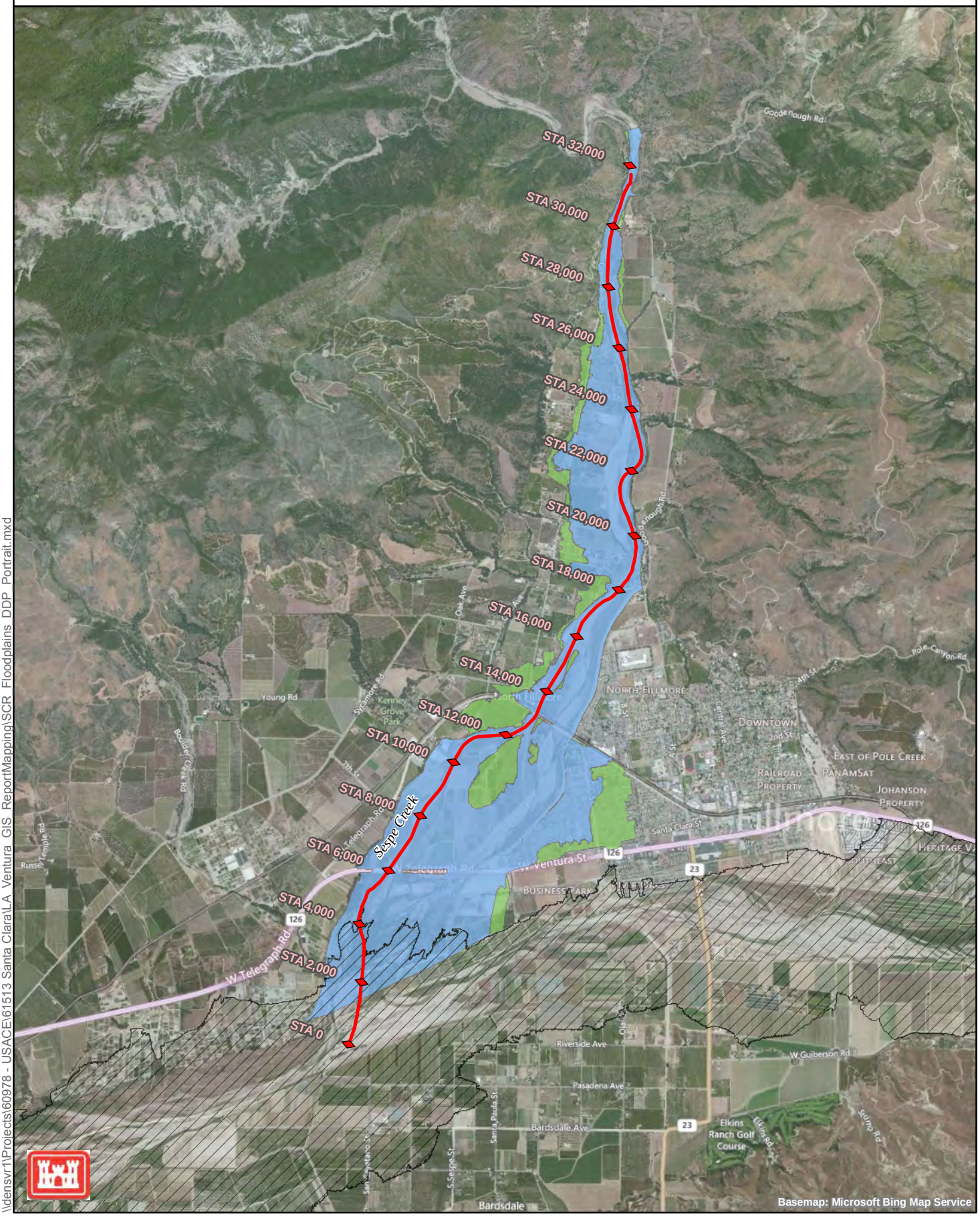
Figure 44-2: Sespe Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 4,000 8,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 45
Bear Creek

45.1 General Description

Bear Creek is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Bear Creek are described in this section.

Bear Creek joins the Santa Clara River from the north, located between O'Leary Creek and Balcom Canyon Wash. The study reach begins at the confluence with the Santa Clara River and extends 2.4 miles upstream. Figure 45-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural. Major crossings over Bear Creek include the Railroad crossing and Highway 126.

45.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in September 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and drop structures along the study reach is summarized in Table 45-1.

Table 45-1
Structures along Bear Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	30+60	Pyle Road (Valley Crest Tree Company)	Span bridge	Flatcar crossing south of Highway 126; 28'x4' conveyance area; deck thickness transitions from 1.5' to 2.5'
2	39+40	Highway 126	Rectangular culvert	7'x4' rectangular concrete culvert; very steep transition into culvert, larger opening upstream than downstream; could not access the upstream end of the culvert for measurement
3	58+60	Railroad Bridge	Pier bridge	Severe scour through the bridge; 5 wood piers, 1.5' thick, refer to Appendix B19 for a sketch of the bridge
4	77+90	Sycamore	Span bridge	14'x6'; ¼ of the conveyance area is blocked by sediment

Notes: Descriptions with dimensions provide width by length.

45.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 45-2.

Table 45-2
Sub-reaches along Bear Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 17+56) ~ Highway 126 (Station 38+45)	Tree farm land use with shrubs and small trees along the banks; sand and cobble bed material; rock and wire gabions protecting banks along extending ~75' downstream of the Highway 126 crossing; landuse is primarily nursery
Sub-reach 2 (Structure 3)	Highway 126 (Station 40+22) ~ Railroad Bridge (Station 58+24)	Dense vegetation (small trees and shrubs); sand and cobble bed material; upstream of the Railroad bridge there is a concrete apron that has been eroded, there is a scoured-out low flow channel through the bridge; landuse is primarily citrus and avocado
Sub-reach 3 (Structure 4)	Railroad Bridge (Station 59+37) ~ Sycamore Road (Station 77+68)	Dense vegetation (small trees and shrubs); sand, cobble, and boulders, erodible sandy bed material; trapezoid channel downstream of the Sycamore crossing; landuse is primarily citrus and avocado
Sub-reach 4 (No structures)	Sycamore Road (Station 78+56) ~ Upstream Study limit (Station 126+05)	Dense vegetation (small trees and shrubs); sand, cobble, and boulders, erodible sandy bed material; severe scour upstream of the Sycamore crossing with nearly vertical banks; landuse is primarily citrus and avocado

45.4 Manning's Roughness Coefficients

The Manning's roughness values for Bear Creek sub-reaches are summarized in Table 45-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 45-3
Manning's Roughness Values along Bear Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 17+56) ~ Highway 126 (Station 38+45)	0.060	0.055	0.060
Sub-reach 2 (Structure 3)	Highway 126 (Station 40+22) ~ Railroad Bridge (Station58+24)	0.075	0.060	0.065
Sub-reach 3 (Structure 4)	Railroad Bridge (Station 59+37) ~ Sycamore Road (Station 77+68)	0.065	0.055	0.065
Sub-reach 4 (No structures)	Sycamore Road (Station 78+56) ~ Upstream Study limit (Station 126+05)	0.065	0.050	0.065

45.5 Hydrology

Two hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 45-1. The peak discharge rates associated with these locations are summarized in Table 45-4.

Table 45-4
Hydrologic Concentration Points along Bear Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
45+40	84	281	511	944	1,386	1,950	2,623	3,806
0	131	436	794	1,467	2,154	3,030	4,075	5,915

45.6 Hydraulic Model

The Bear Creek hydraulic model was developed with 160 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled reach contains four bridges/culverts (see Table 45-1), and three overflow reaches.

45.6.1 Overflow Reaches

Three different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbanks along the study reach. The overflow reaches for Bear Creek are summarized in Table 45-5.

Table 45-5
Overflow Reaches for Bear Creek

Overflow River	Reach	Description of location
BearLft	LeftSplit	Upstream of Highway 126 on the left overbank, flows southeast in a semi-circle back towards the main channel near SCR, based on existing contours
BearLft2	LeftSplit, LeftSplitDS	Downstream of Highway 126 on the left overbank to convey overflow from the main channel south towards Santa Clara River
BearRght	RightSplit	Downstream of Highway 126 on the right overbank to convey overflow from the main channel southwest into the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 45-6.

Table 45-6
Maximum Flows in Bear Creek Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
BearLft	LeftSplit	0	0	0	0	10	41	101	237
BearLft2	LeftSplit	89	207	356	613	940	1,488	2,045	2,802
BearLft2	LeftSplitDS	89	207	356	614	948	1,527	2,144	3,038
BearRght	RightSplit	53	221	517	876	1,241	1,796	2,094	2,819

45.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 126+05 and 125+24) and the two downstream-most cross-sections (Station 18+49 and 17+56) in the hydraulic model. Computed boundary condition slopes are 0.09 and 0.01 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction return was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 45-7.

Table 45-7
Boundary Condition Slopes for the Overflow Reaches of Bear Creek

Overflow River	Reach	Upstream Boundary Slopes	Downstream Boundary Slopes
BearLft	LeftSplit	0.02	Junction return
BearLft2	LeftSplit	0.03	Junction return
BearLft2	LeftSplitDS	Junction return	0.001
BearRght	RightSplit	0.02	0.005

45.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 45-2. Major flooded areas along Bear Creek are summarized for the 100-year and 500-year flood events in Table 45-8.

Table 45-8
Major Flooding along Bear Creek

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 17+56) ~ Highway 126 (Station 38+45)	Flooding extends into the left and right overbanks upstream and downstream of Highway 126. The flooding spreads into the overbank areas until draining to the Santa Clara River	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structure 3)	Highway 126 (Station 40+22) ~ Railroad Bridge (Station 58+24)	Flooding is contained in the main channel except upstream of Highway 126. The flooded areas are farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 3 (Structure 4)	Railroad Bridge (Station 59+37) ~ Sycamore Road (Station 77+68)	Flooding is contained in the main channel except between Sta. 77+68 to Sta. 59+55. The flooded areas are farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 4 (No structures)	Sycamore Road (Station 78+56) ~ Upstream Study limit (Station 126+05)	Flooding is contained in the main channel except between Sta. 86+45 to Sta. 78+56. The flooded areas are farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks

45.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average slope of the channel bottom ranges from eight percent upstream to one percent downstream. Bear Creek has minimal channel capacity downstream of Highway 126 and limited crossing conveyance at Highway 126 and Plye Road. The predominant flow regime for the channel was supercritical.

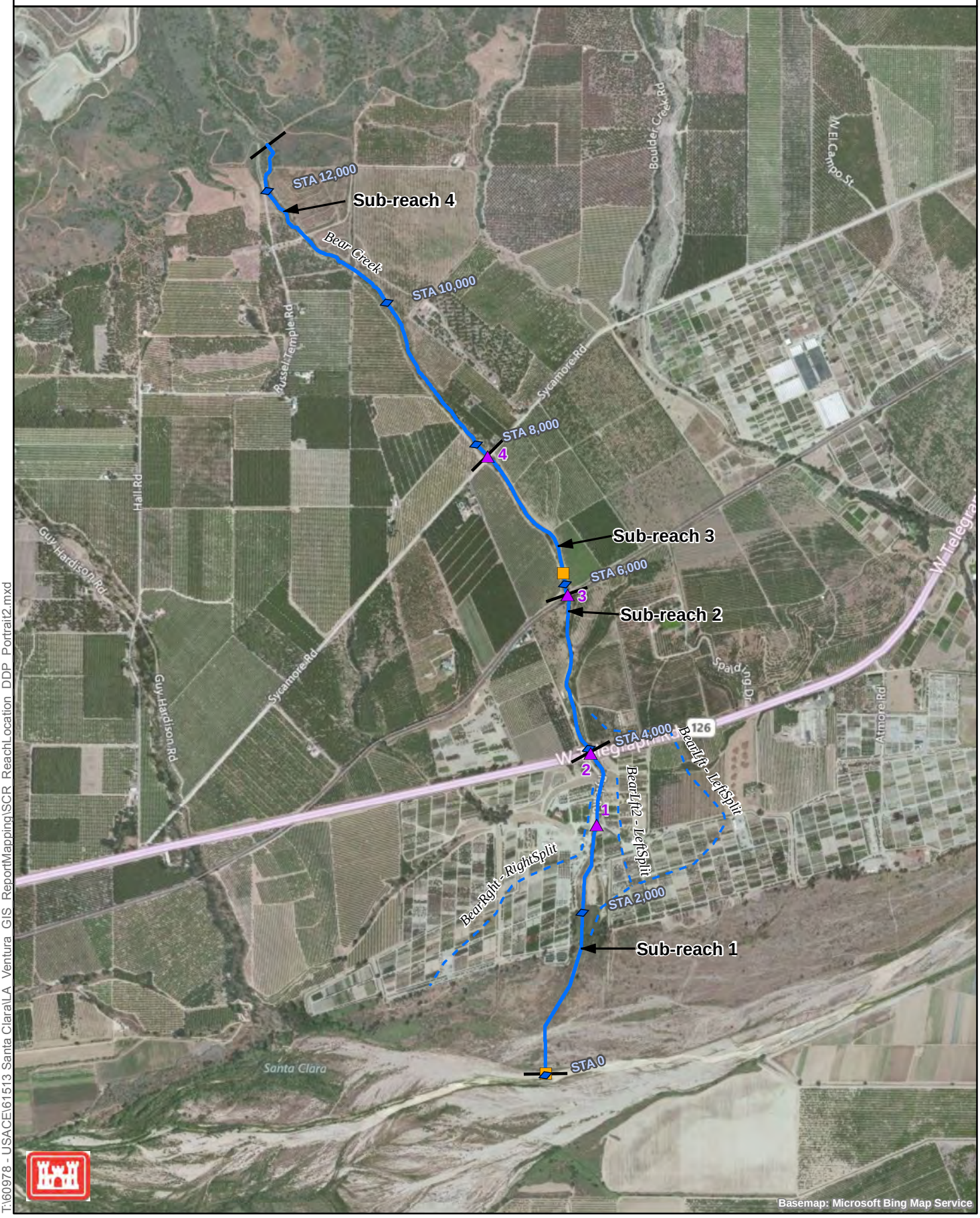
Figure 45-1: Bear Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach



Basemap: Microsoft Bing Map Service

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Figure 45-2: Bear Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 46
Reimer Ditch

46.1 General Description

Reimer Ditch is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Reimer Ditch are described in this section.

Reimer Ditch joins the Santa Clara River from the south, between the locations where O'Leary Creek and Bear Creek join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 2.9 miles upstream. Figure 46-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use along the study reach is primarily agricultural with a few residential properties. Major crossings over Reimer Ditch include Los Angeles Avenue, California Avenue, and South Mountain Road.

46.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 46-1.

Table 46-1
Structures along Reimer Ditch (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	30+00	Service Road 18A	Rectangular Culvert	12'x5' rectangular concrete culvert
2	53+00	Service Road 18B	Span bridge	9'x 4' steel and concrete span bridge; tributary enters on the west side upstream of this crossing
3	79+00	Los Angeles Road	Rectangular culvert	11'x5' at the downstream end and 13'x4' at the upstream end; debris accumulation in the bottom of the channel; there is a large tributary entering on the east side upstream of Los Angeles Avenue; the wingwalls extend along the channel ~25' downstream
4	79+35	Service Road 18D	Span Bridge	7'x4.5' concrete span bridge ~20' upstream of the Los Angeles Road crossing; smooth grouted rock-lined channel upstream
5	92+00	California Avenue	Span Bridge	7'x5.5' Evidence of channel bottom concrete eroding on the upstream side of the crossing; sediment accumulation downstream of this crossing
6	97+20	North of South Mountain Road	Span Bridge	7'x5' concrete span bridge with evidence of channel bottom concrete eroding
7	102+00	South Mountain Road	Span Bridge	12'x5.5' on the downstream side and 13'x5.5' on the upstream side; sediment accumulation in the bottom of the channel on the downstream side, but no sand or sediment in the channel upstream of the crossing

Note: Descriptions with dimensions provide width by length.

46.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 46-2.

Table 46-2
Sub-reaches along Reimer Ditch

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 1+53) ~ the unnamed service road Service Road 18B (Station 52+37)	Earthen trapezoidal channel with berms along the banks; sandy erodible material; primarily citrus in overbanks
Sub-reach 2 (Structures 4 to 7)	Unnamed service road Service Road 18B (Station 53+41) ~ US study limit (Station 126+11)	The channel is primarily armored with grout and rock, and limited rock and wire gabions; primarily citrus in overbanks

46.4 Manning's Roughness Coefficients

Manning's roughness values for the Real Canyon sub-reaches are summarized in Table 46-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 46-3
Manning's Roughness Values along Reimer Ditch

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 1+53) ~ the unnamed service road Service Road 18B (Station 52+37)	0.065	0.040	0.065
Sub-reach 2 (Structures 4 to 7)	Unnamed service road Service Road 18B (Station 53+41) ~ US study limit (Station 126+11)	0.065	0.030	0.065

46.5 Hydrology

Two hydrologic concentration points were provided along the study reach of Reimer Ditch (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 46-1. The peak discharge rates associated with these locations are summarized in Table 46-4.

Table 46-4
Hydrologic Concentration Points along Reimer Ditch (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
45+40	86	287	523	966	1,418	1,995	2,683	3,894
0	190	634	1,153	2,130	3,128	4,400	5,918	8,589

46.6 Hydraulic Model

The Reimer Ditch hydraulic model was developed with 143 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains seven bridges/culverts (see Table 46-1), and three overflow reaches.

46.6.1 Overflow Reaches

Three different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbanks along of the study reach. The overflow reaches for Real Canyon are summarized in Table 46-5.

Table 46-5
Overflow Reaches for Reimer Ditch

Overflow River	Reach	Description of location
Left_OF1	1,2	Upstream of Unnamed Crossing (#7), flows in the left overbank area, parallels the main channel and joins the Santa Clara River downstream of the main channel confluence
Left_OF2	1	Upstream of the California Avenue crossing, flows between Left_OF1 and the main channel and joins the Left_OF1 further downstream
Right_OF1	1	Upstream of Service Road 18D on the right overbank, flows adjacent to the main channel and into the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 46-6.

Table 46-6
Maximum Flows in Reimer Ditch Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Left_OF1	1	0	0	43	104	281	526	886	1,445
Left_OF1	2	13	89	487	1,318	2,056	3,051	4,155	5,987
Left_OF2	1	23	77	263	910	1,425	2,096	2,838	4,093
Right_OF1	1	75	213	280	366	681	1,034	1,383	2,330

46.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 126+11 and 122+16) and the two downstream-most cross-sections (Station 6+29 and 1+53) in the hydraulic model. Computed boundary condition slopes are 0.022 and 0.003 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction return was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 46-7.

Table 46-7
Boundary Condition Slopes for the Overflow Reaches of Reimer Ditch

Overflow River	Reach	Upstream Boundary Slopes	Downstream Boundary Slopes
Left_OF1	1	0.023	Junction return
Left_OF1	2	Junction return	0.007
Left_OF2	1	0.02	Junction return
Right_OF1	1	0.003	0.005

46.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 46-2. Major flooded areas along Reimer Ditch are summarized for the 100-year and 500-year flood events in Table 46-8.

Table 46-8
Major Flooding along Reimer Ditch

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 1+53) ~ the unnamed service road Service Road 18B (Station 52+37)	Flooding extends into the left and right overbanks and continues adjacent to the main channel until draining to the Santa Clara River. The flooded areas include farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structures 4 to 7)	Unnamed service road Service Road 18B (Station 53+41) ~ US study limit (Station 126+11)	Flooding extends into the left and right overbanks upstream at Sta. 142+78. The flooded areas include farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks

46.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average slope of the channel bottom ranges from two percent upstream to 0.3 percent downstream. Reimer Ditch has minimal flow conveyance capacity; therefore, most of the flow overtops into the overbank areas. The predominant flow regime for the channel was supercritical.

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Figure 46-1: Reimer Ditch Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

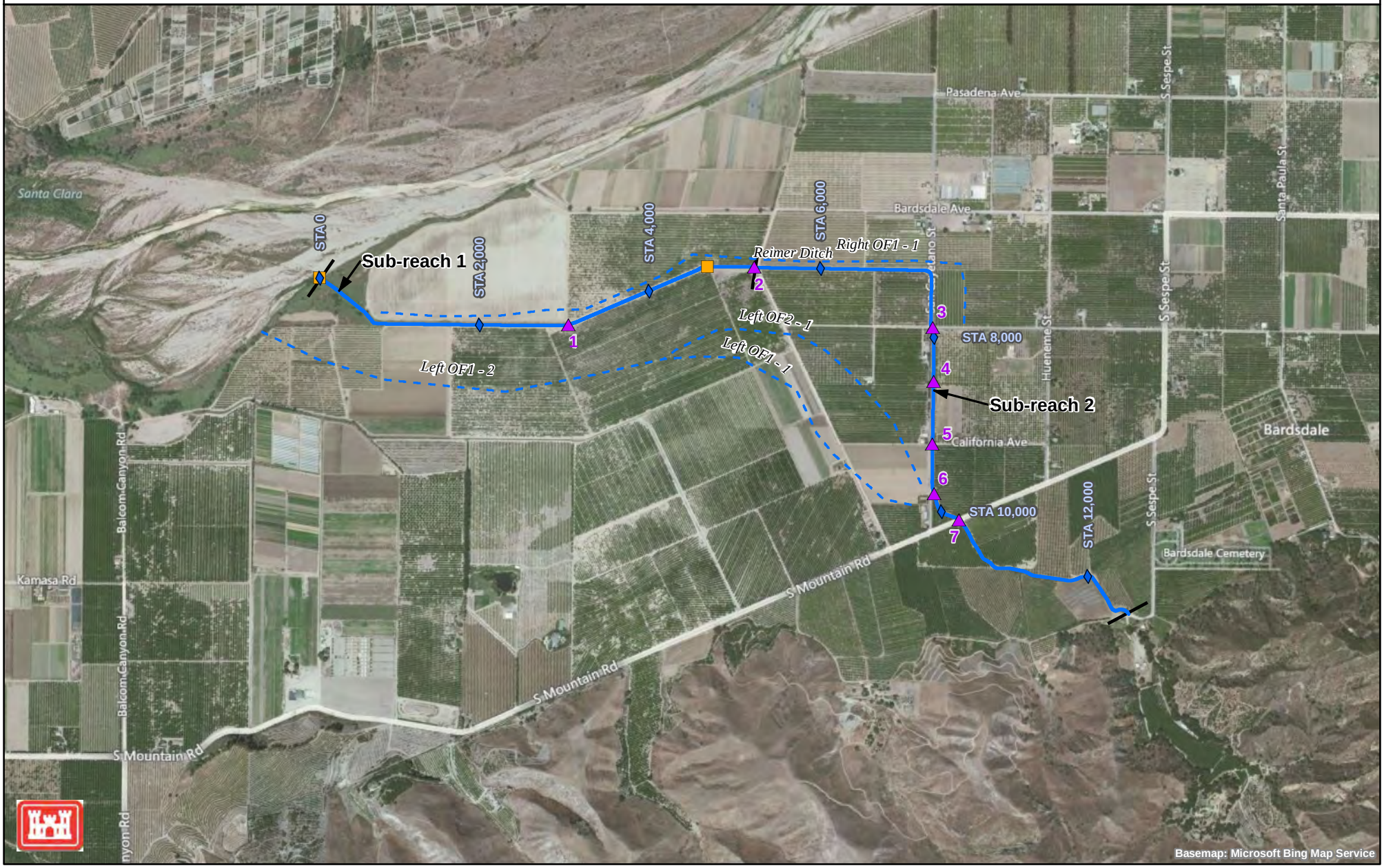

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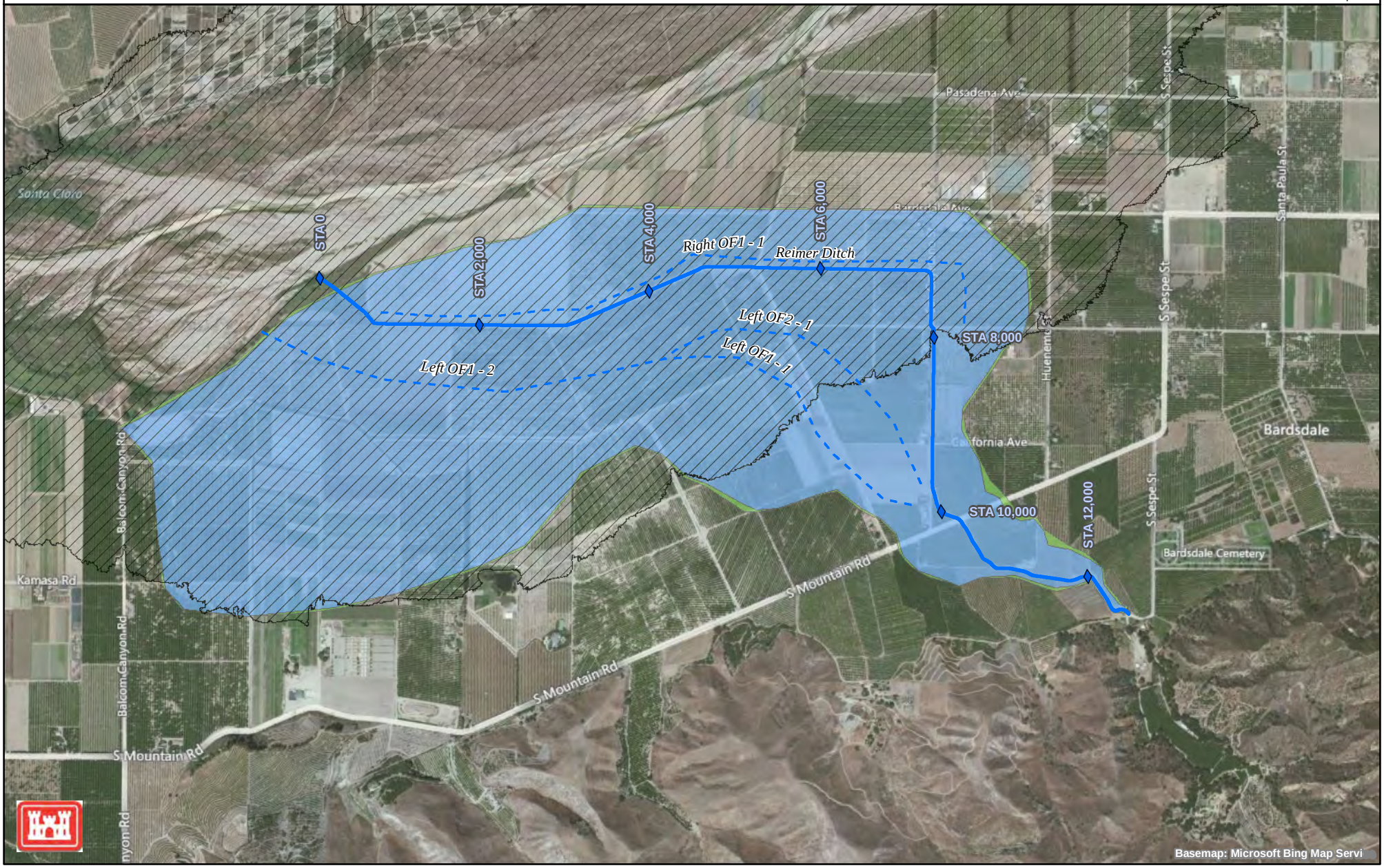
Figure 46-2: Reimer Ditch Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 47
O'Leary Creek

47.1 General Description

O'Leary Creek is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of O'Leary Creek are described in this section.

O'Leary Creek joins the Santa Clara River from the north, between the locations where Balcom Canyon and Reimer Ditch join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 2.3 miles upstream. Figure 47-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural. Major crossings over O'Leary Creek include Highway 126 and the Railroad crossing.

47.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 47-1.

Table 47-1
Structures along O'Leary Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	28+00	Railroad bridge	Span bridge	Substantial scour under the Railroad bridge
2	32+00	Highway 126	Rectangular culvert	2-barrel 10'x8' (each) box culvert; west barrel has exposed rebar, substantial debris (~3' high) blocking flow into east barrel; large drop (~6' high) ~50' downstream of the culvert
3	37+00	Sycamore Road	Span bridge	16.5'x9' conveyance area; grouted boulders downstream of crossing have been eroded by high velocity flow
4	60+00	Hall Canyon Road	Rectangular culvert	10'x10' culvert; culvert is very steep under the road; could not access the downstream side; rebar is exposed inside the culvert, indicating high velocity flow
5	103+00	Toland Road	Rectangular culvert	3 barrel 8'x5.7' (each) rectangular culvert; rounded nose separating teach barrel at the upstream side of the culvert; large drop (~4') at the downstream end of the culvert

Notes: Descriptions with dimensions provide width by length.

47.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 47-2.

Table 47-2
Sub-reaches along O'Leary Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 2+63) ~ Highway 126 (Station 24+36)	Dense shrubs and trees along the banks; sand, gravel and cobble bed material; overgrown banks with evidence of substantial erosion; upstream of the Railroad bridge the banks are severely eroded with ~ 15' high vertical walls; severe scour at downstream side of Highway 126 bridge; citrus in both overbanks
Sub-reach 2 (Structures 3 and 4)	Highway 126 (Station 31+66) ~ Hall Road (Station 58+31)	Overgrown and eroded banks; grouted boulders downstream of the Sycamore Road crossing (OC3); evidence of high flow through Hall Road crossing (exposed rebar); citrus and avocado in both overbanks
Sub-reach 1 (Structure 5)	Hall Road (Station 58+93) ~ US study limit (Station 114+81)	Dense shrubs and trees along the banks; sand, gravel and cobble bed material; wide shallow channel upstream of Hall Road; citrus and avocado in both overbanks

47.4 Manning's Roughness Coefficients

Manning's roughness values for the O'Leary Creek sub-reaches are summarized in Table 47-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 47-3
Manning's Roughness Values along O'Leary Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 2+63) ~ Highway 126 (Station 24+36)	0.065	0.061	0.065
Sub-reach 2 (Structures 3 and 4)	Highway 126 (Station 31+66) ~ Hall Road (Station 58+31)	0.065	0.066	0.065
Sub-reach 1 (Structure 5)	Hall Road (Station 58+93) ~ US study limit (Station 114+81)	0.065	0.055	0.065

47.5 Hydrology

Two hydrologic concentration points were provided along the study reach of O'Leary Creek (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 47-1. The peak discharge rates associated with these locations are summarized in Table 47-4.

Table 47-4
Hydrologic Concentration Points along O'Leary Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
61+52	148	492	895	1653	2,429	3,416	4,594	6,668
0	163	541	985	1,820	2,673	3,760	5,057	7,340

47.6 Hydraulic Model

The O'Leary Creek hydraulic model was developed with 67 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains five bridges/culverts (see Table 47-1), and one overflow reach.

47.6.1 Overflow Reaches

An overflow reach was added to the O'Leary Creek model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs upstream of the Hall Canyon Road due to culvert and channel capacity limitations at this location.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 47-5.

Table 47-5
Maximum Flows in the O'Leary Creek Overflow Reach (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
LeftSplit	LeftSplit	0	0	0	0	0	0	23	129

47.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 107+51 and 104+62) and the two downstream-most cross-sections (Station 1+08 and 00+27) in the hydraulic model. Computed boundary condition slopes are 0.05 and 0.04 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were applied at the upstream end of the overflow reach based on the invert slopes computed between the upstream-most cross-sections (Stations 22+40 and 20+60). The invert slope at the upstream boundary is 0.05. At the downstream boundary a return junction was used to reconnect the overflow reach with the main channel.

47.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 47-2. Major flooded areas along O'Leary Creek are summarized for the 100-year and 500-year flood events in Table 47-6.

Table 47-6
Major Flooding along O'Leary Creek

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Santa Clara River confluence (Station 2+63) ~ Highway 126 (Station 24+36)	Flooding is contained in the main channel	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structures 3 and 4)	Highway 126 (Station 31+66) ~ Hall Road (Station 58+31)	Flooding is contained in the main channel except between Sycamore Road and Highway 126 where the floodplain extends into the left and right overbanks. The flooded areas include farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks, especially in the left overbank upstream of Highway 126 and upstream of Hall Road to Sycamore Road. The flooded areas include farmland
Sub-reach 1 (Structure 5)	Hall Road (Station 58+93) ~ US study limit (Station 114+81)	Flooding is contained in the main channel except near Sta. 63+42 where the floodplain extends into the right overbank. The flooded areas include farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks

47.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately five percent along the study reach. Limiting conveyance structures along O'Leary Creek include Hall Road and Sycamore Road. The predominant flow regime for the channel was subcritical.

Figure 47-1: O'leary Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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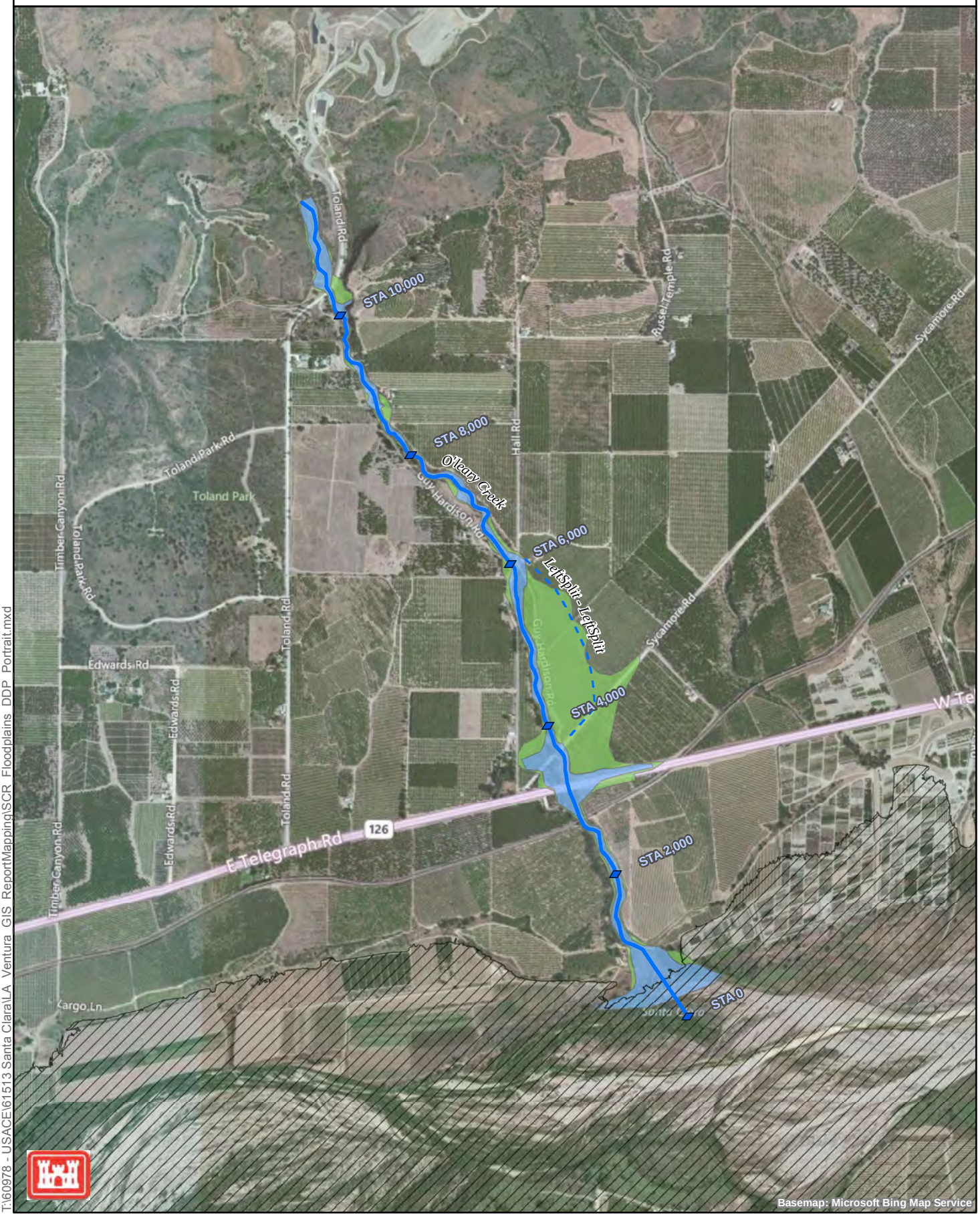
Figure 47-2: O'leary Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 48
Balcom Canyon Wash

48.1 General Description

Balcom Canyon Wash is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Balcom Canyon Wash are described in this section.

Balcom Canyon Wash joins the Santa Clara River from the south, between the locations where Timber Canyon and O'Leary Creek join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 2.2 miles upstream. Figure 48-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agriculture with a few residential properties. Major crossing along Balcom Canyon Wash is South Mountain Road.

48.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 48-1.

Table 48-1
Structures along Balcom Canyon Wash (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	21+50	Unknown Road 16A	Span bridge	Pedestrian timber span bridge; 19'x7', vertical concrete abutments
2	57+50	South Mountain Road	Rectangular culvert	8'x5' rectangular concrete culvert

Notes: Descriptions with dimensions provide width by length.

48.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 48-2.

Table 48-2
Sub-reaches along Balcom Canyon Wash

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	Santa Clara River confluence (Station 19+53) ~ Pedestrian crossing (Station 21+01)	Dense shrubs and small trees along the bank; sandy-silt bed material; overgrown vegetation on banks clear, sandy bottom; eroded banks, shallow channel; overbanks contain the Santa Clara River
Sub-reach 2 (Structure 2)	Pedestrian crossing (Station 22+38) ~ South Mountain Road (Station 57+33)	Uniform, straight earthen channel with berms along both banks downstream of South Mountain Road; citrus landuse in overbanks
Sub-reach 3 (No structures)	South Mountain Road (Station 58+13) ~ US study limit (Station 105+76)	Upstream of South Mountain Road, the channel is grouted rock with near vertical walls; there is a large (~4' diameter) culvert entering on the west bank on the upstream side of South Mountain Road; citrus landuse in overbanks

48.4 Manning's Roughness Coefficients

Manning's roughness values for the Balcom Canyon Wash sub-reaches are summarized in Table 48-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 48-3
Manning's Roughness Values along Balcom Canyon Wash

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	Santa Clara River confluence (Station 19+53) ~ Pedestrian crossing (Station 21+01)	0.060	0.030	0.060
Sub-reach 2 (Structure 2)	Pedestrian crossing (Station 22+38) ~ South Mountain Road (Station 57+33)	0.060	0.030	0.060
Sub-reach 3 (No structures)	South Mountain Road (Station 58+13) ~ US study limit (Station 105+76)	0.075	0.040	0.075

48.5 Hydrology

Two hydrologic concentration points were provided along the study reach of Balcom Canyon Wash (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 48-1. The peak discharge rates associated with these locations are summarized in Table 48-4.

Table 48-4
Hydrologic Concentration Points along Balcom Canyon Wash (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
61+52	113	377	687	1,269	1,864	2,621	3,526	5,117
0	199	661	1,203	2,222	3,263	4,590	6,174	8,960

48.6 Hydraulic Model

The Balcom Canyon Wash hydraulic model was developed with 78 cross-sections to represent the varying channel geometry and hydraulic structures located along the reach. The modeled channel contains two bridges/culverts (see Table 48-1), and three overflow reaches.

48.6.1 Overflow Reaches

Three different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbank along of the study reach. The overflow reaches for Balcom Canyon Wash are summarized in Table 48-5.

Table 48-5
Overflow Reaches for Balcom Canyon Wash

Overflow River	Reach	Description of location
BalcomL	Road Drain	Overflow upstream of South Mountain Road, flows along the south side of the road
BalcomL2	LeftSplit	Overflow on the left overbank downstream of the South Mountain Road that flows northwest into the Santa Clara River
BalcomR	RightSplit	Overflow on the right overbank downstream of the South Mountain Road that flows adjacent to the main channel and into the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 48-6.

Table 48-6
Maximum Flows in the Balcom Canyon Wash Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
BalcomL	Road Drain	0	0	30	302	699	1,166	1,824	3,622
BalcomL2	LeftSplit	0	59	266	1,024	2,003	3,111	4,504	6,795
BalcomR	RightSplit	0	35	322	459	480	685	731	1,209

48.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 105+76 and 99+82) and the two downstream-most cross-sections (Station 21+01 and 19+53) in the hydraulic model. Computed boundary condition slopes are 0.026 and 0.02 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction return was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 48-7.

Table 48-7
Boundary Condition Slopes for the Overflow Reaches of Balcom Canyon Wash

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
BalcomL	1	0.015	0.001
BalcomL2	1	0.0124	0.018
BalcomR	1	0.0124	0.02

48.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 48-2. Major flooded areas along Balcom Canyon Wash are summarized for the 100-year and 500-year flood events in Table 48-8.

Table 48-8
Major Flooding along Balcom Canyon Wash

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	Santa Clara River confluence (Station 19+53) ~ Pedestrian crossing (Station 21+01)	Flooding extends into the left and right overbank areas into the adjacent farmland until draining to the Santa Clara River	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structure 2)	Pedestrian crossing (Station 22+38) ~ South Mountain Road (Station 57+33)	Flooding extends into the left and right overbank areas. The flooded area includes farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 3 (No structures)	South Mountain Road (Station 58+13) ~ US study limit (Station 105+76)	Flooding extends into the left and right overbank areas. The flooded area includes farmland	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks

48.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from nine percent upstream to 0.3 percent downstream. The flow conveyance capacity along the study reach is minimal. Flows greater than the five-year peak magnitude overtop the channel banks. The predominant flow regime for the channel was supercritical.

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Figure 48-1: Balcom Canyon Wash Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

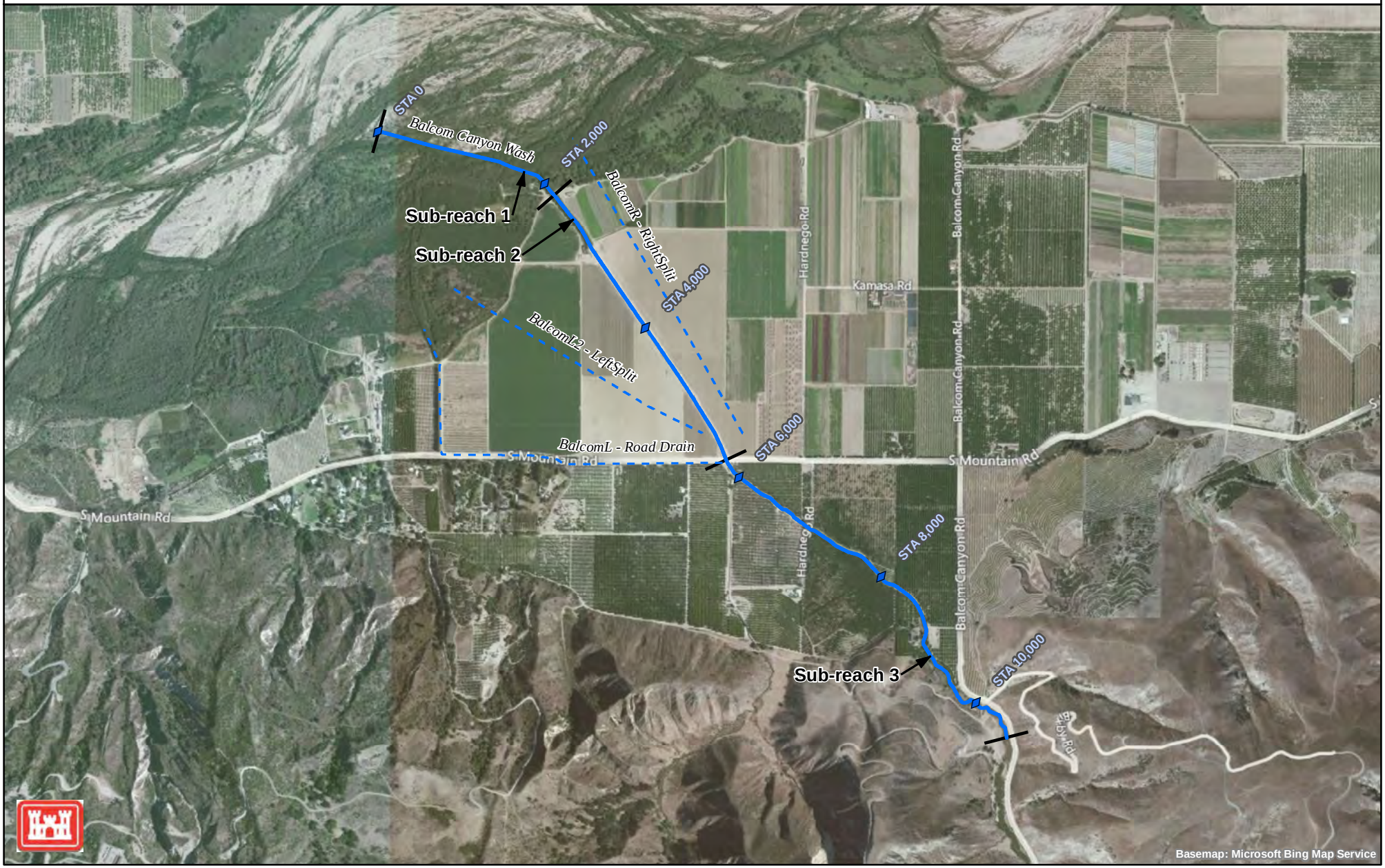

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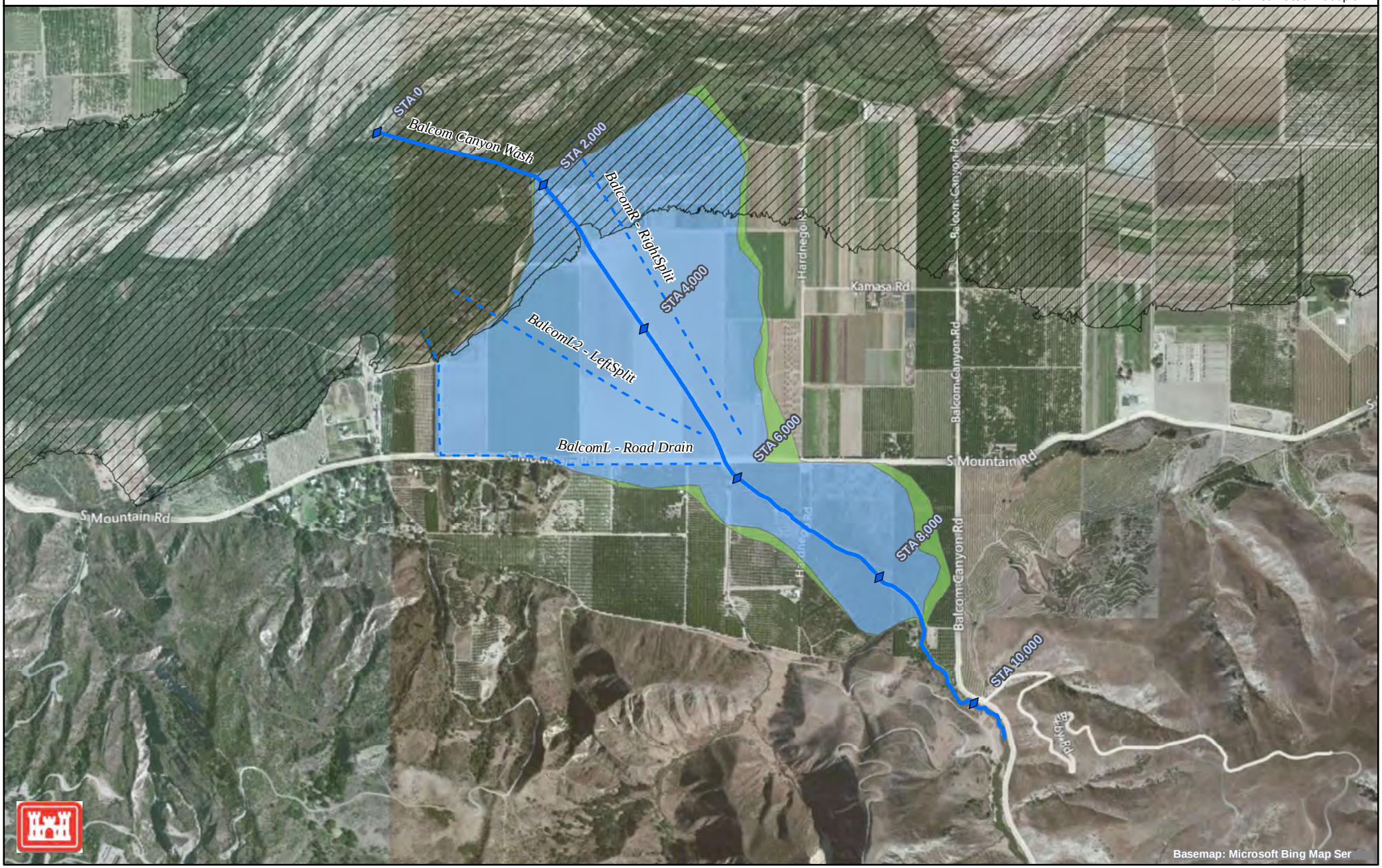
Figure 48-2: Balcom Canyon Wash Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 49
Timber Canyon

49.1 General Description

Timber Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Timber Canyon are described in this section.

Timber Canyon joins the Santa Clara River from the north, between the locations where Orcutt Canyon and Balcom Canyon Wash join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 3.8 miles upstream. Figure 49-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural with some industrial and residential property. Major crossings along Timber Canyon include Highway 126 and the Railroad crossing.

49.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 49-1.

Table 49-1
Structures along Timber Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	25+50	Railroad	Bridge	Wooden trestle bridge, 4 sets of piers (6 columns per pier), length: 75', height from lower chord of bridge deck to invert: 12', deck thickness: 2.8', pipe crossing at DS end hanging lower than lower deck elevation (1-7" & 1-9")
2	34+00	Highway 126	Multiple culverts	2-12'x9' (Span x Rise) concrete box culverts, long curving culverts through Highway 126, warped inlet walls, vertical headwall at outlet (no wingwalls), pier nose at inlet, concrete-lined inlet chute, inlet height reduced by sediment (~7')
3	84+50	Private orchard road	Bridge	12'x9' Arch (see photos in Appendix 15a), built with grouted rock

Note: Could not access upstream of structure #3 (private property).

49.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 49-2.

Table 49-2
Sub-reaches along Timber Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 5+23) ~ Railroad (Station 25+00)	Almost straight, prismatic earthen channel, trapezoidal cross section, sand & gravel channel bed, weed & small brush or no vegetation on both banks, floodplain consisting of agricultural area
Sub-reach 2 (Structure 2)	Railroad (Station 26+04) ~ Highway 126 (Station 31+83)	Meandering earthen channel, irregular cross section, sand & gravel channel bed, tall eucalyptus on both channel banks, floodplain consisting of agricultural area
Sub-reach 3 (Structure 3)	Highway 126 (Station 39+52) ~ US study boundary (Station 184+33)	Natural channel, gravel/cobble/boulder channel bed, floodplain consisting of agricultural area

49.4 Manning's Roughness Coefficients

Manning's roughness values for the Timber Canyon sub-reaches are summarized in Table 49-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 49-3
Manning's Roughness Values along Timber Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station5+23) ~ Railroad (Station 25+00)	0.065	0.050	0.065
Sub-reach 2 (Structure 2)	Railroad (Station 26+04) ~ Highway 126 (Station 31+83)	0.065	0.058	0.065
Sub-reach 3 (Structure 3)	Highway 126 (Station 39+52) ~ US study boundary (Station 184+33)	0.065	0.043	0.065

49.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Timber Canyon (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 49-1. The peak discharge rates associated with these locations are summarized in Table 49-4.

Table 49-4
Hydrologic Concentration Points along Timber Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
110+72	106	351	639	1,180	1,733	2,438	3,279	4,758
65+63	132	438	797	1,473	2,164	3,043	4,093	5,941
0	218	724	1,318	2,435	3,576	5,030	6,765	9,819

49.6 Hydraulic Model

The Timber Canyon hydraulic model was developed with 214 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains three bridges/culverts (see Table 49-1), and four overflow reaches.

49.6.1 Overflow Reaches

Four different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbanks along of the study reach. The overflow reaches for Timber Canyon are summarized in Table 49-5.

Table 49-5
Overflow Reaches for Timber Canyon

Overflow River	Reach	Description of location
Timber2	1	Upstream of the Railroad crossing on the right, flows adjacent to the main channel continuously until draining to the Santa Clara River
Timber3	1	Downstream of the Railroad crossing on the left, flows southeast until draining to the Santa Clara River
Timber4	1	Overflow on the left overbank from Sta. 96+73, flows southeast into adjacent local watershed and eventually flows into the Santa Clara River
Timber5	1	Overflow on the left overbank at Sta. 69+85 to 57+88, flows adjacent to the main channel and reconnects downstream of Highway 126

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 49-6.

Table 49-6
Maximum Flows in the Timber Canyon Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Timber2	1	94	496	1,067	2,161	3,226	4,472	5,841	7,992
Timber3	1	22	65	75	87	107	372	723	1,533
Timber4	1	0	0	0	0	0	0	0	81
Timber5	1	57	266	573	1,272	2,045	3,059	4,290	6,469

49.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 184+33 and 183+20) and the two downstream-most cross-sections (Station 6+67 and 5+23) in the hydraulic model. Computed boundary condition slopes are 0.05 and 0.01 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction return was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 49-7.

Table 49-7
Boundary Condition Slopes for the Overflow Reaches of Timber Canyon

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
Timber2	1	0.028	0.002
Timber3	1	0.024	0.005
Timber4	1	0.13	0.033
Timber5	1	0.041	Junction return

49.8 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 49-2. Major flooded areas along Timber Canyon are summarized for the 100-year and 500-year flood events in Table 49-8.

Table 49-8
Major Flooding along Timber Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station 5+23) ~ Railroad (Station 25+00)	Flooding extends into the left and right overbank areas. Overbank flow continues until draining to the Santa Clara River. The flooded areas include farm land	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 2 (Structure 2)	Railroad (Station 26+04) ~ Highway 126 (Station 31+83)	Flooding extends into the left and right overbank areas. The flooded areas include farm land	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Sub-reach 3 (Structure 3)	Highway 126 (Station 39+52) ~ US study boundary (Station 184+33)	Flooding extends into the left overbank area flowing into Timber 5 at Sta. 69+85. Timber 5 reconnects to the main channel downstream of Highway 126. The flooded areas include farm land	Same as the 100-year flood, with additional flooding into Timber 4 on the left overbank. Flooding in Timber 4 continues until the SCR

49.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from nine percent upstream to 0.3 percent downstream. Structures that are limiting to Timber Canyon conveyance capacity include the Railroad crossing and the Highway 126 bridge. The predominant flow regime for the channel was supercritical.

Figure 49-1: Timber Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

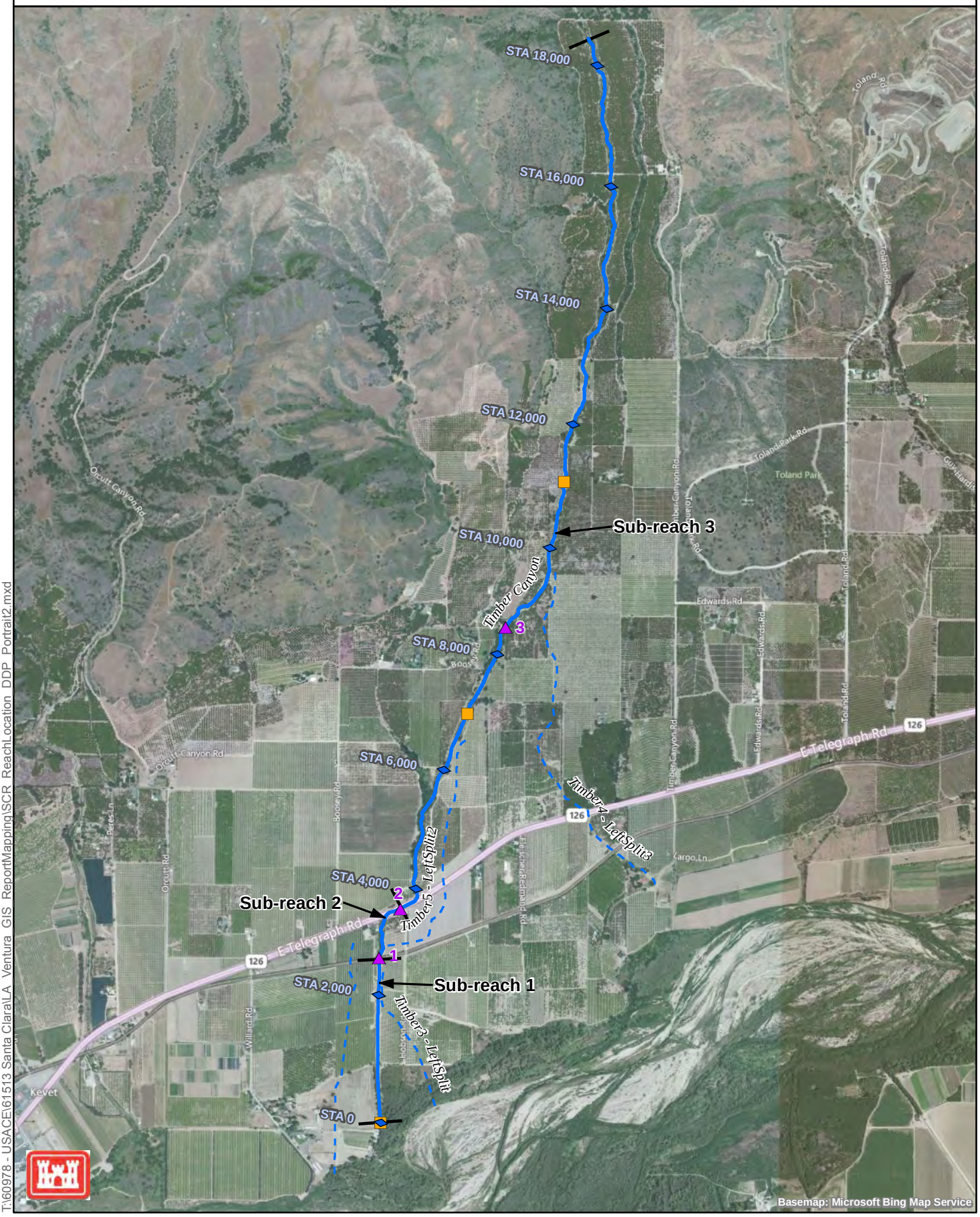

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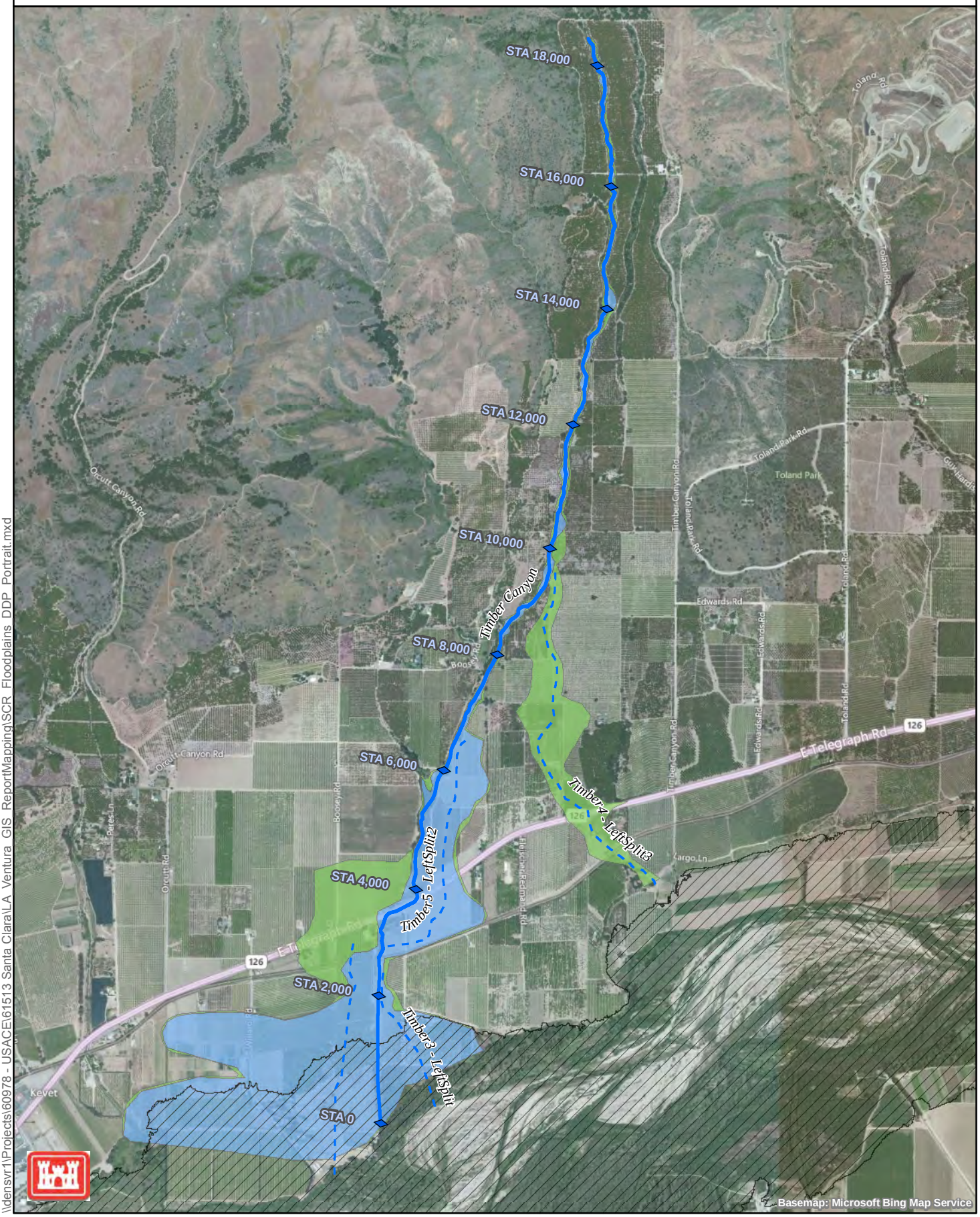
Figure 49-2: Timber Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,000 4,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 50
Orcutt Canyon

50.1 General Description

Orcutt Canyon is a FEMA study reach that joins the Santa Clara River from the north, between the locations where Timber Canyon and Santa Paula Creek join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Orcutt Canyon. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

50.2 Hydraulic Model

FEMA developed the hydraulic model of the study reach, which begins at the confluence with the Santa Clara River and extends approximately 0.75 miles upstream (see Figure 50-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

50.3 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 50-2. Major flooded areas along Orcutt Canyon are summarized for the 100-year and 500-year flood events in Table 50-1.

Table 50-1
Major Flooding along Ocrcutt Canyon

Sub-Reach	100-year	500-year
DS study limit (Station 63+35) ~ US study limit (Station 7+03)	Flooding extends into the left and right overbank from the beginning of the study reach to the confluence with the Santa Clara River	Same as the 100-year extent with additional flooding on the left and right overbanks

50.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from three percent upstream to one percent near the confluence with Santa Clara River. Channel capacity limitations are evident along the study reach. The predominant flow regime is subcritical.

Figure 50-1: Orcutt Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 750 1,500
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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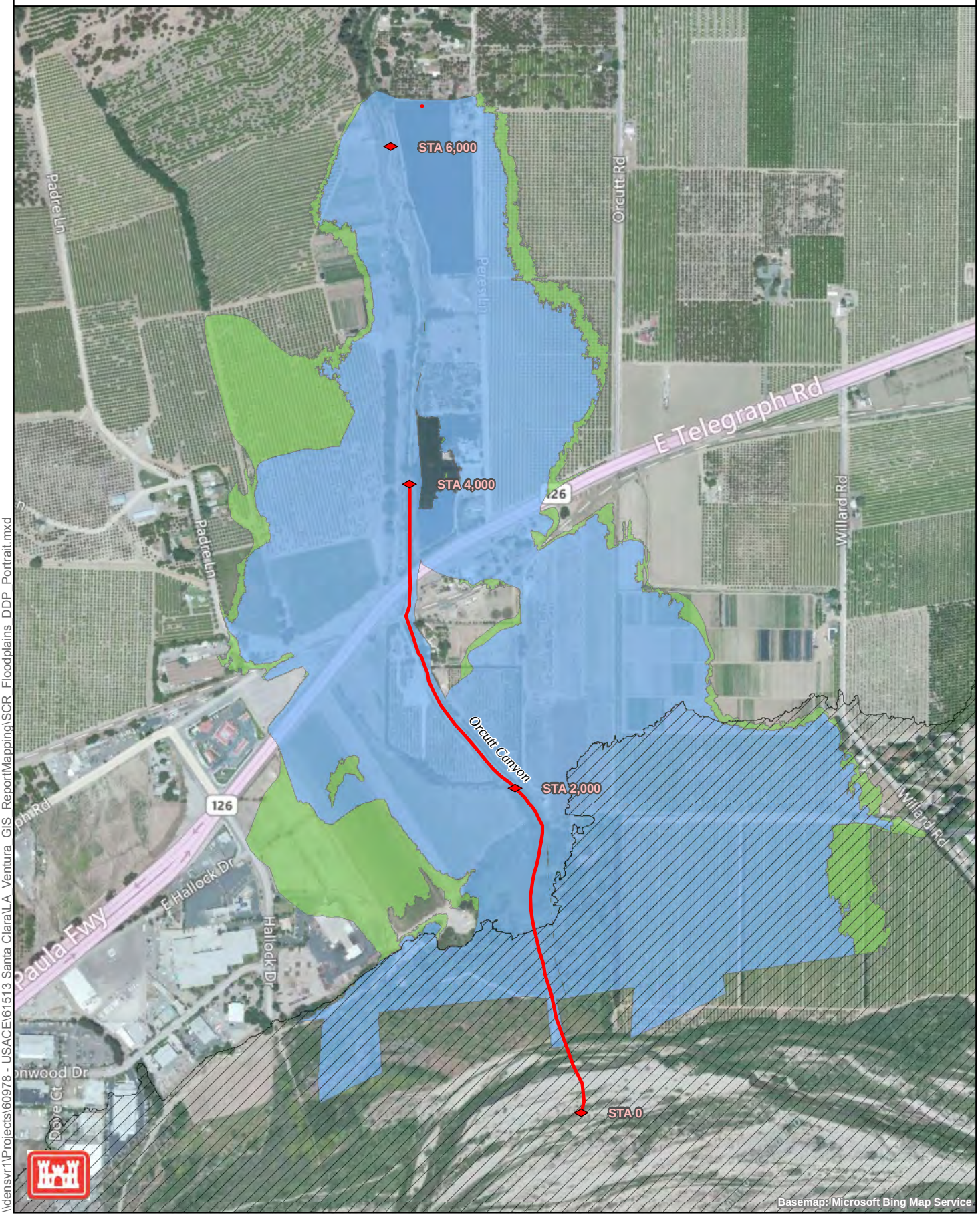
Figure 50-2: Orcutt Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 750 1,500
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 51
Santa Paula Creek

51.1 General Description

Santa Paula Creek is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Santa Paula Creek are described in this section.

Note: the analyses summarized in this section were conducted using the steady state and rigid boundary assumptions described in the Introduction, consistent with the type and level of analysis used in evaluation of the other study reaches presented in this report. The USACE has recently completed a very detailed examination of Santa Paula Creek, which included sediment transport evaluation, hydraulic modeling and floodplain delineation which considers the potential flooding associated with sediment accumulation in the channel. The reader is directed to the USACE study for a more refined assessment of the flood hazard along lower reach of Santa Paula Creek: (reference: U.S. Army Corp of Engineers, *Santa Paula Creek Flood Control Project Hydrology, Hydraulics, and Sedimentation Report, December 2011. Prepared by HDR/CDM JV).*

Santa Paula Creek joins the Santa Clara River from the north, between the locations where Fagan Canyon and Orcutt Canyon join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 9.6 miles upstream. Figure 51-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

The study reach is located within a mixture of agricultural/residential/ industrial areas. Major crossings over Santa Paula Creek include Highway 150 (Ojai Road), Main Street, and Highway 126.

51.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 51-1.

Table 51-1
Structures along Santa Paula Creek (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	19+00	Highway 126	Bridge	2-2 pier bridges but connected by pier walls, underpass trail on left side, vertical concrete wall on left bank, grout rock on right bank, plenty of rocks & boulders on channel bed
2	32+00	Main Street (Telegraph Road)	Bridge	Clear span, vertical walls on both banks, gravel bars on channel bed
3	38+00	Railroad	Bridge	Combined truss & clear span with 1 pier between them (see photos in Appendix 14a), large diameter pipe crossing at US & DS ends at lower deck elevation, vertical wall banks transfer to sloped grouted rock at US side
4	171+25	Bridge Road	Bridge	Clear span, truss bridge on deep canyon, grout/concrete protection on right bank beneath the bridge
5	196+69	Near Rafferty Road	Drop structure	2 vertical drop structures ~30 feet, grouted rock on right bank at US side, gravel bar in the middle on channel bed at US side
6	266+03	Mupu Road at Steckel Park	Bridge	Clear span
7	332+03	Highway 150_A	Bridge	Clear span, grouted rock on both banks
8	338+03	Highway 150_B	Bridge	Clear span, vertical concrete abutment on both banks

Note: Could not access upstream of structure #8 (private property).

51.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 51-2.

Table 51-2
Sub-reaches along Santa Paula Creek

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 14+40) ~ Highway 126 (Station 18+58)	Wide natural channel, gravel/cobble/boulder channel bed, floodplain consisting of natural & industrial area
Sub-reach 2 (Structures 2 and 3)	Highway 126 (Station 21+18)~ about 1 mile US of railroad bridge (Station 93+09)	Wide channelized reach, rectangular or trapezoidal cross section, no vegetation on both banks, gravel/cobble/boulder channel bed, floodplain consisting of agricultural/residential/industrial areas
Sub-reach 3 (Structure 4)	about 1 mile US of railroad bridge (Station 97+64) ~ Bridge Road (Station 170+57)	Natural meandering channel, gravel/cobble/boulder channel bed, floodplain consisting of agricultural/residential areas
Sub-reach 4 (Structures 5 to 8)	Bridge Road (Station 171+73) ~ US study boundary (Station 506+71)	Deep canyon with steep banks, gravel/cobble/boulder channel bed, floodplain consisting of natural mountain area

51.4 Manning's Roughness Coefficients

Manning's roughness values for the Santa Paula Creek sub-reaches are summarized in Table 51-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 51-3
Manning's Roughness Values along Santa Paula Creek

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station 14+40) ~ Highway 126 (Station 18+58)	0.055	0.035	0.055
Sub-reach 2 (Structures 2 and 3)	Highway 126 (Station 21+18)~ about 1 mile US of railroad bridge (Station 93+09)	0.085	0.030	0.130
Sub-reach 3 (Structure 4)	about 1 mile US of railroad bridge (Station 97+64) ~ Bridge Road (Station 170+57)	0.075	0.042	0.130
Sub-reach 4 (Structures 5 to 8)	Bridge Road (Station 171+73) ~ US study boundary (Station 506+71)	0.075	0.048	0.090

51.5 Hydrology

Four hydrologic concentration points were provided along the study reach of Santa Paula Creek (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 51-1. The peak discharge rates associated with these locations are summarized in Table 51-4.

Table 51-4
Hydrologic Concentration Points along Santa Paula Creek (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
496+19	926	3,082	5,607	10,358	15,215	21,400	28,783	41,773
337+34	1,095	3,643	6,629	12,245	17,988	25,300	34,029	49,386
195+58	1,688	5,616	10,218	18,876	27,729	39,000	52,455	76,128
0	1,706	5,674	10,323	19,070	28,013	39,400	52,993	76,909

51.6 Hydraulic Model

The Santa Paula Creek hydraulic model was developed with 194 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains seven bridges/culverts and one drop structure (see Table 51-1), and five overflow reaches.

51.6.1 Overflow Reaches

Five different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbanks along of the study reach. The overflow reaches for Santa Paula Creek are summarized in Table 51-5.

Table 51-5
Overflow Reaches for Santa Paula Creek

Overflow River	Reach	Description of location
Left_OF	1	Downstream of Bridge Road on the left overbank, flowing adjacent to the main channel before returning to the main channel between Sta.143+30 and Sta. 139+26
Left_OF1	1	Upstream of the Railroad crossing on the left, flows adjacent to the main channel continuously until joining the Santa Clara River
Right_OF2	1	Upstream of the Railroad crossing on the right, flows along north side of Highway 126 and eventually flows into the Fagan Canyon floodplain
Right_OF3	1,2	Downstream of Highway 126 on the right, conveys flow which overtops the Railroad and the main channel, flows directly into the Santa Clara River
Right_OF4	1	Break-out reach from Right_OF3, which takes a slightly western path towards the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 51-6.

Table 51-6
Maximum Flows in the Santa Paula Creek Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Left_OF	1	0	0	0	0	0	0	0	53
Left_OF1	1	0	14	596	3,143	5,845	10,115	15,252	25,813
Right_OF2	1	0	0	0	0	900	3,138	6,468	9,323
Right_OF3	1	0	0	0	0	2,293	7,289	14,892	24,216
Right_OF3	2	0	0	0	0	0	940	1,921	4,308
Right_OF4	1	0	0	0	0	2,282	6,359	12,981	19,918

51.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 506+71 and 505+03) and the two downstream-most cross-sections (Station 15+92 and 14+40) in the hydraulic model. Computed boundary condition slopes are 0.05 and 0.011 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction return was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 51-7.

Table 51-7
Boundary Condition Slopes for the Overflow Reaches of Santa Paula Creek

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
Left_OF	1	0.028	Junction return
Left_OF1	1	0.017	0.025
Right_OF2	1	0.023	0.008
Right_OF3	1	0.025	Junction return
Right_OF3	2	Junction return	0.006
Right_OF4	1	Junction return	0.0055

51.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 51-2. Major flooded areas along Santa Paula Creek are summarized for the 100-year and 500-year flood events in Table 51-8.

Table 51-8
Major Flooding along Santa Paula Creek

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station 14+40) ~ Highway 126 (Station 18+58)	Flooding extends into the left and right overbank continuously until draining to the Santa Clara River. The flooded areas include farmland, residential, commercial and industrial property	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structures 2 and 3)	Highway 126 (Station 21+18)~ about 1 mile US of railroad bridge (Station 93+09)	Flooding extends into the left and right overbank areas upstream of the Railroad and continues for this entire sub-reach. The flooded areas include farmland, residential, commercial and industrial property	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 3 (Structure 4)	about 1 mile US of railroad bridge (Station 97+64) ~ Bridge Road (Station 170+57)	Flooded extends into the left and right overbank areas just downstream of Bridge Road. The flooded areas include farmland, roadways, and residential houses	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 4 (Structures 5 to 8)	Bridge Road (Station 171+73) ~ US study boundary (Station 506+71)	Flooding is contained in the main channel except near Sta.338+51 to Sta. 332+03, Sta. 266+40 and Sta. 197+60. The flooded areas include farmland, roadways, and residential houses	Same as the 100-year flood, with additional flooding in the left and right overbanks, especially at Sta. 226+89

51.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately two percent, except at the 30-foot drop between Sta. 196+69 and 195+58. Structures that limit the conveyance capacity of Santa Paula Creek include the Railroad crossing and the Telegraph Road/Main Street bridge. The predominant flow regime for the study reach was supercritical.

Figure 51-1: Santa Paula Creek Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

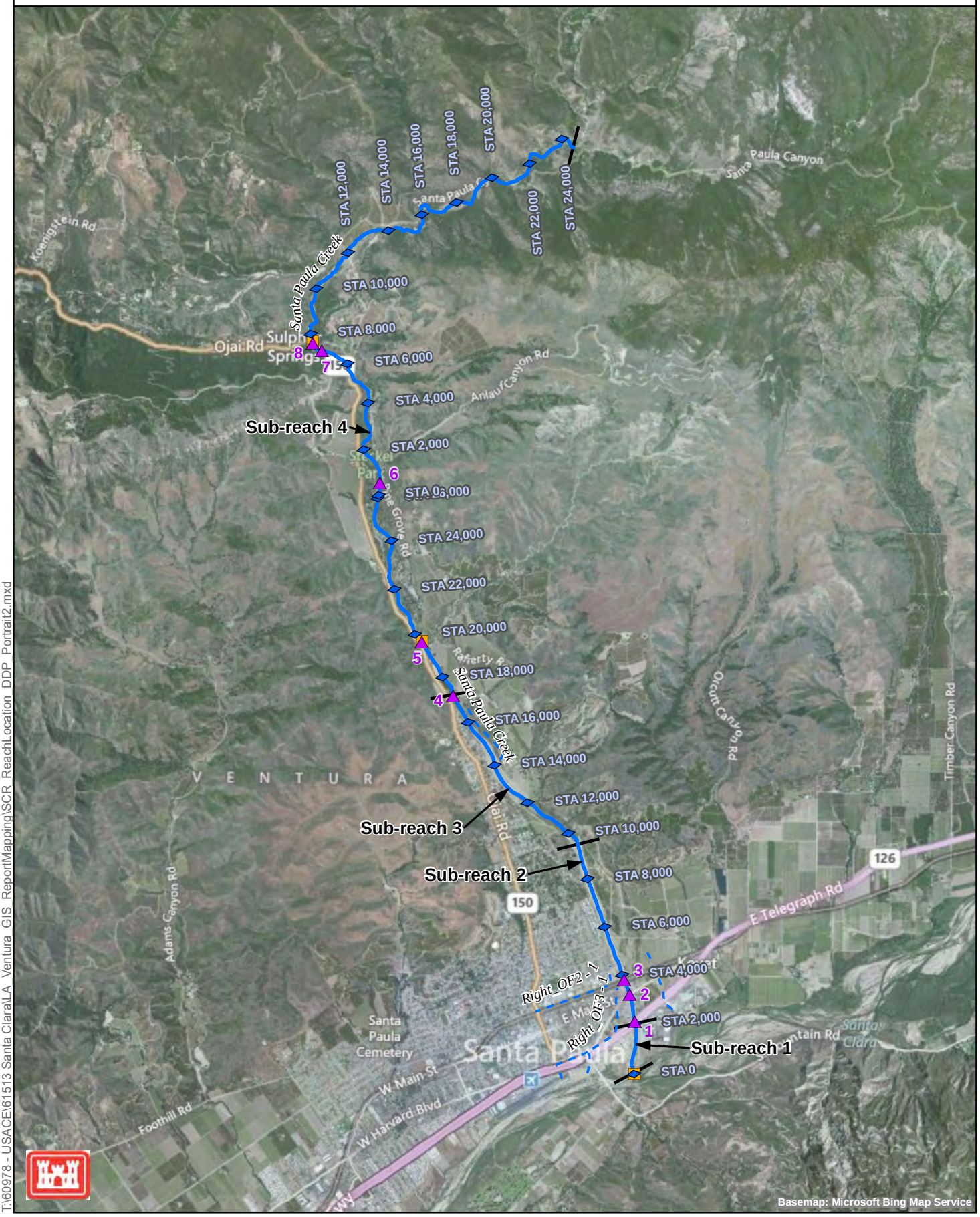

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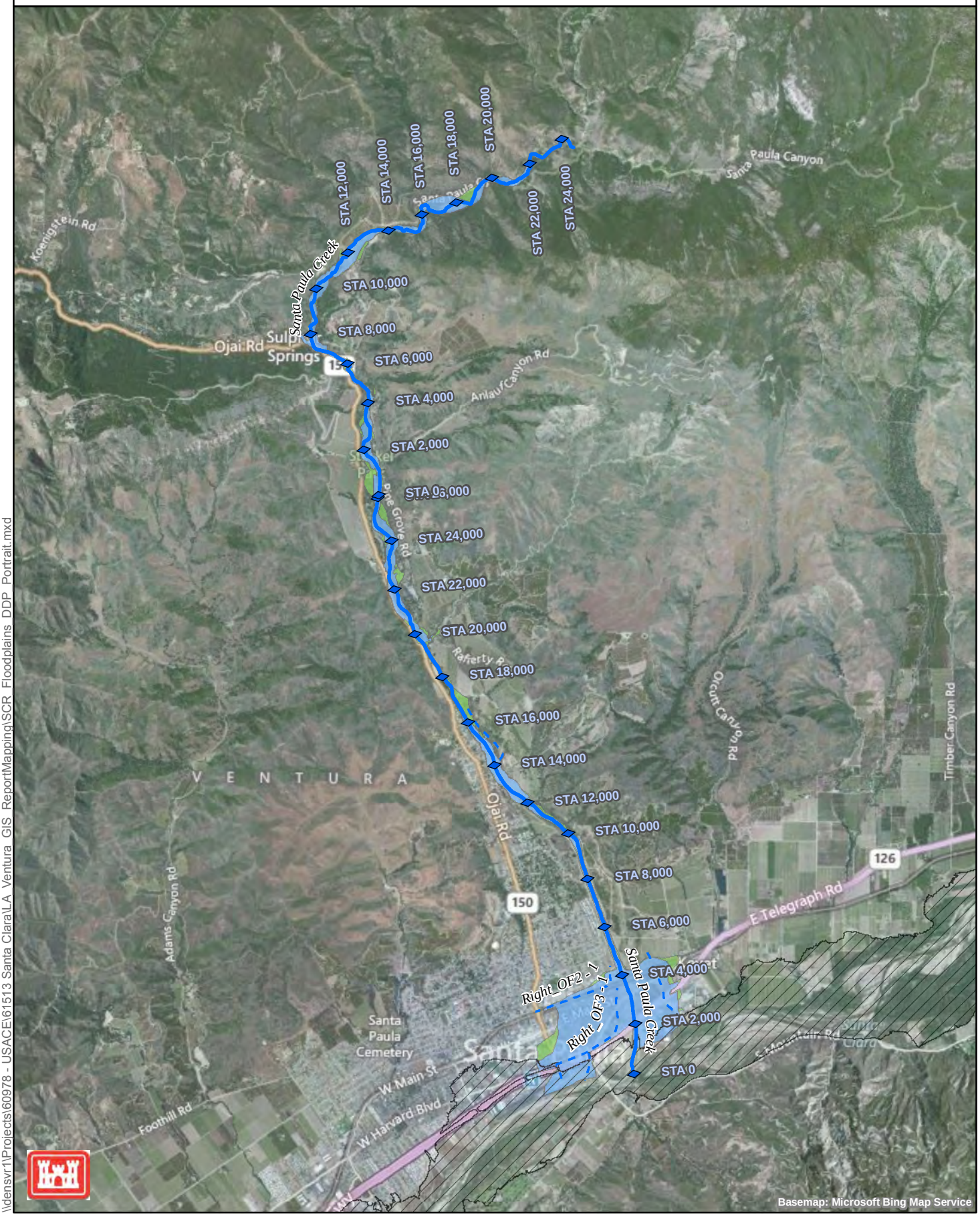
Figure 51-2: Santa Paula Creek Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 52
Fagan Canyon

52.1 General Description

Fagan Canyon is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Fagan Canyon are described in this section.

Fagan Canyon joins the Santa Clara River from the north, between the locations where Peck Road Drain and Santa Paula Creek join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 4.4 miles upstream. Figure 52-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

The study reach is located within a mixture of agricultural/residential/ commercial areas. Major crossings over Fagan Canyon include Santa Paula Street, Main Street, Harvard Boulevard, and Highway 126.

52.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 52-1.

Table 52-1
Structures along Fagan Canyon (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	24+00	Santa Maria Street & Highway 126	Multiple culverts	2-10'x10' (Span x Rise) concrete box culverts, US & DS fully lined with concrete (rectangular cross section), width expansion at DS side, long pier nose at US end (some debris)
2	34+50	Santa Ana Street	Bridge	Clear span, length: 20', height from lower chord of bridge deck to invert: 6', depth from top of curb to lower chord of bridge deck: 3.3', US & DS fully lined with concrete (rectangular cross section), width contraction at DS side
3	38+00	Harvard Boulevard	Bridge	Clear span, length: 20', height from lower chord of bridge deck to invert: 6', depth from top of curb to lower chord of bridge deck: 2.3', US & DS fully lined with concrete (rectangular cross section)
4	42+40	Pedestrian Crossing	Bridge	Clear span, length: 20', height from lower chord of bridge deck to invert: 6.5', depth from top of curb to lower chord of bridge deck: 2.3', US & DS fully lined with concrete (rectangular cross section)
5	45+00	Private road	Bridge	Clear span, length: 20', height from lower chord of bridge deck to invert: 6.5', depth from top of curb to lower chord of bridge deck: 2.3', US & DS fully lined with concrete (rectangular cross section)
6	50+00	Long Culvert	Single culvert (outlet)	Long culvert, 1-20'x7' concrete box culvert, trapezoidal inlet on right wall at DS side (see photos in Appendix 13a)
7	68+00	Santa Paula Street	Single culvert	1-12'x9' concrete box culverts, grouted riprap at DS side, warped inlet and outlet walls, several pipe confluences inside culvert
8	90+00	Upstream of Santa Paula Street	Pipe crossing	Clear span pipeline bridge, block concrete protection on left bank
9	100+50	Unnamed	Single culvert	1-8' circular concrete pipe (projecting, with beveled ring), wide dip crossing, grouted rock at US & DS
10	104+00	Debris Basin downstream of Orchard Road	Debris basin	1-8’ circular concrete pipe, with headwall
11	121+70	Private orchard road	Multiple culverts	1-9.5' steel pipe & 1-5' CMP, earthen dip crossing

Note: Limited access upstream of structure #10 (private property).

52.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 52-2.

Table 52-2
Sub-reaches along Fagan Canyon

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 6)	SCR confluence (Station 11+55) ~ Long culvert (Station 44+42)	Straight, prismatic concrete channel, rectangular cross section, floodplain consisting of residential/commercial areas
Sub-reach 2 (Structure 7)	Long culvert (Station 45+11) ~ Santa Paula Street (Station 67+42)	Almost straight earthen channel, irregular cross section, sand /gravel/cobble channel bed, brush and trees on both channel banks, floodplain consisting of residential area
Sub-reach 3 (Structures 8 to 11)	Santa Paula Street (Station 68+45) ~ US study limit (Station 234+38)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, many trees (eucalyptus & oaks) on both channel banks, most of floodplain consisting of agricultural area with a short DS end portion consisting of cemetery and residential area

52.4 Manning's Roughness Coefficients

Manning's roughness values for the Fagan Canyon sub-reaches are summarized in Table 52-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 52-3
Manning's Roughness Values along Fagan Canyon

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 6)	SCR confluence (Station 11+55) ~ Long culvert (Station 44+42)	0.130	0.015	0.130
Sub-reach 2 (Structure 7)	Long culvert (Station 45+11) ~ Santa Paula Street (Station 67+42)	0.130	0.035	0.130
Sub-reach 3 (Structures 8 to 11)	Santa Paula Street (Station 68+45) ~ US study limit (Station 234+38)	0.080	0.048	0.075

52.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Fagan Canyon (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 52-1. The peak discharge rates associated with these locations are summarized in Table 52-4.

Table 52-4
Hydrologic Concentration Points along Fagan Canyon (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
170+22	70	232	422	779	1,144	1,609	2,164	3,141
107+08	113	377	686	1,268	1,863	2,620	3,524	5,114
0	197	655	1,192	2,202	3,235	4,550	6,120	8,882

52.6 Hydraulic Model

The Fagan Canyon hydraulic model was developed with 178 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains eleven bridges/culverts (see Table 52-1), and two overflow reaches.

52.6.1 Channel Improvements

Channel improvements were added to Fagan Canyon based on as-built drawings. The improved reach extends from the confluence with Santa Clara River to upstream of West Main Street. (references: Ventura County Flood Control District. *Fagan Canyon Unit I From Santa Paula Freeway to Steckel Drive. Project No. 4766*. (Ventura County Flood Control District, 1972), Ventura County Flood Control District. *Fagan Canyon Unit II From Santa Maria Street 526 feet southeasterly. Project No. 4784.* (Ventura County Flood Control District, 1975), County of Ventura Public Works Agency Ventura County Flood Control District. *Fagan Canyon, Unit IV*. (Ventura County Public Works, 1989), and County of Ventura Public Works Agency Ventura County Flood Control District. *Fagan Canyon, Unit V*. (Ventura County Public Works, 1990).)

The improved channel and culverts have capacity to convey the 10-year storm event without overtopping.

52.6.2 Overflow Reaches

Overflow reaches were added to the Fagan Canyon model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach due to limited channel and bridge capacities. Overflow reaches were added along the left and right overbank areas upstream of West Santa Paula Street.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 52-5.

Table 52-5
Maximum Flows in the Fagan Overflow Reaches (cfs)

Overflow River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Right_OF1	0	0	0	139	503	1,328	2,130	3,432
Left_OF1	0	0	0	204	615	1,107	1,871	3,457

52.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 234+38 and 232+90) and the two downstream-most cross-sections (Station14+24 and 11+55) in the hydraulic model. Computed boundary condition slopes are 0.03 and 0.004 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used for the overflow reaches based on the invert slopes computed between the upstream-most cross-sections and downstream-most cross-sections. The computed boundary condition slopes for the left overflow reach are 0.015 (Stations 53+60 and 52+35) and 0.01 (Stations 7+68 and 3+27), at the upstream and downstream ends, respectively, of this reach. The computed boundary condition slopes for the right overflow reach are 0.026 (Stations 32+21 and 30+74) and 0.0003 (Stations 3+93 and 13), at its upstream and downstream ends, respectively.

52.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 52-2. Major flooded areas along Fagan Canyon are summarized for the 100-year and 500-year flood events in Table 52-6.

Table 52-6
Major Flooding along Fagan Canyon

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 6)	SCR confluence (Station 11+55) ~ Long culvert (Station 44+42)	Flooding extends into the left and right overbank continuously until draining to the Santa Clara River. Flooding in the right overbank flows towards Peck Road Drain along Main Street. The flooded areas include residential, commercial and industrial properties	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structure 7)	Long culvert (Station 45+11) ~ Santa Paula Street (Station 67+42)	Flooding extends into the left and right overbanks upstream of West Santa Paula Street. The flooded areas include residential, commercial and industrial properties	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 3 (Structures 8 to 11)	Santa Paula Street (Station 68+45) ~ US study limit (Station 234+38)	Flooding is contained in the main channel except for upstream of Santa Paula Street, Sta. 84+68, and Sta. 121+84. The flooded areas include farmland, open space and residential properties	Same as the 100-year flood, with additional flooding in the left and right overbanks

52.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 0.8 percent along the study reach. Structures that limit the conveyance capacity of Fagan Canyon include the bridges at Santa Paula Street, Railroad/Main Street, the Private Driveway and the Private Pedestrian bridge. The predominant flow regime for Fagan Canyon was supercritical.

Figure 52-1: Fagan Canyon Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

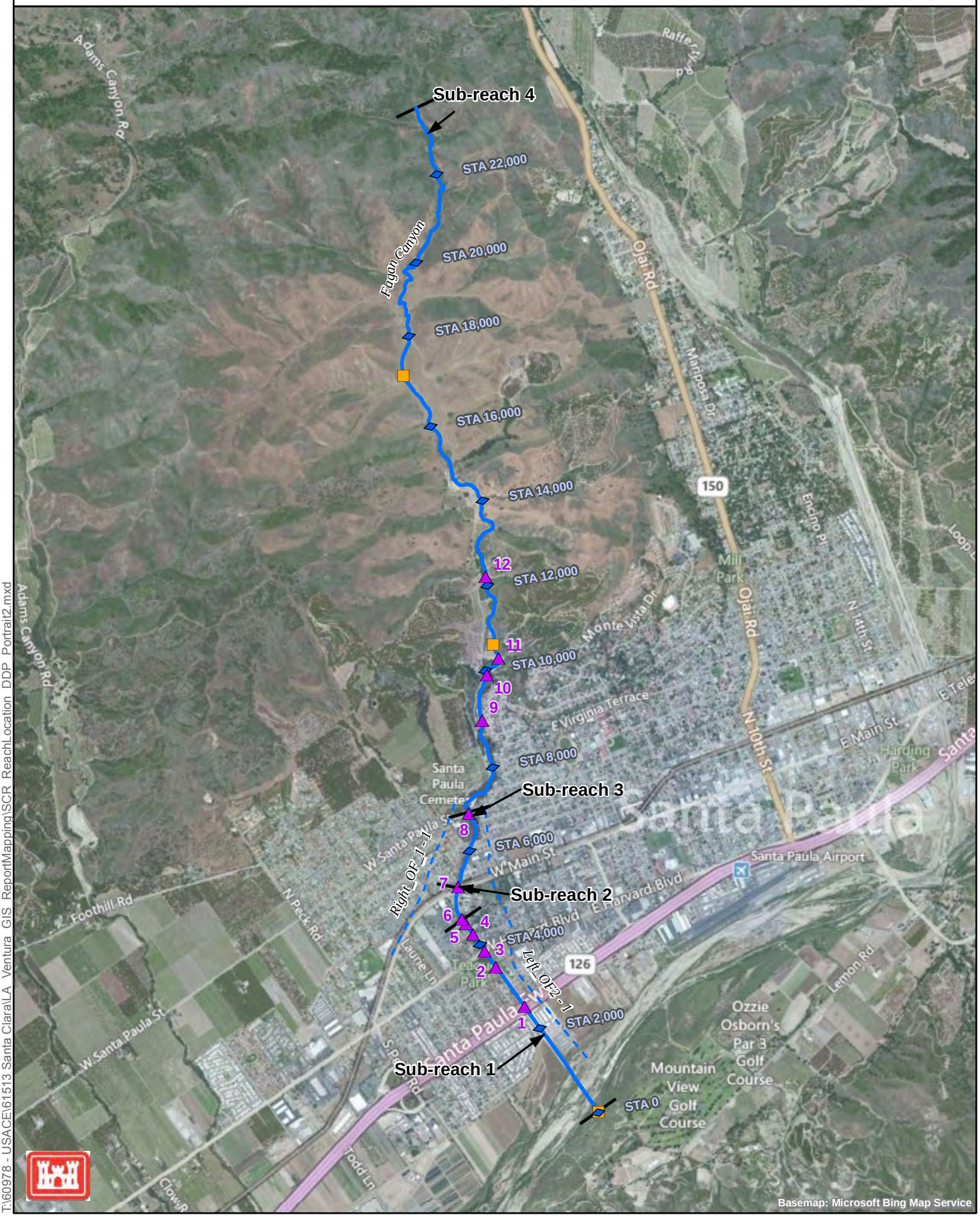

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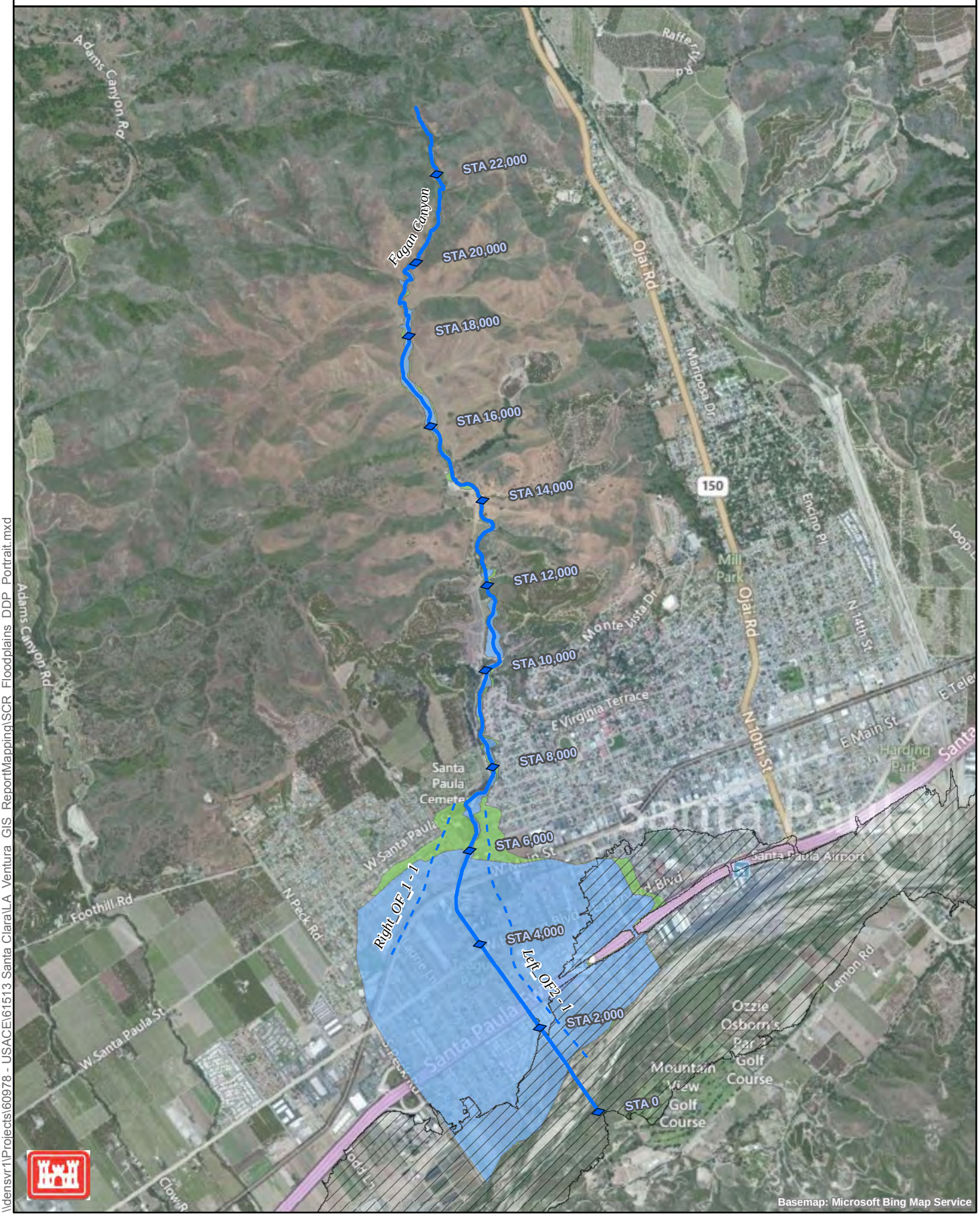
Figure 52-2: Fagan Canyon Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 53
Peck Road Drain

53.1 General Description

Peck Road Drain is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Peck Road Drain are described in this section.

Peck Road Drain joins the Santa Clara River from the north, between the locations were Adams Barranca and Fagan Canyon join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 1.6 miles upstream. Figure 53-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

The study reach is located within a mixture of agricultural, residential, and commercial areas. Major crossings over Peck Road Drain include Foothill Road, Santa Paula Street, Telegraph Road, and Highway 126.

53.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings and culverts located along the study reach is summarized in Table 53-1.

Table 53-1
Structures along Peck Road Drain (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	19+10	Todd Lane	Bridge	Clear span, length: 17', height from lower chord of bridge deck to invert: 8', depth from top of curb to lower chord of bridge deck: 2', US & DS fully lined with concrete (rectangular cross section)
2	27+00	Corporation Street	Multiple culverts	3-8'x4' (Span x Rise) concrete box culverts, US & DS fully lined with concrete (rectangular cross section), steep slope and width contraction at DS side
3	32+00	Highway 126	Multiple culverts	3-8'x4' concrete box culverts, US & DS fully lined with concrete (rectangular cross section)
4	37+00	Faulkner & Peck Roads	Multiple culverts	3-8'x4' concrete box culverts, US & DS fully lined with concrete (rectangular cross section), some debris/grass on piers at US end
5	50+00	Fillmore Street to Telegraph Road	Long culvert	Long culvert connecting Telegraph & Fillmore, 1-5.5' circular concrete pipe (with beveled ring), metal grate & fence at entrance, drop inlet composed of sacks of concrete at US end (see photos in Appendix 12a)
6	50+00	Santa Paula Street	Single culvert	1-6'x2' concrete box culverts, grouted riprap at DS side, telephone poles in right bank
7	71+00	Private road	Single culvert	1-3.5' circular CMP, grouted riprap at DS side, irregular channel filled with grouted stones at US side
8	82+25	Foothill Road	Single culvert	1-2.5' circular CMP at US side, 1-2' circular CMP at left bank (see photos in Appendix 12a)

53.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 53-2.

Table 53-2
Sub-reaches along Peck Road Drain

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 8+41) ~ Todd Lane (Station 19+02)	Straight, prismatic concrete channel, rectangular cross section, floodplain consisting of agricultural area
Sub-reach 2 (Structures 2 to 5)	Todd Lane (Station 19+28) ~ Fillmore Street (Station 42+35)	Straight, prismatic concrete channel, rectangular cross section, floodplain consisting of residential/commercial areas
Sub-reach 3 (Structures 6 to 8)	Fillmore Street (Station 60+46) ~ US study limit (Station 83+20)	Straight, prismatic earthen channel, trapezoidal cross section, sand/gravel/cobble channel bed, no vegetation on both channel banks, floodplain consisting of agricultural/residential areas

53.4 Manning's Roughness Coefficients

Manning's roughness values for the Peck Road Drain sub-reaches are summarized in Table 53-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 53-3
Manning's Roughness Values along Peck Road Drain

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station8+41) ~ Todd Lane (Station 19+02)	0.060	0.015	0.060
Sub-reach 2 (Structures 2 to 5)	Todd Lane (Station 19+28) ~ Fillmore Street (Station 42+35)	0.130	0.015	0.095
Sub-reach 3 (Structures 6 to 8)	Fillmore Street (Station 60+46) ~ US study limit (Station 83+20)	0.130	0.030	0.075

53.5 Hydrology

One hydrologic concentration point was provided along the Peck Road Drain study reach. The location of this hydrologic concentration point is shown in Figure 53-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 53-4.

Table 53-4
Hydrologic Concentration Point along Peck Road Drain (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	304	604	849	1,208	1,504	1,830	2,180	2,749

53.6 Hydraulic Model

The Peck Road Drain hydraulic model was developed with 65 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains eight bridges/culverts (see Table 53-1), and one overflow reach.

53.6.1 Channel Improvements

Channel improvements were added to Peck Road Drain based on as-built drawings. The improved reach extends from Telegraph Road to the confluence with the Santa Clara River (reference: County of Ventura Public Works Agency Ventura County Flood Control District. *Peck Road Drain – Unit I 850 ft South of Harvard Street to Fillmore Street on Peck Road.* DWG. Y-2-530. (Ventura County Public Works, 1970), County of Ventura Public Works Agency Ventura County Flood Control District. *Peck Road Drain – Unit II.* DWG. Y-2-2270. DWG. Y-2-308. (Ventura County Public Works, 1994).

The improved channel and culverts have capacity to convey the 5-year storm event without overtopping. The improved channel capacity without culvert limitations, based on normal depth calculations, is 1,305 cfs, which is equivalent to the 25-year storm event.

53.6.2 Overflow Reaches

An overflow reach was added to the Peck Road Drain model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach due to limited channel and bridge capacities. The overflow reach was added on the left overbank at the upstream study limit.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. Flow contributions from adjacent study reaches were also accounted for within the model. Peck Road Drain receives overflow discharge from Fagan Canyon. The overflow transfer between watersheds was estimated in the Fagan Canyon hydraulic model and added to the corresponding cross-section in the Peck Road Drain model. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 53-5.

Table 53-5
Maximum Flows in Peck Road Drain Overflow Reach (cfs)

Overflow River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Left_OF1	47	253	444	920	1,612	2,494	3,340	5,089

53.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations in the hydraulic model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 83+20 and 82+87) and the two downstream-most cross-sections (Station 8+97 and 8+41) in the hydraulic model. The Peck Road Drain boundary

condition slopes are 0.065 and 0.006 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were applied to the overflow reach based on the invert slopes computed between the two upstream-most cross-sections (Stations 70+76 and 67+97) and two downstream-most cross-sections (Stations 12+15 and 6+73). The computed invert slopes at the boundaries are 0.01 and 0.007 at the upstream and downstream ends of the overflow reach, respectively.

53.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 53-2. Major flooded areas along Peck Road Drain are summarized for the 100-year and 500-year flood events in Table 53-6.

Table 53-6
Major Flooding along Peck Road Drain

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station 8+41) ~ Todd Lane (Station 19+02)	Flooding extends into the left and right overbanks. The flooded areas include residential property	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structures 2 to 5)	Todd Lane (Station 19+28) ~ Fillmore Street (Station 42+35)	Flooding extends into the left and right overbanks areas. The flooded areas include residential and commercial properties	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 3 (Structures 6 to 8)	Fillmore Street (Station 60+46) ~ US study limit (Station 83+20)	Flooding extends into the left and right overbank area from the upstream study limit due to limited channel capacity. A large amount of flooding extends into the left overbank and flows continuously downstream to the Santa Clara River. The flooded areas include residential and commercial properties	Same as the 100-year flood, with additional flooding in the left and right overbanks

53.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 0.8 percent along the study reach. Structures that limit the conveyance capacity of Peck Road Drain include the bridges at the Private Road and Santa Paula Street, the long underground culvert, and the Faulkner Road, Peck Road, and Highway 126 bridges. The computed flow regime for 66 percent of the cross-sections was subcritical

Figure 53-1: Peck Road Drain Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

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Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 53-2: Peck Road Drain Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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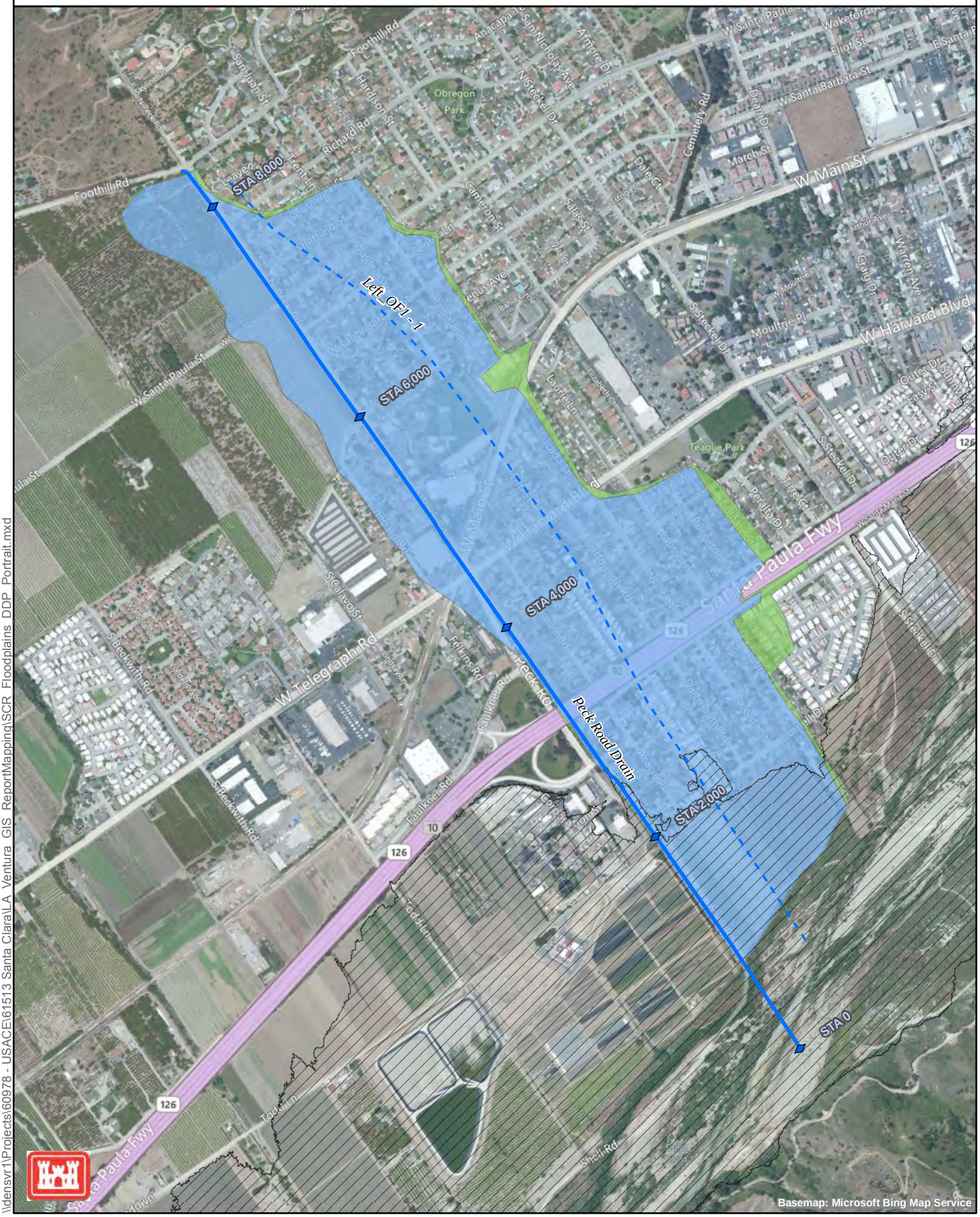
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 54
Adams Barranca

54.1 General Description

Adams Barranca is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Adams Barranca are described in this section.

Adams Barranca joins the Santa Clara River from the north, between the locations where Haines Barranca and Peck Road Drain join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 7.6 miles upstream. Figure 54-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

The upstream study reach is located within an agricultural area, while the area surrounding the downstream study reach is urbanized. Major crossings over Adams Barranca include Foothill Road, Santa Paula Street, Telegraph Road, and Highway 126.

54.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 54-1.

Table 54-1
Structures along Adams Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	23+50	Todd Lane	Bridge	Clear span, length: 18', height from lower chord of bridge deck to invert: 16', concrete-lined channel bed at DS side, gabion wall on both banks at DS side
2	30+00	Highway 126 & Faulkner Road	Multiple culverts	Culverts passing through Highway 126 & Faulkner Road, 2-12'x8' (Span x Rise) concrete box culverts, headwall & wingwalls, warped wingwalls at US & DS ends, pier nose at US end (broken, see photos in Appendix 11a), bottom of culverts filled with sediment
3	37+10	Railroad	Bridge	Clear span, length: 25', height from top of road to invert: 11.4', deck thickness: 4.1'
4	49+50	Telegraph Road	Bridge	Clear span, length: 20', height from lower chord of bridge deck to invert: 10.5', skewed to the right when looking DS, grouted riprap apron at DS side (dropped to earthen invert, see photos in Appendix 11a), sheet pile right bank protection (undermined), many pipes crossing about at bottom of bridge deck elevation (depth from top of k-rail to bottom of pipe is about 6.5')
5	79+60	Santa Paula Street	Bridge	Clear span, length: 18', height from lower chord of bridge deck to invert: 14', drop structures at DS side and under the bridge, weir at US side, pipe crossing at DS side (depth from top of concrete head wall to bottom of pipe is about 5')
6	107+60	Foothill Road	Single culvert	1-20'x12' concrete arch culvert, headwall & wingwalls, DS side very incised, slightly skewed to the left when looking DS
7	157+00	Private road	Multiple culverts (dip crossing + culverts)	2-4.5' circular CMP, pipe crossing at DS end at road elevation, grouted rock on top of culverts

Note: No access upstream of structure #7 (private property).

54.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 54-2.

Table 54-2
Sub-reaches along Adams Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 4+05) ~ Todd Lane (Station 23+50)	Straight earthen channel, irregular /trapezoidal cross section, sand /gravel/cobble channel bed, brush and trees on both channel banks, floodplain consisting of agricultural area
Sub-reach 2 (Structures 2 to 4)	Todd Lane (Station 32+81) ~ Telegraph Road (Station 49+20)	Almost straight earthen channel, irregular cross section, sand /gravel/cobble channel bed, brush and trees on both channel banks, floodplain consisting of agricultural area
Sub-reach 3 (Structures 5 to 7)	Telegraph road (Station 49+80) ~ US study boundary (Station 398+60)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, many trees (eucalyptus & elm) on both channel banks, floodplain consisting of agricultural area

54.4 Manning's Roughness Coefficients

Manning's roughness values for the Adams Barranca sub-reaches are summarized in Table 54-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 54-3
Manning's Roughness Values along Adams Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station 4+05) ~ Todd Lane (Station 23+50)	0.075	0.035	0.075
Sub-reach 2 (Structures 2 to 4)	Todd Lane (Station 32+81) ~ Telegraph Road (Station 49+20)	0.075	0.040	0.075
Sub-reach 3 (Structures 5 to 7)	Telegraph road (Station 49+80) ~ US study boundary (Station 398+60)	0.075	0.046	0.075

54.5 Hydrology

Four hydrologic concentration points were provided along the study reach (see the Introduction for the source of the hydrology information). At some concentration points the reported discharge rates are smaller than at concentration points upstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The locations of these hydrologic concentration points are shown in Figure 54-1. The peak discharge rates associated with these locations are summarized in Table 54-4.

Table 54-4
Hydrologic Concentration Points along Adams Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
308+60	211	702	1,277	2,360	3,466	4,875	6,557	9,516
282+99	267	888	1,616	2,986	4,386	6,169	8,298	12,043
194+09	299	994	1,808	3,340	4,906	6,900	9,281	13,469
0	298	991	1,803	3,330	4,892	6,880	9,254	13,430

54.6 Hydraulic Model

The Adams Barranca hydraulic model was developed with 175 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains seven bridges/culverts (see Table 54-1), a debris/detention facility and two overflow reaches. The debris/detention facility geometry was included in the hydraulic model; however, the model does not account for flow attenuation within the facility.

54.6.1 Overflow Reaches

Overflow reaches were added to the Adams Barranca model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach due to limited channel and bridge capacities. Overflow reaches were added along the left and right overbank areas upstream of West Santa Paula Street.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 54-5.

Table 54-5
Maximum Flows in Adams Barranca Overflow Reaches (cfs)

Overflow River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Right_OF1	0	0	558	1,780	2,128	2,847	2,871	4,452
Left_OF2	0	0	0	260	1,477	2,745	5,104	7,564

54.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 398+60 and 393+38) and the two downstream-most cross-sections (Station 9+37 and 4+05) in the hydraulic model. Computed boundary condition slopes are 0.02 and 0.004 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used for the overflow reaches based on the invert slopes computed between the upstream-most cross-sections and downstream-most cross-sections. The computed boundary condition slopes for the left overflow reach are 0.014 (Stations 85+89 and 80+19) and 0.02 (Stations 10+90 and 3+44), at the upstream and downstream ends, respectively, of this reach. The computed boundary condition slopes for the right overflow reach are 0.012 (Stations 59+79 and 56+13) and 0.004 (Stations 7+57 and 5+46), at its upstream and downstream ends, respectively.

54.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 54-2. Major flooded areas along Adams Barranca are summarized for the 100-year and 500-year flood events in Table 54-6.

Table 54-6
Major Flooding along Adams Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station4+05) ~ Todd Lane (Station 23+50)	Flooding extends into the left and right overbank areas until draining to the Santa Clara River or the adjacent tributary. The flooded areas include farmland, residential neighborhoods, roadways and industrial/commercial properties	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structures 2 to 4)	Todd Lane (Station 32+81) ~ Telegraph Road (Station 49+20)	Flooding extends into the left and right overbank areas start upstream of Santa Paula Street. The flooded areas include farmland, residential neighborhoods, roadways and industrial/commercial properties	Same as the 100-year flood, with additional flooding in the left and right overbanks, especially on the right overbank upstream of Santa Paula Street
Sub-reach 3 (Structures 5 to 7)	Telegraph road (Station 49+80) ~ US study boundary (Station 398+60)	Flooding extends into the left and right overbank areas. The flooded areas include brush open space and residential property near Sta. 169+40, and upstream of Foothill Road	Same as the 100-year flood, with additional flooding in the left and right overbanks

54.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 1.5 percent along the study reach. Structures that limit the conveyance capacity of Adams Barranca include the bridges at Foothill Road, West Santa Paula Street, and Telegraph Road. The predominant flow regime was subcritical.

Figure 54-1: Adams Barranca Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

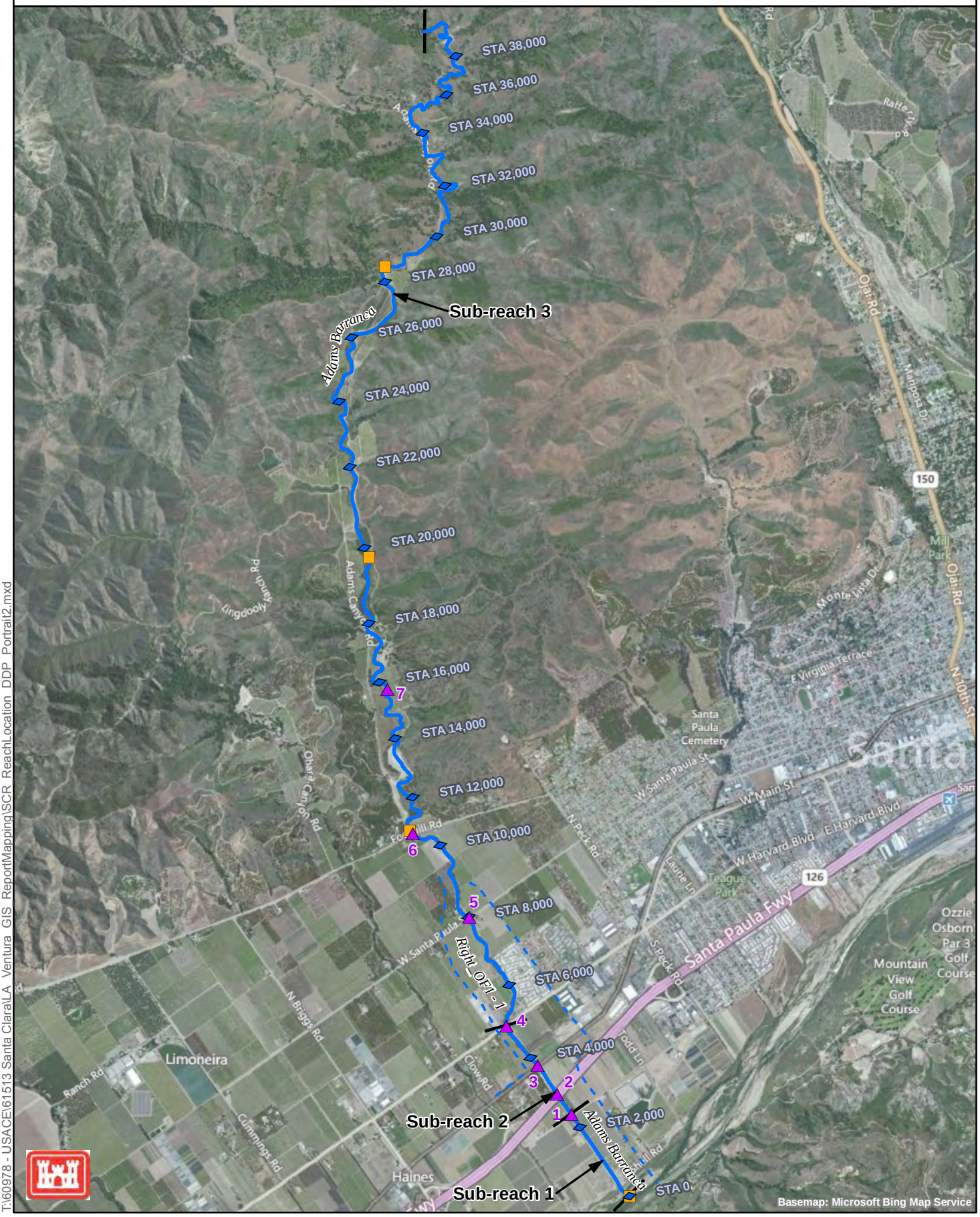

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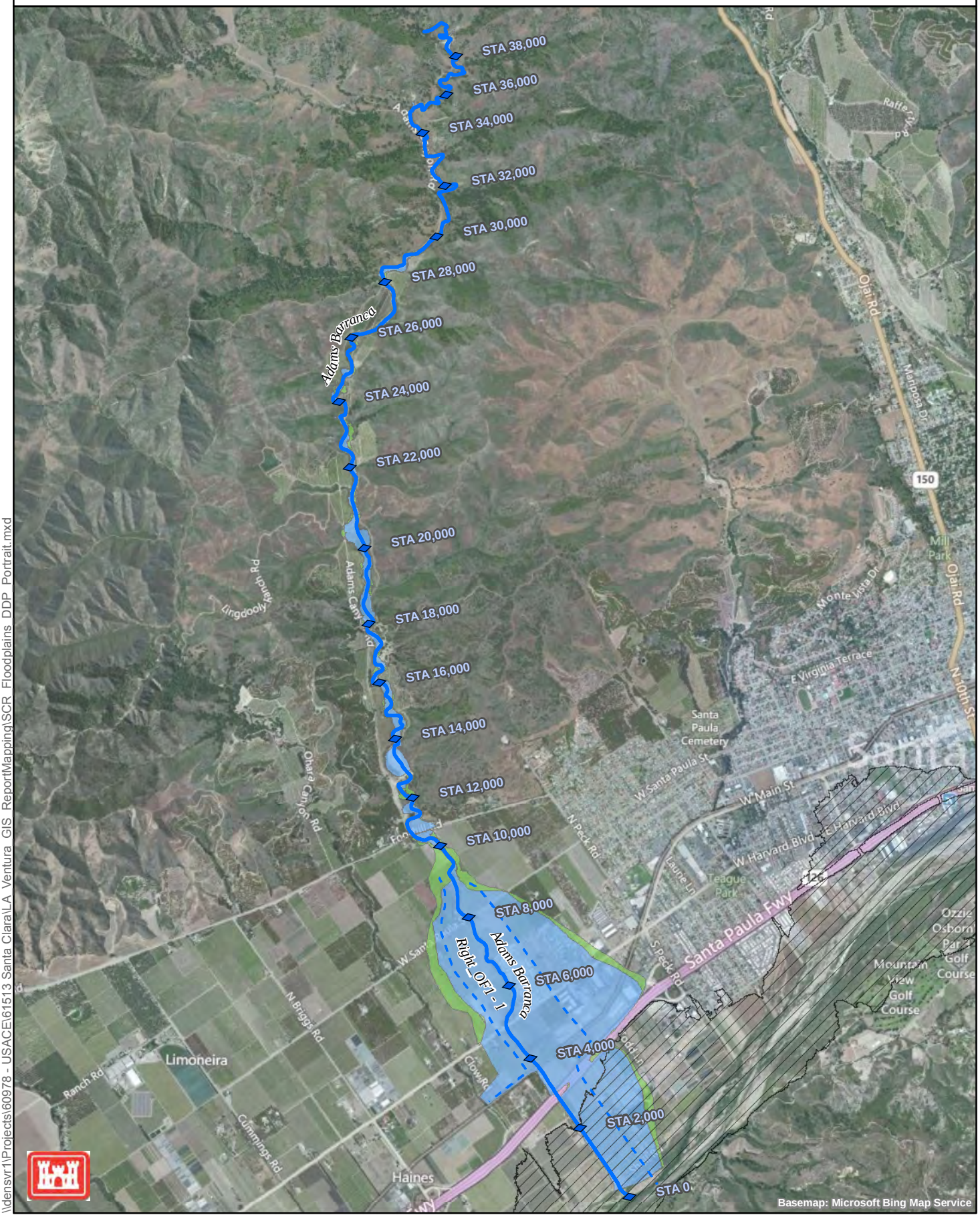
Figure 54-2: Adams Barranca Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 3,000 6,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 55
Haines Barranca

55.1 General Description

Haines Barranca is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Haines Barranca are described in this section.

Haines Barranca joins the Santa Clara River from the north, between the locations where Briggs Road Drain and Adams Barranca join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 3.2 miles upstream. Figure 55-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural with a few residential properties. Major crossings over Haines Barranca include Foothill Road, Santa Paula Street, Telegraph Road, and Highway 126.

55.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized Table 55-1.

Table 55-1
Structures along Haines Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	600	(not a road)	Pipe crossing	Pipe crossing near SCR confluence, a bunch of pipes crossing 6'~8' above channel invert
2	28+00	Highway 126	Multiple culverts	2-8'x8.5' (Span x Rise) concrete box culverts, headwall & wingwalls, warped inlet walls with pier nose (see photos in Appendix 10a), road underpass (14'x14') on left overbank
3	30+80	Faulkner Road	Multiple culverts	2-8'x8.75' concrete box culverts, headwall & wingwalls, bottom of right side culvert filled with sediment, warped inlet walls with pier nose
4	38+40	Railroad	Bridge	Clear span, length: 28', height from top of road to invert: 10.5', deck thickness: 4'
5	52+00	Telegraph Road	Single culvert	1-14'x8' concrete box culvert, headwall & wingwalls, steep concrete chute at US end, warped inlet walls, grouted riprap at US & DS
6	79+00	Santa Paula Street	(not visited)	-
7	108+00	Foothill Road	Bridge	Inaccessible (very deep channel)

Note: Could not see entire study reach. Stopped at Langdooly Ranch (private road).

55.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 55-2.

Table 55-2
Sub-reaches along Haines Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 4+68) ~ Railroad (Station 9+36)	Straight, prismatic earthen channel, trapezoidal cross section, sand /gravel/cobble channel bed, brush and trees on both channel banks, floodplain consisting of agricultural area
Sub-reach 2 (Structures 3 to 7)	Railroad (Station 12+54) ~ US study limit (Station 169+89)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, brush and trees on both channel banks, floodplain consisting of agricultural area

55.4 Manning's Roughness Coefficients

Manning's roughness values for the Haines Barranca sub-reaches are summarized in Table 55-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 55-3
Manning's Roughness Values along Haines Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 4+68) ~ Railroad (Station 9+36)	0.075	0.040	0.075
Sub-reach 2 (Structures 3 to 7)	Railroad (Station 12+54) ~ US study limit (Station 169+89)	0.075	0.040	0.075

55.5 Hydrology

Two hydrologic concentration points were provided along the Haines Barranca study reach. At some concentration points the reported discharge rates are smaller than at concentration points upstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The location of this hydrologic concentration point is shown in Figure 55-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 55-4.

Table 55-4
Hydrologic Concentration Points along Haines Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
89+81	144	480	872	1,612	2,368	3,330	4,479	6,500
0	128	425	773	1,428	2,097	2,950	3,968	5,758

55.6 Hydraulic Model

The Haines Barranca hydraulic model was developed with 158 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains seven bridges/culverts (see Table 55-1), and six overflow reaches.

55.6.1 Overflow Reaches

Six different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbanks along of the study reach. Due to perched cross-sections and conveyance limitations at culverts/bridges, flooding extends into many overflow reaches. The overflow reaches for Haines Barranca are summarized in Table 55-5.

Table 55-5
Overflow Reaches for Haines Barranca

Overflow River	Reach	Description of Location
Right_OF1	1	Upstream of Telegraph Road on the right, flows along north side of Telegraph Road and eventually flows into Briggs Road Drain
Right_OF2	1	Conveys overflow that overtops Telegraph Road on the South, flowing south until the Railroad crossing and flowing along the North side of the Railroad until connecting with Briggs Road Drain
Right_OF3	1	Upstream of the Railroad crossing on the right, flows along north side of Highway 126 and eventually flows into Briggs Road Drain floodplain
Right_OF4	1	Downstream of Highway 126 on the right, flows into the Santa Clara River
Left_OF1	1	Upstream of Telegraph Road on the left, flows along north side of Telegraph Road and eventually flows into Adams Barranca
Left_OF2	1	Downstream of Telegraph Road on the left, flows along existing depression on the left continuously until draining to the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. Flow contributions from adjacent study reaches were also accounted for within the model. Haines Barranca receives overflow discharge from Adams Barranca. The overflow transfer between watersheds was estimated in the Adams Barranca hydraulic model and added to the corresponding cross-section in the Haines Barranca model. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 55-6.

Table 55-6
Maximum Flows in Haines Barranca Overflow Reaches (cfs)

Overflow River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Right_OF1	0	0	0	0	14	66	109	532
Right_OF2	0	0	0	0	0	36	76	499
Right_OF3	0	0	115	280	289	291	294	296
Right_OF4	0	0	0	17	76	397	644	1,458
Left_OF1	0	0	405	1,681	2,408	3,874	4,865	6,894
Left_OF2	0	0	0	0	12	70	113	884

55.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 169+89 and 165+34) and the two downstream-most cross-sections (Station 5+81 and 4+68) in the hydraulic model. Computed boundary condition slopes are 0.012 and 0.026 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches. The boundary condition slopes used for the different overflow reaches are summarized in Table 55-7.

Table 55-7
Boundary Condition Slopes for the Overflow Reaches of Haines Barranca

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
Right_OF1	1	0.012	0.017
Right_OF2	1	0.02	0.006
Right_OF3	1	0.012	0.009
Right_OF4	1	0.009	0.008
Left_OF1	1	0.019	0.008
Left_OF2	1	0.014	0.002

55.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 55-2. Major flooded areas along Haines Barranca are summarized for the 100-year and 500-year flood events in Table 55-8.

Table 55-8
Major Flooding along Haines Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 4+68) ~ Railroad (Station 9+36)	Flooding is contained in the main channel until upstream of Telegraph Road where flooding extends into the left and right overbanks. The floodplain continues in the overbank areas until connecting with Briggs Road Drain (right), Adams Barranca (left) and directly into Santa Clara River	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structures 3 to 7)	Railroad (Station 12+54) ~ US study limit (Station 169+89)	Flooding is contained in the main channel except near Sta. 145+65 and upstream of Santa Paula Street. The flooded areas include farmland and residential properties	Same as the 100-year flood, with additional flooding in the left and right overbanks near Sta. 141+56, and between Sta. 158+35 to Sta. 169+89

55.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slopes range from 1.4 percent upstream to 0.9 percent downstream. Structures that limit the conveyance capacity of Haines Barranca include the bridges at West Santa Paula Street, Telegraph Road, and Highway 126. The predominant flow regime was subcritical.

Figure 55-1: Haines Barranca Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

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Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

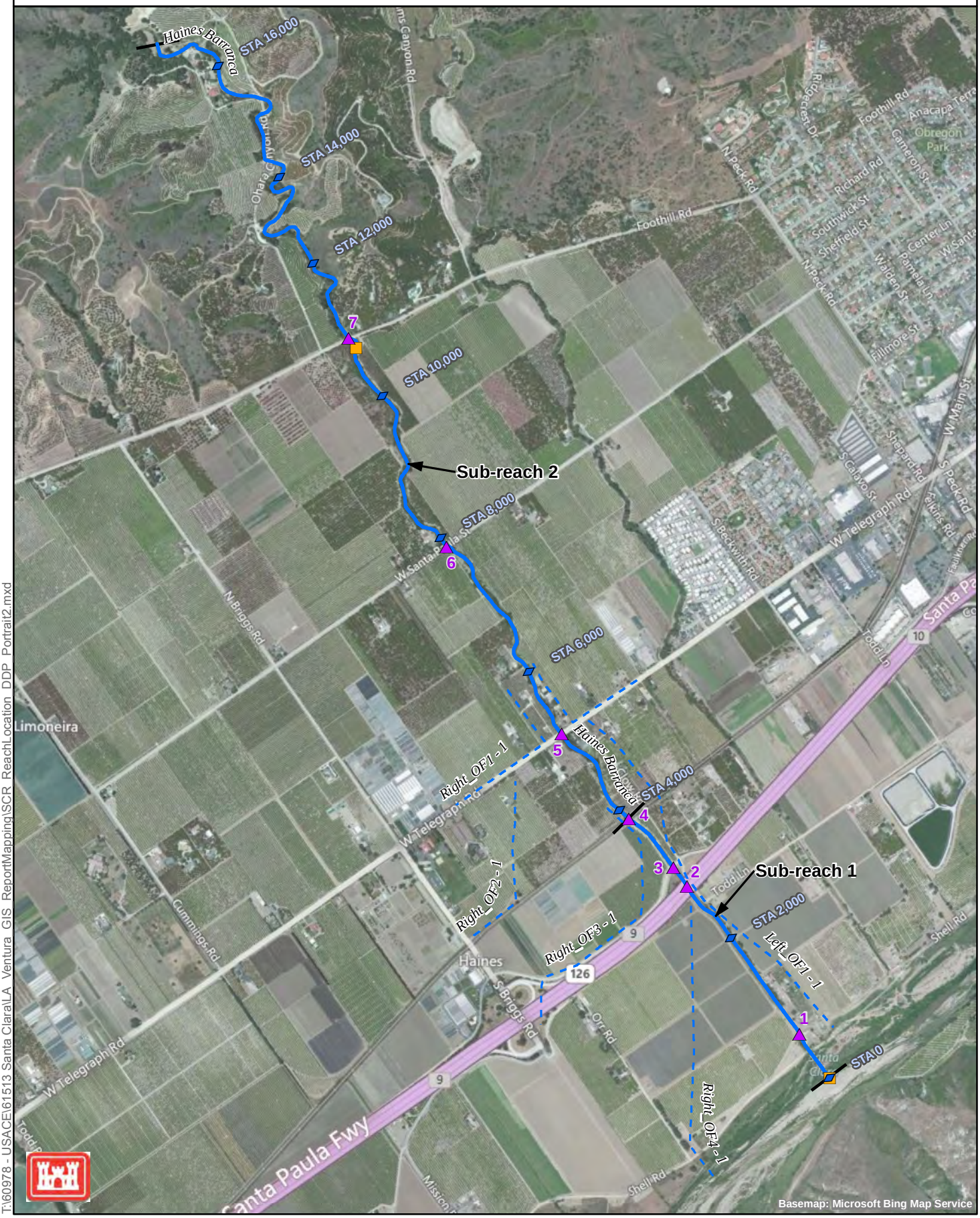

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Figure 55-2: Haines Barranca Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

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Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

Note: Overflows on the right overbank continue to Briggs Road Drain, See Figure 56-2.

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Section 56
Briggs Road Drain

56.1 General Description

Briggs Road Drain is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Briggs Road Drain are described in this section.

Briggs Road Drain joins the Santa Clara River from the north, between the locations where Cummings Road Drain and Haines Barranca join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 1.7 miles upstream. Figure 56-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural with some industrial and residential. Major crossings over Briggs Road Drain include Santa Paula Street, Telegraph Road, and Highway 126 (Santa Paula Freeway).

56.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 56-1.

Table 56-1
Structures along Briggs Road Drain (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	20+73	Shell Road (dirt road)	Pipe overcrossing (dip crossing)	2-level 9 pipes (4"~8" in diameter) crossing over earthen dam located upstream side of the road
2	40+00	Highway 126	Multiple culverts	2-8'x4' (Span x Rise) concrete box culverts, headwall, DS of culverts is a concrete dip crossing for Pinkerton Road, sedimentation at U/S end
3	41+50	Faulkner Road	Multiple culverts	2-8'x4' concrete box culverts, headwall, sloping concrete-lined inlet, pipe crossing at US end but at the road level
4	49+00	Railroad	Multiple culverts	1-4'x3.7' wooden box and 4-5'x3' elliptic CMP (flush with slope), sand bags on top of culverts, pipe crossing at US side (about 1' above channel invert), abrupt width contraction at US side by sheet piles at both banks
5	65+00	Telegraph Road	Single culvert	1-8'x6' concrete box culvert, headwall & wingwalls, broken weir at US end (see photos in Appendix 9a), pipe crossing at DS side but above the road level
6	88+90	Santa Paula Street	Single culvert	1-6'x2' concrete box culvert, DS of culvert connected to concrete-lined channel which is connected to 36" pipe at its DS end, overflow occurs at DS end of the concrete-lined channel (see photos in Appendix 9a and field notes in Appendix 2b), 90-degree bend at US side

56.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 56-2.

Table 56-2
Sub-reaches along Briggs Road Drain

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 7+37) ~ Shell Road (Station 20+19)	Straight with a couple of bends, prismatic earthen channel, trapezoidal cross section, sand & gravel channel bed, willows & trees in channel, floodplain consisting of agricultural and industrial areas
Sub-reach 2 (Structure 2)	Shell Road (Station 20+91) ~ Highway 126 (Station 38+50)	Straight, prismatic earthen channel, trapezoidal cross section, sand & gravel channel bed, no vegetation on both channel banks, floodplain consisting of agricultural area
Sub-reach 3 (Structures 3 to 6)	Highway 126 (Station 40+78) ~ US study limit (Station 89+81)	Straight, prismatic earthen channel, trapezoidal cross section, sand & gravel channel bed, weed & small brush or riprap/broken concrete on both channel banks, floodplain consisting of agricultural area

56.4 Manning's Roughness Coefficients

Manning's roughness values for the Briggs Road Drain sub-reaches are summarized in Table 56-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 56-3
Manning's Roughness Values along Briggs Road Drain

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station 7+37) ~ Shell Road (Station 20+19)	0.075	0.040	0.100
Sub-reach 2 (Structure 2)	Shell Road (Station 20+91) ~ Highway 126 (Station 38+50)	0.075	0.035	0.075
Sub-reach 3 (Structures 3 to 6)	Highway 126 (Station 40+78) ~ US study limit (Station 89+81)	0.075	0.045	0.075

56.5 Hydrology

One hydrologic concentration point was provided along the Briggs Road Drain study reach. The location of this hydrologic concentration point is shown in Figure 56-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 56-4.

Table 56-4
Hydrologic Concentration Point along Briggs Road Drain (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	53	177	322	595	875	1,230	1,654	2,401

56.6 Hydraulic Model

The Briggs Road Drain hydraulic model was developed with 70 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains six bridges/culverts (see Table 56-1), and one overflow reach.

The capacity of the channel is limited. Flows at the top of the study reach were artificially reduced to 500 cfs maximum, and all extra flows were routed down an adjacent flow path to the west. Additional overflows of the main channel were allowed via lateral weirs. Flows in the main channel are reduced to about 110 cfs (< 5-yr peak flow) at the downstream end.

56.6.1 Overflow Reaches

An overflow reach was added to the Briggs Road Drain model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel

path. Overtopping occurs along the study reach due to limited channel and bridge capacities. The overflow reach was added to the right overbank upstream of West Santa Paula Street.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. Flow contributions from adjacent study reaches were also accounted for within the model. Briggs Road Drain receives overflow discharge from Todd Barranca and Haines Barranca. The overflow transfer between watersheds was estimated in Todd Barranca and Haines Barranca hydraulic models and added to the corresponding cross-section in the Briggs Road Drain model. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 56-5.

Table 56-5
Maximum Flow in Briggs Road Drain Overflow Reach (cfs)

Overflow River	River Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
High_Q_OF (right)	1	0	90	228	933	1,542	2,258	3,057	4,647

56.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 89+81 and 89+40) and the two downstream-most cross-sections (Station 11+03 and 7+37) in the hydraulic model. Computed boundary condition slopes are 0.015 and 0.01 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reach. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 115+62 and 109+01) and the two downstream-most cross-sections (Station13+66 and 4+02) in the hydraulic model. Computed boundary condition slopes are 0.007 and 0.015 at the upstream and downstream ends of the model, respectively.

56.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 56-2. Major flooded areas along Briggs Road Drain are summarized for the 100-year and 500-year flood events in Table 56-6.

Table 56-6
Major Flooding along Briggs Road Drain

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station 7+37) ~ Shell Road (Station 20+19)	Flooding extends on the right and left overbanks at the upstream study limit and continuously flows in the overbanks until draining to the Santa Clara River. The flooded areas include farmland and commercial property	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structure 2)	Shell Road (Station 20+91) ~ Highway 126 (Station 38+50)	Flooded extends into the left and right overbank areas. The flooded areas include farmland and commercial property	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 3 (Structures 3 to 6)	Highway 126 (Station 40+78) ~ US study limit (Station 89+81)	Flooded extends into the left and right overbank areas. The flooded areas include farmland and commercial property	Same as the 100-year flood, with additional flooding in the left and right overbanks

56.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 0.6 percent along the study reach. Capacity limitations are evident at all of the crossing structures along Briggs Road Drain. The predominant flow regime was subcritical.

Figure 56-1: Briggs Road Drain Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

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Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 56-2: Briggs Road Drain Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

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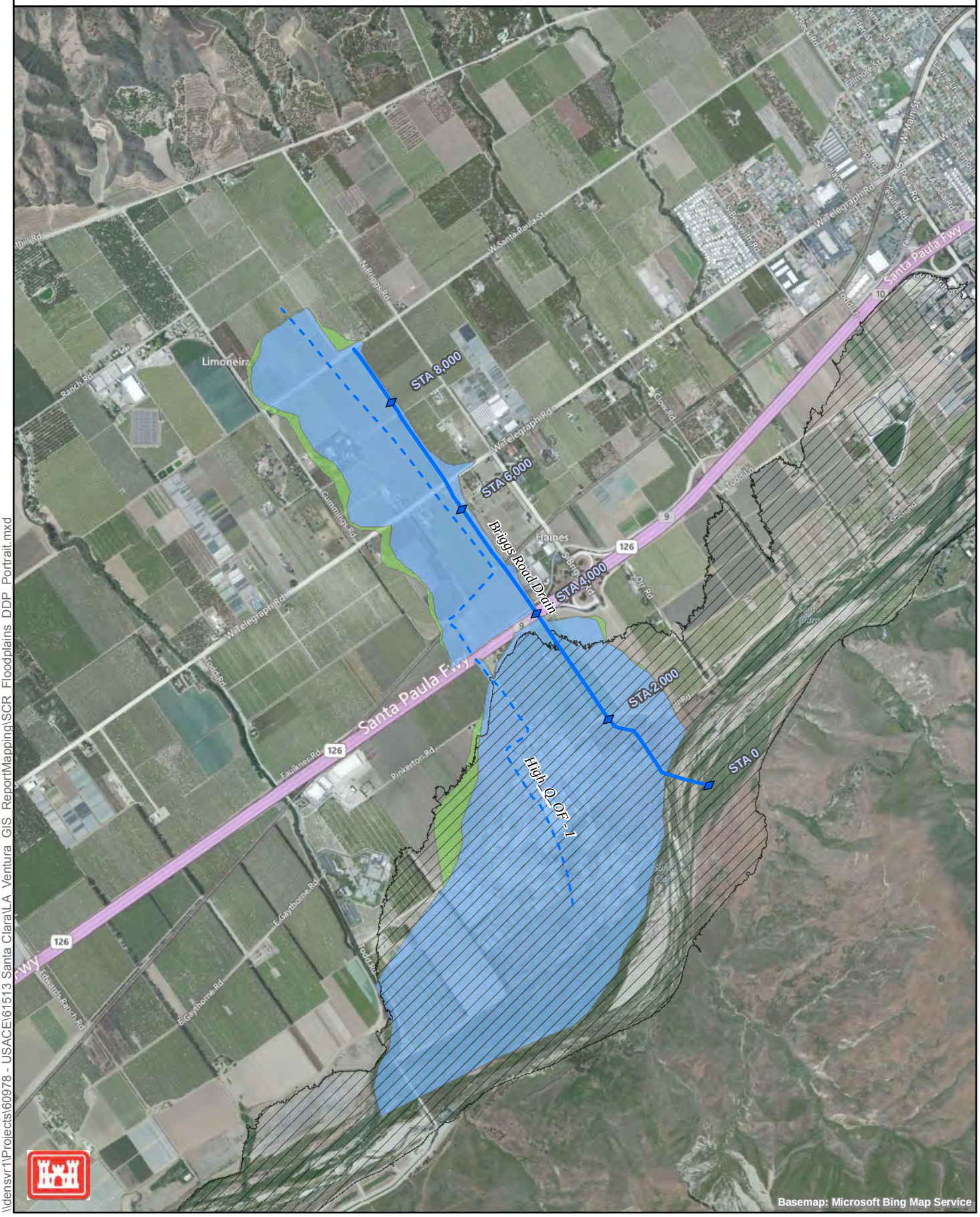
Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 57
Todd Barranca

57.1 General Description

Todd Barranca is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Todd Barranca are described in this section.

Todd Barranca joins the Santa Clara River from the north, between the locations where Ellsworth Barranca and Cummings Road Drain join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 8.7 miles upstream. Figure 57-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural with some industrial and residential areas. Major crossings over Todd Barranca include Foothill Road, Telegraph Road, and Highway 126.

57.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 57-1.

Table 57-1
Structures along Todd Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	54+00	Railroad	Bridge	Clear span, length: 40', deck thickness: 5', dense vegetation at US & DS sides
2	81+05	Downstream of Telegraph Road	Drop Structure	~3 foot drop
3	81+50	Telegraph Road	Bridge	Clear span, elevated arch (see photos in Appendix 7a), length: 55', depth from top of curb to lower chord of bridge deck: 7'
4	130+50	Ranch Road	Bridge	Clear span, flatcar bridge, deck thickness: 3', severely eroded abutment
5	171+00	Foothill Road	Single culvert	1-20'x14' (Span x Rise) concrete box culvert, headwall & wingwalls, severely eroded bank at US side
6	241+50	Private road A	Bridge	Clear span (timber + concrete), 25' x 12' (Width x Height), severely eroded bank at DS side
7	249+45	Wheeler Canyon Road A	Bridge	Clear span (30' x 8'), headwall & wingwalls
8	263+50	Private road B	Bridge	Clear span, severely eroded bank at US side
9	292+50	Private road C	Bridge	Clear span
10	323+20	Wheeler Canyon Road B	Multiple culverts	2-10'x13' concrete box culverts, headwall & wingwalls, collapsed grouted rock at DS side
11	339+04	Downstream of Wheeler Canyon Road C	Drop Structure	~1 foot drop
12	339+50	Wheeler Canyon Road C	Bridge	Clear span, length: 40', depth from top of curb to lower chord of bridge deck: 3.3', headwall & wingwalls, drop structure at DS side
13	347+17	Downstream of Wheeler Canyon Road D	Drop Structure	~1 foot drop
14	347+50	Wheeler Canyon Road D	Bridge	Clear span, length: 30', depth from top of curb to lower chord of bridge deck: 4', headwall & wingwalls, drop structure at DS side
15	354+60	Private road D (2 bridges)	Bridge	2 clear span bridges
16	377+43	Downstream of Private road E	Drop Structure	~ 10 foot drop
17	377+50	Private road E	Bridge	Clear span
18	378+70	Private road F	Bridge	Clear span
19	390+10	Private road G	Bridge	Clear span
20	399+00	Private road H	Bridge	Clear span
21	402+50	Private road I	Bridge	Clear span
22	413+50	Private road J	Bridge	Clear span
23	420+00	Liveoak Avenue	Single culvert	1-7'x4.7'concrete arch culvert, headwall & wingwalls

57.3 Sub-reaches

The study reach was divided into two sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 57-2.

Table 57-2
Sub-reaches along Todd Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 4)	SCR confluence (Station 13+66) ~ Foothill Road (Station 170+17)	Meandering earthen channel, irregular cross section, sand and gravel channel bed, floodplain consisting of agricultural area
Sub-reach 2 (Structures 5 to 23)	Foothill Road (Station 171+20) ~ US study limit (Station 459+75)	Meandering earthen channel, irregular cross section, gravel/cobble channel bed, floodplain consisting of natural mountain area

57.4 Manning's Roughness Coefficients

Manning's roughness values for the Todd Barranca sub-reaches are summarized in Table 57-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 57-3
Manning's Roughness Values along Todd Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 4)	SCR confluence (Station 13+66) ~ Foothill Road (Station 170+17)	0.075	0.052	0.075
Sub-reach 2 (Structures 5 to 20)	Foothill Road (Station 171+20) ~ US study limit (Station 459+75)	0.075	0.052	0.075

57.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Todd Barranca (see the Introduction for the source of the hydrology information). At some concentration points the reported discharge rates are smaller than at the concentration point upstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The locations of these hydrologic concentration points are shown in Figure 57-1. The peak discharge rates associated with these locations are summarized in Table 57-4.

Table 57-4
Hydrologic Concentration Points along Todd Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
459+75	197	656	1,193	2,204	3,238	4,554	6,125	8,889
347+18	298	992	1,805	3,335	4,899	6,890	9,267	13,449
0	288	958	1,742	3,219	4,728	6,650	8,944	12,981

57.6 Hydraulic Model

The Todd Barranca hydraulic model was developed with 252 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains twenty bridges/culverts and four drop structures (see Table 57-1), and five overflow reaches.

57.6.1 Overflow Reaches

Five different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbanks upstream of West Telegraph Road due to limited channel and culvert capacity. The different overflow reaches for Todd Barranca are summarized in Table 57-5.

Table 57-5
Overflow Reaches for Todd Barranca

Overflow River	Reach	Description of Location
Right_OF1	1,2	Upstream of Telegraph Road on the right, flows along the north side of Telegraph Road until it crosses under Telegraph Road and into an existing ditch that conveys flow to the Santa Clara River
Left_OF2	1	Upstream of Telegraph Road on the left, flows along the north side of Telegraph Road towards Cumming Roads Drain
Left_OF3	1	Parallels the main channel on the left overbank conveying overflow from Left_OF2 (across Telegraph Road) and the main channel between Telegraph Road and Highway 126
Left_OF4	1	Parallels the main channel conveying from Left_OF3 (across Highway 126) and the main channel between Highway 126 and the Santa Clara River
Right_126_OF	1	Upstream of Highway 126 on the right overbank, flowing along the north side of Highway 126 to Right_OF1

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 57-6.

Table 57-6
Maximum Flow in Todd Barranca Overflow Reaches (cfs)

Overflow River	Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Right_OF1	1	0	0	0	0	0	231	1,073	2,588
Right_OF1	2	0	0	0	31	876	2,327	3,807	6,326
Left_OF2	1	0	0	0	0	0	219	1,064	2,585
Left_OF3	1	0	0	0	0	21	227	1,082	2,756
Left_OF4	1	0	0	0	1,053	1,762	2,219	3,037	4,634
Right_126_OF	1	0	0	0	31	876	2,106	2,744	3,748

57.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 459+75 and 457+64) and the two downstream-most cross-sections (Station 22+89 and 13+66) in the hydraulic model. Computed boundary condition slopes are 0.036 and 0.006 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 57-7.

Table 57-7
Boundary Condition Slopes for the Overflow Reaches of Todd Barranca

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
Right_OF1	1	0.005	Junction return
Right_OF1	2	Junction	0.013
Left_OF2	1	0.013	0.008
Left_OF3	1	0.013	Junction return
Left_OF4	1	0.012	0.006
Right_126_OF	1	0.007	Junction return

57.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 57-2. Major flooded areas along Todd Barranca are summarized for the 100-year and 500-year flood events in Table 57-8.

Table 57-8
Major Flooding along Todd Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 4)	SCR confluence (Station 13+66) ~ Foothill Road (Station 170+17)	Flooding extends into the right and left overbanks upstream of Telegraph Road and Highway 126. The floodplain on the right overbank extends into an irrigation ditch and surrounding farmland where it continues into the Santa Clara River. The floodplain on the left extends till Cummings Road Drain where it flows in an existing depression until draining to the Santa Clara River. The inundated area includes farmland, roadways, industrial and residential properties	Same as the 100-year flood, with additional flooding in the left and right overbanks
Sub-reach 2 (Structures 5 to 20)	Foothill Road (Station 171+20) ~ US study limit (Station 459+75)	Flooding is contained in the main channel, except some areas where the floodplain extends into the overbanks. The flooded areas include upstream of Foothill Road, upstream of Telegraph Road, Sta. 241+77, Sta. 249+62, Sta. 323+42 to 331+62, Sta. 346+58, Sta. 390+03, Sta. 402+53, and Sta. 413+67 to Sta. 423+32. The flooded areas include farmland, roadways and a few residential properties	Same as the 100-year flood extent with additional flooding on the left and right overbanks near Sta. 376+62, Sta. 354+93, Sta. 233+00, and Sta. 195+65

57.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope ranges from 3.6 percent upstream to 1.3 percent downstream. Structures that limit the flood conveyance capacity of Todd Barranca include Telegraph Road and Highway 126. Channel capacity limitations are evident along the study reach. The predominant flow regime was subcritical.

Figure 57-1: Todd Barranca Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

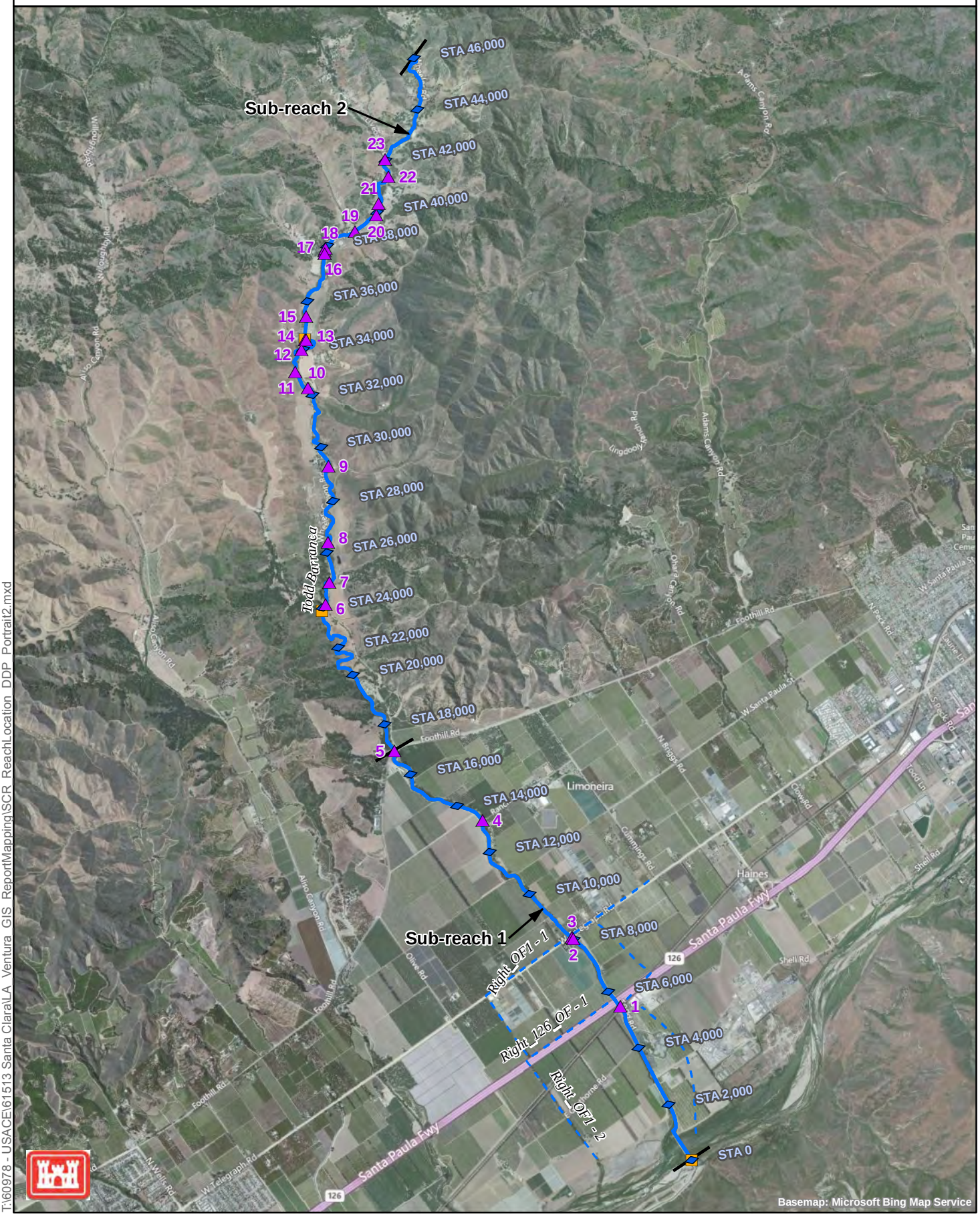

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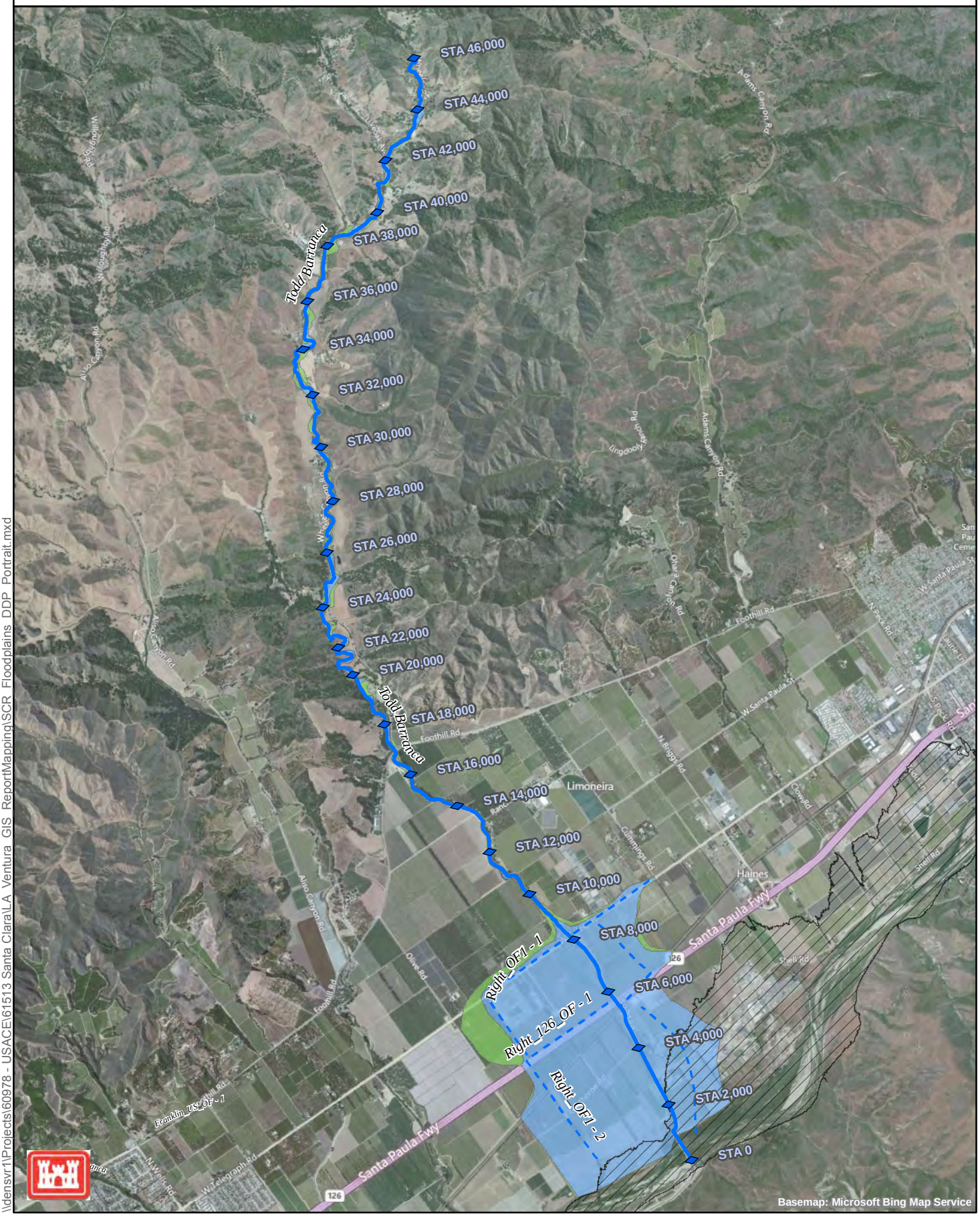
Figure 57-2: Todd Barranca Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 4,000 8,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 58
Ellsworth Barranca

58.1 General Description

Ellsworth Barranca is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Ellsworth Barranca are described in this section.

Ellsworth Barranca joins the Santa Clara River from the north, between the locations where Franklin Barranca and Todd Barranca join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 7.9 miles upstream. Figure 58-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily agricultural with some industrial and residential areas. Major crossings over Ellsworth Barranca include Foothill Road, Telegraph Road, and Highway 126 (Santa Paula Freeway).

58.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings and culverts within the study reach is summarized in Table 58-1.

Table 58-1
Structures along Ellsworth Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	33+75	Railroad	Bridge	4 pier bridge (timber + steel), pier thickness: 1.5'~4', dense vegetation at US side
2	60+00	Highway 126	Bridge	2 pier bridge, pier thickness: 3'~4'
3	85+00	Telegraph Road	Bridge	1 pier bridge (2-40'x15' openings), pier thickness: 1'~2.5', significant debris accumulation at US end
4	130+00	Foothill Road	Bridge	1 pier bridge, pier thickness: 1'~2', depth from top of curb to lower chord of bridge deck: 6.5', skewed to the right when looking DS, significant debris & sediment accumulation at US end
5	212+00	Private road	Bridge	Clear span, high elevation
6	231+80	Private road	Bridge	Clear span, high elevation
7	244+50	Aliso Canyon Road	Bridge	Clear span, deck thickness: 3'

58.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 58-2.

Table 58-2
Sub-reaches along Ellsworth Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 10+06) ~ Foothill Road (Station 129+91)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, floodplain consisting of agricultural area
Sub-reach 2 (Structures 3 to 7)	Foothill Road (Station 131+44) ~ US study limit (Station 416+74)	Meandering earthen channel, irregular cross section, gravel/cobble channel bed, floodplain consisting of natural mountain area

58.4 Manning's Roughness Coefficients

Manning's roughness values for the Ellsworth Barranca sub-reaches are summarized in Table 58-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 58-3
Manning's Roughness Values along Ellsworth Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 10+06) ~ Foothill Road (Station 129+91)	0.060	0.046	0.060
Sub-reach 2 (Structures 3 to 6)	Foothill Road (Station 131+44) ~ US study limit (Station 416+74)	0.075	0.046	0.075

58.5 Hydrology

Two hydrologic concentration points were provided along the Ellsworth Barranca study reach. At the upstream concentration point the reported discharge rates are smaller than at the concentration point downstream, which means that attenuation is expected along the study reach. For this study, flow rates were not decreased in the downstream direction to maintain conservative results. The location of these hydrologic concentration points are shown in Figure 58-1. The peak discharge rates associated with the hydrologic concentration points are summarized in Table 58-4.

Table 58-4
Hydrologic Concentration Points along Ellsworth Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
416+74	420	1395	2,539	4,690	6,890	9,690	13,033	18,915
0	412	1371	2,494	4,608	6,769	9,520	12,804	18,583

58.6 Hydraulic Model

The Ellsworth Barranca hydraulic model was developed with 209 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains seven bridges/culverts (see Table 58-1), and four overflow reaches.

58.6.1 Overflow Reaches

Four different overflow reaches were developed to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs on the right and left overbank along the study reach. The different overflow reaches for Ellsworth Barranca are summarized in Table 58-5.

Table 58-5
Overflow Reaches for Ellsworth Barranca

Overflow River	Reach	Description of location
Foothill_OF (right)	1	Overflow on the right along Foothill Road
Hwy126_channel (right)	1	Overflow on the right upstream of HWY126. Flows under HWY126 towards the Santa Clara River
BTW_HWY126_Ells (right)	1	Overflow from Hwy126_channel river on the left bank, flows directly into the Santa Clara River
West_of (right)	1	Overflow from Hwy126_channel on the right bank, flows parallel to Hwy126_channel starting on the south side of HWY126. Flows into the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 58-6.

Table 58-6
Maximum Flow in Ellsworth Barranca Overflow Reaches (cfs)

Overflow River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Foothill_OF (right)	0	0	0	0	0	0	0	111
Hwy126_channel (right)	0	0	0	0	0	0	0	1,732
BTW_HWY126_Ells (right)	0	0	0	0	0	0	0	870
West_of (right)	0	0	0	0	0	0	0	171

58.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 416+74 and 411+26) and the two downstream-most cross-sections (Station 16+43 and 10+06) in the hydraulic model. Computed boundary condition slopes are 0.024 and 0.005 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 58-7.

Table 58-7
Boundary Condition Slopes for the Overflow Reaches of Ellsworth Barranca

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
Foothill_OF (right)	1	0.025	Junction return
Hwy126_channel (right)	1	0.014	0.027
BTW_HWY126_Ells (right)	1	0.01	0.006
West_of (right)	1	0.011	0.007

58.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 58-2. Major flooded areas along Ellsworth Barranca are summarized for the 100-year and 500-year flood events in Table 58-8.

Table 58-8
Major Flooding along Ellsworth Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 10+06) ~ Foothill Road (Station 129+91)	Flooding extends on the right overbank along Foothill Road and eventually drops back into the main channel. Flooding extends onto adjacent farmland near Sta. 97+33, 83+17, 65+87, and Sta. 36+96	Same as the 100-year flood extent with additional flooding upstream of Highway 126. The floodplain extends into the right overbank along HWY 126, overtops HWY 126 and extends till Franklin Barranca inundating mostly farmland, houses and commercial property
Sub-reach 2 (Structures 3 to 6)	Foothill Road (Station 131+44) ~ US study limit (Station 416+74)	Flooding is contained in the main channel except between Sta. 299+80 and Sta. 191+52 where the floodplain extends into the left and right overbanks inundating farmland and a few residential houses/farms	Same as the 100-year flood extent with additional flooding on the left and right overbanks especially between Sta. 299+80 and Sta. 191+52 and upstream of Foothill Road

58.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope along the study reach is 1.4 percent. Structures that limit the conveyance capacity of Ellsworth Barranca include the bridges at Foothill Road and Highway 126. The predominant flow regime was subcritical.

Figure 58-1: Ellsworth Barranca Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

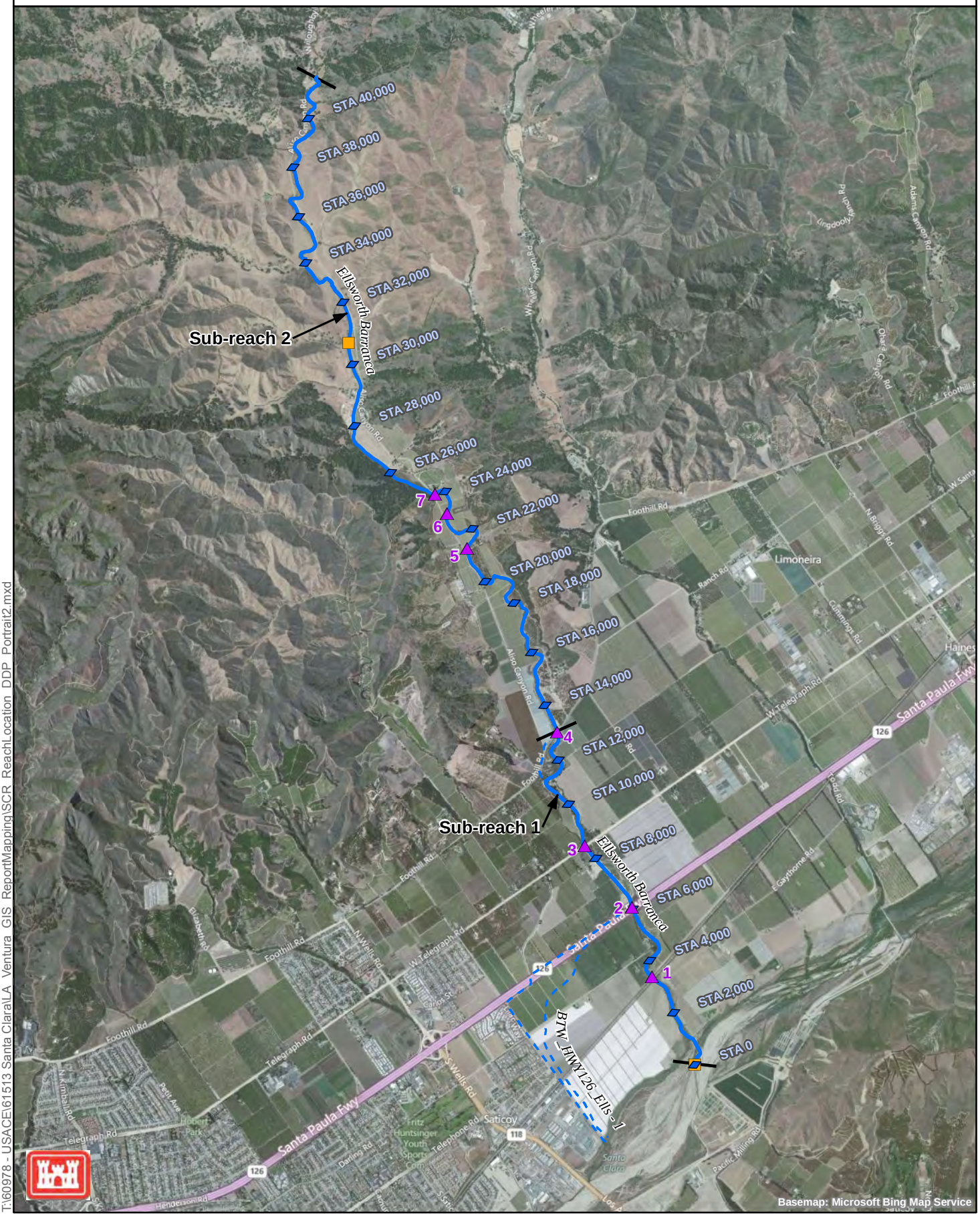

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Figure 58-2: Ellsworth Barranca Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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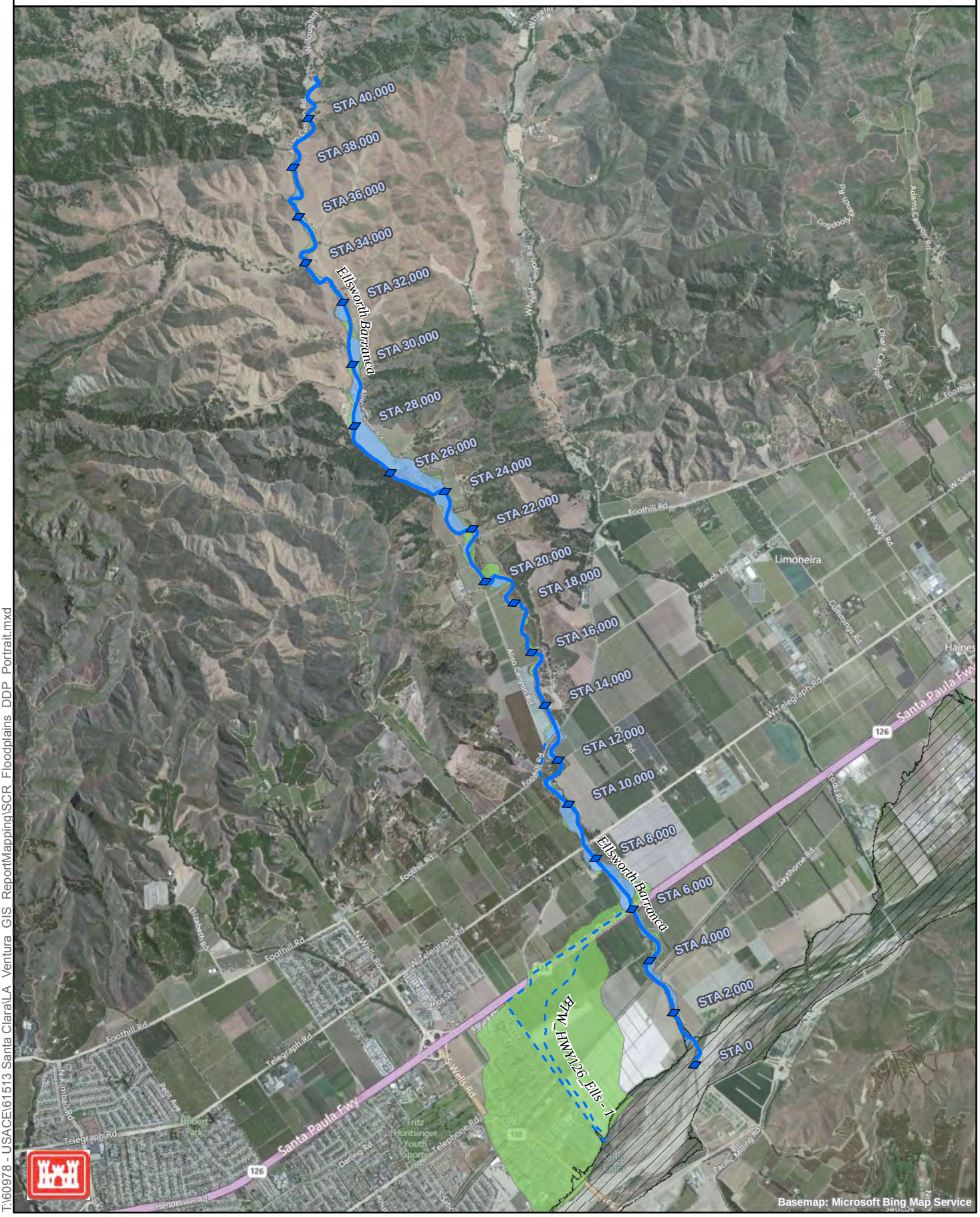
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 59
Sudden, Brown and Franklin Barranca

59.1 General Description

Sudden Barranca, Brown Barranca, and Franklin Barranca are USACE reaches within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Sudden Barranca, Brown Barranca, and Franklin Barranca are described in this section. These three reaches were combined into one section due to the hydraulic connectivity between them.

Sudden Barranca, Brown Barranca, and Franklin Barranca each join the Santa Clara River from the north. These three streams are located between Ellsworth Barranca and Harmon Barranca. The study reach for Sudden, Brown, and Franklin Barranca each begin at the Santa Clara River confluence and extend 2.7 miles, 4 miles, and 3.2 miles upstream, respectively. The Barrancas continually transition between an open channel and closed conduit along the study reaches. Figure 59-1 shows the alignment of the study reaches, the locations of structures, and the surrounding land use.

Land use is primarily residential, with some agriculture areas throughout the vicinity of these Barrancas.

59.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the Sudden, Brown, and Franklin Barrancas is summarized in Table 59-1, Table 59-2 and Table 59-3.

Table 59-1
Structures along Sudden Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	7+20	North Bank Drive	Span bridge	30'x8' concrete span bridge with vertical abutments
2	15+56	Downstream of Railroad	Drop Structure	~4 foot drop
3	15+60	Railroad Bridge	Arched culvert	8'x7' elevated arched culvert under the Railroad; concrete is severely damaged under the culvert and eroded at the downstream drop
4	20+20	Halifax	Span bridge	9'x6.5' concrete span bridge
5	42+96	Las Cruces	Buried culvert	~7'x9' culvert exit; uniform channel
6	50+00	Pueblo Street	Span bridge	10'x6' concrete span bridge
7	95+70	Darling Road to Telegraph Road	Buried culvert	6'x6' culvert entrance, 78″ RCP outlet; steep portion of channel leading into culvert
8	122+00	Unnamed Road 3a	Span bridge	Pedestrian bridge downstream of Foothill Road
9	127+20	Foothill Road	Rectangular Culvert	The culvert bends 90 degrees; there is a 19' concrete drop at the downstream side of the culvert

Notes: Descriptions with dimensions provide width by length.

Table 59-2
Structures along Brown Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	19+40	Private road	Multiple culverts	2-10'x6' (Span x Rise) concrete box culverts, depth from top of curb to lower chord of bridge deck: 2'
2	25+80	Railroad	Bridge	1 pier bridge (2-12'x5' openings), length: 28', pier thickness: 2', vertical concrete wall on both banks, concrete-lined invert under bridge
3	27+50	Private road	Bridge	Clear span, deck thickness: 3', flatcar bridge
4	28+50	Railroad (abandoned)	Bridge	1 pier bridge, pier thickness: 1', deck thickness: 2.3', skewed to the left when looking DS, significant debris at US end
5	37+00	Telephone Road	Single culvert	1-22'x9' concrete box culvert, headwall & wingwalls, grouted riprap at US & DS sides, depth from top of curb to lower chord of bridge deck: 4'
6	49+50	Darling Road	Single culvert	1-25'x5.5' concrete box culvert, depth from top of curb to lower chord of bridge deck: 4', pipe crossing at DS end under bridge, dense vegetation at US & DS sides
7	57+20	Henderson Road	Multiple culverts	3-8'x4.5' concrete box culverts, headwall, dense vegetation at US & DS sides
8	59+50	Ramp to Highway 126 (south)	Multiple culverts	3-8'x4.5' concrete box culverts, headwall & wingwalls, concrete-lined channel at US & DS sides (trapezoidal cross section)
9	63+00	Highway 126	Multiple culverts	3-8'x6' concrete box culverts, headwall & wingwalls, concrete-lined channel at US & DS sides (trapezoidal cross section at DS side, rectangular cross section at US side), lower half of the culverts at left and right ends filled with sediment & debris
10	67+00	Ramp to Highway 126 (north)	Multiple culverts	2-8'x6' concrete box culverts, headwall & wingwalls, concrete-lined channel at US & DS sides (rectangular cross section at DS side, trapezoidal cross section at US side)
11	72+00	Blackburn Road	Multiple culverts	2-8'x6' concrete box culverts, headwall & wingwalls, pier nose at US end
12	90+00	Telegraph Road	Single culvert	10'x8' concrete arch at DS end/10'x10' drop inlet at US end (see photos in Appendix 4a), drop inlet will act as orifice during high flows
13	119+60	Foothill Road	Single culvert	Arch drop inlet at US end filled with sediment (effectively 12'x3'), could not access DS end (see photos in Appendix 4a), US end arch invert elevation (top of sediment) is 9.5' lower than US channel invert elevation

Table 59-3
Structures along Franklin Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	29+11	Railroad	Bridge	Clear span, depth from top of curb to lower chord of bridge deck: 3.8', concrete-lined channel at US & DS sides, channel cross section transition from rectangular (DS) to trapezoidal (US) and invert elevation drop at US side
2	46+32	Darling Road	Bridge	Clear span (25'x5'(Width x Height)), concrete-lined channel at US & DS sides (trapezoidal cross section)
3	60+47	Highway 126	Multiple culverts	2-8'x10' concrete box culverts, headwall & wingwalls, pier nose at US end, skewed to the left when looking DS
4	84+20	Telegraph Road	Single culvert	1-12'x6' (DS end)/12'x7' (US end) concrete box culvert, headwall & wingwalls, rectangular concrete channel at DS side, grouted riprap channel at US sides
5	89+90	Downstream of Foothill	Drop structure	10.5'x3.5' concrete rectangular weir, grouted riprap at DS side, 9' channel invert elevation drop between US & DS
6	108+50	Foothill Road	Single culvert	1-8'x7'concrete box culvert, headwall & wingwalls, sandbag retaining walls at DS side, vertical concrete wall left bank at US sides, 90-degree bend at US side, 3' drop structure at US side, 4' drop at DS end
7	113+85	Private road	Single culvert	1-7'x5'concrete box culvert, headwall & wingwalls
8	142+00	Unnamed	Multiple culverts (channel stabilization structure by Ventura County)	1-5' circular CMP at DS end/1-5' drop circular inlet at US end and 1-4.5' circular CMP overflow culvert (see photos in Appendix 5a)

59.3 Sub-reaches

Each of the study reaches (Sudden, Brown, and Franklin Barranca) were divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of Sudden, Brown, and Franklin Barranca sub-reaches are summarized in Table 59-4, Table 59-5, and Table 59-6, respectively.

Table 59-4
Sub-reaches along Sudden Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 2)	SCR confluence (Station 5+71) ~ Railroad (Station 15+19)	Almost straight, prismatic and earthen channel, trapezoidal cross section, sand & gravel channel bed downstream of Railroad, concrete rectangular channel upstream; vegetation increasing toward SCR confluence (dense brush and grasses); floodplain consisting primarily of residential areas
Sub-reach 2 (Structures 4 to 7)	Railroad (Station 16+06) ~ Darling Road (Station 56+62)	Uniform rectangular concrete channel; primarily residential land use
Sub-reach 3 (Structures 8 and 9)	Darling Road (Station 96+32) ~ US study limit (Station 140+63)	Uniform trapezoidal concrete channel; residential, citrus and avocado in west overbank; citrus and residential in east overbank

Table 59-5
Sub-reaches along Brown Barranca

Sub-reach	Sub-reach Location	Left Overbank
Sub-reach 1 (Structures 1 to 5)	SCR confluence (Station 0+66) ~ Henderson Road (Station 56+57)	Almost straight, prismatic earthen channel, trapezoidal cross section, sand & gravel channel bed, floodplain consisting of industrial, agricultural, and residential areas
Sub-reach 2 (Structures 6 to 12)	Henderson Road (Station 57+46) ~ Blackburn Road (Station 71+62)	Straight, prismatic concrete channel, trapezoidal/rectangular cross sections, floodplain consisting of agricultural and residential area
Sub-reach 3 (Structure 13)	Blackburn Road (Station 72+50) ~ US study limit (Station 201+84)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, floodplain consisting of residential (DS of Foothill Rd) natural mountain (US of Foothill Rd) areas

Table 59-6
Sub-reaches along Franklin Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	SCR confluence (Station 10+39) ~ Telegraph Road (Station 83+91)	Straight, prismatic concrete channel, trapezoidal/rectangular cross sections, floodplain consisting of agricultural and residential area
Sub-reach 2 (Structures 2 to 5)	Telegraph Road (Station 84+87) ~ Foothill Road (Station 108+02)	Straight, prismatic earthen channel, trapezoidal cross section, sand & gravel channel bed, floodplain consisting of agricultural area
Sub-reach 3 (Structures 6 to 8)	Foothill Road (Station 108+99)~ US study limit (Station 168+46)	Meandering earthen channel, irregular cross section, sand/gravel/cobble channel bed, floodplain consisting of natural mountain area

59.4 Manning's Roughness Coefficients

Manning's roughness values for the Sudden Barranca, Brown Barranca, and Franklin Barranca sub-reaches are summarized in Table 59-7, Table 59-8 and Table 59-9, respectively. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 59-7
Manning's Roughness Values along Sudden Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 2)	SCR confluence (Station 5+71) ~ Railroad (Station 15+19)	0.130	0.050	0.130
Sub-reach 2 (Structures 4 to 7)	Railroad (Station 16+06) ~ Darling Road (Station 56+62)	0.130	0.015	0.130
Sub-reach 3 (Structures 8 and 9)	Darling Road (Station 96+32) ~ US study limit (Station 140+63)	0.090	0.015	0.090

Table 59-8
Manning's Roughness Values along Brown Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 to 5)	SCR confluence (Station 0+66) ~ Henderson Road (Station56+57)	0.100	0.040	0.100
Sub-reach 2 (Structures 6 to 12)	Henderson Road (Station 57+46) ~ Blackburn Road (Station 71+62)	0.100	0.015	0.100
Sub-reach 3 (Structure 13)	Blackburn Road (Station 72+50) ~ US study limit (Station 201+84)	0.090	0.052	0.090

Table 59-9
Manning's Roughness Values along Franklin Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	SCR confluence (Station 10+39) ~ Telegraph Road (Station 83+91)	0.075	0.015	0.100
Sub-reach 2 (Structures 2 to 5)	Telegraph Road (Station 84+87) ~ Foothill Road (Station 108+02)	0.075	0.040	0.075
Sub-reach 3 (Structures 6 to 8)	Foothill Road (Station 108+99)~ US study limit (Station 168+46)	0.075	0.046	0.075

59.5 Hydrology

Hydrologic concentration points were provided along each of the study reaches. (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 59-1. The peak discharge rates associated with these locations are summarized in Table 59-10, Table 59-11, and Table 59-12.

Table 59-10
Hydrologic Concentration Points along Sudden Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
134+37	25	82	149	276	405	570	767	1,113
0	227	452	636	904	1,126	1,370	1,632	2,058

Table 59-11
Hydrologic Concentration Points along Brown Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
119+27	68	225	409	755	1,110	1,561	2,099	3,047
62+13	100	332	605	1,117	1,641	2,307	3,103	4,504
0	118	392	713	1,316	1,934	2,720	3,658	5,309

Table 59-12
Hydrologic Concentration Points along Franklin Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
142+27	36	120	219	404	594	835	1,123	1,630
56+90	60	199	362	668	981	1,380	1,856	2,694
0	171	569	1,035	1,912	2,808	3,950	5,313	7,710

59.6 Hydraulic Model

The Sudden Barranca, Brown Barranca, and Franklin Barranca study reaches were combined into one hydraulic model due to the hydraulic connectivity between the three study reaches. The hydraulic model was developed with 352 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reaches. The modeled channels contains eight bridges/culverts and one drop structure along Sudden Barranca (see Table 59-1), thirteen bridges/culverts along Brown Barranca (see Table 59-2), eight bridges/culverts along Franklin Barranca (see Table 59-3), and seven overflow reaches.

59.6.1 Channel Improvements

Channel improvements were added to Sudden Barranca and Franklin Barranca based on as-built drawings. The improved reach for Sudden Barranca extends from the confluence with Santa Clara River to the long buried culvert between Darling and Telegraph Road. (reference: Ventura County Flood Control District. *Sudden Barranca Unit I DWG No. Y-2-1007 (Project No. 4771).* (Ventura County Flood Control District, 1976), Ventura County Flood Control District. *Sudden Barranca – Grade Stabilizers DWG No. Y-2-1350 (Project No. 4740)* (Ventura County Flood Control District, 1979), Ventura County Flood Control District. *Sudden Barranca Unit III at Telephone Road DWG No. Y-2-1711 (Project No. 82502).* (Ventura County Flood Control District, 1984), County of Ventura Public Works Agency, Ventura County Flood Control District. *Sudden Barranca in Tracts 4043 and 4044 DWG No. Y-2-1833 (Project No. 80719)* (Ventura County Public Works Agency, 1985), County of Ventura Public Works Agency, Ventura County Flood Control District. *Sudden Barranca – Units V & VI DWG No. Y-2-2192 (Project No. 80786 and 82506).* (Ventura County Public Works, Agency1993)).

The improved channel and culverts (for Sudden Barranca) have capacity to convey the 5-year storm event without overtopping.

The improved reach for Franklin Barranca extends from the confluence with Santa Clara River to Highway 126. (reference: USACE Hydraulic HEC-RAS model of Brown Barranca).

The improved channel and culverts (for Franklin Barranca) have capacity to convey the 5-year storm event without overtopping.

59.6.2 Overflow Reaches

Overflow reaches were added to the Sudden Barranca, Brown Barranca, and Franklin Barranca model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path and join the adjacent reaches. Overtopping occurs along the study reaches due to limited channel and bridge capacities. Overflow reaches were added along left and right overbank areas of Sudden Barranca, Brown Barranca, and Franklin Barranca. The different overflow reaches are summarized in Table 59-13. The depth and extend of flooding in the developed overbank determined for this study are very approximate. More detailed, two-dimensional modeling which accounts for street capacities, storm drain configurations, and blockages associated with structures would be required to accurately define the overbank flooding limits and hydraulic characteristics.

Table 59-13
Overflow Reaches for Sudden, Brown, and Franklin Barranca

Overflow River	Reach	Description of location
US_sudden_OF (left)	1	Overflow from Sudden Barranca on the left overbank near the upstream study limit, flows south towards Telegraph Road
Telephone_sudden (left)	1, 2	Upstream of Telegraph Road crossing on the left overbank, to convey flow along the north side of the Telegraph Road
Sudden_overflow (left)	1	Overflow from Telephone_sudden river on the south side of Telegraph Road, flows towards Santa Clara River
Tele_OF	1	Overflow from Telephone_sudden river on the south side of Telegraph Road, flows towards Brown Barranca
Brown_OF (right)	1	Downstream of the Railroad crossing on Brown Barrancas right overbank to convey overflow to the Santa Clara River
Franklin_US (right)	1	Overflow from Franklin Barranca on the right upstream overbank, flows back into Franklin Barranca
Franklin_DS (right)	1	Between Franklin and Brown Barranca, flows towards the Santa Clara River

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reaches for the different discharge frequencies are included in Table 59-14.

Table 59-14
Maximum Flow in Sudden, Brown, and Franklin Barranca Overflow Reaches (cfs)

Overflow River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
US_sudden_OF (left)	0	75	131	121	305	527	648	992
Telephone_sudden (left)	20	133	302	518	688	887	992	1,266
Sudden_overflow (left)	0	0	14	59	106	153	311	459
Tele_OF	0	60	232	446	623	804	920	1,197
Brown_OF (right)	0	0	0	284	754	1,266	1,866	3,263
Franklin_US (right)	0	0	15	9	110	91	308	883
Franklin_DS (right)	0	0	208	878	1,864	3,072	4,381	7,948

59.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel reaches. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections and the two downstream-most cross-sections in the hydraulic model for each reach. Computed boundary condition slopes for Sudden Barranca are

0.018 (Station 140+63 and 138+96) and 0.15 (Station 6+58 and 5+71) at the upstream and downstream ends of the reach, respectively. Computed boundary condition slopes for Brown Barranca are 0.03 (Station 201+84 and 198+40) and 0.036 (Station 5+02 and 66) at the upstream and downstream ends of the reach, respectively. Computed boundary condition slopes for Franklin Barranca are 0.08 (Station 168+46 and 165+91) and 0.01 (Station 12+74 and 10+39) at the upstream and downstream ends of the reach, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reaches (when a junction was not used). The boundary condition slopes used for the different overflow reaches are summarized in Table 59-15.

Table 59-15
Boundary Condition Slopes for the Overflow Reaches of Sudden, Brown, and Franklin Barrancas

Overflow River	Reach	Upstream Boundary Slope	Downstream Boundary Slope
S_sudden_OF (left)	1	0.037	Junction return
Telephone_sudden (left)	1	0.006	Junction return
Telephone_sudden (left)	2	Junction	Junction return
Sudden_overflow (left)	1	0.019	Junction return
Tele_OF	1	0.014	Junction return
Brown_OF (right)	1	0.005	0.011
Franklin_US (right)	1	0.03	Junction return
Franklin_DS (right)	1	0.046	0.009

59.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 59-2. Many cross-sections within the model are perched, and flow moves between Sudden Barranca, Brown Barranca and Franklin Barranca at several locations under peak 100- and 500-year flood conditions. Major flooded areas along Sudden Barranca, Brown Barranca, and Franklin Barranca are summarized for the 100-year and 500-year flood events in Table 59-16, Table 59-17, and Table 59-18.

Table 59-16
Major Flooding along Sudden Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 2)	SCR confluence (Station 5+71) ~ Railroad (Station 15+19)	Flooding is contained in the main channel	Same as the 100-year flood extend with additional flooding upstream of the Railroad crossing
Sub-reach 2 (Structures 4 to 7)	Railroad (Station 16+06) ~ Darling Road (Station 56+62)	Flooding extends into the left overbank due to overtopping that occurs downstream of Telegraph Road. Flooded areas included residential property and roads	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (Structures 8 and 9)	Darling Road (Station 96+32) ~ US study limit (Station 140+63)	The floodplain overtops Foothill Road into the farmland on the left overbank	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

Table 59-17
Major Flooding along Brown Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 to 5)	SCR confluence (Station 0+66) ~ Henderson Road (Station 56+57)	Flooding extends into the right overbank upstream of Blackburn Road until the confluence with the Santa Clara River. Also, additional left bank overflow occurs upstream of Darling Road	Same as the 100-year flood extend with additional flooding upstream of the Railroad crossing
Sub-reach 2 (Structures 6 to 12)	Henderson Road (Station 57+46) ~ Blackburn Road (Station 71+62)	Flooding is contained in the main channel	Same as the 100-year flood extend with additional flooding upstream of the Railroad crossing

Table 59-18
Major Flooding along Franklin Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structure 1)	SCR confluence (Station 10+39) ~ Telegraph Road (Station 83+91)	Continuous flooding on the left and right overbanks until the confluence with SCR. Flooding in the right overbank inundates residential neighborhoods and roads. Flooding on the left overbank inundates farmland	Same as the 100-year flood extent with additional flooding on the left and right overbanks
Sub-reach 2 (Structures 2 to 5)	Telegraph Road (Station 84+87) ~ Foothill Road (Station 108+02)	Flooding extends into the left overbank inundating farmland	Same as the 100-year flood extent with additional flooding on the left and right overbanks
Sub-reach 3 (Structures 6 to 8)	Foothill Road (Station 108+99)~ US study limit (Station 168+46)	Flooding is contained in the main channel except for upstream of Foothill Road where flooding extends into the right overbank inundating farmland	Same as the 100-year flood extent with additional flooding on the left and right overbanks

59.9 Profiles

Channel and water surface profiles for the peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D for Sudden, Brown and Franklin Barranca.

The Sudden Barranca study reach has average channel bed slopes ranging from 2.5 percent upstream to 0.4 percent downstream. Channel capacity limitations are evident along the study reach. The Telegraph Road is a significant obstruction. The predominant flow regime was supercritical.

The Brown Barranca study reach has average channel bed slopes ranging from three percent upstream to one percent downstream. Channel capacity limitations are evident along the study reach. Conveyance limitations are apparent at Foothill Road and all bridge/culvert structures downstream of Telegraph Road. The predominant flow regime was supercritical.

The Franklin Barranca study reach has average channel bed slopes ranging from three percent upstream to one percent downstream. Channel capacity limitations are evident along the study reach. Conveyance limitations are apparent at all bridge/culvert structures along the study reach. The predominant flow regime was supercritical.

Figure 59-1: Sudden, Brown, Franklin Barrancas Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

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Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 59-2: Sudden, Brown, Franklin Barrancas Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

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Feet

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Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 60
Clark Barranca

60.1 General Description

Clark Barranca is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Clark Barranca are described in this section.

Clark Barranca joins the Santa Clara River from the north, between the locations where Harmon Barranca and Sudden Barranca join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 3.0 miles upstream. The Clark Barranca transitions back and forth between open channel and closed conduit. There is a baffled drop structure at the downstream end of the study reach. Figure 60-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use is primarily residential, with some agricultural areas located primarily within the east overbank, upstream of Telegraph Road.

For Clark Barranca, USACE has not included additional updates to site-specific information provided by the Ventura County Watershed Protection District. Adjustments would need to be made to the hydraulic modeling that are not consistent with other models used throughout the watershed. The current model and floodplain mapping results presented in this section are consistent with the hydraulic modeling approach and mapping for other tributaries in the watershed. As such, Ventura County Watershed Protection District reserves the right to add an addendum to modify the hydraulic analysis for the Clark Barranca reach and revise the estimated floodplain map based on the revised hydraulic modeling results.

60.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 60-1.

Table 60-1
Structures along Clark Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	8+42	Downstream of Pedestrian Bridge	Drop structure	Drop structure with baffles, ~ 20 foot drop
2	970	Pedestrian Bridge	Span bridge	Steel Pedestrian bridge between Northview Drive and the outlet
3	82+86	North View Drive	Buried culvert	Culvert is buried from Northview Drive to upstream of Highway 126
4	85+00	Lakewood Avenue and Blackburn Road	Buried culvert	Culvert is buried under Lakewood Avenue and Blackburn Road
5	94+00	Blackburn and Banner Avenue	Buried culvert	Buried concrete culvert takes a 90 degree bend between the upstream and downstream ends
6	103+00	Balboa Street	Rectangular Culvert	8'x3.5' culvert under road
7	138+65	Telegraph Road	Buried culvert	Culvert appears to be buried from Telegraph Road upstream to El Dorado; channel appears to change direction under Telegraph Road
8	146+50	Calaveras Road	Rectangular Culvert	~4'x4' culvert under road
9	148+00	Foothill Road	Rectangular Culvert	~4'x4' culvert under road

Note: Descriptions with dimensions provide width by length.

60.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 60-2.

Table 60-2
Sub-reaches along Clark Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 to 3)	SCR confluence (Station 7+30) ~ North Bank Drive (Station 14+09)	Almost straight, earthen channel, silty-sand bed material with some cobbles; dense brush, small trees, and shrubs; floodplain consisting primarily of residential areas
Sub-reach 2 (Structure 4)	North Bank Drive (Station 83+13) ~ Highway 126 (Station 84+12)	Buried culvert with 90 degree bends; residential in east overbank; residential, citrus, and row crops in west overbank
Sub-reach 3 (Structures 5 to 7)	Highway 126 (Station 85+30) ~ Telegraph Road (Station 115+84)	Uniform rectangular and trapezoidal concrete channel; residential landuse in east and west overbanks
Sub-reach 4 (Structures 8 and 9)	Telegraph Road (Station 138+81) ~ Foothill Road (Station 147+91)	Buried culvert with 90 degree bends; residential, citrus, and avocado in east overbank; residential in west overbank
Sub-reach 5 (No structures)	Foothill Road (Station 148+66)~ Upstream study limit (Station 156+51)	Uniform trapezoidal channel, smooth grouted rock and bare earth; avocado and citrus in overbanks

60.4 Manning's Roughness Coefficients

Manning's roughness values for the Clark Barranca sub-reaches are summarized in Table 60-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 60-3
Manning's Roughness Values along Clark Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 7+30) ~ North Bank Drive (Station 14+09)	0.130	0.045	0.130
Sub-reach 2 (Structure 3)	North Bank Drive (Station 83+13) ~ Highway 126 (Station 84+12)	0.130	0.015	0.130
Sub-reach 3 (Structures 4 to 6)	Highway 126 (Station 85+30) ~ Telegraph Road (Station 115+84)	0.130	0.015	0.130
Sub-reach 4 (Structures 7 and 8)	Telegraph Road (Station 138+81) ~ Foothill Road (Station 147+91)	0.100	0.015	0.130
Sub-reach 5 (No structures)	Foothill Road (Station 148+66)~ Upstream study limit (Station 156+51)	0.090	0.035	0.130

60.5 Hydrology

One hydrologic concentration point was provided along the Clark Barranca study reach. The location of this hydrologic concentration point is shown in Figure 60-1. The peak discharge rates associated with this hydrologic concentration point are summarized in Table 60-4.

Table 60-4
Hydrologic Concentration Point along Clark Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
0	256	508	715	1,016	1,266	1,540	1,834	2,313

60.6 Hydraulic Model

The Clark Barranca hydraulic model was developed with 108 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains eight bridges/culverts and one drop structure (see Table 60-1), and one overflow reach.

60.6.1 Channel Improvements

Channel improvements were added to Clark Barranca based on as-built drawings. The improved reach extends from the confluence with the Santa Clara River to Telegraph Road (reference: Ventura County California. *Storm Drain Telegraph Road at Clark Barranca. F.B. 454-480.* (Ventura County, 1927), Ventura County Flood Control District. *Storm Drain through lot 46 from Telegraph Road at Blackburn Rd. F.B. 486.* (Ventura County, 1929), Ventura County Flood Control District. *Clark Barranca – Unit I 300' Downstream of S.P.R.R. to Denver Street.* (Ventura County Flood Control District, 1971), Ventura County Flood Control District. *Clark Barranca – Unit II From Denver St. to Santa Paula Freeway.* (Ventura County Flood Control District, 1972), Ventura County Flood Control District. *Clark Barranca – Unit III El Dorado Street to Telegraph Road. DWG Y-2-2037.* (Ventura County Flood Control District, 1990)).

The improved channel and culverts have capacity to convey the 5-year storm event without overtopping.

60.6.2 Overflow Reaches

An overflow reach was added to the Clark Barranca model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach due to limited channel and bridge capacities. The overflow reach was added to the right overbank upstream of Foothill Road.

The depth and extend of flooding in the developed overbank determined for this study are very approximate. More detailed, two-dimensional modeling which accounts for street capacities, storm drain configurations, and blockages associated with structures would be required to accurately define the overbank flooding limits and hydraulic characteristics.

Overflow Reach Discharges

One hydrologic concentration point was defined for Clark Barranca based on the hydrologic study (see Section 60.5). The flow associated with this hydrologic concentration point were input at the top of the hydraulic model, into a west-to-east running roadside channel that has very little capacity. Hydraulic calculations indicate that if the runoff totals are input at this location, most of the discharge would immediately overtop the channel, and would travel generally southward through developed areas that parallel the existing Clark Barranca channel. Based on this assumption, the defined floodplains for 100-year and 500-year overbank flows are confined to the west side of the existing channel. However, if more detailed hydrologic study was performed by adding additional hydrologic concentration points distributed along Clark Barranca, overbank flooding from the main channel could occur at different locations from those determined in this study.

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 60-5.

Table 60-5
Maximum Flow in Clark Barranca Right Overflow Reach (cfs)

Reach	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	266	518	725	1,026	1,276	1,550	1,844	2,323

60.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 156+51 and 156+00) and the two downstream-most cross-sections (Station 8+42 and 7+30) in the hydraulic model. Computed boundary condition slopes are 0.013 and 0.18 at the upstream and downstream ends of the model, respectively.

The normal depth boundary conditions for the overflow reach were developed based on the invert slopes computed between the upstream-most cross-sections (Stations 141+31 and 140+20) and between the downstream-most cross-sections (Stations 5+47 and 3+36). The upstream and downstream slopes at the boundaries of the overflow reach are 0.037 and 0.17, respectively.

60.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 60-2. Major flooded areas along Clark Barranca are summarized for the 100-year and 500-year flood events in Table 60-6.

Table 60-6
Major Flooding along Clark Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	SCR confluence (Station 7+30) ~ North Bank Drive (Station 14+09)	A small amount of the flow is contained in the main channel. The floodplain overflows into the right overbank downstream of Foothill Road. The floodplain extends into residential property	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 2 (Structure 3)	North Bank Drive (Station 83+13) ~ Highway 126 (Station 84+12)	A small amount of the flow is contained in the main channel. The floodplain overflows into the right overbank downstream of Foothill Road. The floodplain extends into residential property	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 3 (Structures 4 to 6)	Highway 126 (Station 85+30) ~ Telegraph Road (Station 115+84)	A small amount of the flow is contained in the main channel. The floodplain overflows into the right overbank downstream of Foothill Road. The floodplain extends into residential property	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 4 (Structures 7 and 8)	Telegraph Road (Station 138+81) ~ Foothill Road (Station 147+91)	The floodplain overtops Foothill Road into the right overbank. The flooded areas include residential property.	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Sub-reach 5 (No structures)	Foothill Road (Station 148+66)~ Upstream study limit (Station 156+51)	The floodplain overtops Foothill Road into the right overbank. The flooded areas include residential property	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

60.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope along the study reach is two percent, except for the 18 percent drop directly upstream of the confluence with Santa Clara River. A majority of the flow overtops into the right overbank due to the limited channel capacity upstream of Foothill Road. The computed flow regime for 66 percent of the cross-sections was supercritical.

Figure 60-1: Clark Barranca Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

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Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

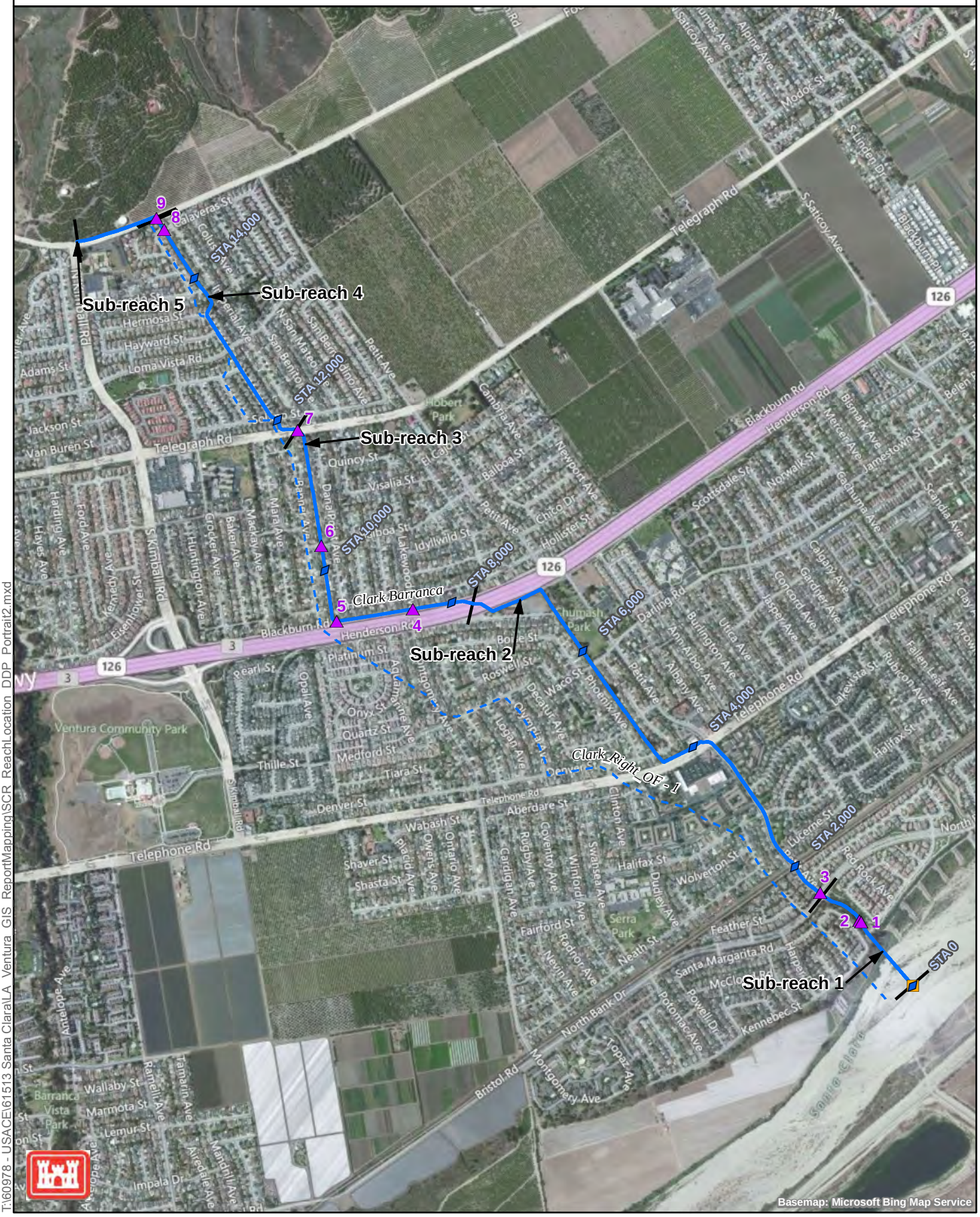

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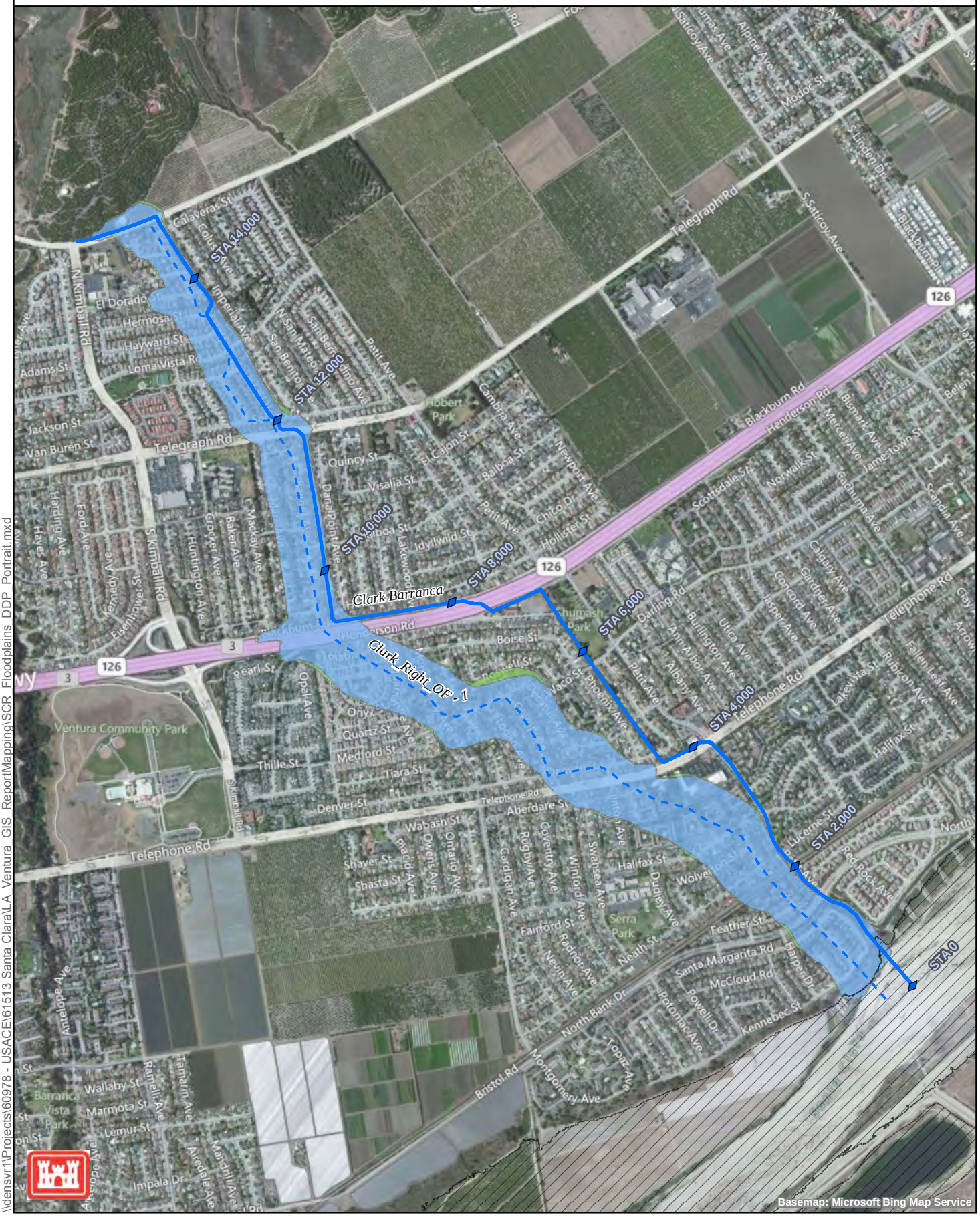
Figure 60-2: Clark Barranca Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,500 3,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 61
Harmon Barranca

61.1 General Description

Harmon Barranca is a USACE reach within the Santa Clara River Watershed Feasibility Study. Reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods, analysis assumptions, floodplain delineations and profiles of Harmon Barranca are described in this section.

Harmon Barranca joins the Santa Clara River from the north, between the locations where Moon Ditch and Clark Barranca join the mainstem. The study reach begins at the confluence with the Santa Clara River and extends 4.2 miles upstream. Figure 61-1 shows the alignment of the study reach, the locations of structures, and the surrounding land use.

Land use along Harmon Barranca is primarily agricultural and residential. Upstream of Foothill Road the channel is severely incised and unstable.

61.2 Structures

Field reconnaissance of the Santa Clara River tributaries was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts, and structures along the study reach is summarized in Table 61-1.

Table 61-1
Structures along Harmon Barranca (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	12+00	North Bank and Elba	Single culvert	20'x5.25'; change in channel geometry and slope through culvert
2	28+00	Railroad	Span bridge	Steel and concrete span bridge; cobbles and sand under the bridge
3	40+00	Bristol Street	Span bridge	14'x9' sand at downstream end of culvert covering the bottom
4	64+00	Ralston Street	Arch culvert	24'x13.5' elevated arch culvert
5	87+00	Telephone Street	Circular culvert	11' diameter; upstream end of circular culvert is a rectangular culvert with a very steep slope – exposed rebar, evidence of high velocity
6	112+00	Highway 126	Elliptical culvert	13' diameter; large concrete weir ~6' high at upstream entrance; baffle blocks and concrete drop at downstream end
7	137+00	Telegraph Road	Rectangular culvert	10'x10' steep slope throughout culvert; could not field locate the downstream end of the culvert, very dense vegetation may be covering exit
8	174+00	Foothill Road	Rectangular culvert	12'x12' upstream entrance; steep entrance evidence of concrete being eroded by high velocity flow

Note: Descriptions with dimensions provide width by length.

61.3 Sub-reaches

The study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 61-2.

Table 61-2
Sub-reaches along Harmon Barranca

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structures 1 and 2)	Confluence with Santa Clara River (Station 0+64) ~ the Railroad Crossing (Station 27+47)	Maintenance road, open field, and citrus along east overbank, residential/commercial in west overbank; eroded channel banks, large rocks, and cobble in channel; portions of channel are grouted and riprap lined; some large trees in the right overbank
Sub-reach 2 (Structures 3 to 6)	Railroad Crossing (Station 28+11) ~ Highway 126 (Station 110+00)	Sand and gravel bed material, natural channel upstream of Bristol Street (HB4); dense trees and shrubs along channel banks, large trees along top of bank; detention storage upstream of HB4 west overbank; grouted boulders and concrete bag walls near Ralston (HB5) ; citrus, small row crops, and residential along east overbank; residential along west overbank
Sub-reach 3 (Structures 7 to 8)	Highway 126 (Station 114+91) ~ Foothill Road (Station 172+47)	Gravel and cobble natural channel, grouted boulders upstream of Telegraph Road (HB8); could not find downstream end of Telegraph Road culvert; large eucalyptus and palm trees, dense vegetation and shrubs; citrus and avocado along west overbank; residential and citrus along east overbank
Sub-reach 4 (No structures)	Foothill Road (Station 175+87) ~ US study limit (Station 218+75)	Steep channel walls and dense vegetation; severely eroded banks ~30' high vertical eroded channel walls; avocado and citrus in overbanks

61.4 Manning's Roughness Coefficients

Manning's roughness values for the Harmon Barranca sub-reaches are summarized in Table 61-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 61-3
Manning's Roughness Values along Harmon Barranca

Sub-reach	Sub-reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structures 1 and 2)	Confluence with Santa Clara River (Station 0+64) ~ the Railroad Crossing (Station 27+47)	0.060	0.045	0.130
Sub-reach 2 (Structures 3 to 6)	Railroad Crossing (Station 28+11) ~ Highway 126 (Station 110+00)	0.100	0.050	0.130
Sub-reach 3 (Structures 7 to 8)	Highway 126 (Station 114+91) ~ Foothill Road (Station 172+47)	0.130	0.050	0.090
Sub-reach 4 (No structures)	Foothill Road (Station 175+87) ~ US study limit (Station 218+75)	0.090	0.050	0.090

61.5 Hydrology

Three hydrologic concentration points were provided along the study reach of Harmon Barranca (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 61-1. The peak discharge rates associated with these locations are summarized in Table 61-4.

Table 61-4
Hydrologic Concentration Points along Harmon Barranca (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
172+47	156	519	945	1745	2,564	3,606	4,850	7,039
86+19	174	578	1051	1942	2,853	4,013	5,397	7,833
0	200	667	1,213	2,241	3,292	4,630	6,227	9,038

61.6 Hydraulic Model

The Harmon Barranca hydraulic model was developed with 118 cross-sections to represent varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains eight bridges/culverts (see Table 61-1), and one overflow reach.

61.6.1 Overflow Reaches

An overflow reach was added to the Harmon Barranca model to compute the hydraulic characteristics and flooding limits of flows that leave the main channel path. Overtopping occurs along the study reach during extreme events due to limited channel and bridge capacities. The overflow reach was added to the right overbank upstream of the Railroad crossing. The depth and extend of flooding in the developed overbank determined for this study are very approximate. More detailed, two-dimensional modeling which accounts for street capacities, storm drain configurations, and blockages associated with structures would be required to accurately define the overbank flooding limits and hydraulic characteristics.

Overflow Reach Discharges

The overflow discharges were estimated using lateral weir structures and the split flow optimization option. The maximum flow obtained in the overflow reach for the different discharge frequencies are included in Table 61-5.

Table 61-5
Maximum Flow in Harmon Barranca Right Overflow Reach (cfs)

River	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
Overflow (left)	0	0	0	0	0	0	457	2,407

61.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the main channel model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 218+75 and 213+78) and the two downstream-most cross-sections (Station 3+95 and 64) in the hydraulic model. Computed boundary condition slopes are 0.015 and 0.003 at the upstream and downstream ends of the model, respectively.

Normal depth boundary conditions were also used at the upstream and downstream locations of the overflow reach. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 47+33 and 41+96) and the two downstream-most cross-sections (Station 4+57 and 1+47) in the hydraulic model. Computed boundary condition slopes are 0.019 and 0.022 at the upstream and downstream ends of the model, respectively.

61.8 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 61-2. Major flooded areas along Harmon Barranca are summarized for the 100-year and 500-year flood events in Table 61-6.

Table 61-6
Major Flooding along Harmon Barranca

Sub-reach	Sub-reach Location	100-year	500-year
Sub-reach 1 (Structures 1 and 2)	Confluence with Santa Clara River (Station 64) ~ the Railroad Crossing (Station 27+47)	Due to limited channel capacity, the floodplain extends into the right overbank inundating several residential and commercial properties. The right overflow channel follows the natural overbank grade until it reaches Ventura Freeway 101 where it flows along the north bank into Santa Clara River	Same as the 100-year flood extent with slightly wider boundaries on the left and right overbanks
Sub-reach 2 (Structures 3 to 6)	Railroad Crossing (Station 28+11) ~ Highway 126 (Station 110+00)	Floodplain is contained in the main channel except for directly upstream of the Railroad. Due to insufficient capacity of the Railroad the floodplain extends into the left and right overbanks	Same as the 100-year flood extent with slightly wider boundaries on the left and right overbanks
Sub-reach 3 (Structures 7 to 8)	Highway 126 (Station 114+91) ~ Foothill Road (Station 172+47)	Floodplain is contained in the main channel except in specific areas including Sta. 115+99 and upstream of Telegraph Road	Same as the 100-year flood extent with slightly wider boundaries on the left and right overbanks
Sub-reach 4 (No structures)	Foothill Road (Station 175+87) ~ US study limit (Station 218+75)	The floodplain extends beyond the low flow channel into the adjacent open space in the overbank areas	Same as the 100-year flood extent with slightly wider boundaries on the left and right overbanks

61.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope along the length of the study reach is two percent. Structures that are limiting the flood conveyance capacity of Harmon Barranca include the bridges at Foothill Road, Highway 126, Telephone Street, Telegraph Road and the Railroad. The predominant flow regime was subcritical.

Figure 61-1: Harmon Barranca Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

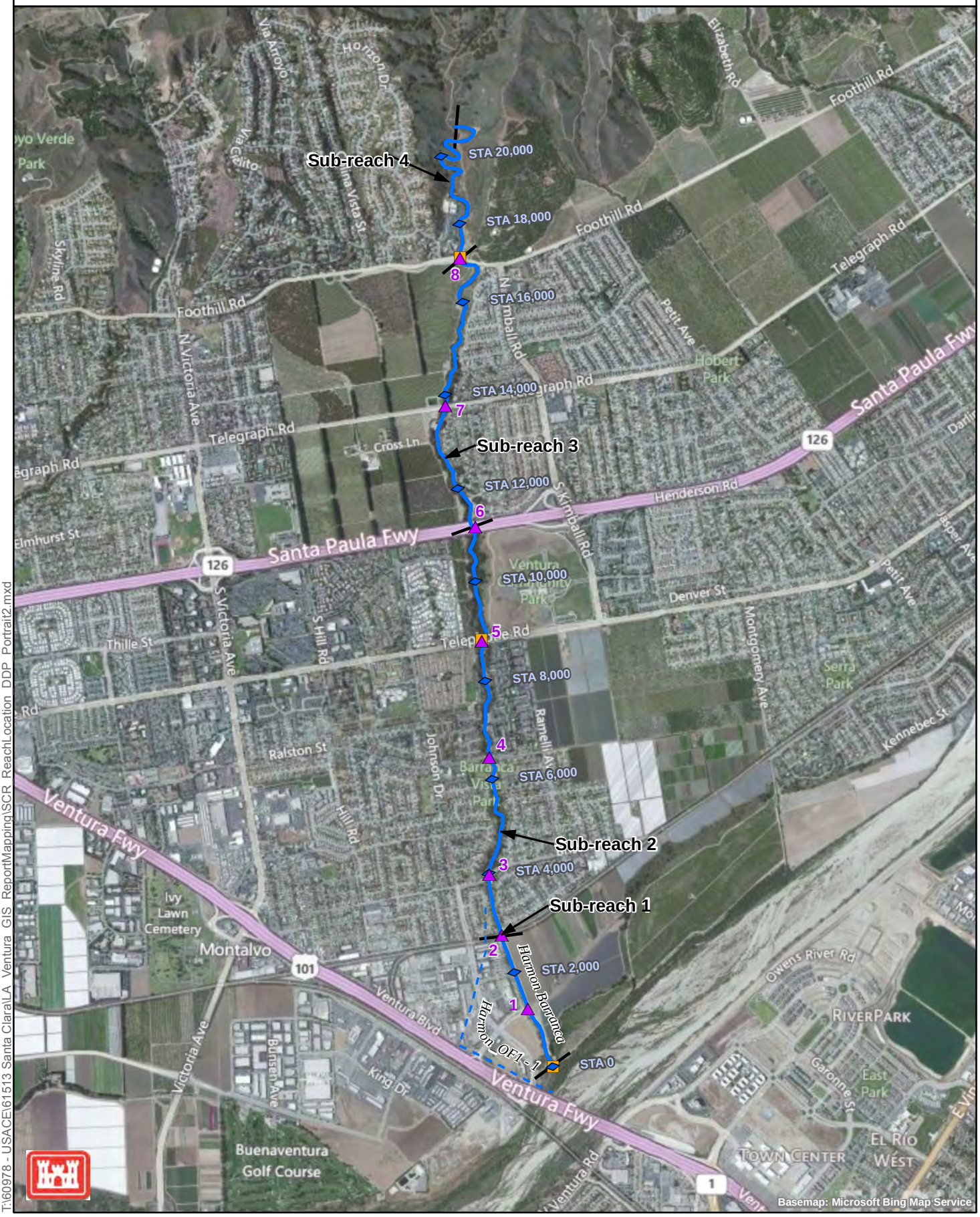

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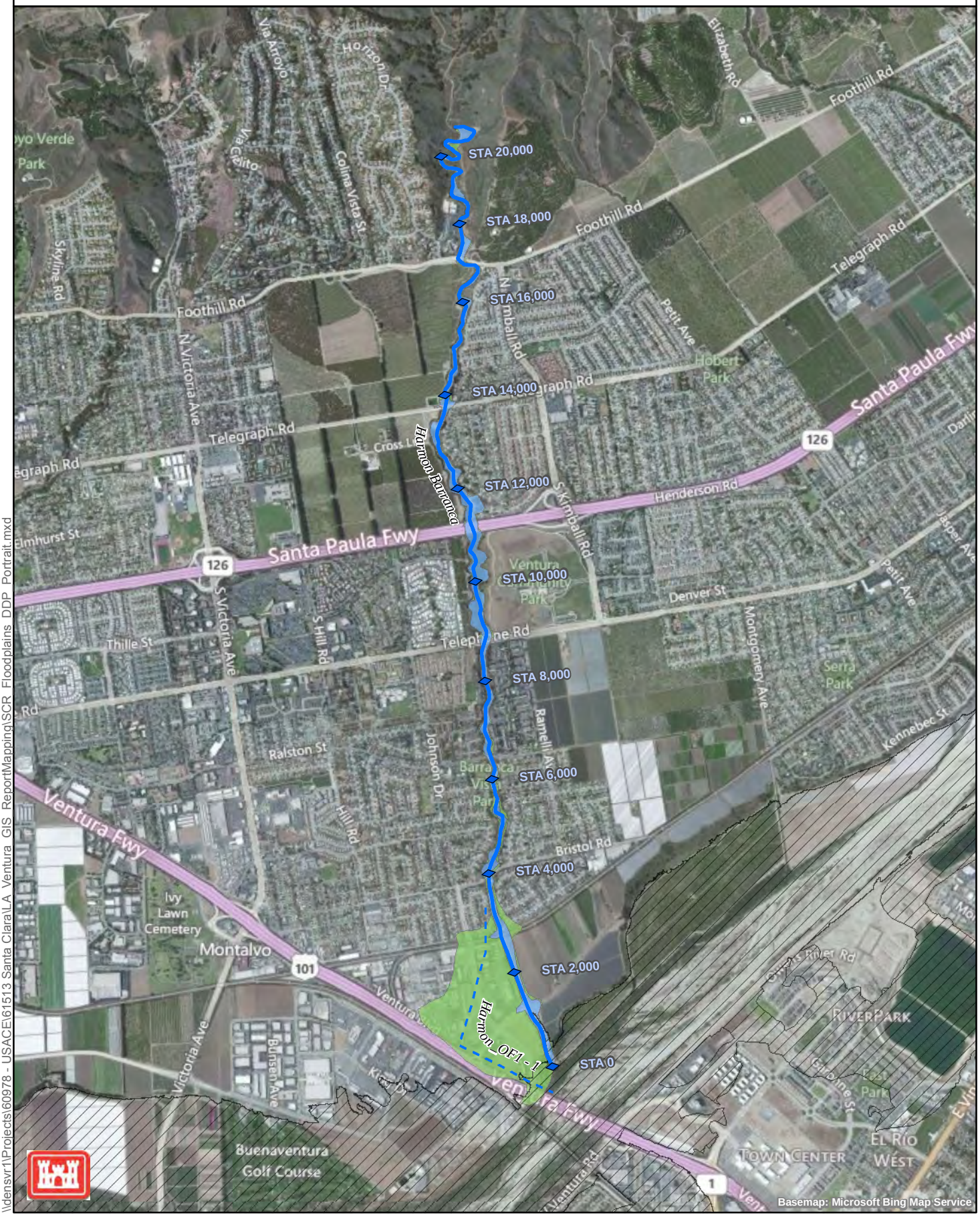
Figure 61-2: Harmon Barranca Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 2,500 5,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 62
El Rio Drain

62.1 General Description

El Rio Drain is a FEMA study reach that joins the Santa Clara River from the south, between the locations where Harmon Barranca and Patterson Drain join the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of El Rio Drain. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

62.2 Hydraulic Model

FEMA developed the hydraulic model for the study reach, which begins at the confluence with the Santa Clara River and extends upstream approximately 1.2 miles. (see Figure 62-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

62.3 Flood Boundaries

Flood boundaries for the 100- and 500-year flood events are presented in Figure 62-2. Major flooded areas along El Rio Drain are summarized for the 100-year and 500-year flood events in Table 62-1.

Table 62-1
Major Flooding along El Rio Drain

Sub-Reach	100-year	500-year
DS study limit (Station 8+63) ~ US study limit (Station 73+20)	Flooding is contained in the main channel except for upstream of Orchard Road and at Sta. 48+66. The flooded areas include commercial and residential properties	Flooding extends into the left overbank area continuously until draining to the Santa Clara River. The flooded areas include commercial and residential properties

62.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slopes is approximately eleven percent along the FEMA study reach. Channel capacity limitations are evident along the study reach under the 500-year flood conditions. The predominant flow regime is subcritical.

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Figure 62-1: El Rio Drain Study Reach Location Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 62-2: El Rio Drain Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 63
Patterson Drain

63.1 General Description

Patterson Drain is a FEMA study reach that joins the Santa Clara River from the south, downstream of the El Rio Drain confluence with the mainstem. The approved FEMA hydraulic model was acquired and used for floodplain delineations and profiles of Patterson Drain. Field reconnaissance was not conducted by the USACE or its contractors along this reach.

63.2 Hydraulic Model

FEMA developed the hydraulic model for the study reach, which begins at the confluence with the Santa Clara River and extends upstream approximately one mile (see Figure 63-1). The hydraulic model was not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

63.3 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figure 63-2. Major flooded areas along Patterson Drain are summarized for the 100-year and 500-year flood events in Table 63-1.

Table 63-1
Major Flooding along Patterson Drain

Sub-Reach	100-year	500-year
DS study limit (Station 6+53) ~ US study limit (Station 75+65)	Flooding into the right overbank areas. The flooded area includes a few residences and a golf course	Flooding extends into the right overbank area. The flooded areas include a golf course, and residential properties

63.4 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The average channel bed slope is approximately 0.1 percent along the study reach. Channel capacity limitations are evident along the study reach. The predominant flow regime is subcritical.

Figure 63-1: Patterson Drain Study Reach Location Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 63-2: Patterson Drain Floodplain Map
Santa Clara River Watershed
Feasibility Study
LA and Ventura Counties, CA

0 1,000 2,000
Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

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Section 64
Santa Clara River

64.1 General Description

The Santa Clara River study reach includes one USACE reach and two FEMA reaches. Detailed descriptions of reach characteristics (structures, geometry, landuse, etc.), hydraulic modeling methods and assumptions are presented for the USACE reach only. The floodplain delineations and profiles for the Santa Clara River tributary (including both the USACE and FEMA reaches) are summarized in Sections 64.8 and 64.9.

The USACE study reach extends along a 10.5 mile stretch located between Tick Canyon and Aliso Canyon. The FEMA study reach includes the remaining sections of the Santa Clara River. Figures 64-1a through 64-1h show the alignment of the study reach, the locations of structures, and the surrounding land use.

The Santa Clara River watershed land use is a combination of agricultural, open space, commercial, industrial, and residential properties.

64.2 Structures

Field reconnaissance of the Santa Clara River was conducted in 2008 to obtain measurements of bridge/culvert geometries, to assess existing channel roughness conditions, and to document adjacent land uses along the study reach. Photographs and field notes collected during the field reconnaissance are presented in Appendices A and B, respectively.

Information about crossings, culverts and drop structures within the USACE study reach are summarized in Table 64-1.

Table 64-1
Structures along Santa Clara River (from Downstream to Upstream)

Structure No.	River Station	Road Name	Type	Description
1	139+64	Soledad Canyon Road 1	Pier bridge	Concrete bridge, 6 piers, deck thickness: 3′
2	448+80	Soledad Canyon Road 2	Pier bridge	Concrete bridge, 3 piers, deck thickness: 5~6ft

64.3 Sub-reaches

The USACE study reach was divided into several sub-reaches having relatively constant physical characteristics including main channel geometry, bed material, overbank area land use, and degree of channel meandering. The limits and major features of the sub-reaches are summarized in Table 64-2.

Table 64-2
Sub-reaches along Santa Clara River

Sub-reach	Sub-reach Location	Description
Sub-reach 1 (Structure 1)	DS study limit (Station 0+40) ~ 9,500 ft DS of US study limit (Station 490+12)	Thick vegetated channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space and farmland
Sub-reach 2 (Structure 2)	9,500 ft DS of US study limit (495+83) ~ US study limit (Station 582+64)	Broad vegetated channel, sand/gravel/cobbles channel bed, floodplain consisting of brushy open space and residential

64.4 Manning's Roughness Coefficients

The Manning's roughness values for each sub-reach of the USACE study reach are summarized in Table 64-3. (Note: the procedures used for determination of these values are described in the Introduction. Supporting calculations are provided in Appendix C.)

Table 64-3
Manning's Roughness Values along Santa Clara River

Sub-Reach	Sub-Reach Location	Left Overbank	Main Channel	Right Overbank
Sub-reach 1 (Structure 1)	DS study limit (Station 0+40) ~ 9,500 ft DS of US study limit (Station 490+12)	0.05	0.044	0.05
Sub-reach 2 (Structure 2)	9,500 ft DS of US study limit (495+83) ~ US study limit (Station 582+64)	0.06	0.044	0.05

64.5 Hydrology

Five hydrologic concentration points were provided along the USACE study reach (see the Introduction for the source of the hydrology information). The locations of these hydrologic concentration points are shown in Figure 64-1a through 64-1h. The peak discharge rates associated with these locations are summarized in Table 64-4.

Table 64-4
Hydrologic Concentration Points along Santa Clara River (cfs)

River Station	2-year	5-year	10-year	25-year	50-year	100-year	200-year	500-year
450+00	440	1,480	2,800	5,510	8,550	12,660	18,150	28,080
385+72	550	1,830	3,460	6,810	10,560	15,650	22,440	34,710
147+90	600	2,010	3,800	7,480	11,610	17,200	24,660	38,150
140+22	710	2,360	4,470	8,790	13,640	20,210	28,980	44,830
0	750	2,500	4,720	9,280	14,400	21,340	30,600	47,330

64.6 Hydraulic Model

The Santa Clara River hydraulic model was developed with 188 cross-sections to represent the varying channel geometry and hydraulic structures located along the study reach. The modeled channel contains two bridges/culverts (see Table 64-1).

64.6.1 FEMA Reach

FEMA developed hydraulic models for two reaches along the Santa Clara River: a downstream model that extends from the confluence with the Pacific Ocean to the downstream limit of the USACE study reach (near the confluence with Tick Canyon); and an upstream model that extends from the upstream limit of the USACE study reach (near the confluence with Aliso Canyon) to the confluence with Soledad Canyon. The hydraulic models were not reviewed or modified other than to update and extend the hydrology to conform to the latest study values, as discussed in the Introduction.

64.7 Boundary Conditions

Normal depth boundary conditions were used at the upstream and downstream locations of the USACE model. These boundary conditions were developed based on the channel bottom slopes computed between the two upstream-most cross-sections (Station 582+64 and 580+05) and the two downstream-most cross-sections (Station 2+54 and 40) in the hydraulic model. Computed boundary condition slopes are 0.015 and 0.02 at the upstream and downstream ends of the model, respectively.

64.8 Flood Boundaries

Flood boundaries for 100- and 500-year flood events are presented in Figures 64-2a through 64-2h. Major flooded areas along Santa Clara River are summarized for the 100-year and 500-year flood events in Table 64-5.

Table 64-5
Major Flooding along the Santa Clara River

Sub-Reach	100-year	500-year
USACE Reach		
DS study limit ~ Soledad Canyon Road	Flooding is contained to the open space adjacent to the low flow channel. Additional overbank flooding occurs downstream of Soledad Canyon Road (Sta. 44+442 to 424+62), at Sta. 389+25, Sta. 350+67, Sta. 261+43, Sta. 247+68, Sta. 200+07, Sta. 130+98, Sta. 83+22, and Sta. 7+70. The inundated areas include residential areas, parking lots, open space and the Railroad	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
Soledad Canyon Road ~ US study limit	In general, flooding is contained to the open space adjacent to the low flow channel; except flooding extends into the left overbanks at Sta. 573+62 to Sta. 532+66	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks
FEMA Reaches		
SCR mouth ~ Los Angeles Avenue	Flooding extends into the left overbank at Sta. 407+99 until it reaches the Pacific Ocean. Additional flooding in the right overbank occurs starting at Sta. 349+28 and continues until the Pacific Ocean	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks
Los Angeles Avenue ~ Los Angeles County boundary	Flooding extends into the left and right overbanks for a majority of the reach until Sta. 529+68. The flooded areas include farmland, residential, commercial and industrial properties	Same as the 100-year flood, with slightly extended boundaries in the left and right overbanks especially at Sta. 493+87 and upstream of Los Angeles Avenue
Los Angeles County boundary ~ USACE DS study limit	Flooding is contained to the open space adjacent to the low flow channel. Additional overbank flooding occurs at Sta. 308+484 to 307+598 (right), Sta. 307+598 to Sta. 305+625 (left), Sta. 283+601 to Sta. 282+457 (right), Sta. 279+242 to Sta. 276+016 (left), Sta. 219+874 to Sta. 216+595 (left) and Sta. 215+320 to Sta. 209+651 (right). The inundated areas include residential neighborhoods, commercial property, parking lots, open space, and farmland	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks. Areas with noticeable differences are at Sta. 296+003 to Sta. 293+795 (left/right), Sta. 293+058 to Sta. 290+710 (left/right), Sta. 283+601 to Sta. 276+016 (left), Sta. 274+646 to Sta. 271+083 (left), Sta. 267+673 to Sta. 266+338 (left), Sta. 263+975 to Sta. 258+685 (left), and Sta. 232+969 to Sta. 231+451 (right). The inundated areas include residential neighborhoods, commercial property, parking lots, open space, and farmland
USACE US study limit ~ FEMA US study limit	Flooding is contained to the open space adjacent to the low flow channel. Additional overbank flooding occurs at Sta. 406+075 (right), Sta. 396+836 (right), and Sta. 396+565 to sta. 389+786 (left). The inundated areas include residential areas, parking lots, open space, the Railroad and Soledad Canyon	Same as the 100-year flood extent with slightly wider boundary on the left and right overbanks

64.9 Profiles

Channel and water surface profiles for peak 500-, 200-, 100-, 50-, 25-, 10-, 5-, and 2-year flood events are presented in Appendix D. The channel bed slope along the Santa Clara River ranges from 1.5 percent in the upstream reaches to 0.2 percent downstream near the confluence with the Pacific Ocean. Structures that limit the conveyance capacity of the Santa Clara River include the bridges at Los Angeles Avenue, and Highway 101. The majority of flooding is due to channel capacity limitations. The predominant flow regime was subcritical.

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Figure 64-1 (Index): Santa Clara River Study Reach Location Map

Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 35,000 70,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

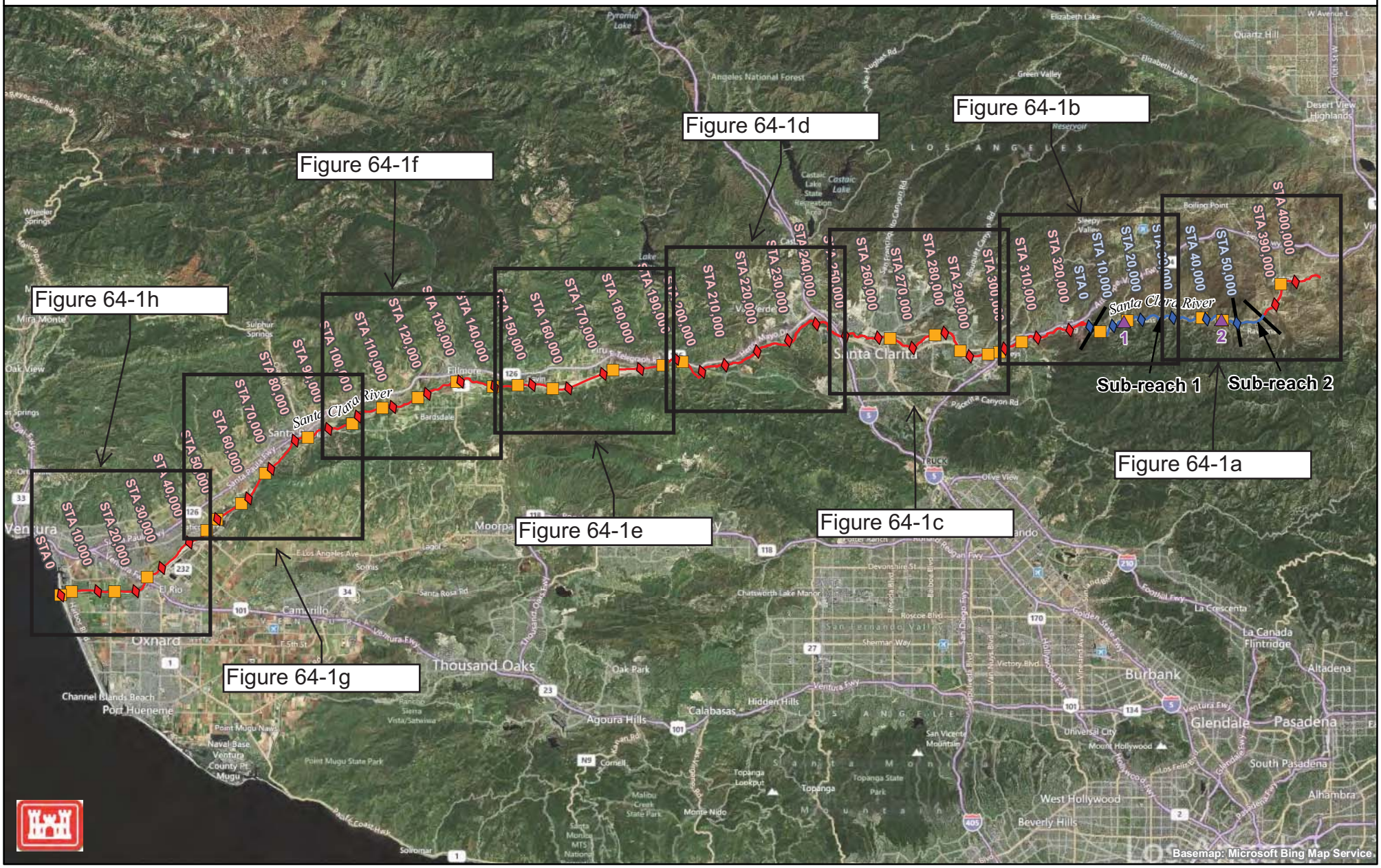

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Figure 64-1a: Santa Clara River Study Reach Location Map (1 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

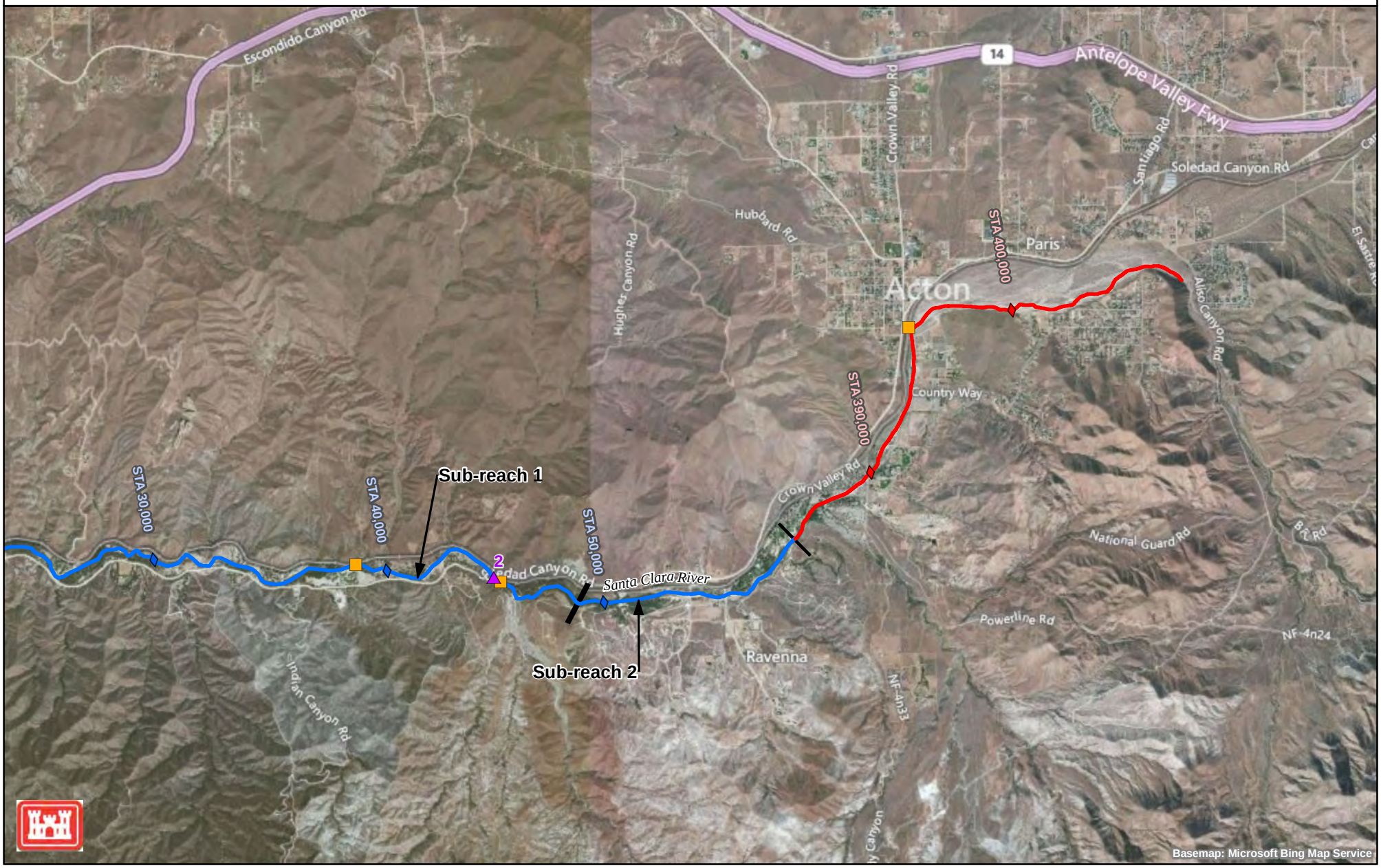

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Figure 64-1b: Santa Clara River Study Reach Location Map (2 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 64-1c: Santa Clara River Study Reach Location Map (3 of 8)

Santa Clara River Watershed Feasibility Study

LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

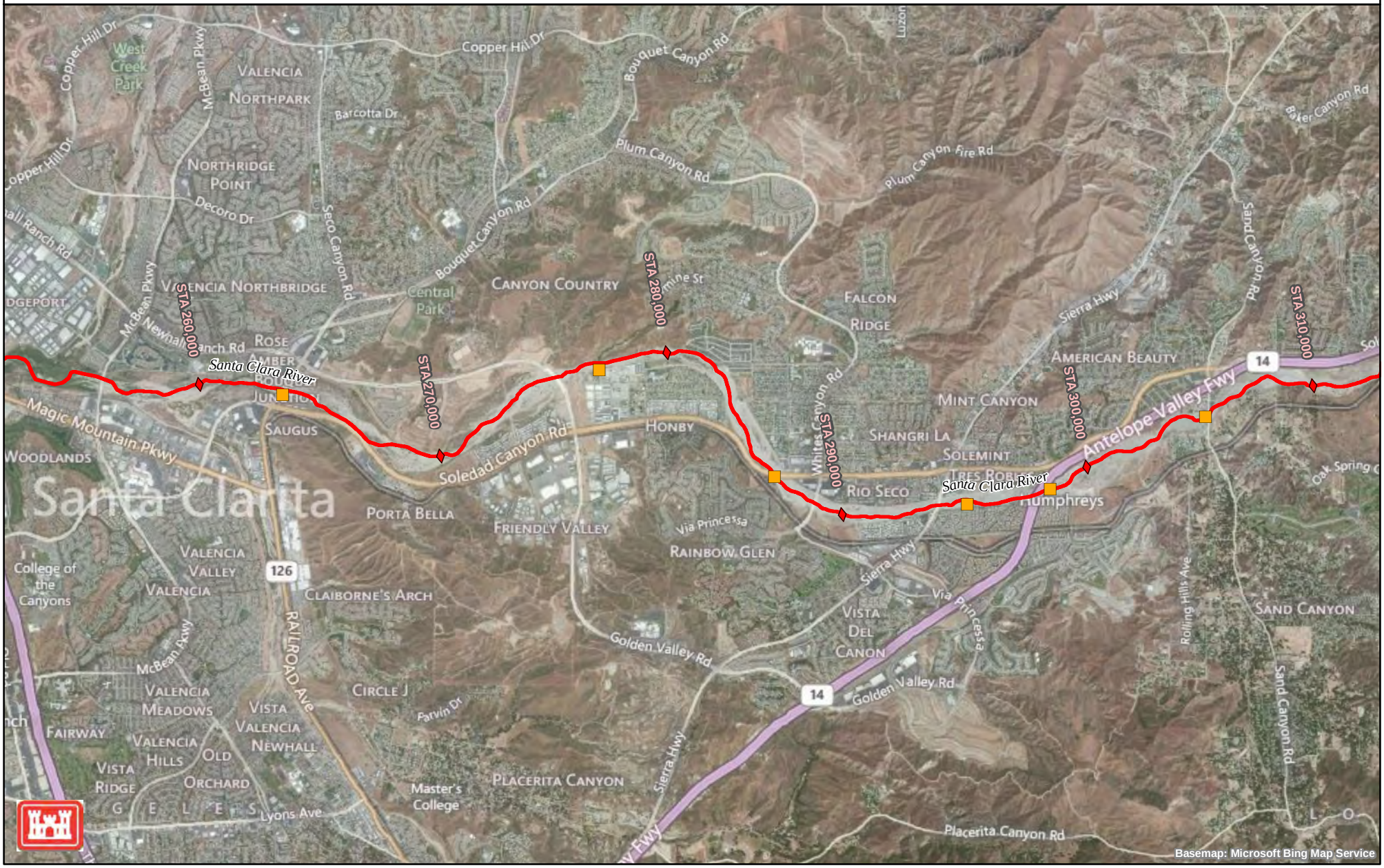

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Figure 64-1d: Santa Clara River Study Reach Location Map (4 of 8)

Santa Clara River Watershed Feasibility Study

LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 64-1e: Santa Clara River Study Reach Location Map (5 of 8)

Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 64-1f: Santa Clara River Study Reach Location Map (6 of 8)

Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 64-1g: Santa Clara River Study Reach Location Map (7 of 8)

Santa Clara River Watershed Feasibility Study

LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

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Figure 64-1h: Santa Clara River Study Reach Location Map (8 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Structure
- Concentration Point Location
- Station Point (FEMA)
- Station Point (USACE)
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

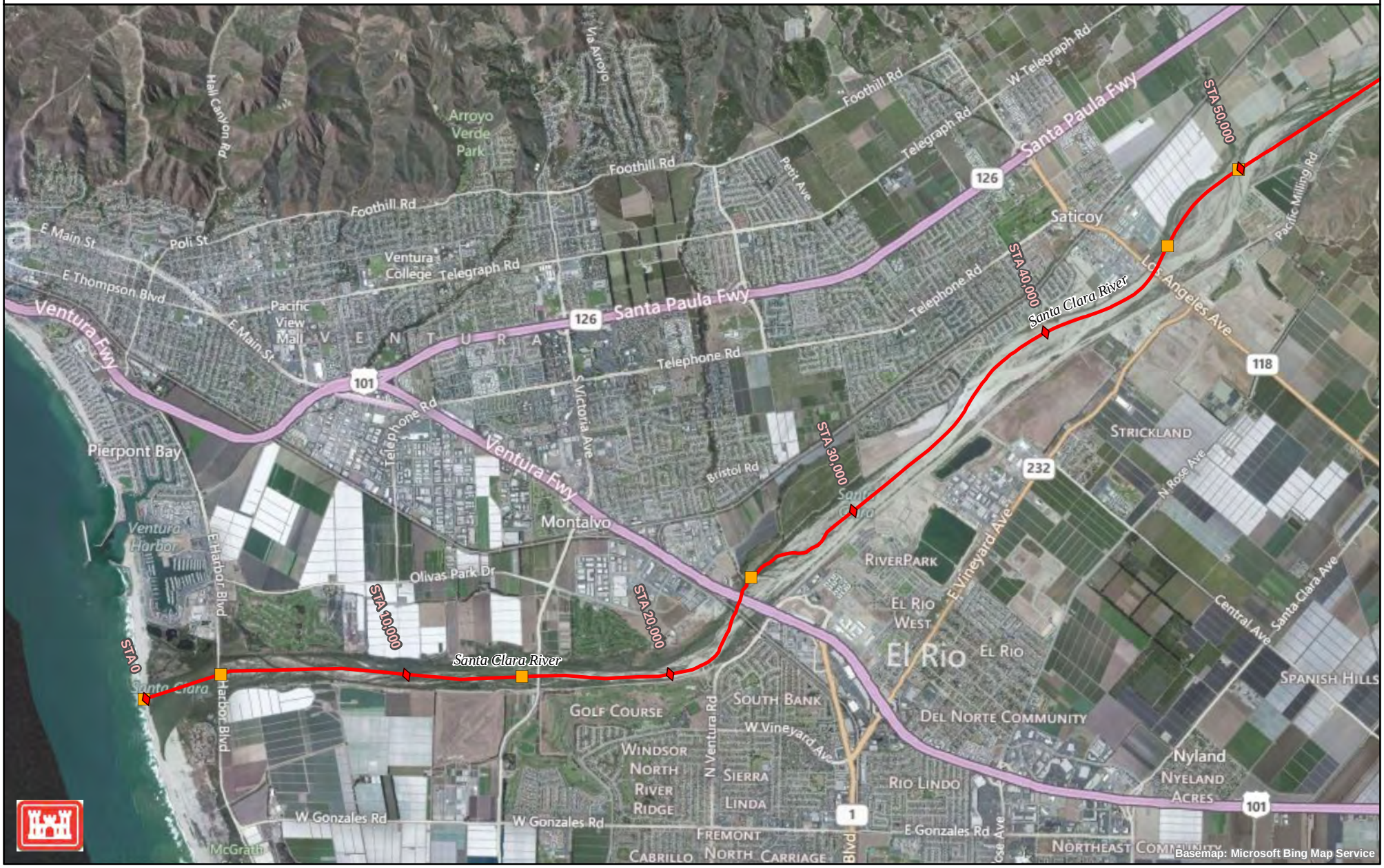

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Figure 64-2 (Index): Santa Clara River Floodplain Map
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 35,000 70,000 Feet

N

Legend
- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach

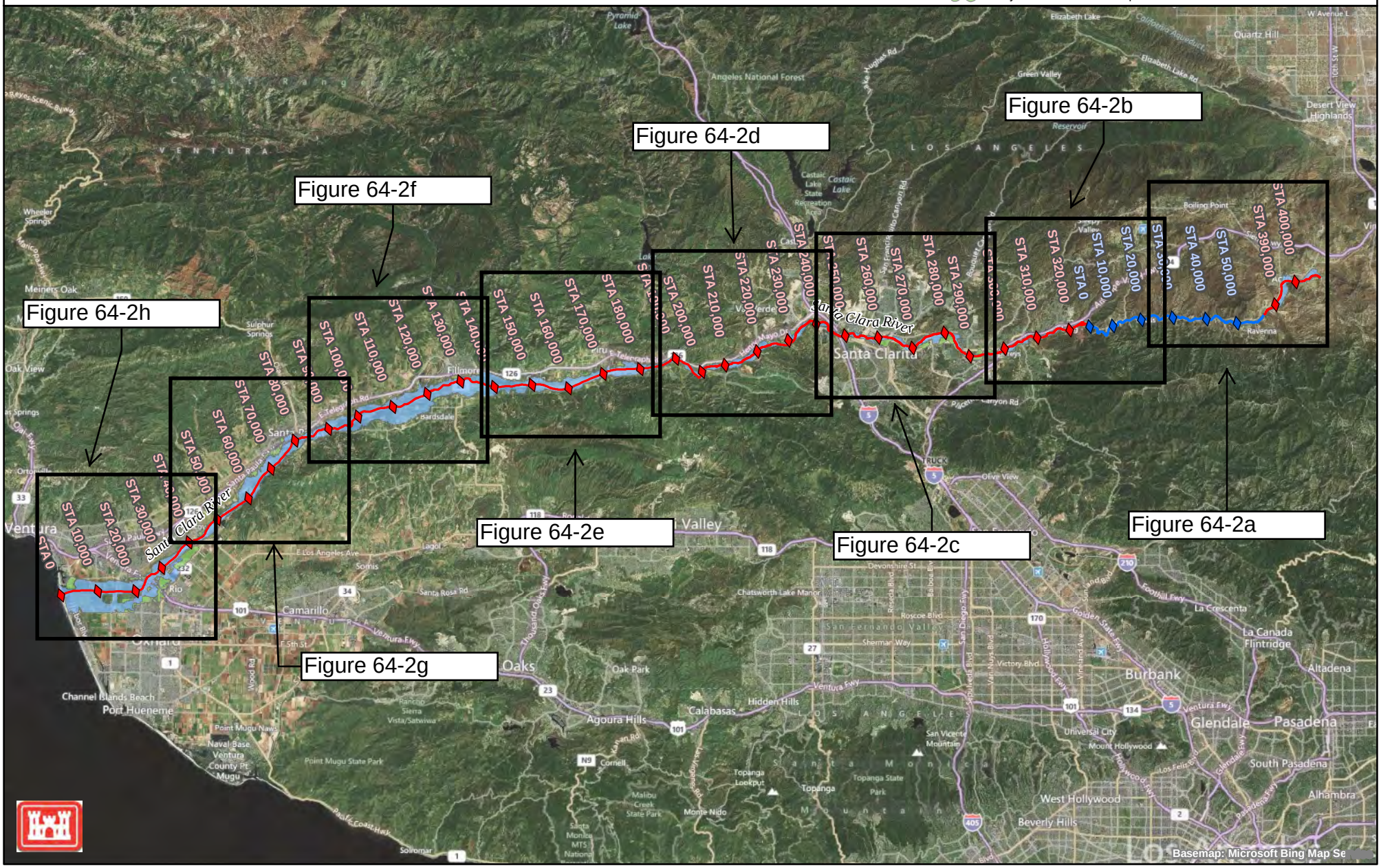

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Figure 64-2a: Santa Clara River Floodplain Map (1 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

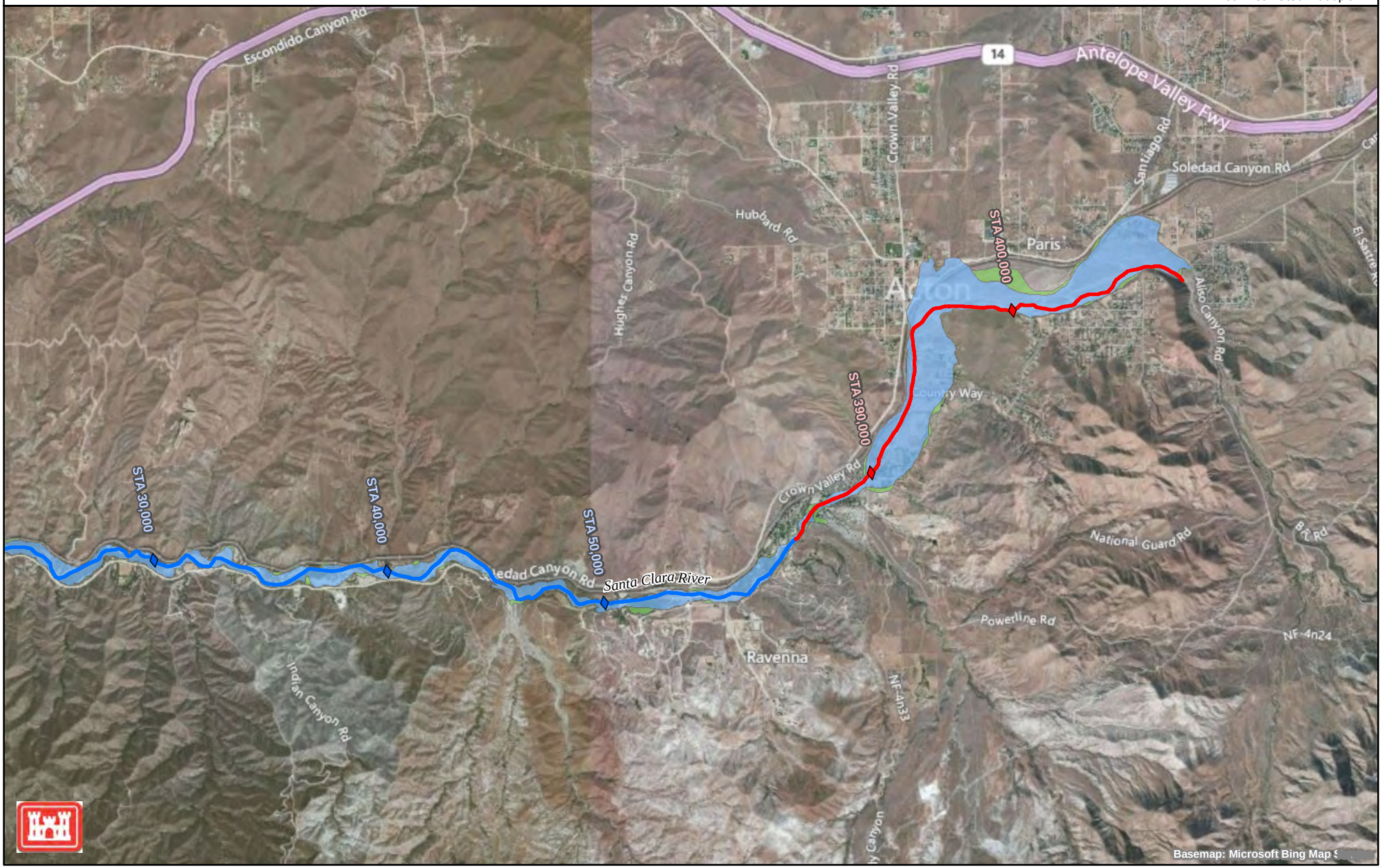

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Figure 64-2b: Santa Clara River Floodplain Map (2 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

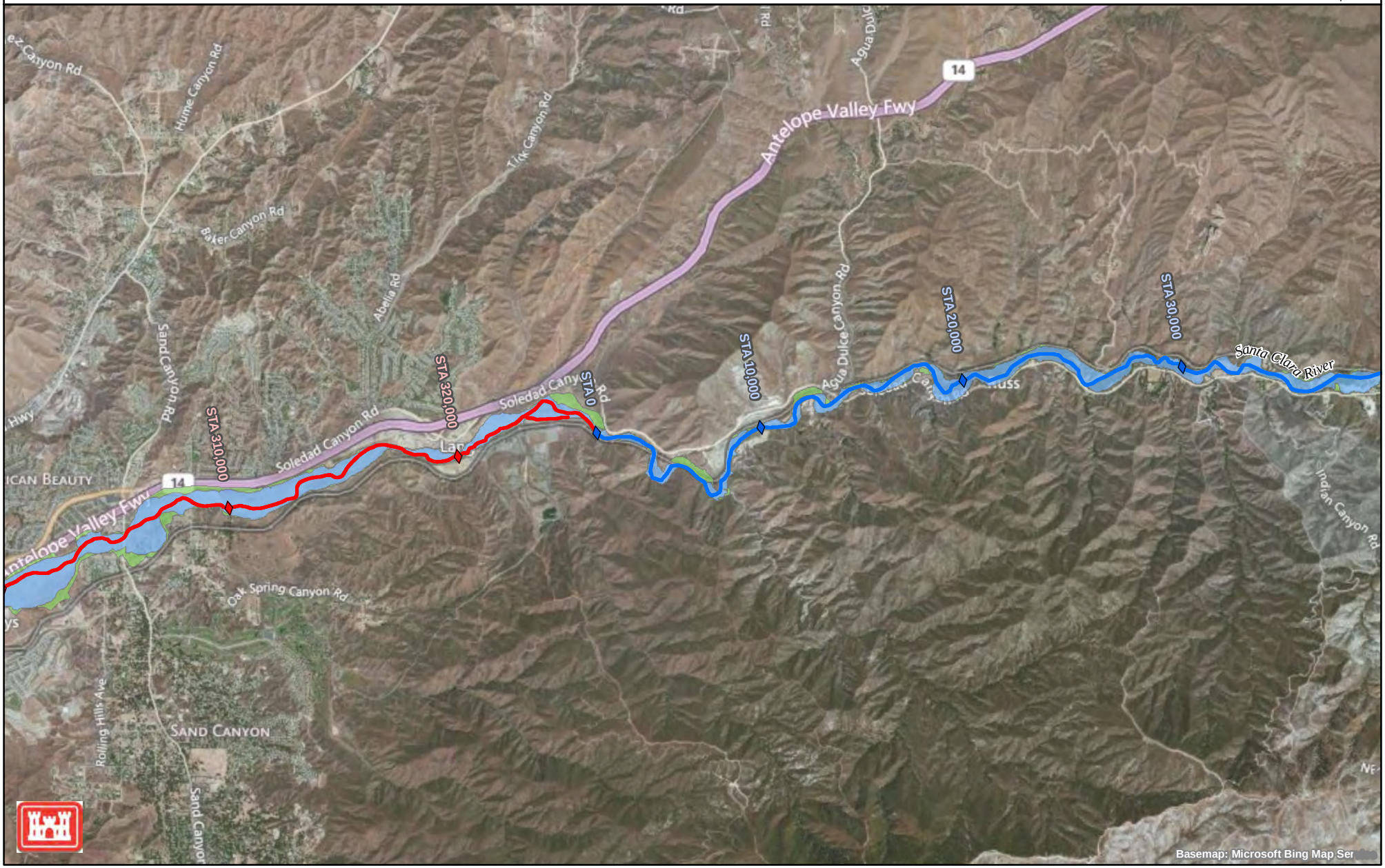

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Figure 64-2c: Santa Clara River Floodplain Map (3 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

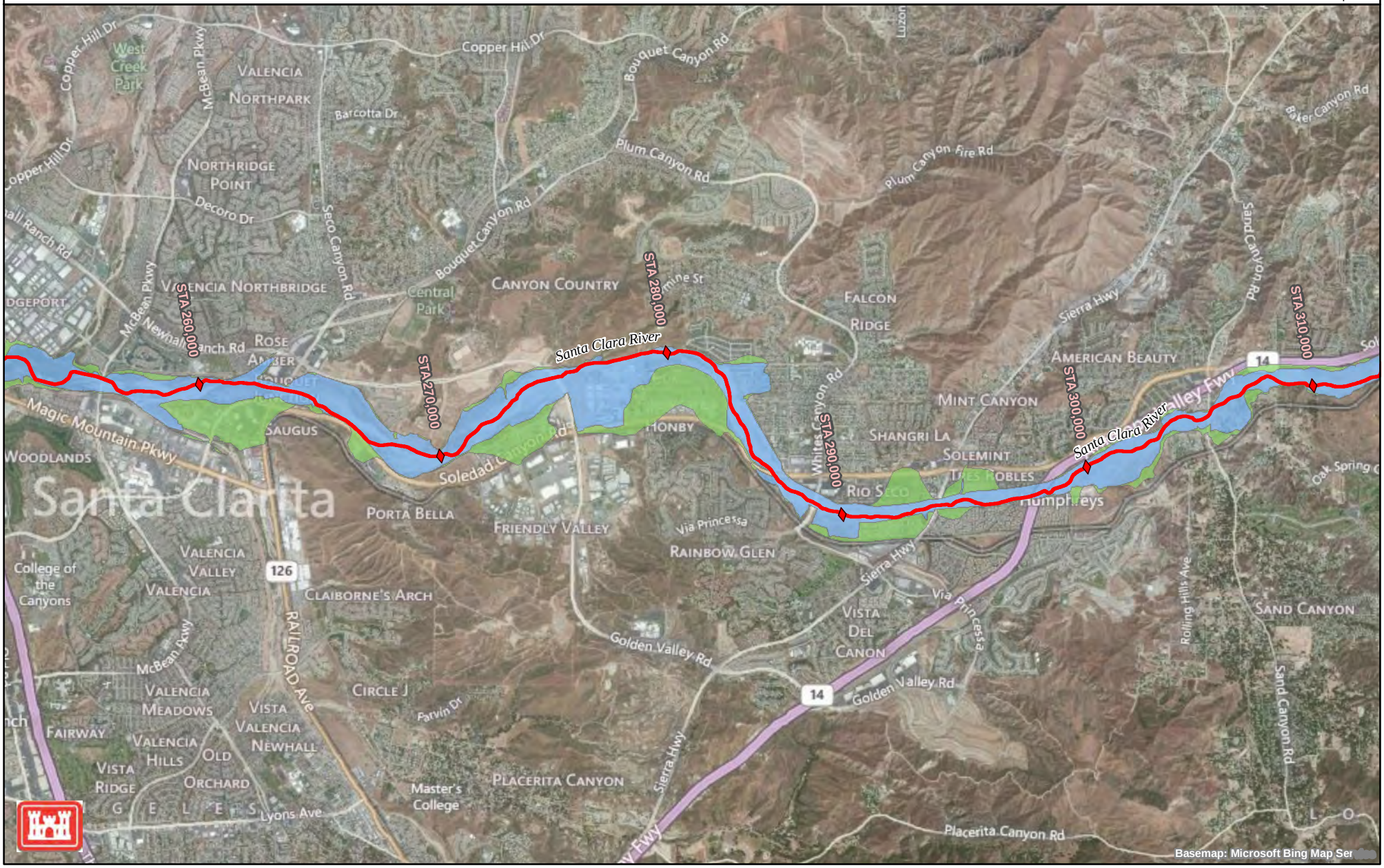

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Figure 64-2d: Santa Clara River Floodplain Map (4 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

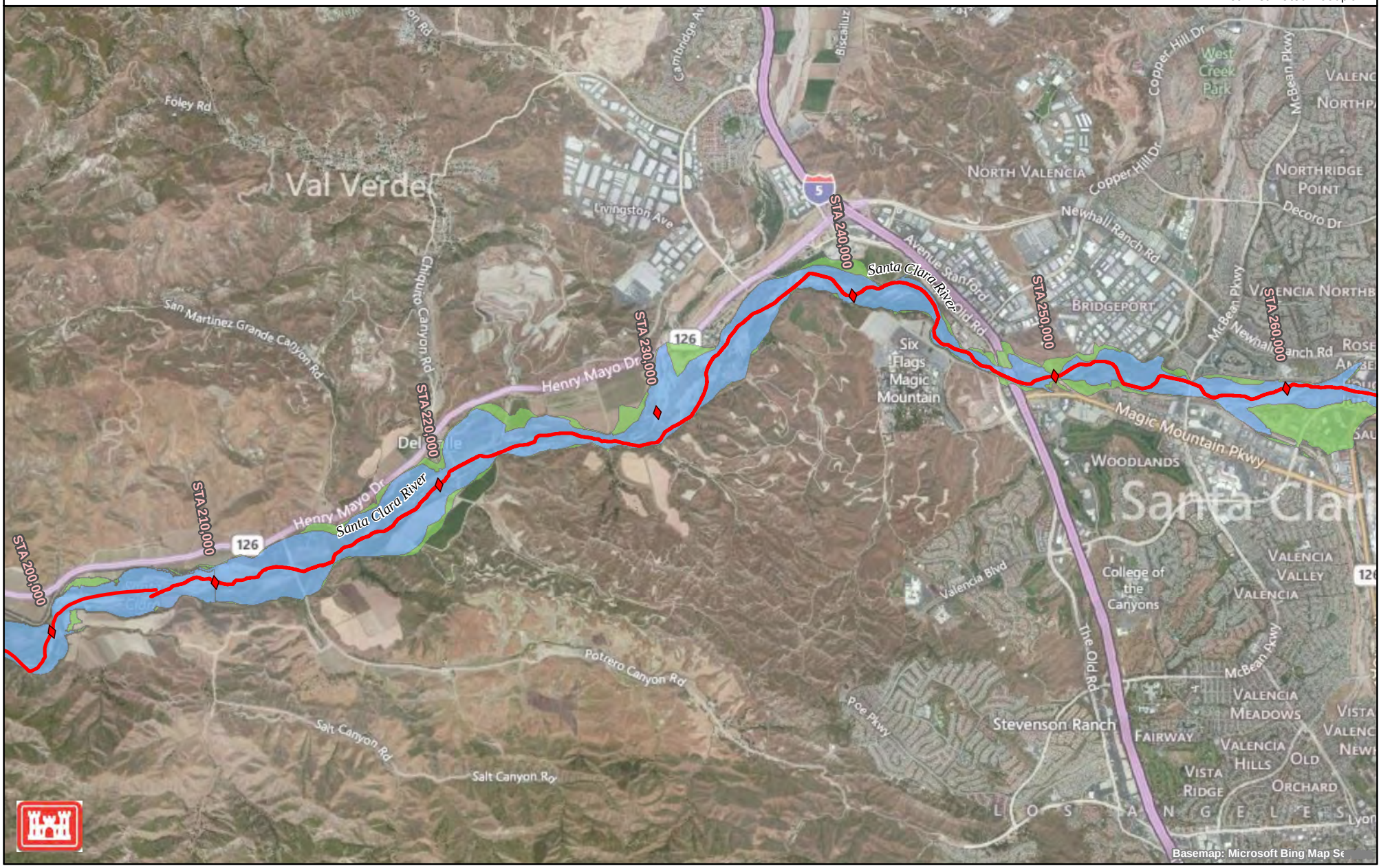

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Figure 64-2e: Santa Clara River Floodplain Map (5 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

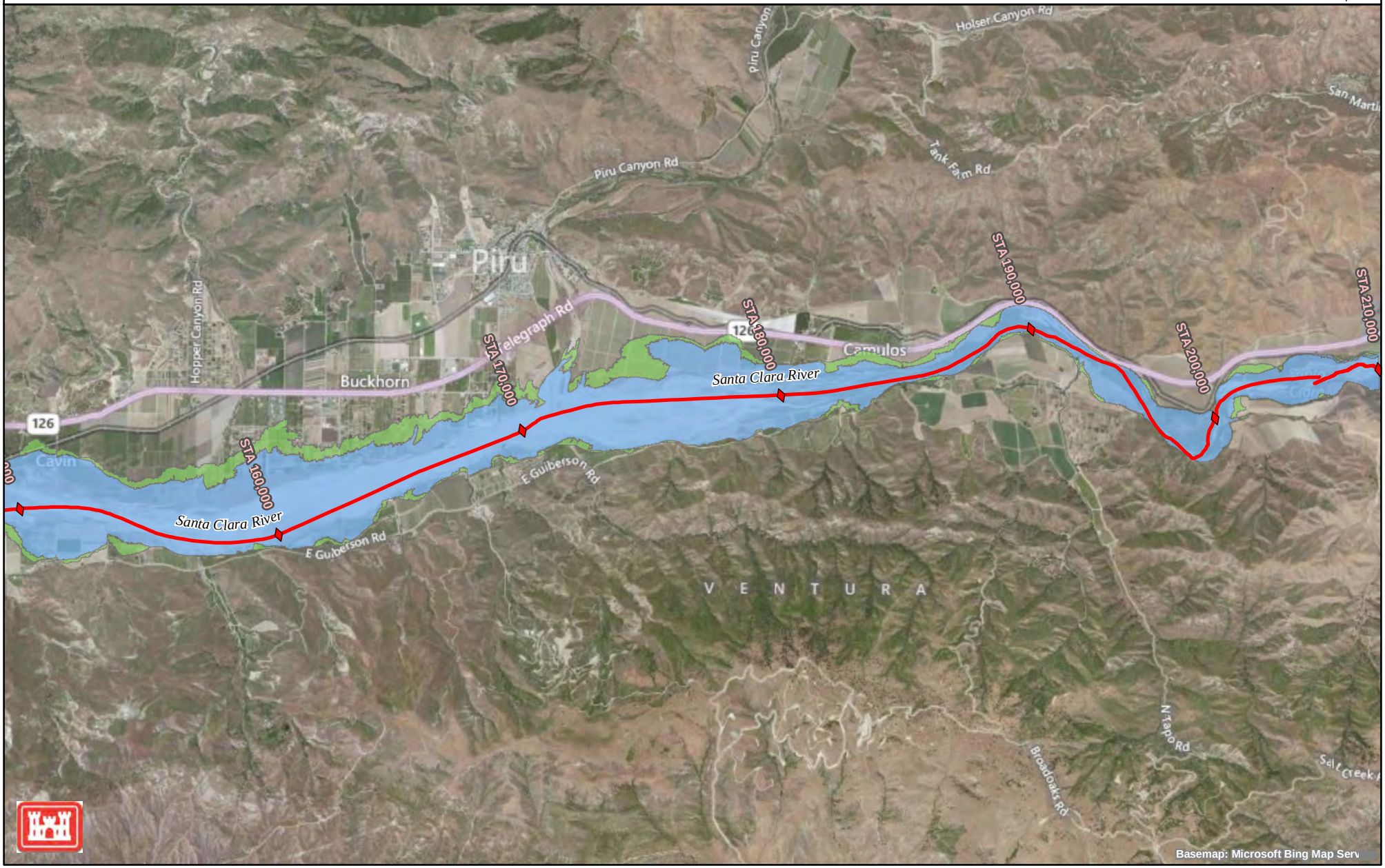

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Figure 64-2f: Santa Clara River Floodplain Map (6 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

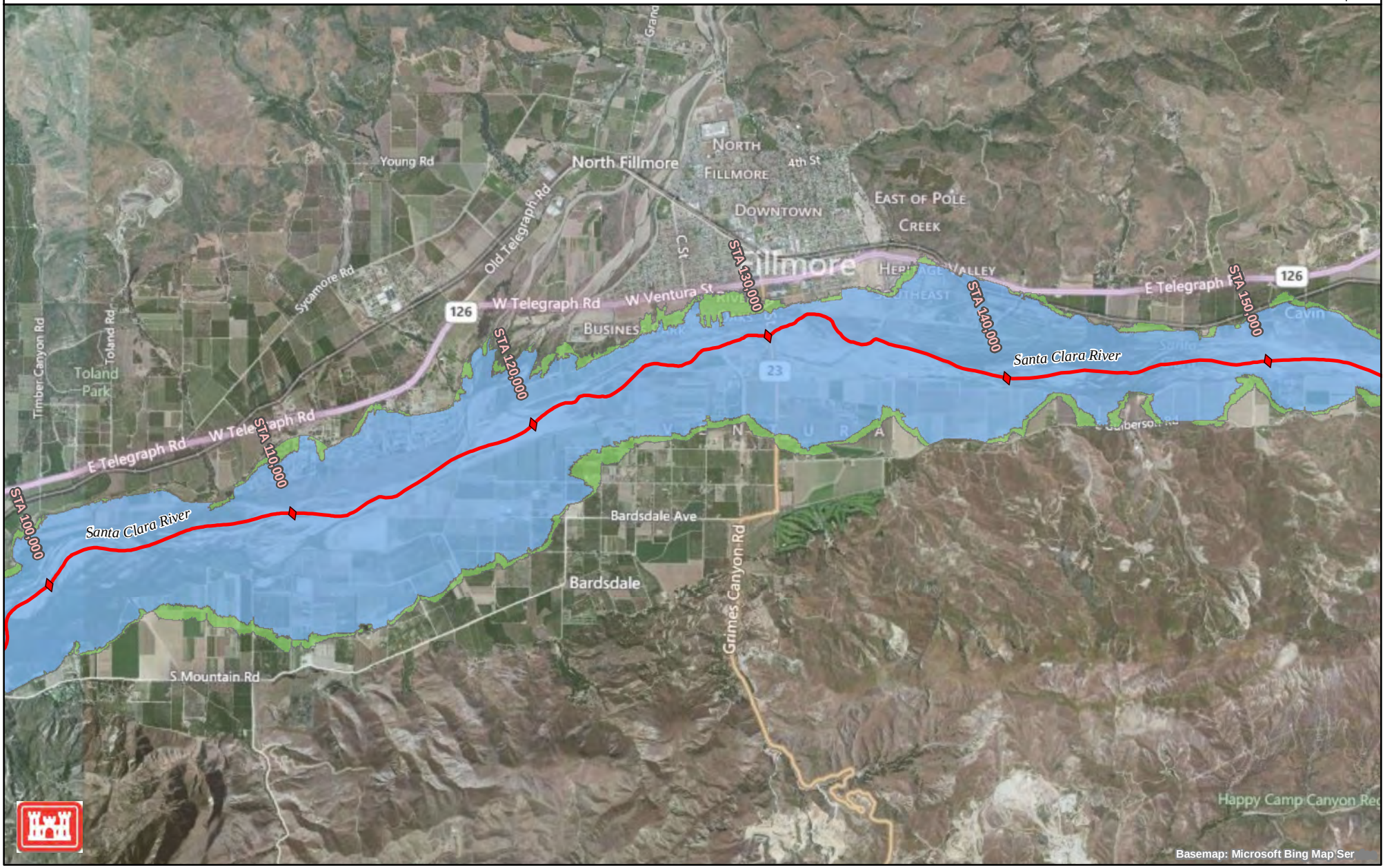

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Figure 64-2g: Santa Clara River Floodplain Map (7 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain

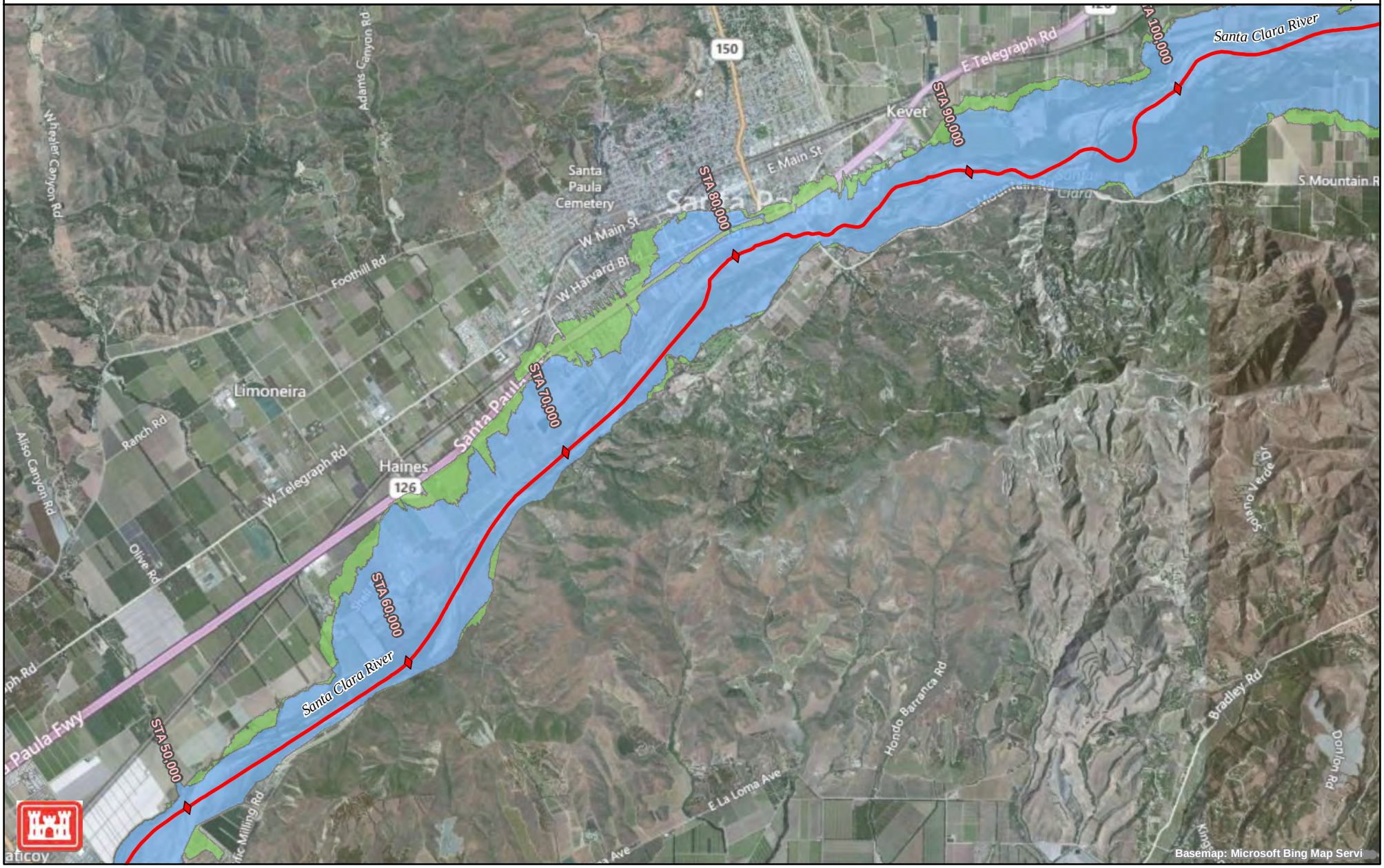

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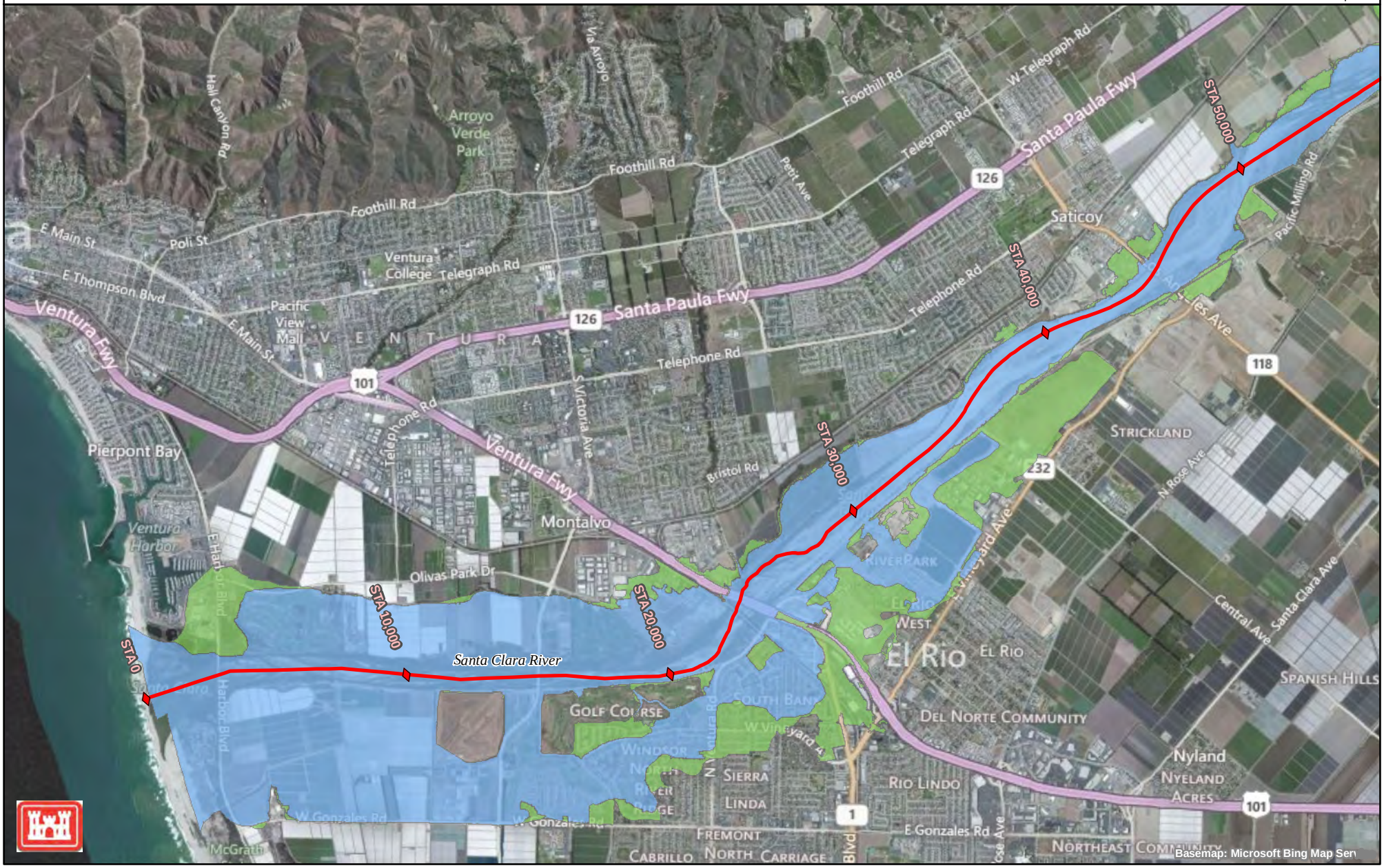
Figure 64-2h: Santa Clara River Floodplain Map (8 of 8)
Santa Clara River Watershed Feasibility Study
LA and Ventura Counties, CA

0 5,000 10,000 Feet

N

Legend

- Station Point (FEMA)
- Station Point (USACE)
- 100-year Estimated Floodplain
- 500-year Estimated Floodplain
- FEMA Main Reach
- FEMA Overflow Reach
- USACE Main Reach
- USACE Overflow Reach
- Downstream Reach 100-Year Estimated Floodplain



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Section 65
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Appendices A thru F
Provided on the Accompanying CD.

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