Berryessa Creek Project

Santa Clara County, California

Appendix B

Engineering and Design

Part I: Hydraulic Analysis of Alternatives

TETRA TECH

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BERRYESSA CREEK PROJECT

APPENDIX B, Part I: Hydraulic Analysis of Alternatives

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CHAPTER 1: INTRODUCTION

This portion of the engineering appendix describes the approach and results of hydraulic modeling efforts for the Berryessa Creek Project under without-project conditions and under project alternative scenarios. Only hydraulic analyses are presented; the supporting hydrology is described in the report *Berryessa Creek Watershed Hydrology Report* by Northwest Hydraulic Consultants (NHC 2003, 2006).

This appendix reports the results of the incremental analysis, preliminary array of alternatives analysis, and the final array of alternatives analysis. The incremental analysis was conducted to determine the viability of various improvements along the study reach. The preliminary array of alternatives was then developed using the information from the incremental analysis and the without-project HEC-RAS model. Finally, the final array of alternatives was narrowed down to include the No Action plan and three project alternatives.

Between when the analysis of the incremental and preliminary array of alternatives were conducted (2006-2009) and the analysis of the final array of alternatives was conducted (2010-2011) the study methodology changed. The changes in methodology take into account recent developments in modeling technology to more accurately reflect the conditions in the study area. The HEC-RAS model was also updated to reflect the latest design of the project located immediately downstream of the study area, the Santa Clara Valley Water District's (SCVWD) Lower Berryessa Creek Project. This report describes both the original hydraulic analysis methodology developed for the GRR and the revised methodology developed for the final array of alternatives. Hydraulic modeling of the Berryessa Creek channel was conducted using the Corps of Engineers HEC-RAS computer program. Due to the length of the study a number of versions of the HEC-RAS programs have been used over the years. Floodplain mapping was conducted using the FLO-2D 2-dimensional modeling software with the approach and results described in *Appendix B: Part II Floodplain Development*.

The GRR study reach extends from just upstream of Old Piedmont Road to just downstream of Calaveras Boulevard. All vertical elevation data referenced in this report, including cross sectional and profile plots, are relative to the NAVD88 datum (2.6' higher than NGVD29). The extreme vertical exaggeration in HEC-RAS profile and section views in this report should be noted (100H:1V or greater in some instances). All cross sections are shown looking downstream, and references to right and left bank are likewise based on downstream views.

Figure 1-1 shows the extent of the study area in relation to the overall watershed area.

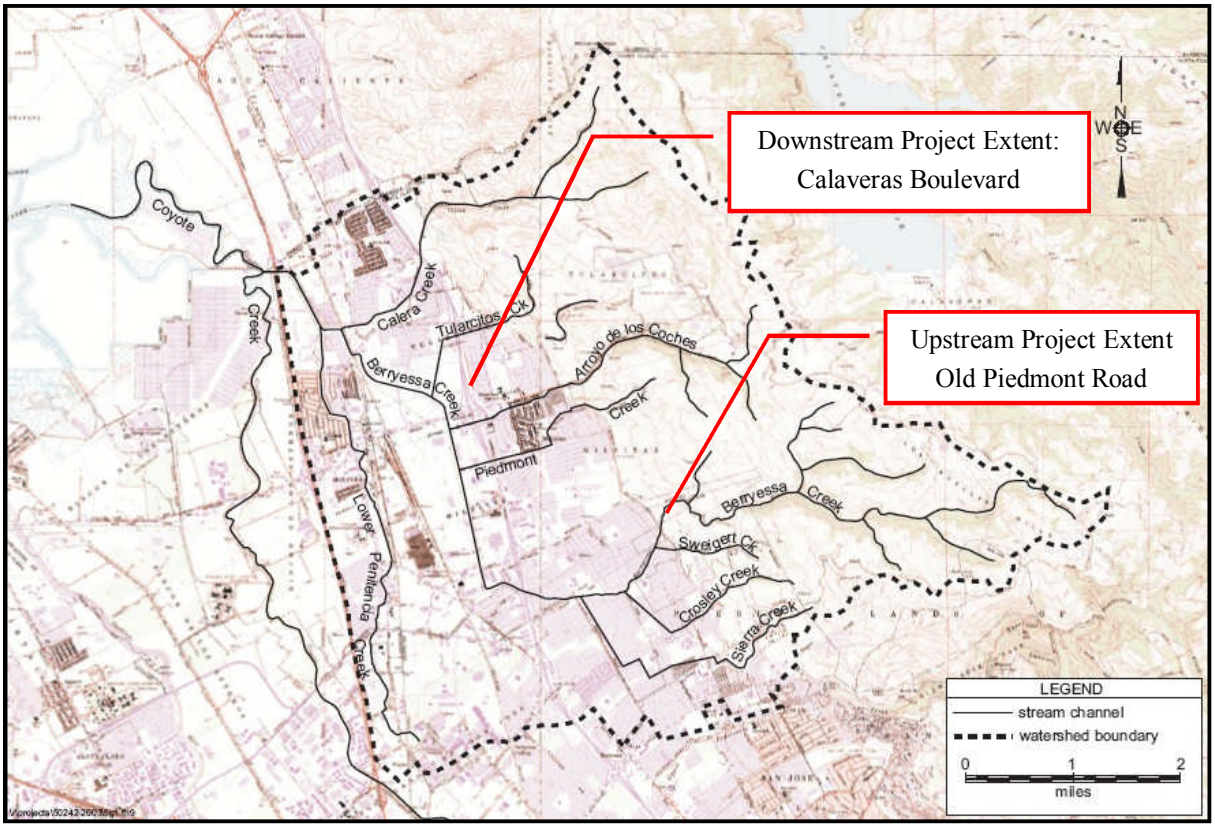

Figure 1-1 Berryessa Creek Study Reach (Source: NHC 2003)

CHAPTER 2: WITHOUT-PROJECT MODEL

The without-project condition was modeled using both the original GRR methodology and the revised GRR methodology in order to ensure that any changes resulting from the change in methodology did not skew the results.

The original GRR without-project conditions hydraulic model was used for the incremental analysis and the development and analysis of the preliminary array of alternatives. The original GRR model was first developed by HDR, Inc. (HDR 2004a) in 2004 with final revisions completed by Tetra Tech in 2009. Changes and updates made to the HDR model are covered in a technical memorandum under separate cover (Tetra Tech 2005a). The preliminary alternative analysis for the study area was completed in 2009 and included the project reaches extending from Old Piedmont Avenue to I-680 for the reach upstream of Interstate 680 (I-680) and I-680 to Calaveras Boulevard for the reach downstream of I-680.

In 2010 and 2011, revisions to the without-project conditions GRR model were carried out. The revisions since 2010 (hereafter called the revised GRR model) are further refinements of the original GRR model. During the analysis of the array of preliminary alternatives it was determined that a federally funded project upstream of I-680 was not justified. Therefore the revised without-project GRR HEC-RAS model was modified to model only the channel reach downstream of the I-680 culvert. The Berryessa Creek channel upstream of the I-680 culvert is now completely modeled by the Upper Berryessa FLO-2D model (see *Appendix B, Part II: Without-Project Floodplain Development*) and the channel reach upstream of I-680 of the HEC-RAS model is not used for the final array of alternatives. The HEC-RAS model was also modified to run in the unsteady mode. Finally, the model reach downstream of the study area (downstream of Calaveras Boulevard) was modified to reflect the Santa Clara Valley Water District's Lower Berryessa Project 60% design.

The following sections describe both the original and revised without-project GRR models. The original without-project GRR modeling is presented to preserve continuity for model results used in the incremental and preliminary alternative array analyses done in the early planning stages of the study that will not be updated for the revised GRR modeling effort.

2.1 Original GRR Model

2.1.1 Model Input

2.1.1.1 Discharge

Watershed delineations, rainfall-runoff relations, and peak flow hydrology were taken from the NHC, Inc. hydrology report (NHC 2003, 2006). Discharges used as input into the hydraulic model are taken from the future conditions values published in the NHC hydrology report (NHC 2003, 2006). Table 2-1 shows the peak discharges used in the without-project model.

Table 2-1 Discharges and flow change locations used as model input

Sta.	Description	Peak Discharge by Percent Chance Exceedance (cfs)								
		50%	20%	10%	4%	2%	1%	0.9%	0.5%	0.2%
362+42	Upstream Extent	240	420	560	830	1090	1430	1540	1820	2130
331+36	Sweigert Creek	260	450	600	890	1180	1530	1640	1960	2300
311+68	Crosley Creek	300	500	700	1000	1340	1740	1875	2220	2600
287+58	Sierra Creek	470	710	830	1260	1630	2140	2250	2660	3140
218+21	Montague Expressway	610	960	1220	1620	2020	2780	2810	3490	4200
174+70	Yosemite Drive	620	990	1170	1770	2200	2910	3000	3580	4290
166+54	Piedmont Creek	830	1350	1600	2450	2990	3800	4010	4520	5230
144+67	Arroyo de los Coches	1090	1730	2050	3040	3740	4700	5150	5490	6480

Source: NHC 2003 and HDR 2004a

These discharges represent fully contained flows. Reductions for existing breakout locations are covered in *Appendix B, Part II: Floodplain Development*. Further details on the underlying assumptions and changes to confluence locations are covered in Tetra Tech (2005a) technical memorandum.

2.1.1.2 Geometry

(a) Cross Sections

The HEC-RAS model developed by HDR includes approximately 200 cross sections within the study reach. Cross sections in the HDR model were generally cut based on a digital terrain model developed from aerial photography with supplemental ground survey conducted by SCVWD in 2004. Adjustments made subsequently by Tetra Tech to without-project conditions cross sections are described in the 2005a technical memorandum. Cross section locations are shown in Figure 2-1.

Figure 2-2 shows the overall channel profile within the study reach. The bed slope ranges from approximately 2% at the upstream end to 0.5% at the downstream end of the study reach. Significant grade breaks are shown in Figure 2-2 below. Localized grade breaks are present at concrete drop structures (just downstream of Old Piedmont Road, just upstream of Morrill Avenue, inside Cropley Avenue Culvert, just upstream of I-680) and at the sedimentation basin downstream of the Piedmont-Cropley Culvert.

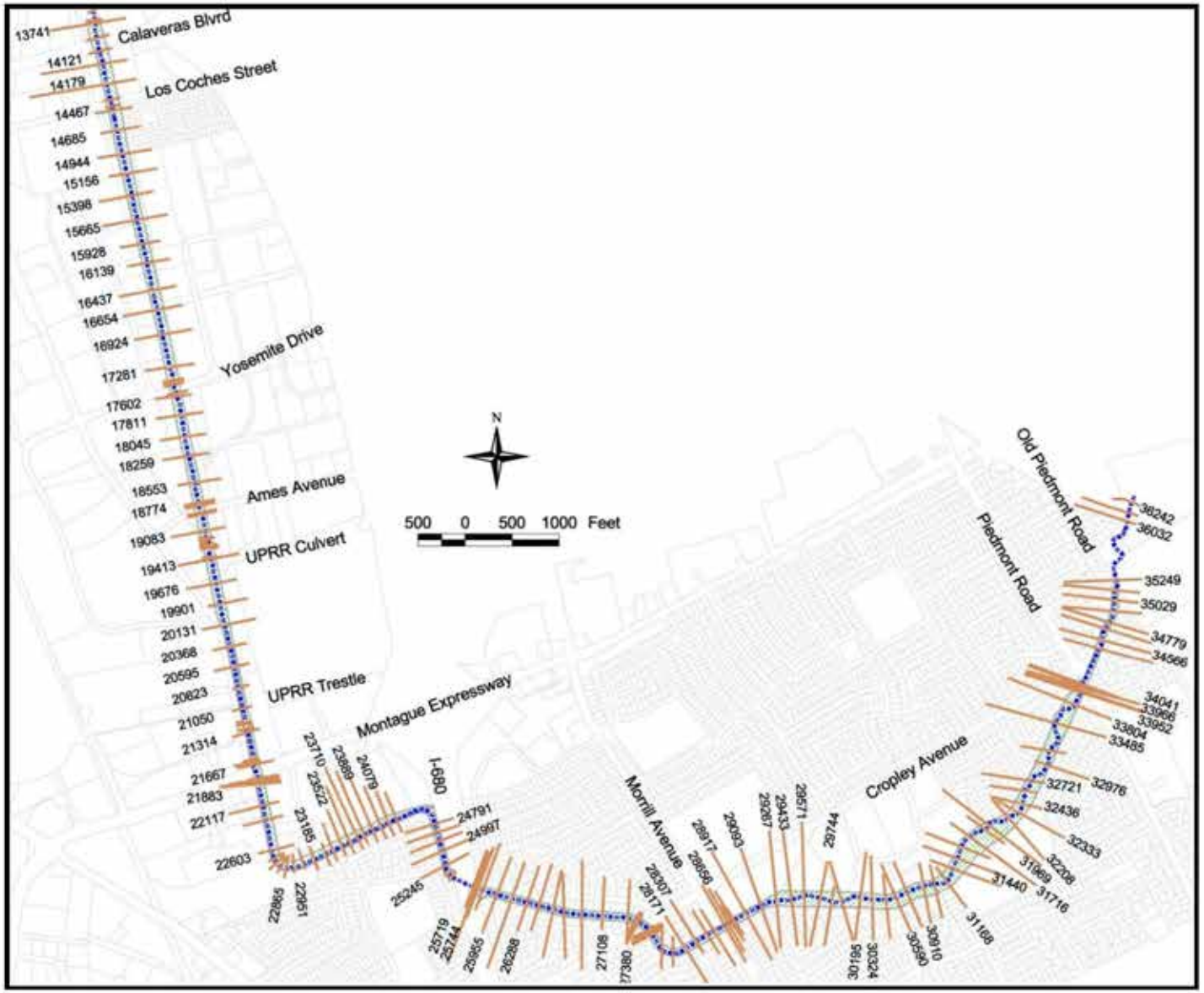

Figure 2-1 HEC-RAS Cross Section Locations (Based on HDR 2004)

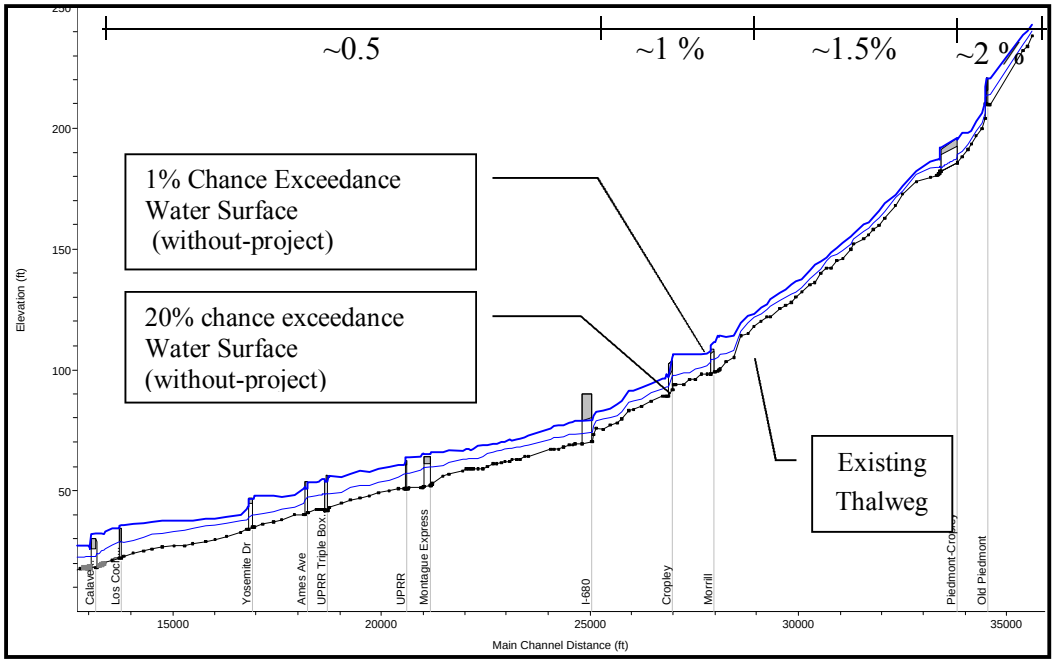

Figure 2-2 Berryessa Creek Profile with Average Bed Slopes

(b) Bridges and Culverts

The without-project conditions geometry file includes twelve structures within the original study reach, as shown in Table 2-2. The four structures upstream of I-680 were subsequently removed from the project area as described below. The without-project conditions model assumes complete maintenance (sediment removal) at bridge and culvert crossings. The effective height of the existing Piedmont-Cropley Culvert, for instance, is modeled as the actual constructed concrete culvert height of 7 feet. Up to 3 feet of sediment deposition has been observed within some of the bridges and culverts, as documented by HDR (2004) and verified through high sediment marks by Tetra Tech during a field visit in October 2004.

Table 2-2 Modeled Bridges and Culverts

HEC-RAS Station	Description	Modeled Type	Approximate Dimensions
351+70	Old Piedmont Road	Bridge	15' span x 6' height, irregular opening
342+55	Piedmont-Cropley	Culvert	Single 12' span x 7' height box culvert
285+93	Morrill Avenue	Culvert	Double 10' span x 9' height box culvert
275+69	Cropley Avenue	Bridge	Double 9.5' span x 8.5' height box culvert
255+75	I-680	Bridge	60' top span x 10' height, trapezoidal channel
217+38	Montague Expressway	Bridge	Double 12' span x 9' height box culvert
212+47	UPRR Trestle	Bridge	40' top span x 10' height, 4 sets of piers
193+33	UPRR Culvert	Culvert	Triple 11' span x 12' height box culvert
188+43	Ames Avenue	Bridge	75' top span x 10' height, trap. channel, single pier
175+18	Yosemite Drive	Bridge	75' top span x 10' height, trap. channel, single pier
143+88	Los Coches Street	Bridge	75' top span x 10' height, trap. channel, single pier
138+03	Calaveras Boulevard	Bridge	50' span x 7' height, 4 continuous piers

As-built bridge plans were obtained for several of the bridges and culverts. A comparison of the plans with observed conditions is presented in Tetra Tech, 2005a, along with changes made to bridges, culverts, and lateral structures for the without-project conditions model. The lateral structures are included in the model to convey overflows; and detailed descriptions and results of overflows are included in *Appendix B, Part II: Without-Project Floodplain Development*. For bridge modeling in the HEC-RAS model, concrete barriers are generally considered part of the bridge deck, while rails are not.

2.1.2 Results

2.1.2.1 Hydraulic Parameters

Table 2-3 shows average hydraulic parameters for the without-project conditions discharges between each set of bridge or culvert crossings. D is the channel hydraulic depth in feet, and V is the average channel velocity in feet per second. These parameters are shown graphically in Figure 2-3 and Figure 2-4.

Figure 2-3 shows that the highest velocities are encountered in the vicinity of the UPRR railroad trestle. Higher localized velocities arise at some of the bridge crossings; however, these higher velocities are offset in the reach-averaged values as flows back up upstream of undersized bridge and culvert entrances. The depths generally increase in the downstream direction as the drainage areas and corresponding peak discharges increase as shown in the Figure 2-3 and Figure 2-4. A comparison of the 50% to 1% chance exceedance event parameters in Figure 2-4 reveals the effect of flows backing up at bridges and culverts. In these areas, the localized 1% chance exceedance velocities decrease and the hydraulic depth increases significantly due to the backwater effect. These figures and tables present results for contained discharges only; that is, the hydraulic parameters presented for any given reach

assumes upstream containment measures. Results accounting for breakout flows reducing the channel discharge are presented in *Appendix B, Part II: Without-Project Floodplain Development*.

Table 2-3 Original GRR Model Without-Project Hydraulic Results

Bounding Bridge or Culvert		Percent Chance Exceedance			
		50%		1%	
From	To	Vel	Depth	Vel	Depth
		(ft/s)	(ft)	(ft/s)	(ft)
Upstream Extent	Old Piedmont Road	6.3	1.8	8.7	4.1
Old Piedmont Rd	Piedmont-Cropley	7.2	1.8	10.7	4.9
Piedmont-Cropley	Morrill Avenue	5.5	2.2	6.6	3.3
Morrill Avenue	Cropley Avenue	5.6	2.6	5.5	6.9
Cropley Avenue	I-680	8.5	2.6	12.5	5.1
I-680	Montague Expressway	5.5	3.1	7.3	5.4
Montague Expressway	UPRR Trestle	7.1	4.1	8.6	7.4
UPRR Trestle	UPRR Culvert	6.9	3.4	9.3	7.1
UPRR Culvert	Ames Avenue	4.6	4.3	7.2	6.6
Ames Avenue	Yosemite Drive	7.0	3.3	6.7	6.4
Yosemite Drive	Los Coches Street	6.0	3.5	5.5	6.4
Los Coches Street	Calaveras Boulevard	6.4	4.7	5.9	8.9
Calaveras Boulevard	Downstream Extent	3.2	4.1	4.2	9.1

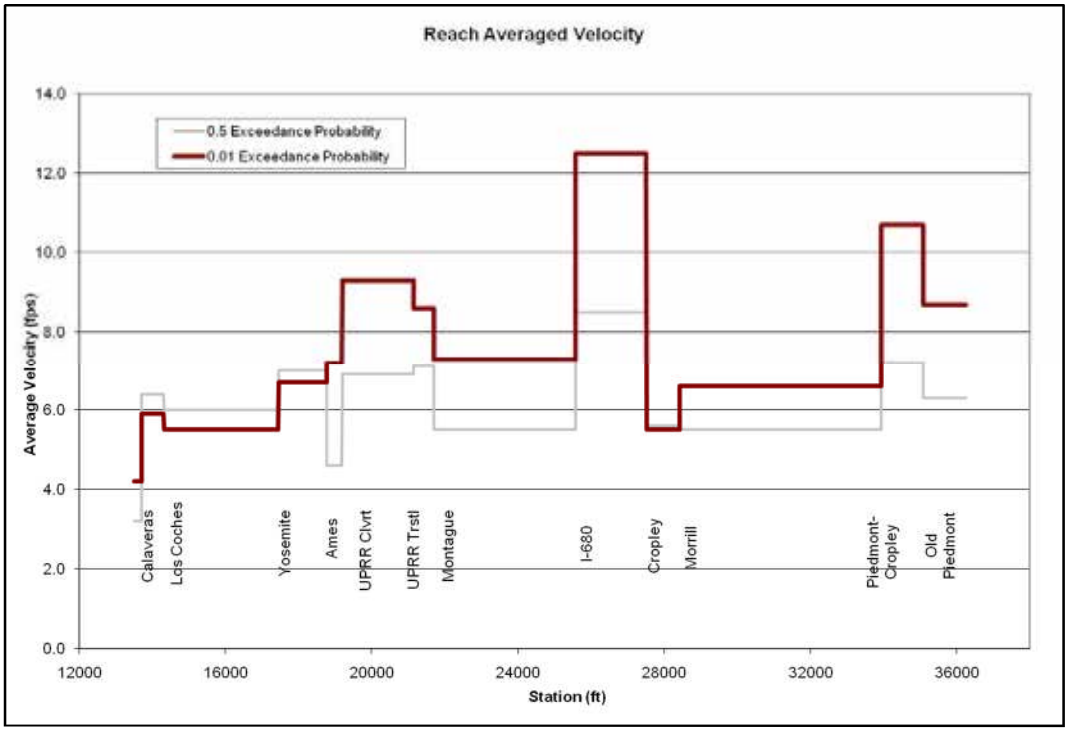

Figure 2-3 Average Channel Velocities between Bridges and Culverts

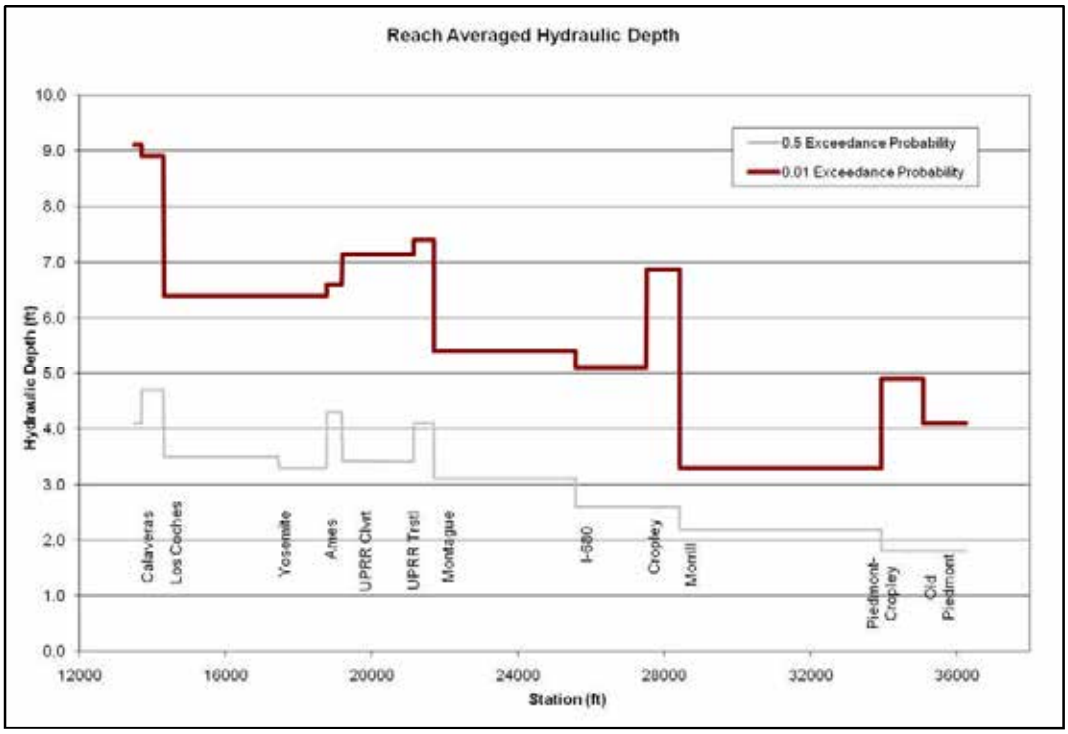

Figure 2-4 Average Hydraulic Depth between Bridges and Culverts

2.2 Revised GRR Model

2.2.1 Model Input

2.2.1.1 Discharge

The conversion of the GRR HEC-RAS Berryessa Creek model from steady to unsteady required the development of hydrographs representing various inflows to the Berryessa Creek Channel. The primary inflow hydrograph to the revised HEC-RAS model is the outflow from the I-680 culvert. The I-680 culvert outflow hydrograph was developed from the output of the Revised Upper Berryessa FLO-2D model (see *Appendix B, Part II: Without-Project Floodplain Development*). The remaining inflow hydrographs to Berryessa Creek consist of subarea runoff and tributary creeks. The inflow hydrographs were taken from the future conditions 2003 HEC-HMS model corresponding to the values published in the NHC hydrology report (NHC 2003). Table 2-4 lists the peak discharges for each inflow hydrograph used in the without-project model, HEC-RAS inflow station and HEC-HMS model nodes used to develop the inflow hydrographs. No changes were made to the hydrology for this study.

The reported discharge hydrographs represent the inflows to the Berryessa Creek channel from I-680 to the confluence with Penitencia Creek. The unsteady HEC-RAS model allows the flows to escape the channel at the existing breakout locations covered in *Appendix B, Part II: Without-Project Floodplain Development*.

Table 2-4 Discharges and flow change locations used as model input

RAS Sta.	HMS Node	Description	Peak Discharge by Percent Chance Exceedance (cfs)							
			50	20	10	4	2	1	0.5	0.2
254+71	-na-	I-680 Outflow from FLO-2D model	490	701	953	1,145	1,403	1,544	1,610	1,771
218+32	B13 RM 3.73	Subarea B12	269	382	461	692	811	928	1,073	1,227
174+48	B15 RM 2.96	Subarea B14	96	149	176	245	275	317	361	414
166+54	B17 RM 2.76	Piedmont Creek	244	387	450	715	821	858	900	900
144+67	B17a RM 2.58	Los Coches Creek	264	429	559	833	868	928	911	951
141+21	B19 RM 2.43	Calaveras Blvd Overflow	0	0	0	0	197	400	400	400
124+03	B21 RM 2.21	Tularcitos Creek	208	332	408	595	652	660	678	685
89+53	B23 RM 1.52	Berryessa Pump	107	150	150	150	150	150	150	150
74+53	B25 RM 1.22	Wrigley-Ford Pump	251	378	432	432	432	432	432	432
59+53	B27 RM 0.94	Calera Creek	180	292	367	521	669	869	1,099	1,261
56+53	B29 RM 0.77	Abbot Pump	583	851	1,041	1,330	1,436	1,568	1,676	1,710
51+53	B31 RM 0.14	Jurgens Pump	127	150	150	150	150	150	150	150
49+74	B 33 RM 0.00	Cal Circle Pump	22	30	34	42	48	56	63	71

Source: NHC 2003

2.2.1.2 Geometry

Two changes were made to the original GRR Berryessa Creek geometry. The first change was to eliminate the model reach and all associated cross sections above cross section 25471. The second was to update the model reach below cross section 13741 to reflect the SCVWD's 60% design for the Lower Berryessa Project. Cross section 25471 represents the outlet of the I-680 culvert and is the upstream end of the revised GRR HEC-RAS model. No changes were made to the channel cross sections, bridges, or culverts between stations 13741 and 25471. The topographic data used in the study area of the HEC-RAS model are derived from 2002 USACE 2' contour interval topography relative to the NAVD 88 datum.

The original GRR HEC-RAS model reach below station 13741 (downstream face of Calaveras Boulevard) was based on the most conservative of the proposed SCVWD Lower Berryessa Project alternatives available during the development of the original GRR model. Since then the SCVWD has designated the Lower Berryessa Project alternative and proceeded to 60% level of design. The SCVWD provided a HEC-RAS model based on the 60% design for the Lower Berryessa Project. The reach downstream of station 13741 in the

SCVWD HEC-RAS model was used to replace the reach downstream of station 13741 in the revised GRR HEC-RAS model. No changes were made to the SCVWD model except for minor changes in hydraulic modeling parameters to facilitate unsteady flow modeling and revising the stationing to match those used in the revised GRR HEC-RAS model.

2.2.2 Results

2.2.2.1 Hydraulic Parameters

Table 2-5 shows average hydraulic parameters for the without-project conditions discharges between each set of bridge or culvert crossings. Depth is the channel hydraulic depth in feet, and Vel is the average channel velocity in feet per second. These parameters are shown graphically in Figure 2-5 and Figure 2-6.

As seen in the Original Model in the previous section, Figure 2-5 shows that the highest velocities are encountered in the trapezoidal reach between the UPPR Trestle and Culvert. Additionally, higher, localized velocities are seen between the Ames Avenue and Yosemite Drive bridges. As with the Original Model, a comparison of the 50% to 1% chance exceedance event parameters in Figure 2-6 show that for the 1% chance exceedance event the bridges and culverts upstream of Yosemite Avenue cause the flows to backup, increasing the flow depths upstream.

Table 2-5 Revised Model Without-Project Hydraulic Results

Bounding Bridge or Culvert		Percent Chance Exceedance			
		50%		1%	
From	To	Vel	Depth	Vel	Depth
		(ft/s)	(ft)	(ft/s)	(ft)
I-680	Montague Expressway	5.2	3.2	6.1	3.4
Montague Expressway	UPRR Trestle	6.4	4.3	7.0	6.2
UPRR Trestle	UPRR Culvert	6.4	3.4	8.1	5.3
UPRR Culvert	Ames Avenue	4.7	3.7	6.0	5.2
Ames Avenue	Yosemite Drive	6.3	3.2	7.3	3.9
Yosemite Drive	Los Coches Street	5.8	3.6	5.7	3.0
Los Coches Street	Calaveras Boulevard	7.3	3.2	5.3	4.0

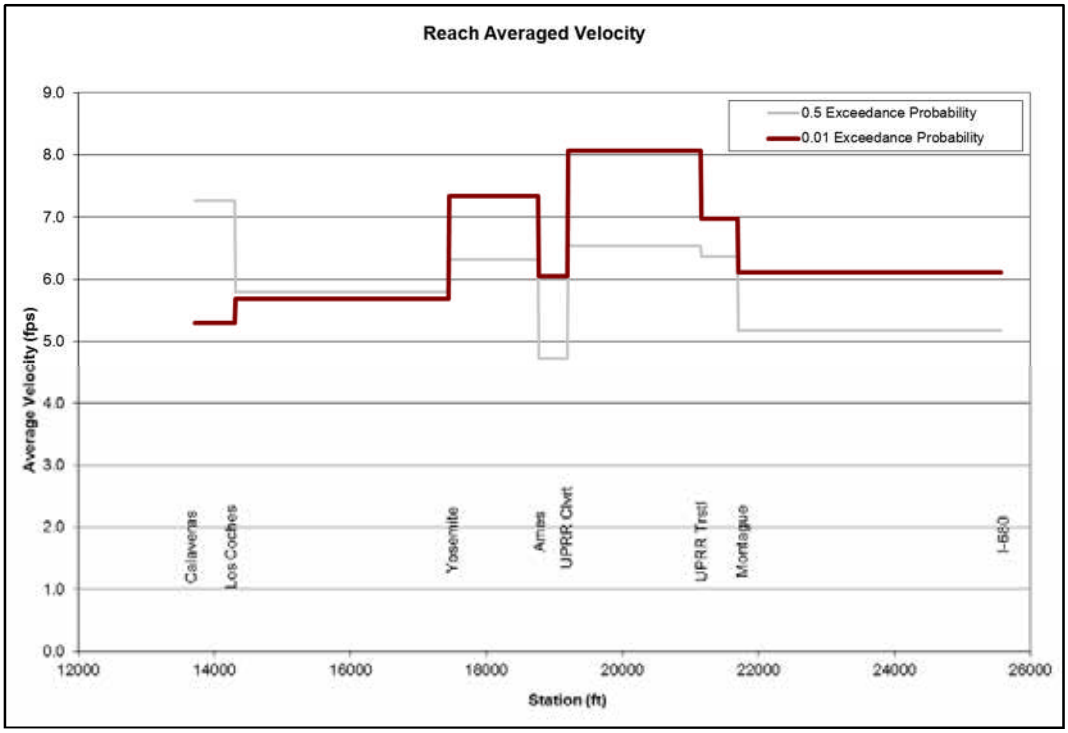

Figure 2-5 Average Channel Velocities between Bridges and Culverts

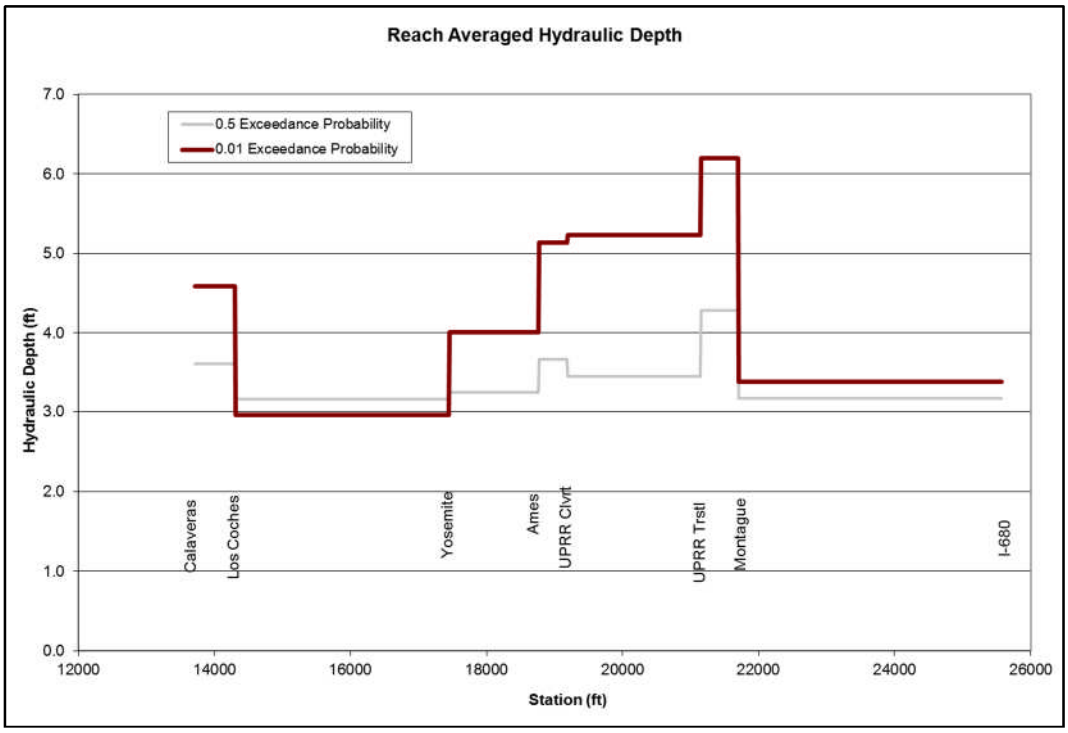

Figure 2-6 Average Hydraulic Depth between Bridges and Culverts

CHAPTER 3: INCREMENTAL ANALYSIS

The incremental analysis was conducted using the original GRR without-project methodology. The original GRR without-project HEC-RAS model contains the 50% chance exceedance event throughout the project reach. Higher discharges begin to break out of the existing channel. In 2006, an incremental analysis was conducted to determine the capacity of each bridge or culvert and intermediate channel reach as well as the action needed to contain each incremental flow from the 50% through the 0.2% chance exceedance events. The original GRR steady flow HEC-RAS model as described in Section 2.1 was used as the basis for the incremental analysis. The incremental analysis is based on the 2003 NHC report and does not account for the updates in the 2006 addendum (NHC 2003, 2006). The incremental analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680. Therefore, the incremental analysis covers the entire study reach from upstream of Old Piedmont Road to Calaveras Boulevard.

3.1 Model Input

3.1.1 Discharge

Adjustments to the model were made cumulatively, so each incremental discharge assumes fully contained conditions (no breakout flows).[1] Overflows are covered separately in *Appendix B, Part II: Floodplain Development*. Discharges for two percent chance exceedance events not published in the NHC hydrology report (NHC 2003) were interpolated between published values to determine intermediate points of overflow. A plot of discharge versus return period was used to ensure that interpolated discharges fell within a smooth curve between computed discharges. Figure 3-1 shows a plot of the curves used to interpolate discharges.

[1] The incremental analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680 and includes analysis of the reach above I-680 not conducted for the final array of alternatives.

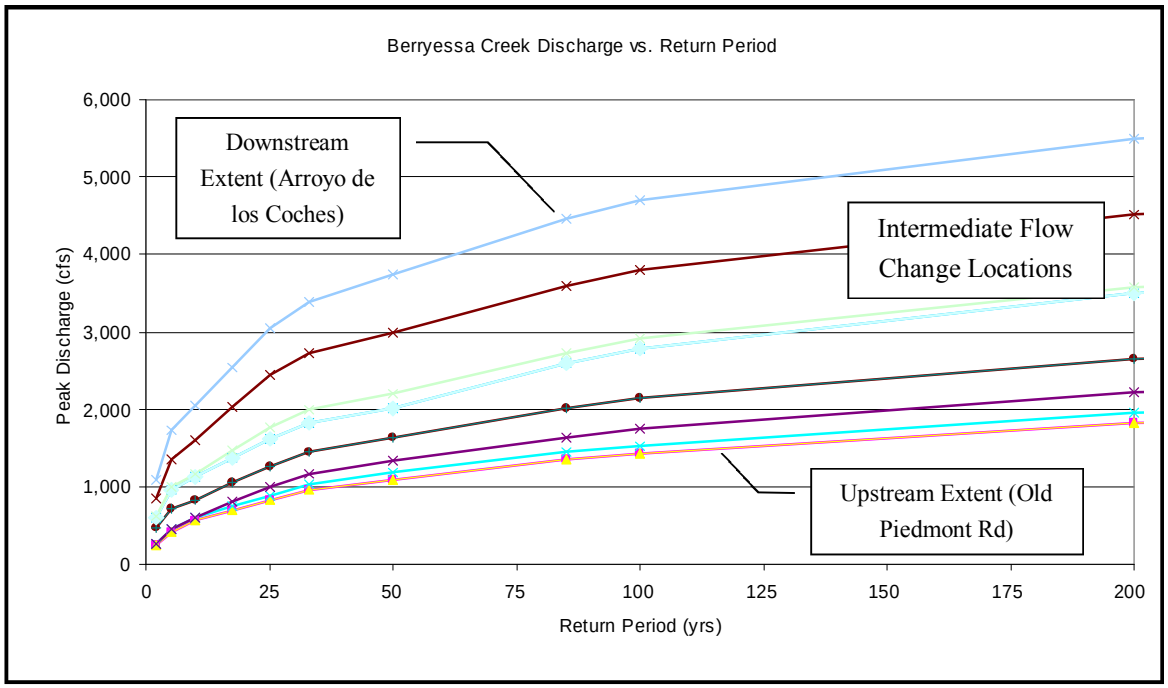

Figure 3-1 Discharge vs. return period for flow change locations

Table 3-1 lists the future conditions discharges published in the NHC hydrology report (NHC 2003) and the interpolated discharges used in the incremental analysis.

Table 3-1 Discharges and flow change locations used for the incremental analysis

HEC-RAS Station	Flow Change Location	Peak Discharge by Percent Chance Exceedance (cfs)									
		50%	20%	10%	5%[1]	4%	3%[1]	2%	1%	0.5%	0.2%
362+42	Upstream	240	420	560	731	830	960	1090	1430	1820	2130
331+36	Sweigert Creek	260	450	600	784	890	1035	1180	1530	1960	2300
311+68	Crosley Creek	300	550	700	1102	1000	1445	1340	1740	2220	2600
286+56	Sierra Creek	470	710	830	1102	1260	1445	1630	2140	2660	3140
218+21	Montague Expressway	610	960	1120	1437	1620	1820	2020	2780	3490	4200
174+70	Yosemite Drive	620	990	1170	2138	1770	2720	2200	2910	3580	4290
166+54	Piedmont Creek	830	1350	1600	2677	2450	3390	2990	3800	4520	5230
144+22	Los Coches Street	1090	1730	2050	3132	3040	3915	3740	4700	5490	6480

Note: 1. Discharges listed in grey columns list discharges interpolated from the reported 2003 values.
Source: NHC 2003

3.1.2 Geometry

(a) Levees

As discharges were incrementally increased in the with-project scenarios, levees were added to cross sections with breakout flows in order to contain the flows. Levees were generally added using the levee function (vertical encroachments) within HEC-RAS, with selected sections modified to ensure that levees with 2:1 side slopes and 12' top widths could be placed within the project footprint without requiring excessive additional height on the levees. In cases where the earthen levees could not be contained within the right of way, vertical concrete floodwalls or additional rights of way are required as described in Chapter 4. Manning's n values for this analysis are described in the following chapter.

(b) Bridges and Culverts

Bridges and culverts were removed from the model individually to quantify the effect on the water surface profile. Individual bridges and culverts with overtopping flows were then resized in conjunction with channel modifications to accommodate each respective incremental discharge. In general, headwall extensions were considered at each bridge or culvert prior to complete replacement; further details on the configuration of the proposed headwall extensions are given in *Appendix B, Part IV: Design and Cost of Alternatives*. The maximum vertical headwall extension was selected as 36" in height. Beyond this threshold, only complete replacement was considered. Replacement spans were attempted in 2' width increments until the discharge passed with no weir flow; pressure flow was allowed to the maximum headwall extension. Capacities listed are for the threshold passing condition without consideration of freeboard requirements.

All bridge and culvert resizing assumes complete maintenance (sediment removal) to the invert as in the without-project models. Bridge design plans from the GDM study were used as the basis for resizing the upstream UPRR trestle. Though the modeled inverts differ from the design plans, the general channel shape from the plans was used in modeling the proposed replacement bridge. Bridge replacement scenarios assume concrete barriers are part of the bridge deck (obstructed), while rails are not.

(c) Channel Excavation

Proposed channel excavation for increased conveyance was generally modeled using the HEC-RAS channel modification function. Channel excavation templates generally follow a smooth slope between existing bridge inverts. Further details on templates for channel modifications are described in Chapter 4.

3.2 Results

This section summarizes the results of modifications to individual bridges and culverts and intermediate channel reaches.[2] The cumulative results of project alternative combinations are presented in Chapter 4. Table 3-2 summarizes the action needed to contain each flow profile by percent chance exceedance. Individual features are presented in order from upstream to downstream. Shading in the table is shown to differentiate channel widening and levees from structural modifications or replacement of bridge or culvert crossings. The corresponding discharges are shown in Table 3-1. Selection of flow profiles for project alternatives was based on the costs of containing each of the incremental flow profiles as described in *Appendix C: Economics*. Table 3-2 shows that earthwork or levee construction begins with the 20% chance exceedance event in a single location and becomes necessary at ten locations for containing the 4% chance exceedance event. Bridge and culvert modifications begin at the 4% chance exceedance event, and full replacement is required at six locations in the 1% chance exceedance event. The results at each feature cannot be interpreted independently, as the size of the channel affects capacities of bridges and culverts, and the size of the bridges and culverts, in turn, affects the capacity of the channel reach.

[2] The incremental analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680 and includes analysis of the reach above I-680 not conducted for the final array of alternatives.

Table 3-2 Action Required to Contain Nearest Percent Chance Exceedance Event

	Percent Chance Exceedance									
Reach/Crossing	**50%**	**20%**	**10%**	**5%**	**4%**	**3%**	**2%**	**1%**	**0.5%**	**0.2%**
Upstream of Old Piedmont Rd	NA	NA	NA	NA	LV	LV	LV	LV	LV	LV
Old Piedmont Road	NA	NA	NA	NA	NA	NA	MC	RC	RC	RC
Old Piedmont Rd to Pied-Crop	NA	NA	NA	NA	NA	BP	BP	BP	BP	BP
Piedmont-Cropley Culvert	NA	NA	GM	GM	GM	MC	MC	RC	RC	RC
Piedmont-Cropley to Messina Dr.	NA	NA	LV	LV	LV	LV	LV	LV	LV	LV
Messina Dr. to Morrill Ave	NA	NA	NA	LV	LV	LV	LV	LV	LV	LV
Morrill Ave Drop&Clvrt+Sierra Cnfl	NA	NA	NA	NA	NA	NA	MC	RC	RC	RC
Morrill Avenue to Cropley Avenue	NA	NA	NA	NA	LV	EX	EX	EX	EX	EL
Cropley Avenue Culvert	NA	NA	NA	NA	NA	MC	MC	RC	RC	RC
Cropley Ave to I-680	NA	NA	NA	NA	NA	NA	NA	NA	LV	LV
I-680	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
I-680 to Montague Expressway	NA	NA	LV	LV	LV	LV	LV	LV	LV	LV
Montague Expressway Culvert	NA	NA	NA	GM	MC	MC	MC	RC	RC	RC
Montague Expy to UPRR Trestle	NA	NA	NA	LV	LV	EL	EL	EL	EL	EL
Railroad Trestle	NA	NA	NA	NA	NA	NA	RC	RC	RC	RC
UPRR Trestle to Culvert	NA	NA	NA	NA	NA	NA	NA	EX	EL	EL
Railroad Culvert	NA	NA	NA	NA	NA	MC	MC	MC	MC	RC
UPRR Culvert to Ames Ave	NA	NA	NA	NA	NA	EX	EX	EX	EX	EL
Ames Avenue Bridge	NA	NA	NA	NA	NA	MC	MC	MC	MC	MC
Ames Ave to Yosemite Dr	NA	NA	NA	LV	LV	EL	EL	EL	EL	EL
Yosemite Drive Bridge	NA	NA	NA	NA	NA	MC	MC	MC	MC	MC
Yosemite Dr to Los Coches St	NA	LV	LV	LV	LV	EL	EL	EL	EL	EL
Los Coches Street Bridge	NA	NA	NA	GM	GM	MC	MC	MC	MC	RC
Los Coches St to Calaveras Blvd	NA	NA	NA	LV	LV	EL	EL	EL	EL	EL
Calaveras Blvd Bridge	NA	NA	NA	GM	MC	MC	MC	MC	RC	RC
Downstream of Calaveras Blvd	NA	NA	NA	NA	NA	EX	EX	EL	EL	EL

Key:

No Action	**NA**
Levee	**LV**
General Maintenance	**GM**
Channel Widening	**EX**
Channel Widening with Levees	**EL**
Bank Protection	**BP**
Modify Crossing	**MC**
Replace Crossing	**RC**

CHAPTER 4: PRELIMINARY ARRAY OF ALTERNATIVES

The preliminary array of alternatives was developed from 2006 to 2009 with the help of the information developed in the incremental analysis. The preliminary array of alternatives analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680. Therefore, the preliminary array of alternatives analysis covers the entire study reach from upstream of Old Piedmont Road to Calaveras Boulevard. The GRR with-project scenarios are built on the original GRR without-project HEC-RAS model and associated assumptions as described in Section 2.1. The preliminary array of alternatives were developed as either a moderate level of protection or FEMA certifiable level of protection to size the project features for the project alternative combinations. The following describes the two levels of protection used in the design of the preliminary analysis:

- *Profile A: Moderate Protection.* Hydraulic structure capacity and levees/top of bank are designed at the water surface level corresponding to the median 0.9% chance exceedance event. The scenario for this level of containment includes channel modifications in addition to modifications and/or complete replacement at bridge and culvert crossings. The modification or retrofitting work includes shoring and transition structures (UPRR Culvert, Ames Avenue Bridge, Yosemite Drive Bridge); headwall extensions with transition structure (Los Coches Street Bridge, Calaveras Boulevard Bridge); and bridge replacement (Old Piedmont Road Bridge, Piedmont-Cropley Culvert, Messina Pedestrian Bridge, Morrill Avenue Culvert, Cropley Avenue Culvert, UPRR Trestle, Montague Expressway Culvert). Modifications within channel reaches include channel widening, bank stabilization, and earthen levee or concrete floodwall construction. Additional details on the individual project features are included in *Appendix B, Part IV: Design and Cost of Alternatives*.

- *Profile B: FEMA Certification Protection.* Risk and uncertainty principles were used in the development of the B alternatives. Hydraulic structure capacity and levees/top of bank are determined according to criteria developed by the U.S. Army Corps of Engineers (Corps) Engineering Circular No. 1110-2-6067 "Certification of Levee Systems for the National Flood Insurance Program," dated September 30, 2008. The Corps HEC-FDA program was used to determine the conditional non-exceedance probability (CNP). The alternatives were broken into reaches, and index points were assigned for each reach. The hydraulic and hydrologic data from the study were input for each index point along with the top of levee elevations to determine the CNP for each reach. Each reach was analyzed according to the above criteria and the top of levee elevations that satisfied the criteria were determined. The resulting elevations from the analyses were then used in the development of the B alternative designs. The scenario for this level of containment involves complete replacement of all bridges and culverts with the exception of the Ames Avenue and Yosemite Drive crossings, which would require shoring/stabilization of existing abutments and construction of transition structures, and the I-680 crossing, which would not be affected. Modifications within channel reaches include excavation and levee/wall construction.

Additional details on the individual project features are included in *Appendix B, Part IV: Design and Cost of Alternatives*.

Further details on the selection of design level of protection are presented in *Appendix C: Economics*. The preliminary alternatives evaluation includes a no action alternative and five project alternatives:

- *Alternative 1 (No Action)*. Without-project condition as described in Section 2.1, assuming routine maintenance.

- *Alternative 2A (Incised Trapezoidal Channel)*. Earthen trapezoidal section with varying bottom width and 2:1 side slopes with a moderate level of containment. Access road intermittently along top of bank or within channel at approximate level of 4% chance exceedance event. Cellular bank stabilization with rip rap toe protection throughout. Levees as required with 2:1 side slopes and 12' top width.

- *Alternative 2B (Incised Trapezoidal Channel)*. Earthen trapezoidal section with varying bottom width and 2:1 side slopes with a FEMA-certifiable level of containment. Access road intermittently along top of bank or within channel at approximate level of 4% chance exceedance event. The designed level of the maintenance road may vary in order to suit local maintenance needs. Cellular bank stabilization with rip rap toe protection throughout. Levees and floodwalls as required with 2:1 side slopes and 12' top width. Limited additional right of way.

- *Alternative 3B (Terraced Trapezoidal Channel)*. Earthen section with 10' bottom width low flow channel, 3:1 side slopes, 3' deep. FEMA-certifiable level of containment. Two 15' wide vegetated floodplain terraces. Levees as required with 2:1 side slopes and 12'-18' top width. Cellular bank stabilization on slopes with rip rap toe protection throughout. Access road along one or both banks, with optional recreational trail. Additional right of way as required.

- *Alternative 4 (Walled Trapezoidal Channel)*. 10' bottom width earthen low-flow channel with 3:1 side slopes, 3' deep. FEMA-certifiable level of containment. Two vegetated floodplain benches bounded by vertical concrete floodwalls, 32' wide on the left bank, and 10' wide on the right bank. Access road location varies along the top of one or both banks or within channel. Optional recreational trails. Wall extensions as required to contain flows. Limited additional right of way.

- *Alternative 5 (Authorized Plan)*. Levees in the Greenbelt. Concrete trapezoidal channel in downstream of I-680.

All project features upstream of I-680 (including both channel work and bridge and culvert modifications) are consistent among the B alternatives. Bridge and culvert modification and replacement scenarios downstream of I-680 are likewise consistent among the B alternatives; the alternatives differ only in the configuration of the channel reaches between the structures.

Plan views and typical sections showing the overall configuration of each alternative are presented in *Appendix B, Part IV: Design and Cost of Alternatives*.

4.1 Model Input

The following section describes the methodology used in the preliminary array of alternatives analysis.[3]

4.1.1 Flow

Peak discharges for the with-project alternatives were retained from the without-project future conditions hydrology as tabulated above. For comparison purposes, all project conditions models were run both mixed and subcritical, with subcritical results being used to design levee heights and bridge capacities, while mixed run results were used to determine hydraulic parameters for the design of channel and bank stabilization features. All with-project models were checked for convergence in optimized split flow routines as discussed in *Appendix B, Part II: Floodplain Development*.

4.1.2 Geometry

Without-project cross sections were adjusted to reflect the three project alternatives. A description of each typical cross section, including dimensions and side slopes, is presented in *Appendix B, Part IV: Design and Cost of Alternatives*.

Channel excavation was modeled using the HEC-RAS channel modification function. The channel modification routine was run for affected individual sections using composite cut templates with the fill option toggled off (representing excavation only). The option to "daylight once" is also toggled off so that the cut slope is extended along the entire channel. Fill to represent earthen levees was added either as individual cross section points or modeled as vertical levees as applicable. The channel modification routine creates duplicate points in some locations, so the point filter is run with all tolerances set to 0 in order to remove duplicate points. After the routine is run, the new geometry is created. With-project sections were located within the assumed available right of way where possible. Potential discrepancies in the available right of way data are described in Tetra Tech, 2005a.

Manning's roughness coefficients in the Greenbelt reach were retained from the without-project model. A discussion on the selection of n values is included in the HDR report (2004a). Roughness coefficients for project sections downstream of I-680 were assigned using the $n = (n_b + n_1 + n_2 + n_3 + n_4)m$ method as described in EM 1110-2-1601, where n_b is the base value, n_1, n_2, n_3, and n_4 account for surface irregularities, section variation, obstructions, and vegetation, respectively, and m is a coefficient accounting for meandering.

[3] The preliminary array of alternatives analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680 and includes analysis of the reach above I-680 not conducted for the final array of alternatives.

Hardened access roads are assigned a coefficient of 0.02. The designed main channel is assigned a value of 0.03 to reflect a smooth, maintained, earthen channel with grass-lined banks. Vegetated terraces are assigned a coefficient of 0.045. Coefficients for meandering and irregularities are not increased because of the straight nature of this reach and in order to remain consistent with the HDR analysis (2004). Further refinement of Manning's n values is recommended upon selection of vegetation type and density on floodplain benches. Lateral variation in n-values was included in the cross sections to ensure that the water surfaces from composite n values reflect similar water surface elevations. Sensitivity of the water surface elevations to changes in overall cross section roughness was presented in the HDR hydraulics report (2004a). In general, water surfaces are less sensitive to variations in n-values where the water surface profile is controlled by a constricting bridge or culvert. Placement of dense vegetation or lack of maintenance may result in an overall increase in the roughness and require higher levees in some locations. Results of a sediment transport analysis may also require future adjustments to the roughness coefficients in order to simulate meandering, irregularities from channel scour or deposition, and other factors related to the geomorphology of the channel.

Berryessa Creek is earthen channel with the potential for movement of the bed material and changes in the bed form over the course of an event. This change in bed form may impact the roughness of the bed and subsequently the resulting water surface profile. To ensure that the n values used in the HEC-RAS model were reasonable based on bed form type; the Manning's n values used to model the channel were checked against the typical range of Manning's n values for the anticipated bed form type. The anticipated bed form for Berryessa Creek within the project area during high flows is sand dunes based on the anticipated hydraulic conditions and bed sediment type using Figure 5.23 from Sediment Transport Technology by Simon and Senturk (Simon 1992). The typical n value for this type of bed form is 0.02 to 0.04 per Table 4.2 in River Mechanics by Pierre Julien (Julien 2002), Generally, the n values used in the Berryessa Creek HEC-RAS modeling fall within the range of 0.03 to 0.035. This is well within the typical value range for sand dunes. Therefore the n values used are representative of the anticipated bed form type in the Berryessa Creek channel.

4.2 Alternative Development using Risk-Based Project Performance

Project performance for the Berryessa Creek Flood Control Project Post Authorization Study was estimated using the Corps risk-based Monte Carlo simulation program HEC- FDA (Flood Damage Analysis), Version 1.2.4. The HEC-FDA program integrates hydrology, hydraulics, geotechnical and economic relationships to determine damages, flooding risk and project performance.[4] Uncertainty is incorporated for each relationship, and the model samples from a distribution for each observation to estimate damage and flood risk. The Berryessa Creek model includes the following relationships for each economic impact area:

[4] The preliminary array of alternatives analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680 and includes analysis of the reach above I-680 not conducted for the final array of alternatives.

- Probability-Discharge (with uncertainty determined by period of record)
- Stage-Discharge (stage in the channel with estimated error in feet)
- Stage-Damage (not used in this application, starting values added to run program)

The alternatives developed for this study focused on two different levels of protection. The alternative "A" group (Alternative 2A) was developed to pass the 1% chance exceedance event. The "B" category of alternatives, alternatives 2B, 3B, and 4B, were developed to FEMA-certifiable standards as defined in Engineering Circular (EC) 1110-2-6067. The EC lays out the criteria for determining acceptable top of levee elevations in terms of risk-based project performance.

4.2.1 Methodology

(a) Analysis Criteria

Risk and uncertainty principles were used in the development of the 2B, 3B, and 4B alternatives. The goal of the "B" alternatives is to ensure that the alternative designs shall be certifiable for the FEMA National Flood Insurance Program (NFIP). This was done using the criteria presented in the USACE Engineering Circular No. 1110-2-6067 "Certification of Levee Systems for the National Flood Insurance Program" dated September 30, 2008. The criteria for certification of a riverine levee system are as follows:

- The conditional non-exceedance probability (CNP) must be greater than 90% from overtopping of the 1% chance exceedance flood event for all reaches of the levee system.
- If the top of levee elevation if less than three feet above the FEMA base flood elevation, the levee can only be certified if the CNP is greater than 95%.
- The top of levee elevation shall not be less than 2 feet above the FEMA base flood elevation in any event, regardless if the CNP is 95% or greater.

Portions of the Berryessa Creek alternative designs include entrenched channels. EC 1110-2-6067 does not include criteria for entrenched channels. Based on conversations and e-mail correspondence with the Corps (USACE 2008b), for reaches with entrenched channels, the criteria used shall be a minimum bank elevation equal to the 90% CNP at for the FEMA Base Flood Event; with no minimum distance above the base flood for the entrenched channel bank.

In addition to the above criteria for both leveed and entrenched channel reaches, the project evaluation criteria selected is the 0.9% chance exceedance event (1/111 chance) rather than the 1% chance exceedance event. The use of the 0.9% chance exceedance event was selected to provide for robust alternative designs with respect to FEMA certification, against possible future changes in the hydrology or hydraulics. The 0.9% chance exceedance event was selected to ensure that the resulting alternatives would meet the final guidance for entrenched channels when finalized. The guidance was finalized and accepted after this analysis was completed, and this assumption was not carried on for the final array alternatives.

(b) Analysis Method

Risk-based project performance was used to ensure that the alternative designs meet the FEMA certification criteria presented in the previous section. To accomplish this, HEC-FDA version 1.2.4 was used to determine the conditional non-exceedance probability (CNP) for the three "B" alternatives. This section describes the methodologies followed to determine the top of levee elevations and to analyze entrenched channel reaches.

First, each "B" alternative was broken up into reaches and index points were assigned. Then each reach was analyzed as either a leveed or entrenched channel as appropriate. The leveed reaches were analyzed to determine the appropriate top of levee elevation to use for the reach. Entrenched channel reaches were analyzed to determine if the channel would be FEMA certifiable or if levees may be needed. The application for each type of channel is presented below. The results from the analyses were then used in the development of the final design for each of the "B" alternatives.

Leveed Reach

In order to determine the necessary top of levee elevations to satisfy the levee FEMA certification criteria, the following steps were used.

1. The top of levee elevation for each reach was set to the 0.9% chance exceedance event elevation plus 3 feet for each index point and HEC-FDA was run
2. The CNP for the 0.9% chance exceedance event was linearly interpolated from the HEC-RAS CNP output (HEC-FDA output only includes the 10, 4, 2, 1, 0.4, and 0.2 percent chance exceedance events).
3. For reaches with less than a 95% CNP, the top of levee was set at 0.9% chance exceedance stage plus three feet and recorded for that reach. For reaches with greater than 95% CNP the top of levee was revised to 0.9% chance exceedance stage plus two feet and HEC-FDA was run for the revised reaches.
4. The CNP for the 0.9% chance exceedance event was interpolated for the revised reaches.
5. For revised reaches with less than 95% CNP the top of levee was increased by 0.25 ft. For revised reaches with a CNP greater than 95% the top of levee was set to the top of levee elevation and recorded. HEC-FDA was run for the revised reaches.
6. Steps 4 and 5 were repeated until a CNP of greater than 95% was reached and recorded for all revised reaches. If the iterations result in the top elevation of levee returning to the 0.9% chance exceedance stage plus three feet originally used in Step 1, the top of levee elevation is recorded as 0.9% chance exceedance stage plus three feet.
7. The final difference between the 0.9% chance exceedance stage and the top of levee elevation was determined and applied to the all sections of for individual reach.

Entrenched Channel Reach

For the entrenched channel sections the following steps were used.

1. The HEC-FDA top of levee elevation for each reach was set to the 0.9% flood event elevation plus 0.25 feet for each index point and HEC-FDA was run.
2. The CNP for the 0.9% chance exceedance event was interpolated from the HEC-RAS CNP output.
3. For revised reaches with less than 90% CNP the top of levee was increased by 0.25 ft. For revised reaches with a CNP greater than 90% the top of levee was set to the Top of Levee elevation and recorded. HEC-FDA was run for the revised reaches.
4. The CNP for the 0.9% chance exceedance event was interpolated from the HEC-RAS CNP output.
5. Steps 3 and 4 were repeated until a CNP of greater than 90% was reached and recorded for all reaches.
6. The resulting top of levee elevation was compared to the lower of the left and right bank elevation. Reaches in which the lowest top of bank was higher than the final top of levee elevation, the reach passed. Reaches where the top of levee elevation was higher than the lowest top of bank elevation, the bank was considered to have failed, and thus deemed a levee reach and analyzed according to the methodology for levee reaches.

4.2.2 Inputs

In developing a risk-based project performance model a number of different inputs are required. The following inputs were developed for the Berryessa Creek analysis:

- Reaches and index point locations
- Hydrologic
- Hydraulic
- Economic
- Top of Levee Elevation

The following section describes each of the inputs used for the risk based performance in detail.

(a) Reaches and Index Points

Reaches are developed by grouping similar sections of channel into one reach. One representative cross section is chosen for each reach as the index point. This index point is the location where the hydraulic, hydrologic and economic inputs are assigned for that reaches. The Berryessa Creek greenbelt area reaches were determined differently from the balance of the study area.

The Berryessa Creek channel outside of the Greenbelt reach was divided into 9 reaches[5] based on the alternative channel design. The developed channel was divided into reaches based on similar cross sections grouped into one reach. The reach description, upstream bounding section, downstream bounding section and index point are listed in Table 4-1.

Table 4-1 Reach Descriptions for Study Area not including Greenbelt Reach

Reach	Downstream Section	Index Location	Upstream Section	Alternative
Upstream Old Piedmont Rd.	35191	35350	36242	B upstream [1]
Old Piedmont to Piedmont-Cropley	34467	34959	35139	B upstream [1]
Morrill Ave to Cropley Ave	27642	28307	28525	B upstream [1]
Cropley Ave to I-680	25688	26419	27499	B upstream [1]
I-680 to Montague Blvd.	21738	22274	25575	2B, 3B, 4B
Montague to UPRR Trestle	21738	21601	21247	2B, 3B, 4B
UPRR Trestle to UPRR Triple Box	19333	20131	21247	2B, 3B, 4B
UPPR Triple Box to Ames Ave.	18843	19158	19333	2B, 3B, 4B
Ames Ave. to Calaveras Blvd.	13803	16924	18843	2B, 3B, 4B

1. Only one "B" alternative was developed upstream of I-680.

Due to the complexity of the greenbelt area upstream of Interstate 680, reach and index point assignments were done at more frequent intervals. The greenbelt was divided into a number of different reaches based on the cross sections used in the HEC-RAS model. Reaches were developed for each cross section. In locations along the greenbelt with multiple closely spaced cross sections, the sections were grouped together and only one section was analyzed. The reach description, upstream bounding section, downstream bounding section and index point are listed in Table 4-2.

Table 4-2 Reach Descriptions for Greenbelt Reach

Reach	Downstream Section	Index Location	Upstream Section
33966	33904	33966	34041
33773	33756	33773	33804
33485	33480	33485	33490
33378	33370	33378	33380
33166	33136	33166	33207
32976	32889	32976	33136

[5] The hydraulic reaches discussed in this appendix refer to the hydraulic reaches specified in the scope of work to ensure hydraulic performance goals were met. The Economic Appendix discusses the results of the economic analysis on economic reaches developed independently of the hydraulic reaches, based on economic criteria. The reaches referenced in this and the economic appendix are independent and are not meant to correlate between appendices.

Reach	Downstream Section	Index Location	Upstream Section
32877	32753	32877	32889
32721	32659	32721	32753
32645	32631	32645	32659
32580	32575	32580	32585
32436	32430	32436	32440
32333	32330	32333	32339
32208	32200	32208	32210
32097	32090	32097	32100
31969	31960	31969	31970
31905	31900	31905	31910
31716	31710	31716	31720
31571	31570	31571	31572
31440	31322	31440	31559
31168	31160	31168	31170
31078	31070	31078	31080
30965	30910	30965	31026
30808	30800	30808	30810
30720	30720	30720	30731
30590	30580	30590	30600
30478	30470	30478	30480
30324	30304	30324	30327
30195	30190	30195	30200
30043	30040	30043	30050
29983	29980	29983	29990
29873	29870	29873	29880
29744	29740	29744	29750
29571	29570	29571	29580
29433	29430	29433	29440
29199	29093	29199	29267
28917	28910	28917	28920
28758	28749	28758	28770

(b) Hydrologic Inputs

The hydrologic inputs were developed from the Berryessa Creek Watershed Hydrology Report by NHC dated April 2003, amended in October 2006. HEC-FDA allows for the entry of eight standard percent chance exceedance events. The events used were the 50, 20, 10, 4, 2, 1, 0.4, and 0.2 percent chance exceedance events. The data were imported into HEC-FDA from the HEC-RAS using the HEC-RAS water surface profiles import file. The hydrologic data used for each index location is presented in Table 4-1 and Table 4-2.

Confidence limits were applied to the hydrologic data using the guidelines presented in EM 1110-2-1619 "Engineering and Design Risk-based Analysis for Flood Damage Reduction Studies" dated August 1996. An equivalent period of record of 35 years was applied to the hydrologic data for all reaches and was used by the HEC-FDA program to calculate the confidence limits. Table 4-3 lists the hydrologic data used and Table 4-4 lists the hydrologic curve assigned to each reach.

Table 4-3 HEC-FDA Hydrologic Curves Input

Percent Chance Exceedance	Hydrologic Curve					
	1	2	3	4	5	6
50%	240	260	300	470	610	620
20%	420	450	500	710	960	990
10%	560	600	700	830	1220	1170
4%	830	890	1000	1260	1620	1770
2%	1090	1180	1340	1630	2020	2200
1%	1430	1530	1740	2140	2780	2910
0.4%	1820	1960	2220	2660	3490	3580
0.2%	2130	2300	2600	3140	4200	4290

Table 4-4 Reach Hydrologic Curve Assignment

Hydrologic Curve	Reach
1	Upstream of Old Piedmont Rd., Old Piedmont to Piedmont-Cropley, Greenbelt Reaches 33966 to 33166
2	Greenbelt Reaches 32976 to 30590
3	Greenbelt Reaches 30478 to 28917
4	Montague, d/s of Cropley Greenbelt Reaches 28171 to 28758, Morrill Ave to Cropley Ave, Cropley Ave to I-680, Montague to UPRR Trestle
5	Montague to UPRR Trestle , UPRR Trestle to UPRR Triple Box, UPPR Triple Box to Ames Ave.
6	Ames Ave. to Calaveras Blvd.

(c) Hydraulic Inputs

The hydraulic data inputs for each reach were taken from the preliminary HEC-RAS modeling of the alternatives developed for this study. The preliminary HEC-RAS alternative models were run using an "infinite-wall" methodology. The 50, 20, 10, 4, 2, 1, 0.4, and 0.2 percent chance exceedance event stage data were imported into the HEC-FDA model for each index location. An error in the water surface stage was applied to the hydraulic data using the guidelines presented in EM 1110-2-1619 "Engineering and Design Risk-based Analysis for Flood Damage Reduction studies" dated August 1996. The stage error was computed by HEC-FDA using the standard deviation of the error range. The standard deviation was developed using the results from HEC-RAS model runs using high and low Manning's n values for each alternative. The standard deviation was developed from the following equation:

- $S = E_{mean} / 4$ where
- S = standard deviation of error range
- E_{mean} = mean stage difference between high and low Manning's n HEC-RAS runs

The standard deviation of the stage error was applied to the stage-discharge curve increasing linearly up to the stage of the 1% chance exceedance event. The error was set as a constant above the 1% chance exceedance event stage. The hydraulic inputs for the Upper and Lower Berryessa Models are shown in Table 4-5 and Table 4-6.

Table 4-5 Stage for Percent Chance Exceedance Event

Reach	Water Surface Stage for Percent Chance Exceedance Event, ft								Stage Error, ft
	50%	20%	10%	4%	2%	1%	0.4%	0.2%	
Upstream Old Piedmont Rd.	218.6	219.51	219.9	220.52	221.16	221.95	222.79	223.41	0.09
Old Piedmont to Piedmont-Cropley	203.03	203.69	204.11	204.89	205.55	206.05	206.64	207.07	0.18
33966	181.24	182.21	182.82	183.81	184.65	185.59	186.52	187.23	0.17
33773	180.41	181.11	181.54	182.16	182.61	183.05	183.94	183.95	0.28
33485	177.68	178.04	178.28	178.72	179.13	179.60	180.07	180.56	0.27
33378	176.17	176.70	177.09	177.71	178.17	178.66	178.97	179.39	0.38
33166	171.99	172.36	172.61	173.03	173.39	173.81	174.43	174.87	0.09
32976	166.71	167.37	167.83	168.63	169.34	170.09	170.71	171.31	0.13
32877	165.27	165.83	166.22	166.86	167.43	168.21	169.32	169.66	0.11
32721	162.99	163.67	164.11	164.83	165.46	166.14	166.94	167.48	0.16
32645	162.22	162.67	163.00	163.54	164.02	164.54	165.12	165.55	0.13
32580	161.35	161.92	162.27	162.85	163.33	163.86	164.37	164.61	0.38
32436	159.26	159.63	159.92	160.42	160.86	161.34	161.91	162.58	0.20

Reach	Water Surface Stage for Percent Chance Exceedance Event, ft								Stage Error, ft
	50%	20%	10%	4%	2%	1%	0.4%	0.2%	
32333	157.12	157.59	157.89	158.40	158.83	159.27	159.75	160.60	0.22
32208	154.96	155.41	155.71	156.20	156.62	157.13	157.70	158.10	0.27
32097	153.57	154.06	154.38	154.93	155.41	155.96	156.59	156.99	0.37
31969	151.93	152.32	152.57	153.01	153.40	153.82	154.30	154.80	0.12
31905	149.97	150.38	150.66	151.13	151.54	152.00	152.51	152.88	0.19
31716	147.46	148.05	148.43	149.07	149.62	150.21	150.87	151.34	0.38
31571	145.37	145.98	146.37	147.03	147.61	148.23	148.78	149.13	0.36
31440	144.34	144.86	145.21	145.79	146.31	146.93	147.50	147.89	0.34
31168	139.92	140.33	140.60	141.07	141.49	141.95	142.54	143.00	0.13
31078	138.59	139.23	139.66	140.40	141.04	141.75	142.52	143.09	0.26
30965	136.99	137.33	137.56	138.08	138.57	139.11	139.71	140.22	0.24
30808	135.18	135.67	135.99	136.51	136.96	137.44	137.98	138.38	0.35
30720	134.22	134.65	134.94	135.42	135.82	136.25	136.71	137.02	0.22
30590	131.89	132.23	132.46	132.83	133.18	133.55	133.96	134.39	0.14
30478	129.43	129.98	130.46	131.10	131.72	132.39	133.10	133.78	0.40
30324	128.28	128.89	129.38	129.99	130.58	131.22	131.84	132.35	0.41
30195	126.97	127.31	127.60	127.99	128.38	128.79	129.25	129.59	0.12
30043	124.06	124.54	124.93	125.34	125.78	126.28	126.84	127.28	0.34
29983	122.98	123.32	123.61	124.21	124.82	125.41	126.08	126.53	0.35
29873	121.54	122.19	122.72	123.38	124.01	124.53	125.03	125.41	0.47
29744	120.76	121.45	121.95	122.56	123.15	123.62	123.98	124.43	0.45
29571	118.89	119.12	119.45	119.89	120.37	121.12	122.34	123.37	0.36
29433	117.05	117.73	118.34	119.19	120.05	120.92	122.20	123.30	0.18
29199	113.19	113.96	114.62	115.49	116.38	117.34	118.39	119.17	0.36
28917	106.59	107.68	108.52	109.53	110.61	112.41	113.25	114.02	0.35
28758	106.35	107.61	108.15	109.83	111.11	112.93	113.94	114.75	0.19
Morrill Ave to Cropley Ave	218.60	219.51	219.9	220.52	221.16	221.95	222.79	223.41	0.28
Cropley Ave to I-680	203.03	203.69	204.11	204.89	205.55	206.05	206.64	207.07	0.49

Table 4-6 Stage for Percent Chance Exceedance Event

Reach	Water Surface Stage for Percent Chance Exceedance Event, ft								Stage Error, ft
	50%	20	10%	4%	2%	1%	0.4%	0.2%	
Alternative 2B									
I-680 to Montague Blvd.	58.39	58.93	59.30	60.21	61.04	62.61	64.15	66.77	0.49
Montague to UPRR Trestle	55.75	56.57	57.19	58.15	59.10	60.89	62.52	64.10	0.44
UPRR Trestle to UPRR Triple Box	49.44	50.13	50.59	51.28	51.97	53.30	54.58	56.07	0.40
UPPR Triple Box to Ames Ave.	46.27	41.03	47.52	48.19	48.80	49.82	50.78	52.52	0.48
Ames Ave. to Calaveras Blvd.	36.65	37.60	38.02	39.27	40.01	41.37	44.91	47.39	0.63
Alternative 3B									
I-680 to Montague Blvd.	57.92	58.58	59.02	59.91	60.68	62.04	63.30	64.55	0.47
Montague to UPRR Trestle	55.35	56.16	56.70	57.49	58.25	59.64	60.90	62.14	0.30
UPRR Trestle to UPRR Triple Box	49.06	49.80	50.28	50.98	51.66	52.99	54.27	55.79	0.55
UPPR Triple Box to Ames Ave.	46.13	46.95	47.46	48.16	48.77	49.79	50.62	52.38	0.54
Ames Ave. to Calaveras Blvd.	36.38	37.40	37.83	39.08	39.78	40.81	41.77	42.64	0.62
Alternative 4B									
I-680 to Montague Blvd.	58.39	58.93	59.30	60.21	61.04	62.61	64.15	66.77	0.45
Montague to UPRR Trestle	55.75	56.57	57.19	58.15	59.10	60.89	62.52	64.10	0.20
UPRR Trestle to UPRR Triple Box	49.44	50.13	50.59	51.28	51.97	53.30	54.57	56.07	0.61
UPPR Triple Box to Ames Ave.	46.27	47.03	47.52	48.19	48.80	49.82	50.69	52.53	.65
Ames Ave. to Calaveras Blvd.	36.65	37.60	38.02	39.26	40.00	41.10	42.37	43.46	0.73

(d) Economic Inputs

As the name suggests, HEC-FDA is primarily used as a flood damage analysis tool, of which project performance is one aspect. Therefore, economic inputs in the form of stage-damage curves and floodplain structure locations are required. The economic inputs are independent of the project performance results. For analyses performed for this study, one dummy damage curve and one dummy structure were entered into the HEC-FDA model. This economic data consisted of one data point and was used only to allow the calculation of the CNP and did not affect the performance evaluation or represent any particular structure in the floodplain.

(e) Top of Levee Elevations

The top of levee elevations were used as the target for the HEC-FDA program to determine the CNP for each reach of each alternative. A top of levee elevation was entered for all reaches based on the analysis methodology for that reach. The top of levee was based on a height above the FEMA base flood level for all reaches.

The top of levee elevations for the greenbelt area were determined using the HEC-RAS cross section data. The greenbelt index sections were inspected and the left and right top of levee elevations determined. For sections with apparent existing levees, the elevation was taken at the highest point at which the width of the existing ground section was a minimum of 20 feet. For entrenched portions of the channel the top of bank was used. The lower of the left or right bank was taken as the top of levee elevation for the section.

The top of levee elevations for the leveed reaches were then adjusted using the steps described above until the design criteria were met. The top of levee elevations were based on the lowest bank elevation for entrenched channel reaches. The final tops of levee elevations were used as the basis for the final alternative design.

4.2.2.2 Project Performance Results

The risk-based project performance was determined according to the methodologies described above for each reach[6]. Table 4-7 and Table 4-8 list the results for Upper and Lower Berryessa Creek Study areas, respectively. The tables list the reach, type of reach (entrenched or leveed), CNP results for the final successful iteration, height above base flood corresponding to final successful iteration, and required top of bank elevations for leveed reaches.

As seen in Table 4-7, the B alternatives generally meet the design criteria as an entrenched channel in the reach upstream of I-680 (where the project features are identical between the alternatives). This is primarily due to the use of terraces in the greenbelt reach which greatly reduces extent and height of levees required in the Greenbelt reach. The few locations that do require levees correspond to the primary breakout locations, and the majority of the areas showing flooding in the without-project analysis. The height above base flood was applied to any additional cross sections in the specific reach to obtain a similar project performance. In the case of entrenched channels the height above base flood was used to check the top of bank elevation for any additional cross sections in the reach to ensure that they met the minimum acceptable height above base flood for that reach.

[6] The hydraulic reaches discussed in this appendix refer to the hydraulic reaches specified in the scope of work to ensure hydraulic performance goals were met. The Economic Appendix discusses the results of the economic analysis on economic reaches developed independently of the hydraulic reaches, based on economic criteria. The reaches referenced in this and the economic appendix are independent and are not meant to correlate between appendices.

Table 4-7 Risk-Based Project Performance Results Upstream of I-680

Reach	Reach Type	Existing Top of Levee/Bank Elevation, ft	CNP using Channel Criteria	Height above Base Flood	Required Top of Bank using Levee Criteria
Upstream Old Piedmont Rd.	Levee	222.58	0.446	+2.0ft	223.95
Old Piedmont to Piedmont-Cropley	Entrenched	210.58	0.99	+1.25ft	-
33966	Entrenched	189.97	0.99	+1.75 ft	-
33773	Entrenched	185.08	0.99	+1.25 ft	-
33485	Entrenched	182	0.99	+1.25 ft	-
33378	Entrenched	180.78	0.99	+1.25 ft	-
33166	Entrenched	177.39	0.99	+1.25 ft	-
32976	Entrenched	173	0.99	+1.25 ft	-
32877	Entrenched	171.33	0.99	+1.5 ft	-
32721	Entrenched	168.79	0.99	+1.5 ft	-
32645	Entrenched	167.24	0.99	1+.25 ft	-
32580	Entrenched	166	0.99	+1.0 ft	-
32436	Entrenched	162.85	0.96	+1.25 ft	-
32333	Entrenched	161	0.98	+1.5 ft	-
32208	Entrenched	160	0.99	+1.25 ft	-
32097	Entrenched	158.06	0.99	+1.25 ft	-
31969	Entrenched	157.41	0.99	+1.0 ft	-
31905	Entrenched	154.52	0.99	+1.0 ft	-
31716	Entrenched	152.99	0.99	+1.25 ft	-
31571	Entrenched	150.3	0.99	+1.25 ft	-
31440	Levee	147.38	0.478	+2.0 ft	148.93
31168	Entrenched	144.24	0.99	+1.25 ft	-
31078	Entrenched	144.17	0.99	+1.5 ft	-
30965	Entrenched	143.12	0.99	+1.25 ft	-
30808	Entrenched	140.35	0.99	+1.25 ft	-
30720	Entrenched	138.75	0.99	+1.25 ft	-
30590	Entrenched	137.5	0.99	+1.0 ft	-
30478	Entrenched	136	0.99	+1.5 ft	-
30324	Entrenched	133.12	0.9877	+1.25 ft	-
30195	Entrenched	131.22	0.99	+1.0 ft	-
30043	Entrenched	129.58	0.99	+1.25 ft	-

Reach	Reach Type	Existing Top of Levee/Bank Elevation, ft	CNP using Channel Criteria	Height above Base Flood	Required Top of Bank using Levee Criteria
29983	Entrenched	129.57	0.99	+1.25 ft	-
29873	Entrenched	127.97	0.99	+1.25 ft	-
29744	Entrenched	127	0.999	+1.25 ft	-
29571	Entrenched	124.2	0.9958	+2.0 ft	-
29433	Levee	122.2	0.4936	+2.5 ft	123.42
29199	Entrenched	120	0.9959	+2 ft	-
28917	Entrenched	114.42	0.9513	+1.75 ft	-
28758	Levee	112.59	0.1183	+3 ft	115.93
Morrill Ave to Cropley Ave	Entrenched	107.19	0.9992	+1.25 ft	-
Cropley Ave to I-680	Entrenched	90.56	0.9998	+1.5 ft	-

As seen in Table 4-8, all alternatives require the use of levees or floodwalls for certification and purposes downstream of I-680. This is primarily due to large peak flows and limited rights of way through the Lower Berryessa Creek study area. Generally, the reaches passed by meeting the 90% CNP for base flood plus 3 feet requirement. Only for Alternative 3B did the reach above Montague Blvd. exceed a CNP of 95% to allow the use of a base flood plus 2.5 ft for certification. In addition, a short reach of Alternative 4B between Montague and the UPRR Trestle required a base flood plus 3.1ft for certification. The height above the base flood as listed in Table 4-8 was applied to the remainder of the cross sections in the reach to ensure that they meet the minimum acceptable height above base flood for that reach.

Table 4-8 Risk-based Project Performance Results Downstream of I-680

Reach	Reach Type	Base Flood Water Surface, ft	Top of Levee Elevation, ft	Height above Base Flood	CNP for Final Iteration
Alternative 2B					
I-680 to Montague Blvd.	Levee	62.6	65.61	+3ft	0.9123
Montague to UPRR Trestle	Levee	60.9	63.9	+3ft	0.9077
UPRR Trestle to UPRR Triple Box	Levee	53.3	56.3	+3ft	.9604
UPPR Triple Box to Ames Ave.	Levee	49.8	52.82	+3ft	.9615
Ames Ave. to Calaveras Blvd.	Levee	41.4	44.34	+3ft	.9675
Alternative 3B					
I-680 to Montague Blvd.	Levee	62.04	64.54	+2.5ft	.9617
Montague to UPRR Trestle	Levee	59.64	62.64	+3ft	.9850
UPRR Trestle to UPRR Triple Box	Levee	52.99	55.99	+3ft	.9451
UPPR Triple Box to Ames Ave.	Levee	49.79	52.79	+3ft	.9672
Ames Ave. to Calaveras Blvd.	Levee	47.08	50.08	+3ft	.9983
Alternative 4B					
I-680 to Montague Blvd.	Levee	65.61	62.61	+3ft	.9127
Montague to UPRR Trestle	Levee	60.89	63.99	+3.1ft	.9011
UPRR Trestle to UPRR Triple Box	Levee	53.3	56.3	+3ft	.9450
UPPR Triple Box to Ames Ave.	Levee	49.82	52.82	+3ft	.9459
Ames Ave. to Calaveras Blvd.	Levee	41.1	44.1	+3ft	.9550

4.3 Results

This section summarizes the hydraulic characteristics of project conditions alternatives. Further details on cross sections, quantities and costs are included in *Appendix B, Part IV: Design and Cost of Alternatives*. All project features were modeled individually to determine the associated hydraulic effects prior to combining the features into composite with-project alternative models.[7] Summary results of hydraulic parameters are presented in Table 4-9 with additional details in Table 4-10.

[7] The incremental analysis was conducted before the final determination was made that there was no justification for federal involvement above I-680 and includes analysis of the reach above I-680 not conducted for the final array of alternatives.

Table 4-9 With-Project Hydraulic Results Summary

Bounding Bridge or Culvert		1% Percent Chance Exceedance											
		2A		2B		3A		3B		4A		4B	
From	To	D (ft)	V (fps)	D (ft)	V (fps)	D (ft)	V (fps)	D (ft)	V (fps)	D (ft)	V (fps)	D (ft)	V (fps)
Upstream Extent	Old Piedmont Rd	5.4	2.4	7.0	3.9	7.7	6.2	8.4	3.4	7.8	4.8	8.4	3.4
Old Piedmont Rd	Piedmont-Cropley	5.7	1.9	7.2	3.1	8.1	4.9	9.0	5.0	8.6	4.8	9.0	5.0
Piedmont-Cropley	Morrill Avenue	4.9	1.8	5.8	2.3	6.3	3.0	6.4	3.1	7.2	3.6	6.4	3.1
Morrill Avenue	Cropley Avenue	5.2	2.4	5.8	3.4	4.6	5.8	4.7	6.9	5.6	7.6	4.7	6.9
Cropley Avenue	I-680	7.6	2.4	9.0	3.2	11	4.7	11	4.7	11	5.4	11	4.7
I-680	Montague Expy	5.2	3.1	5.8	3.9	6.5	4.9	6.8	5.3	7.2	6.2	6.8	5.3
Montague Expy	UPRR Trestle	6.1	4.3	7.2	5.5	7.4	7.2	7.6	7.3	8.0	8.6	7.6	7.3
UPRR Trestle	UPRR Culvert	6.4	3.4	7.4	4.6	8.5	6.1	8.6	7.1	7.4	7.9	8.6	7.1
UPRR Culvert	Ames Avenue	4.2	3.9	5.1	5.0	6.1	5.9	6.2	6.3	6.3	7.5	6.2	6.3
Ames Avenue	Yosemite Drive	6.3	3.2	7.2	4.4	6.0	5.3	5.8	6.3	6.3	7.6	5.8	6.3
Yosemite Drive	Los Coches Street	5.8	3.5	5.7	4.1	5.5	5.7	5.4	6.3	5.8	7.6	5.4	6.3
Los Coches St	Calaveras Blvd	6.8	3.8	6.8	5.4	6.6	6.5	6.3	7.1	6.8	8.2	6.3	7.1
Calaveras Blvd	Downstream Extent	5.1	3.0	6.4	4.2	7.7	5.7	8.1	6.3	8.3	7.8	8.1	6.3

These results are for fully contained flows. Comparison to existing conditions is therefore hypothetical only; the computed without-project water surface elevation at any point assumes full containment at each upstream section, and flows are restricted to the extent of each cross section in the event of breakout. Results accounting for breakout flows are presented in *Appendix B, Part II: Floodplain Development*, and *Appendix B, Part III: Geomorphology*.

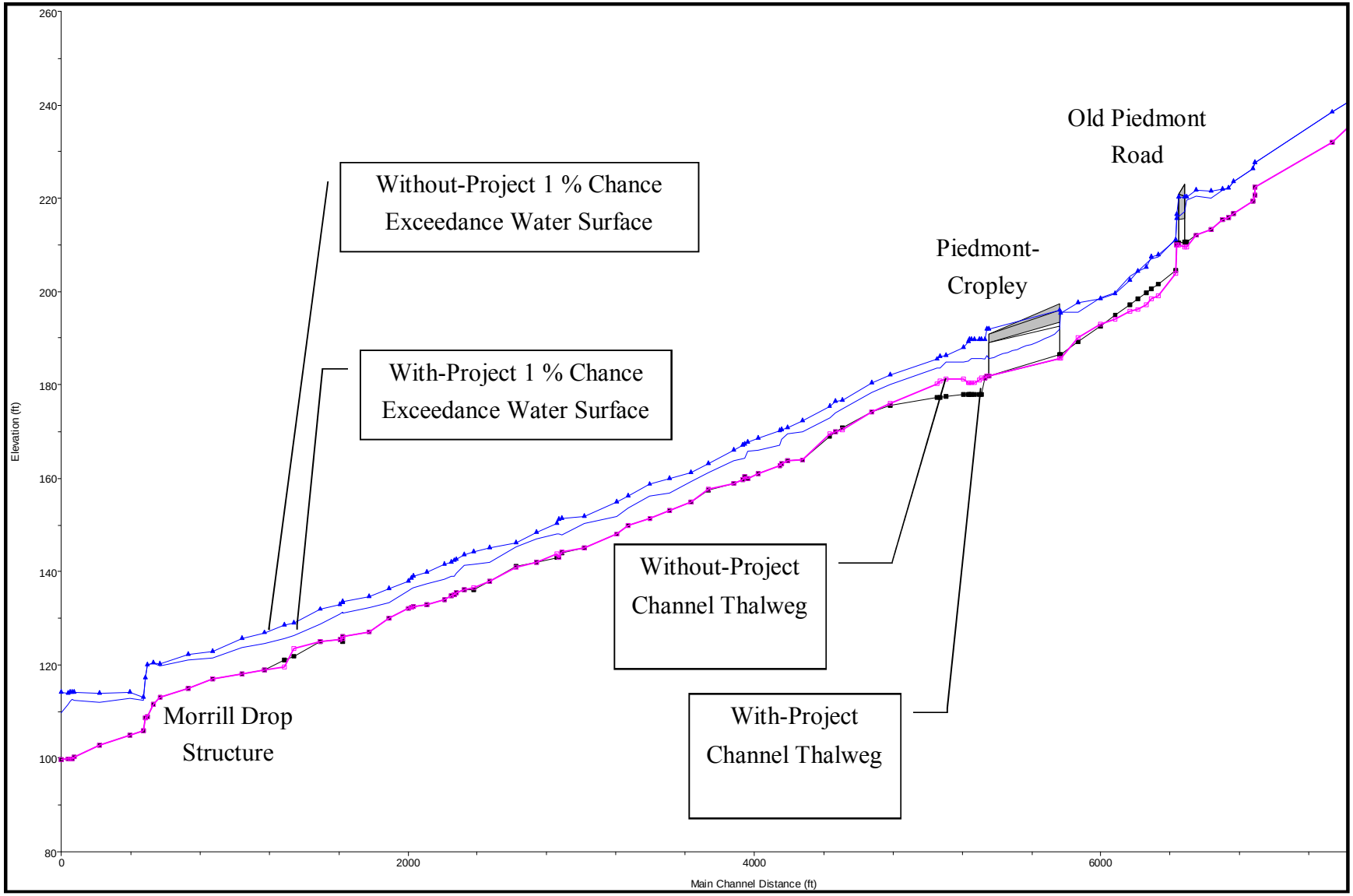

Figure 4-1 Water Surface Profile U/S of I-680, Without-Project vs. Alt 2A

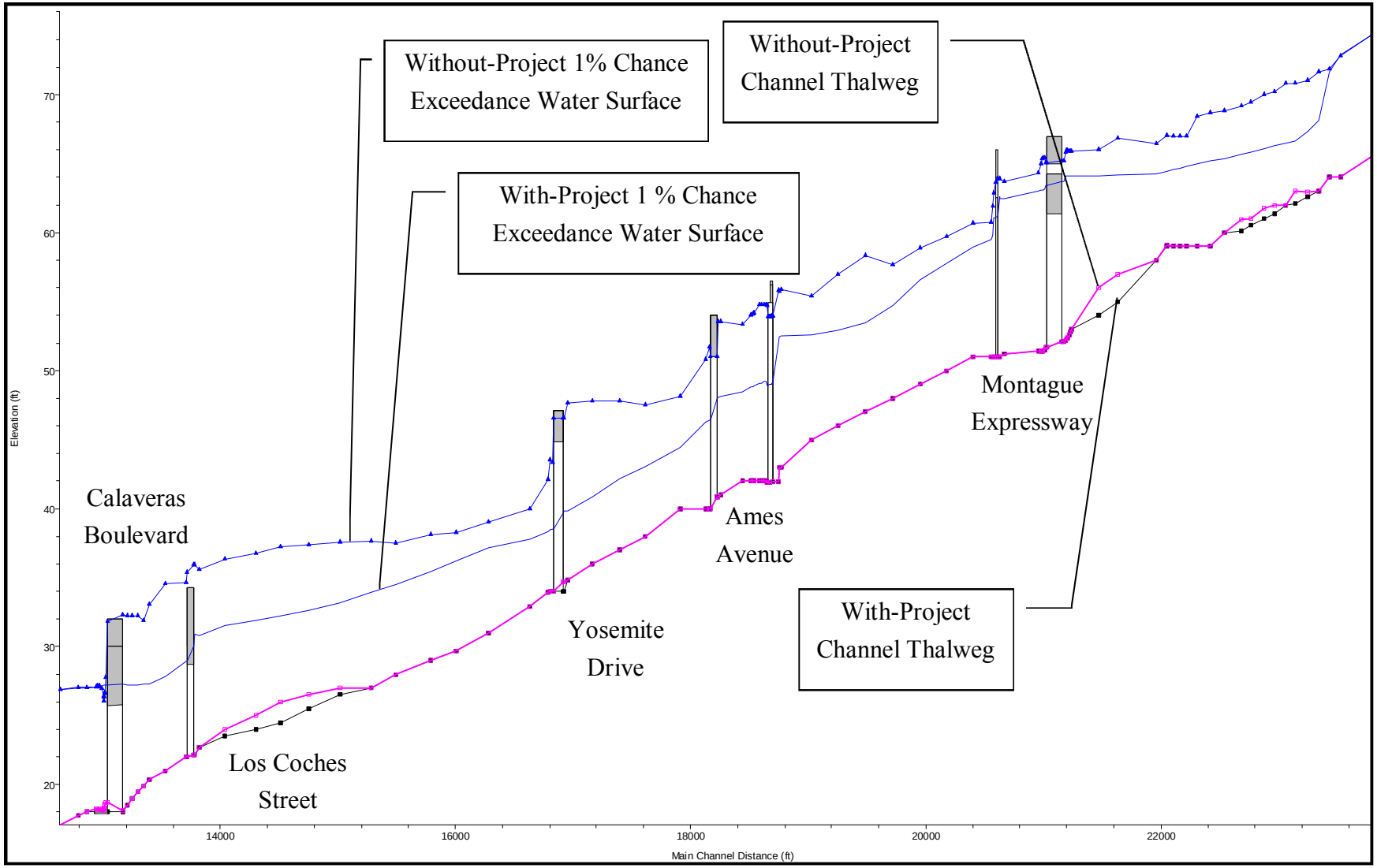

Figure 4-2 Water Surface Profile D/S of I-680, Without-Project vs. Alt. 2A

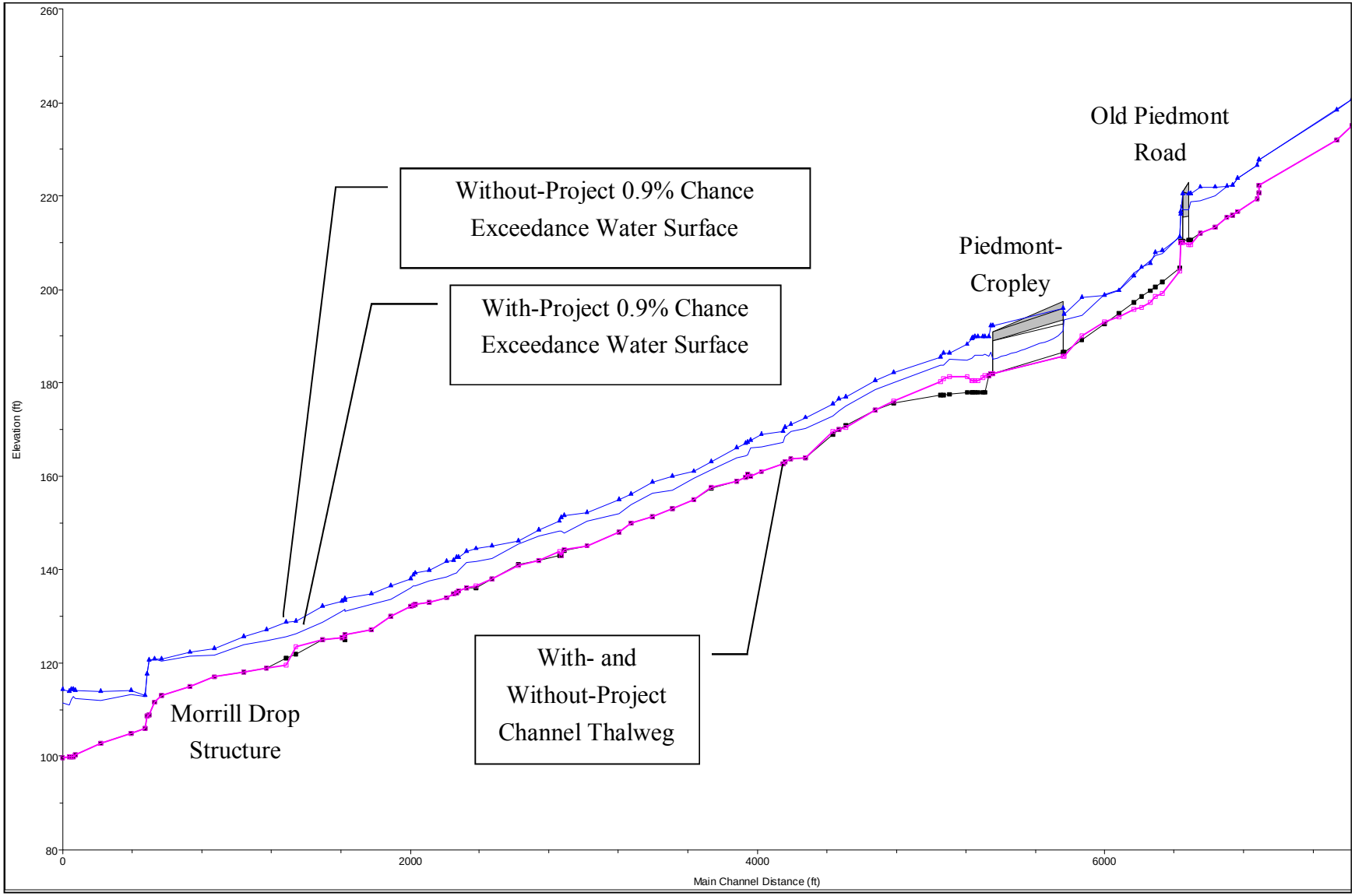

Figure 4-3 Water Surface Profile U/S of I-680, Without-Project vs. B Alternatives

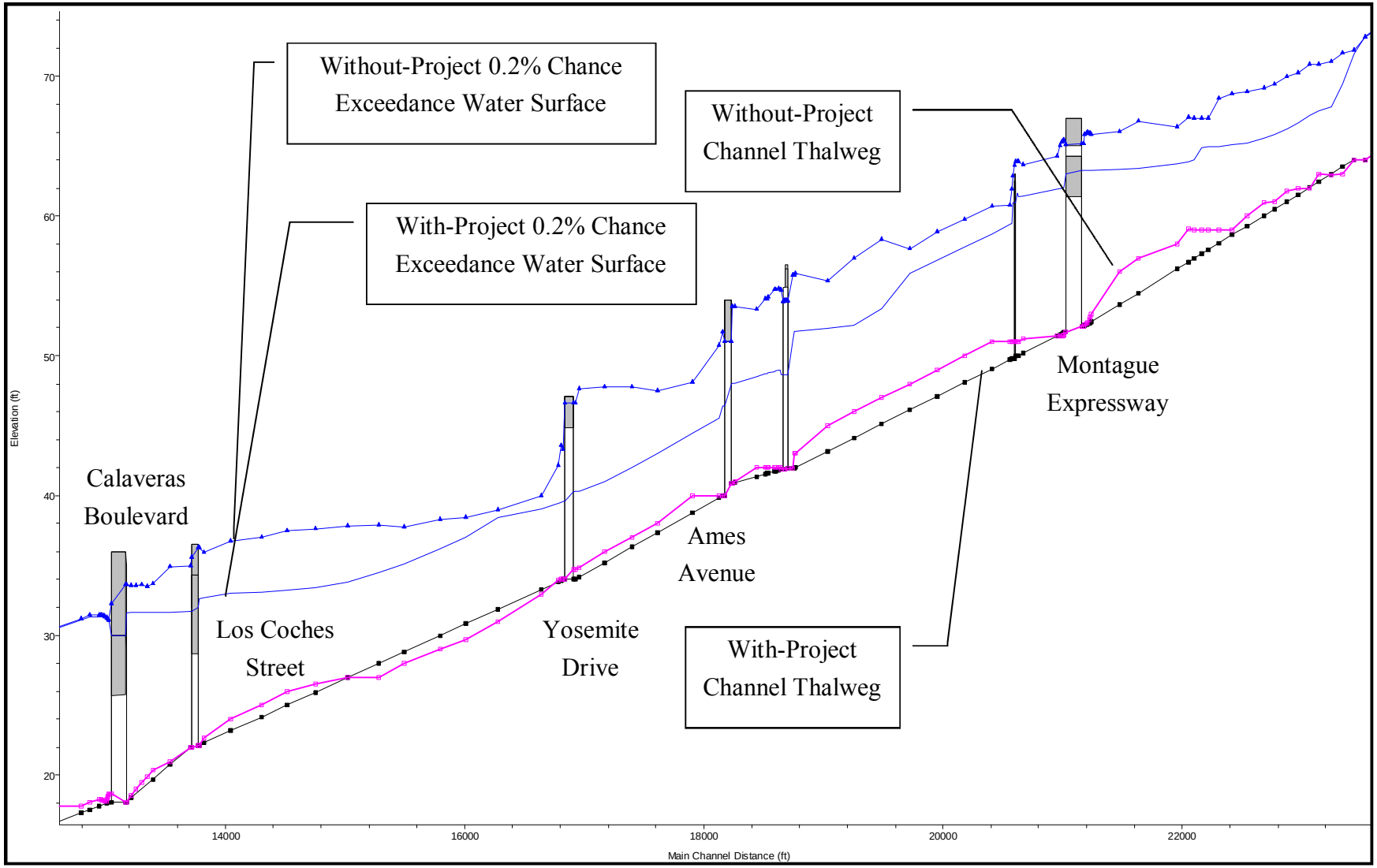

Figure 4-4 Water Surface Profile D/S of I-680, Without-Project vs. Alt. 2B

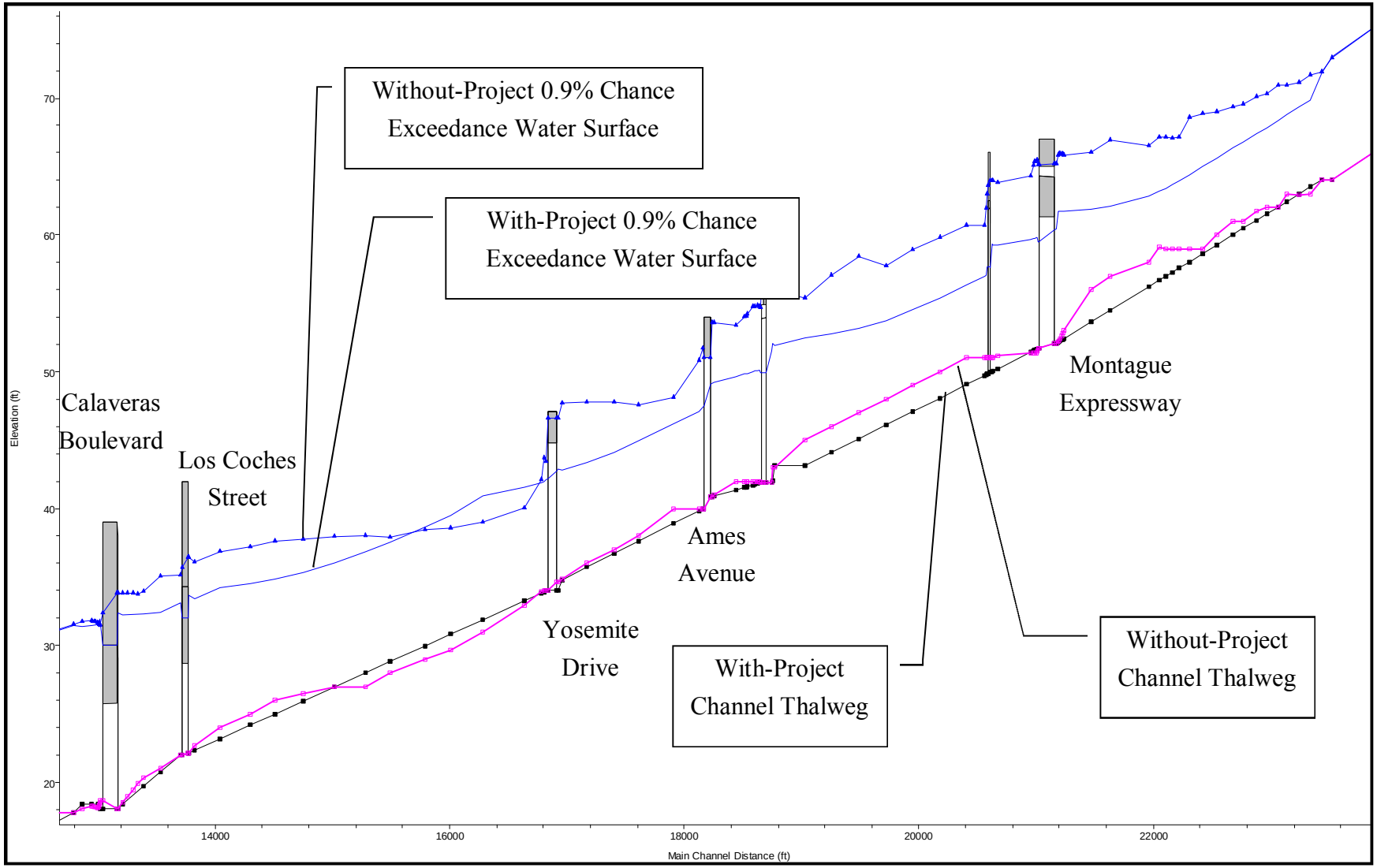

Figure 4-5 Water Surface Profile D/S of I-680, Without-Project vs. Alt. 3B

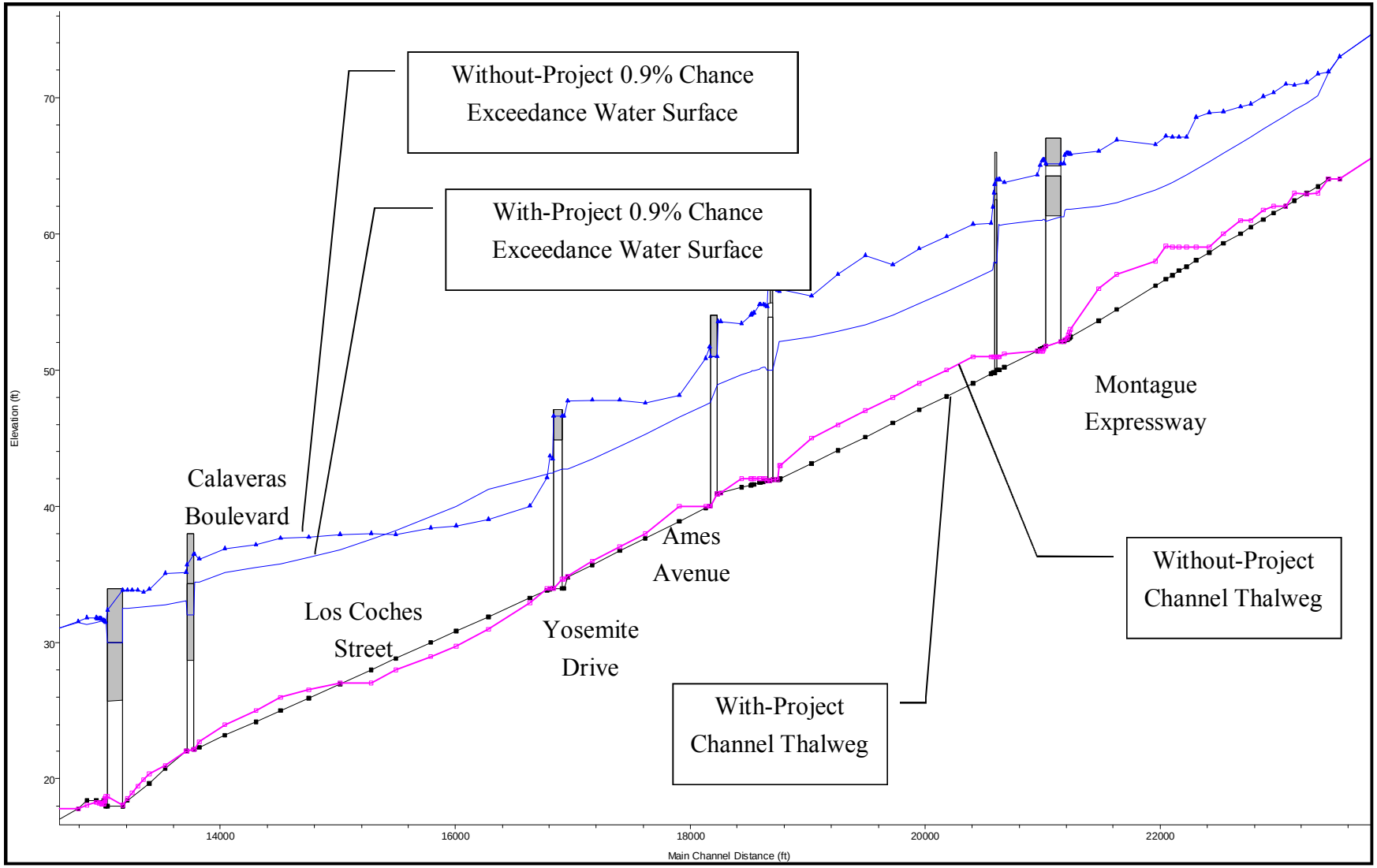

Figure 4-6 Water Surface Profile D/S of I-680, Without-Project vs. Alt. 4B

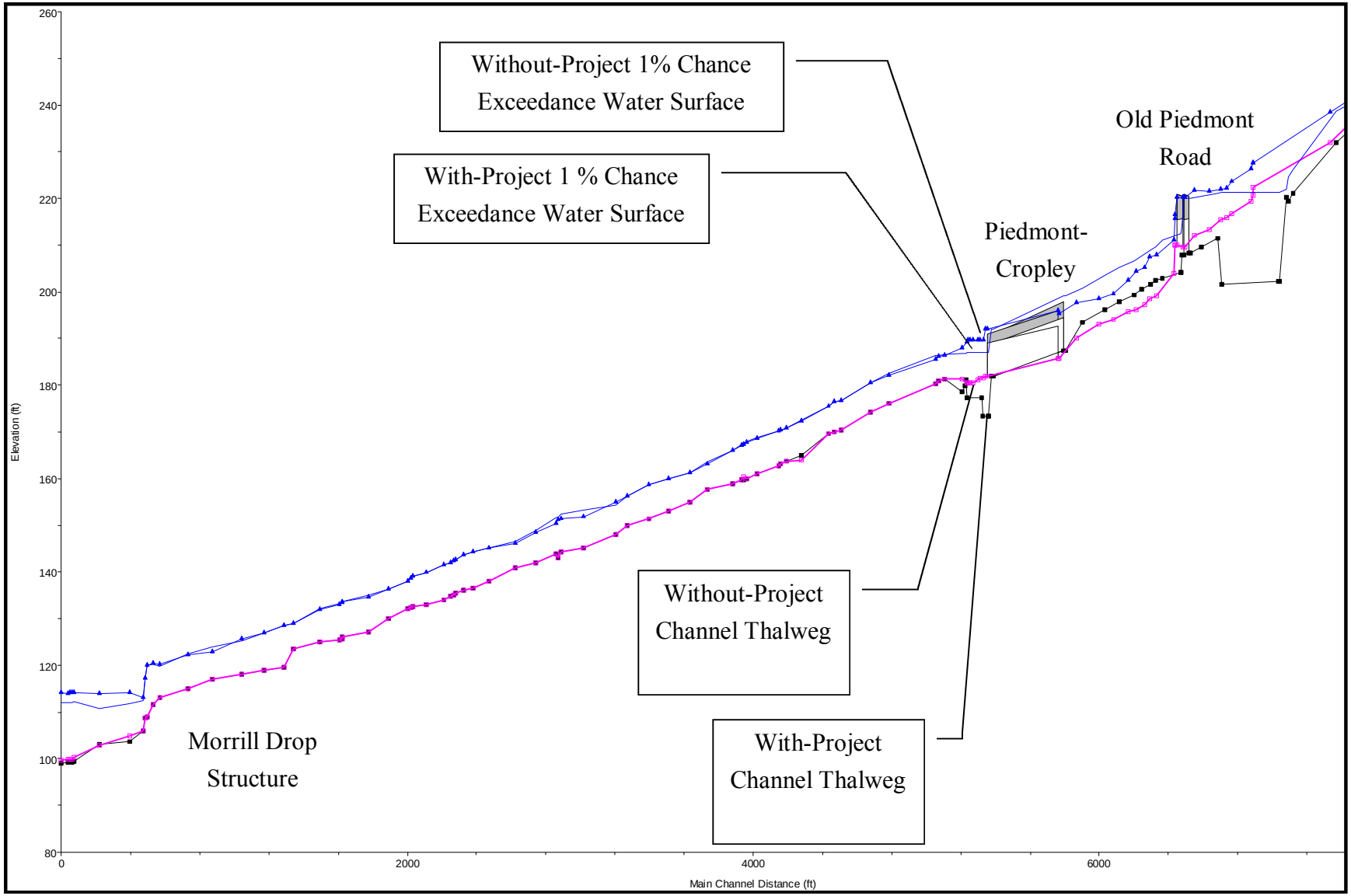

Figure 4-7 Water Surface Profile U/S of I-680, Without-Project vs. Alt. 5

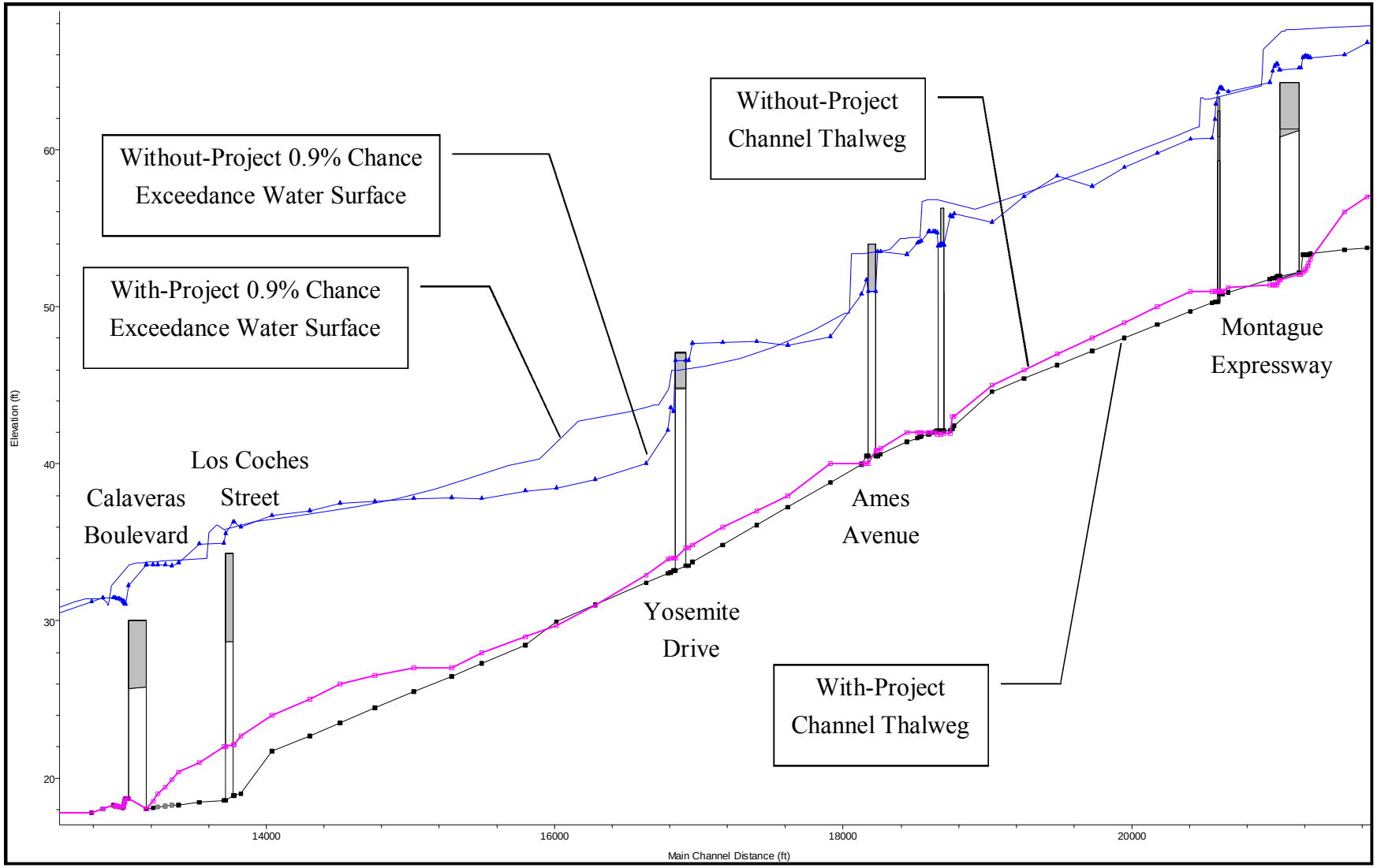

Figure 4-8 Water Surface Profile D/S of I-680, Without-Project vs. Alt. 5

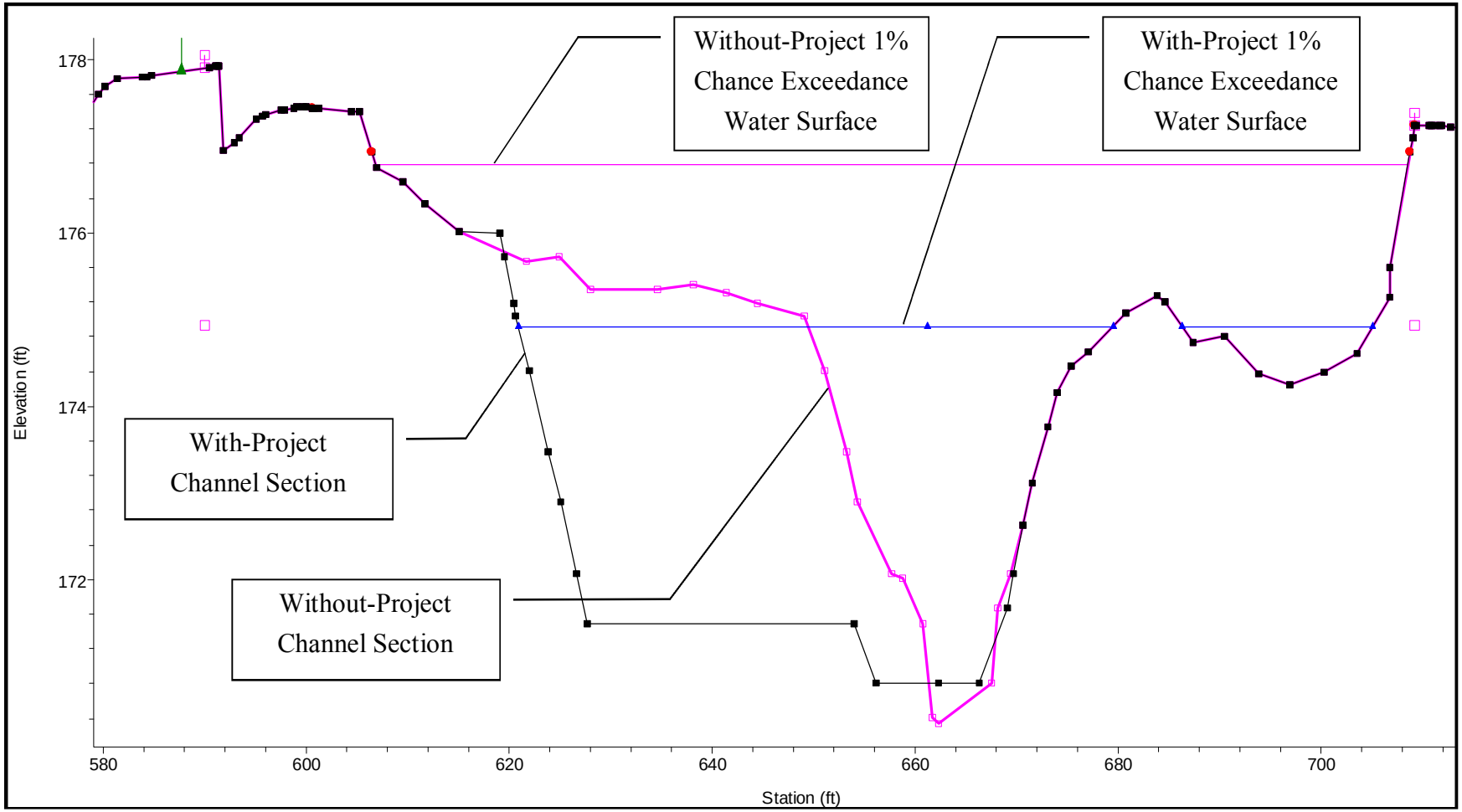

Figure 4-9 Typical U/S section, with- and without-project conditions for Alt 2A

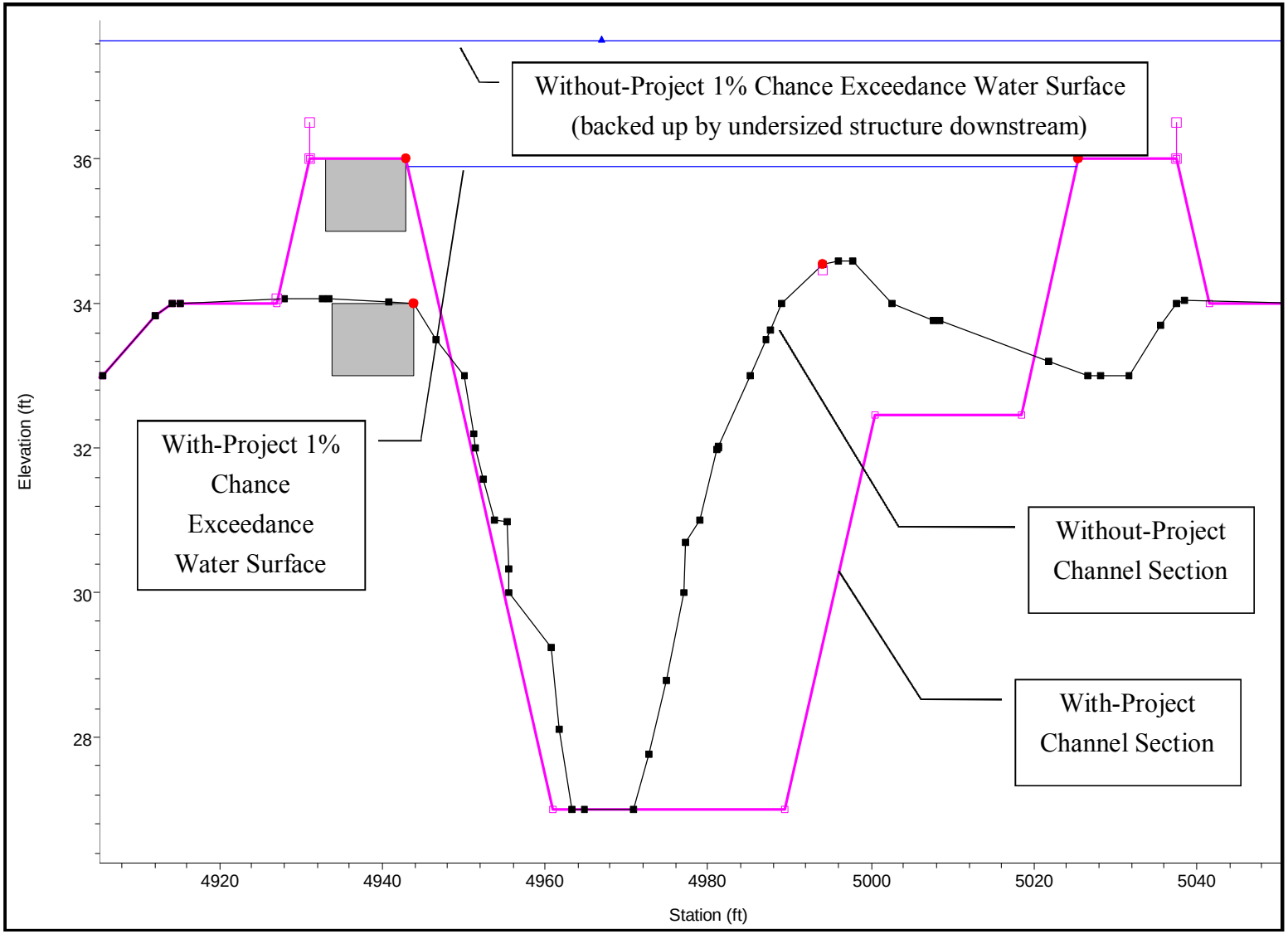

Figure 4-10 Typical D/S section, with- and without-project geometry for Alt. 2A

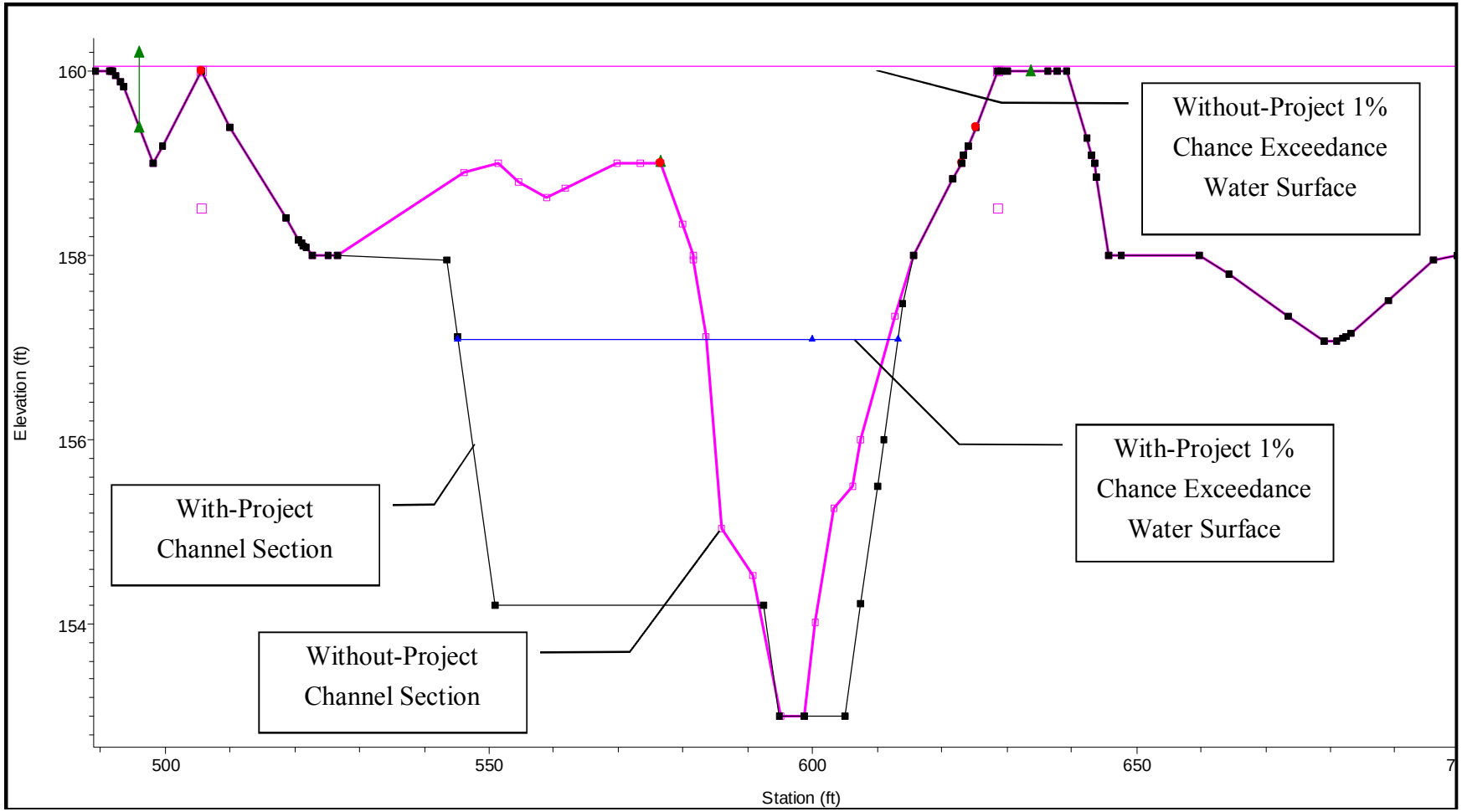

Figure 4-11 Typical U/S section, with- and without-project geometry for B Alternatives

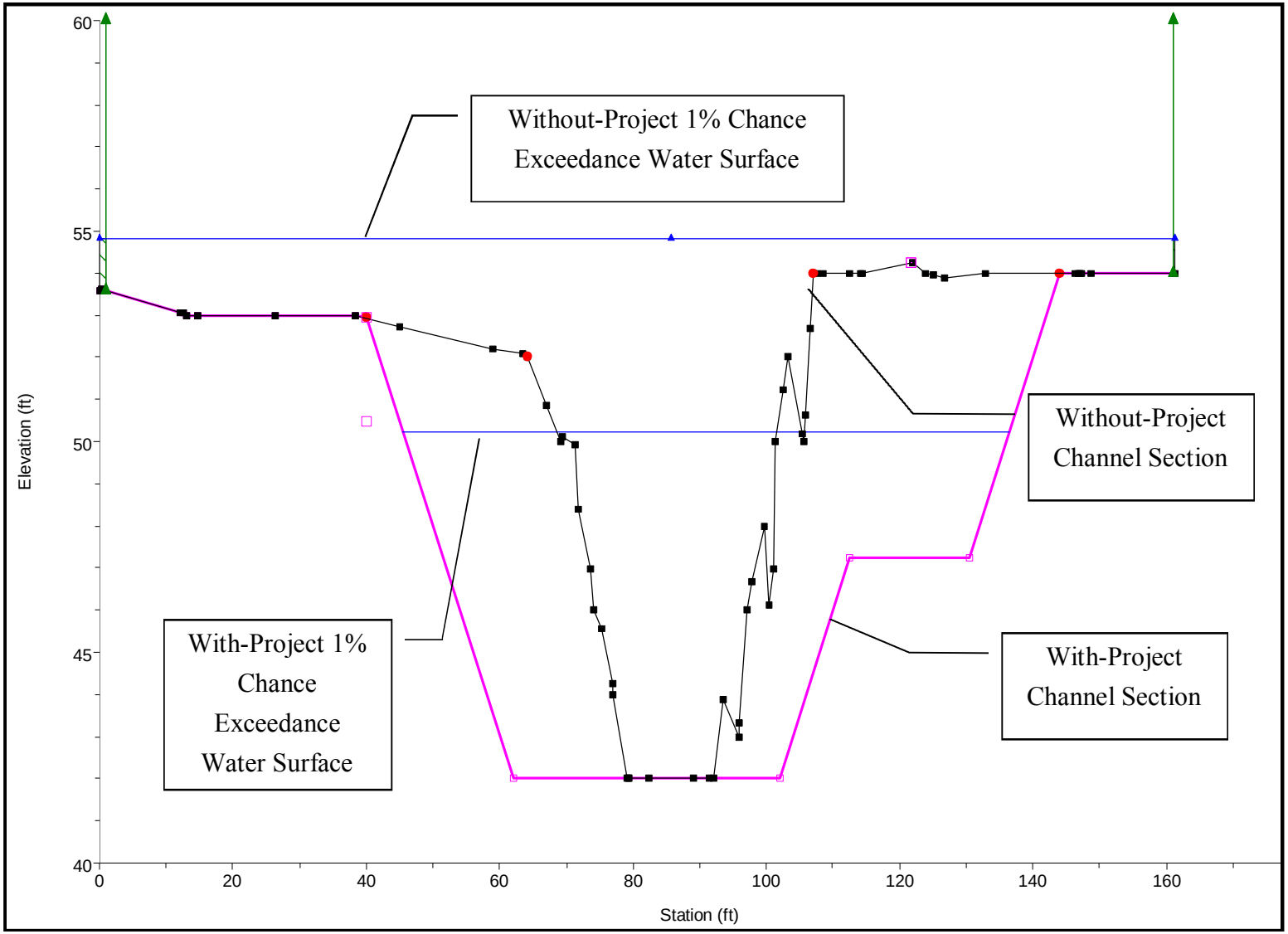

Figure 4-12 Typical D/S section, with- and without project geometry for Alt. 2B

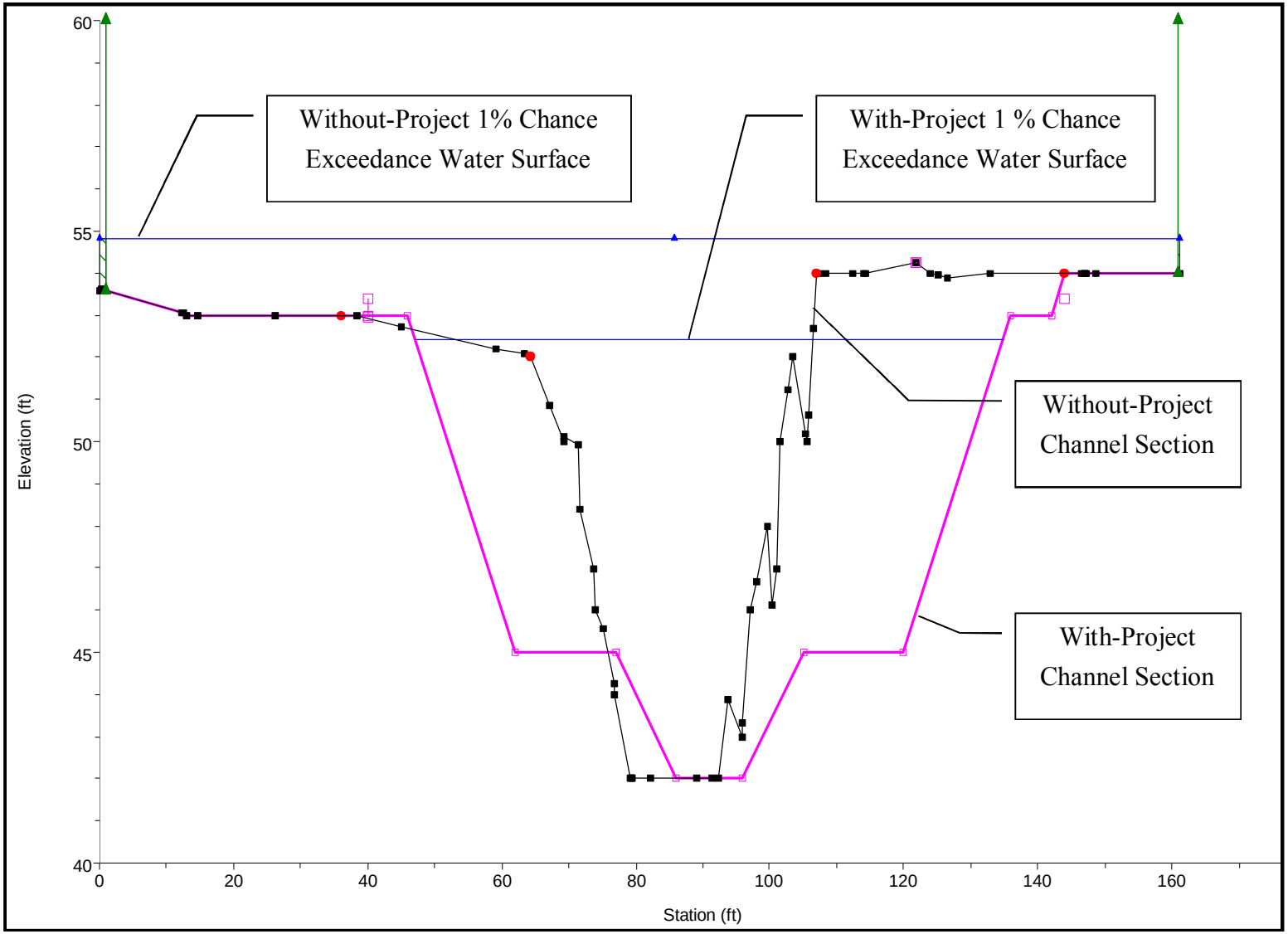

Figure 4-13 Typical D/S section, with- and without-project geometry for Alt. 3B

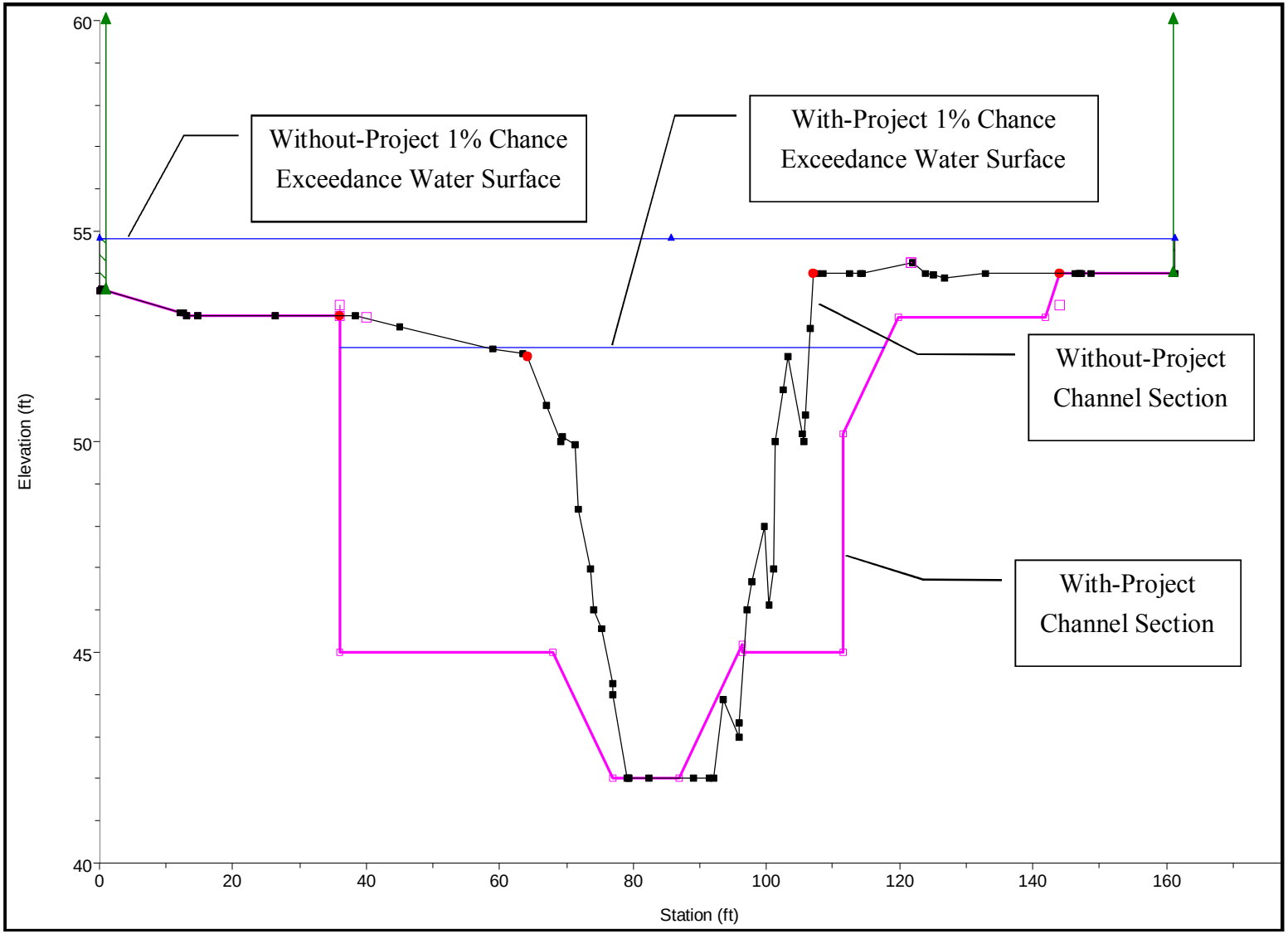

Figure 4-14 Typical D/S section, with- and without-project geometry for Alt. 4B

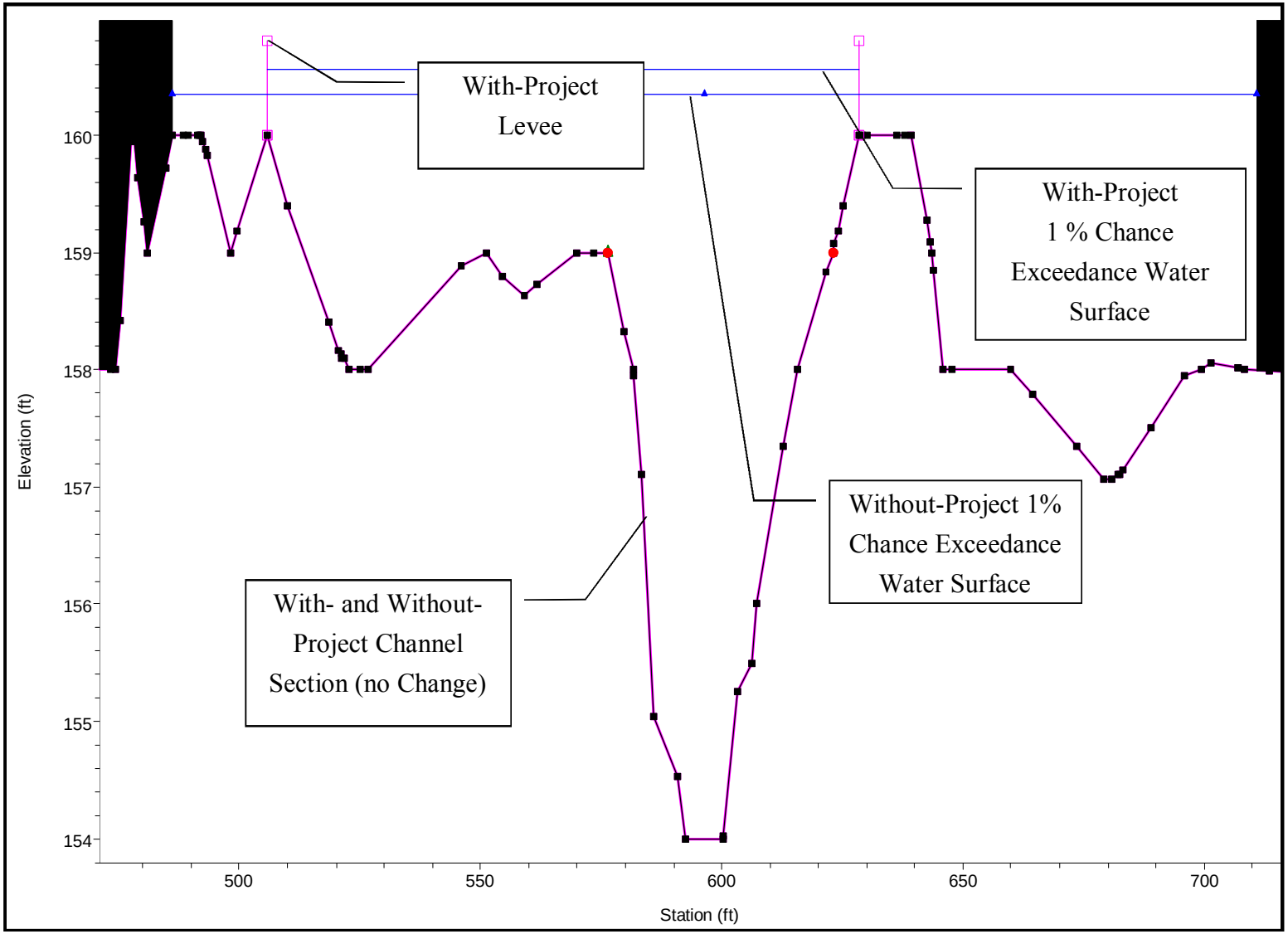

Figure 4-15 Typical U/S section, with- and without-project conditions for Alternative 5

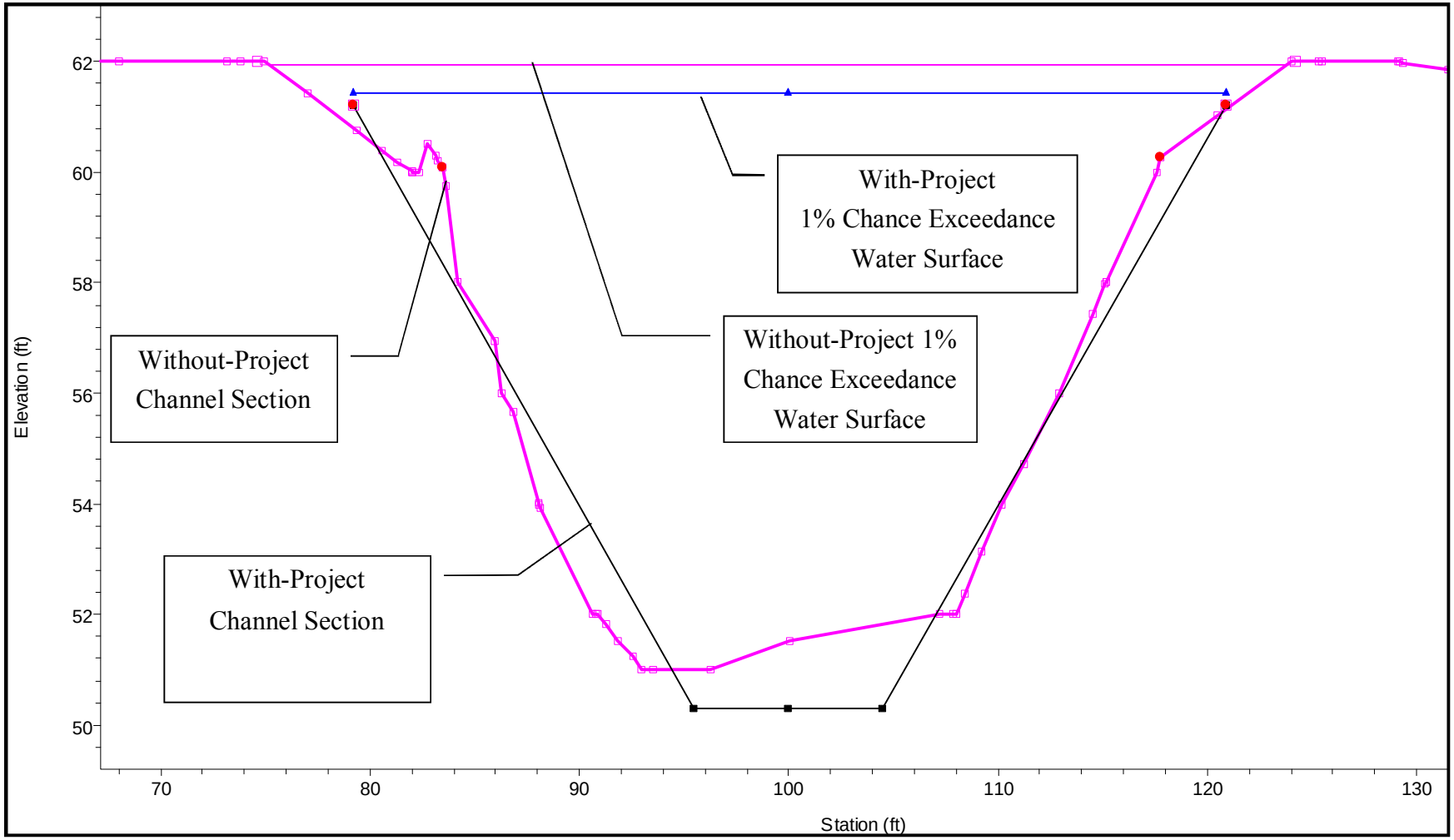

Figure 4-16 Typical D/S section, with- and without-project conditions for Alternative 5

Table 4-10 Summary of 1% Chance Exceedance Water Surface Elevations by Alternatives

Sta	Baseline		Alt 2A		Alt 2B		Alt 3B		Alt 4B		Alt 5	
	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth
	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft
36242	10.2	3.2	9.8	3.3	10.2	3.2	10.2	3.2	10.2	3.2	10.2	3.2
36126	9.7	4.7	8.7	2.4	9.7	4.7	9.7	4.7	9.7	4.7	9.7	4.7
36032	9.1	4.1	9.1	4.1	9.1	4.1	9.1	4.1	9.1	4.1	9.5	5.2
35589	8.4	3.6	8.4	3.6	8.4	3.6	8.4	3.6	8.4	3.6	10.8	3.6
35586	7.1	4.3	7.1	4.3	7.1	4.3	7.1	4.3	7.1	4.3	11.0	3.8
35476	10.4	3.4	10.4	3.4	10.4	3.4	10.4	3.4	10.4	3.4	7.2	1.6
35448	6.9	4.9	6.8	5.0	6.9	4.9	6.9	4.9	6.9	4.9	0.7	14.0
35418	10.7	4.3	10.8	4.2	10.7	4.3	10.7	4.3	10.7	4.3	0.7	14.4
35350	9.0	4.4	10.1	4.0	9.0	4.4	9.0	4.4	9.0	4.4	0.6	16.6
35285	7.2	6.5	8.9	5.7	7.2	6.5	7.2	6.5	7.2	6.5	1.5	7.2
35249	2.9	5.4	3.4	4.9	2.9	5.4	2.9	5.4	2.9	5.4	6.3	11.2
35191	8.7	2.0	7.1	9.8	8.7	2.0	8.7	2.0	8.7	2.0	8.1	11.9
Old Piedmont												
35139	14.8	6.8	12.2	5.7	14.8	6.8	14.8	6.8	14.8	6.8	13.8	5.9
35134	12.1	4.5	12.1	4.5	12.1	4.5	12.1	4.5	12.1	4.5	8.6	8.7
35132	14.1	6.1	13.6	5.8	14.1	6.1	14.1	6.1	14.1	6.1	8.6	8.7
35029	8.3	5.7	11.7	4.3	8.3	5.7	8.3	5.7	8.3	5.7	10.3	5.0
34989	8.6	6.3	8.0	5.8	8.6	6.3	8.6	6.3	8.6	6.3	12.0	4.5
34959	13.2	5.4	9.3	4.1	13.2	5.4	13.2	5.4	13.2	5.4	12.0	4.5
34909	9.6	5.9	9.9	5.3	9.6	5.9	9.6	5.9	9.6	5.9	12.0	4.5
34863	13.0	5.3	11.2	5.5	13.0	5.3	13.0	5.3	13.0	5.3	12.0	4.5
34779	12.0	4.5	10.0	4.9	12.0	4.5	12.0	4.5	12.0	4.5	12.1	4.5
34694	8.6	4.3	11.0	5.8	8.6	4.3	8.6	4.3	8.6	4.3	12.1	4.5
34566	7.2	4.0	6.1	6.6	7.2	4.0	7.2	4.0	7.2	4.0	12.1	4.5
34467	14.0	9.1	5.7	9.7	14.0	9.1	14.0	9.1	14.0	9.1	10.3	12.5
Piedmont-Cropley												
34041	7.5	3.5	12.1	4.5	7.5	3.5	7.5	3.5	7.5	3.5	7.5	3.5
34032	4.7	6.7	10.8	3.6	4.7	6.7	4.7	6.7	4.7	6.7	4.0	12.1
34010	2.6	7.6	2.9	8.0	2.6	7.6	2.6	7.6	2.6	7.6	2.8	8.4
33997	2.7	7.3	3.3	7.0	2.7	7.3	2.7	7.3	2.7	7.3	2.8	8.4
33966	2.8	7.3	3.9	6.3	2.8	7.3	2.8	7.3	2.8	7.3	3.1	7.1
33952	2.8	7.1	3.8	7.5	2.8	7.1	2.8	7.1	2.8	7.1	3.0	7.0
33942	3.8	5.2	6.1	5.9	3.8	5.2	3.8	5.2	3.8	5.2	4.3	4.9
33933	5.7	3.5	6.3	6.0	5.7	3.5	5.7	3.5	5.7	3.5	3.4	6.0
33904	9.0	2.5	7.2	5.6	9.0	2.5	9.0	2.5	9.0	2.5	4.6	7.2
33804	6.0	2.6	3.5	4.2	6.0	2.6	6.0	2.6	6.0	2.6	5.0	3.0
33773	5.0	3.3	7.4	2.3	5.0	3.3	5.0	3.3	5.0	3.3	5.0	3.7
33756	7.2	2.8	6.8	2.5	7.2	2.8	7.2	2.8	7.2	2.8	4.3	3.7
33485	6.3	2.6	6.8	3.1	6.3	2.6	6.3	2.6	6.3	2.6	10.5	3.4
33378	7.6	3.0	7.6	3.0	7.6	3.0	7.6	3.0	7.6	3.0	8.5	3.1
33207	6.4	2.4	8.0	2.4	6.4	2.4	6.4	2.4	6.4	2.4	6.4	2.4
33166	5.2	2.5	8.3	2.8	5.2	2.5	5.2	2.5	5.2	2.5	5.2	2.5
33136	7.8	1.9	9.5	2.8	7.8	1.9	7.8	1.9	7.8	1.9	7.9	1.9
32976	5.8	2.3	5.3	4.5	5.8	2.3	5.8	2.3	5.8	2.3	5.6	2.4
32889	6.4	2.1	5.6	4.3	6.4	2.1	6.4	2.1	6.4	2.1	8.8	3.6
32877	6.2	2.2	9.0	2.5	6.2	2.2	6.2	2.2	6.2	2.2	7.1	2.9
32753	9.3	2.7	7.2	3.4	9.3	2.7	9.3	2.7	9.3	2.7	6.2	3.5

Sta	Baseline		Alt 2A		Alt 2B		Alt 3B		Alt 4B		Alt 5	
	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth
	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft
32721	4.7	4.7	6.0	3.6	4.7	4.7	4.7	4.7	4.7	4.7	8.6	4.4
32659	9.0	3.9	5.2	4.6	9.0	3.9	9.0	3.9	9.0	3.9	8.4	4.1
32645	5.6	3.4	10.0	3.1	5.6	3.4	5.6	3.4	5.6	3.4	8.6	4.0
32631	5.7	3.3	7.4	3.3	5.7	3.3	5.7	3.3	5.7	3.3	8.6	4.1
32580	5.5	3.7	6.5	3.6	5.5	3.7	5.5	3.7	5.5	3.7	8.4	3.8
32436	4.9	2.6	8.2	2.4	4.9	2.6	4.9	2.6	4.9	2.6	8.6	3.1
32333	7.1	4.0	8.1	3.2	7.1	4.0	7.1	4.0	7.1	4.0	9.1	4.5
32208	5.3	3.9	8.4	2.9	5.3	3.9	5.3	3.9	5.3	3.9	7.3	3.9
32097	7.0	3.0	5.2	3.2	7.0	3.0	7.0	3.0	7.0	3.0	7.0	3.0
31969	7.7	2.3	9.3	2.7	7.7	2.3	7.7	2.3	7.7	2.3	7.7	2.3
31905	5.9	3.0	9.5	2.8	5.9	3.0	5.9	3.0	5.9	3.0	8.3	2.5
31716	8.3	3.7	5.7	3.8	8.3	3.7	8.3	3.7	8.3	3.7	5.2	4.7
31587	1.0	3.9	9.6	2.9	1.0	3.9	1.0	3.9	1.0	3.9	6.7	4.9
31571	5.7	4.0	5.8	4.0	5.7	4.0	5.7	4.0	5.7	4.0	9.0	4.8
31559	9.2	3.4	6.0	3.9	9.2	3.4	9.2	3.4	9.2	3.4	8.9	4.7
31440	6.2	2.7	6.0	3.0	6.2	2.7	6.2	2.7	6.2	2.7	6.3	3.1
31322	6.8	1.4	6.8	2.6	6.8	1.4	6.8	1.4	6.8	1.4	7.6	1.9
31168	3.0	2.9	8.5	2.7	3.0	2.9	3.0	2.9	3.0	2.9	3.7	3.0
31078	5.2	2.2	5.6	4.2	5.2	2.2	5.2	2.2	5.2	2.2	5.9	2.5
31026	5.4	2.7	5.3	3.9	5.4	2.7	5.4	2.7	5.4	2.7	5.4	2.7
30978	7.9	2.7	10.3	3.3	7.9	2.7	7.9	2.7	7.9	2.7	8.0	2.7
30965	7.1	2.8	7.2	2.9	7.1	2.8	7.1	2.8	7.1	2.8	7.1	2.9
30952	8.3	3.2	7.1	3.3	8.3	3.2	8.3	3.2	8.3	3.2	8.3	3.3
30910	7.2	4.8	7.4	3.2	7.2	4.8	7.2	4.8	7.2	4.8	7.2	4.8
30808	8.4	2.6	6.1	3.3	8.4	2.6	8.4	2.6	8.4	2.6	8.4	2.6
30731	6.2	3.1	6.8	3.1	6.2	3.1	6.2	3.1	6.2	3.1	6.2	3.1
30720	7.3	2.5	6.8	2.9	7.3	2.5	7.3	2.5	7.3	2.5	7.3	2.5
30701	8.2	2.3	7.2	2.9	8.2	2.3	8.2	2.3	8.2	2.3	8.2	2.3
30590	5.2	4.4	8.4	2.2	5.2	4.4	5.2	4.4	5.2	4.4	5.2	4.4
30478	8.3	2.7	5.3	3.9	8.3	2.7	8.3	2.7	8.3	2.7	7.1	2.4
30327	4.9	3.1	6.8	3.8	4.9	3.1	4.9	3.1	4.9	3.1	5.5	3.1
30324	6.0	2.8	5.0	4.1	6.0	2.8	6.0	2.8	6.0	2.8	5.7	3.0
30304	6.3	2.6	6.0	3.5	6.3	2.6	6.3	2.6	6.3	2.6	5.9	2.8
30195	5.2	2.5	9.2	2.6	5.2	2.5	5.2	2.5	5.2	2.5	5.7	2.6
30043	8.2	2.1	7.2	3.3	8.2	2.1	8.2	2.1	8.2	2.1	8.2	2.1
29983	5.1	3.2	6.8	3.4	5.1	3.2	5.1	3.2	5.1	3.2	5.1	3.2
29873	9.4	4.5	6.5	4.2	9.4	4.5	9.4	4.5	9.4	4.5	9.4	4.5
29744	7.0	4.2	5.4	3.1	7.0	4.2	7.0	4.2	7.0	4.2	8.0	3.9
29571	9.1	3.2	7.3	2.8	9.1	3.2	9.1	3.2	9.1	3.2	6.1	4.2
29433	6.2	3.6	5.2	3.7	6.2	3.6	6.2	3.6	6.2	3.6	9.5	3.9
29267	5.9	5.4	7.5	3.9	5.9	5.4	5.9	5.4	5.9	5.4	8.3	5.0
29231	3.9	6.3	3.9	7.1	3.9	6.3	3.9	6.3	3.9	6.3	4.6	6.2
29215	5.1	7.3	6.0	6.7	5.1	7.3	5.1	7.3	5.1	7.3	5.2	7.2
29199	14.1	6.1	14.1	6.2	14.1	6.1	14.1	6.1	14.1	6.1	14.1	6.1
29171	14.0	6.6	14.4	6.5	14.4	6.5	14.4	6.5	14.4	6.5	14.4	6.5
29093	8.5	5.4	10.1	5.1	9.5	5.3	10.1	5.1	9.5	5.3	11.6	5.1
28917	8.3	5.6	11.8	5.0	9.6	5.3	11.9	5.0	9.6	5.3	12.6	4.9
28770	5.6	5.9	8.3	4.7	6.4	5.2	8.2	4.7	6.4	5.2	3.6	13.0

Sta	Baseline		Alt 2A		Alt 2B		Alt 3B		Alt 4B		Alt 5	
	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth
	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft
28758	4.7	7.3	5.8	5.9	5.1	6.7	5.8	5.9	5.1	6.7	4.3	13.0
28749	5.1	5.7	8.5	4.3	5.8	5.0	7.5	3.9	5.8	5.0	4.3	13.0
28738	6.4	6.9	11.6	4.3	7.3	6.1	11.6	4.3	7.3	6.1	4.3	13.1
28699	4.0	4.7	9.4	2.8	4.9	3.8	9.4	2.8	4.9	3.8	4.2	13.3
28656	6.7	5.1	7.5	7.3	9.9	9.3	9.9	9.3	9.9	9.3	6.7	5.1
Morrill												
28528	13.3	5.5	11.6	7.1	13.3	5.5	13.3	5.5	13.3	5.5	13.3	5.5
28447	5.9	6.2	6.8	5.7	6.1	6.1	6.1	6.0	6.1	6.0	7.3	6.7
28307	6.1	5.6	7.9	4.8	6.5	5.4	6.6	5.4	6.6	5.4	7.0	6.8
28171	6.0	7.4	8.0	5.2	6.5	7.0	6.6	6.9	6.6	6.9	6.8	7.0
28025	4.3	6.7	6.4	3.8	4.6	6.3	4.7	6.2	4.7	6.2	6.5	7.1
27895	3.0	9.7	4.9	5.4	4.0	9.3	3.3	9.3	3.3	9.3	6.2	7.3
27705	4.1	9.6	5.8	6.4	4.4	9.3	4.5	9.2	4.5	9.2	6.0	7.6
27689	4.1	9.6	5.9	5.8	4.4	9.3	4.5	9.2	4.5	9.2	5.9	7.6
27675	4.1	9.7	5.7	6.4	4.4	9.3	4.5	9.2	4.5	9.2	5.9	7.6
27658	3.7	7.6	5.2	5.7	3.9	7.3	4.0	7.2	4.0	7.2	5.9	7.6
27642	6.0	6.9	7.9	11.6	10.9	4.8	11.4	10.1	11.4	10.1	7.7	11.3
Cropley												
27499	14.5	8.0	9.7	9.4	14.5	8.0	14.5	8.0	14.5	8.0	14.5	8.0
27481	9.3	6.3	9.4	6.3	9.4	6.3	9.3	6.3	9.3	6.3	9.4	6.3
27459	13.0	5.3	13.0	5.3	13.0	5.3	13.0	5.3	13.0	5.3	13.0	5.3
27380	12.7	5.0	12.7	5.0	12.7	5.0	12.7	5.0	12.7	5.0	12.7	5.0
27108	12.0	4.5	12.0	4.5	12.0	4.5	12.0	4.5	12.0	4.5	12.0	4.5
26889	13.3	5.5	13.3	5.5	13.3	5.5	13.3	5.5	13.3	5.5	13.3	5.5
26695	12.4	5.7	12.4	5.7	12.4	5.7	12.4	5.7	12.4	5.7	12.4	5.7
26577	12.2	4.6	12.2	4.6	12.2	4.6	12.2	4.6	12.2	4.6	12.2	4.6
26419	13.2	5.4	13.2	5.4	13.2	5.4	13.2	5.4	13.2	5.4	13.1	5.4
26288	13.0	5.3	13.0	5.3	13.0	5.3	13.0	5.3	13.0	5.3	13.0	5.3
26123	13.0	5.2	13.0	5.2	13.0	5.2	13.0	5.2	13.0	5.2	13.0	5.2
25955	13.4	5.6	13.4	5.6	13.4	5.6	13.4	5.6	13.4	5.6	13.4	5.6
25798	12.8	5.2	12.8	5.2	12.8	5.2	12.8	5.2	12.8	5.2	12.8	5.2
25744	12.9	5.2	12.9	5.2	12.9	5.2	12.9	5.2	12.9	5.2	12.9	5.2
25719	6.8	6.4	6.8	6.4	6.8	6.4	6.8	6.4	6.8	6.4	8.6	6.2
25705	6.0	6.4	6.0	6.4	6.0	6.4	6.0	6.4	6.0	6.4	7.5	6.2
25688	5.2	7.0	5.2	7.0	5.2	7.0	5.2	7.0	5.2	7.0	6.5	6.3
I-680												
25296	5.4	5.5	5.4	5.5	5.4	5.5	5.4	5.5	5.4	5.5	5.9	5.2
25245	6.2	6.6	6.3	6.6	6.3	6.6	6.3	6.6	6.2	6.6	6.9	6.0
25155	6.4	5.1	6.4	5.1	6.4	5.1	6.4	5.1	6.4	5.1	7.4	5.2
24997	7.5	5.3	7.5	5.3	7.5	5.3	7.5	5.3	7.5	5.3	8.4	6.1
24886	7.3	5.6	7.3	5.6	7.3	5.6	7.3	5.6	7.3	5.6	8.7	6.0
24791	7.1	5.2	7.1	5.2	7.1	5.2	7.1	5.2	7.1	5.2	9.2	5.8
24694	8.2	4.6	8.3	4.6	8.3	4.6	8.3	4.6	8.3	4.6	11.4	5.1
24171	9.2	5.6	9.1	5.7	9.2	5.7	9.2	5.7	9.2	5.7	8.7	5.9
24079	10.7	5.0	10.8	5.0	10.8	5.0	10.8	5.0	10.8	5.0	8.6	5.9
23986	8.9	5.3	10.7	3.6	10.5	3.4	8.6	4.3	7.3	4.4	8.6	5.9
23889	7.8	4.7	10.2	3.3	10.2	3.2	8.6	4.3	7.3	4.4	8.5	5.9
23786	6.3	4.4	8.3	3.5	8.5	3.4	8.6	4.3	7.2	4.4	8.4	6.0

Sta	Baseline		Alt 2A		Alt 2B		Alt 3B		Alt 4B		Alt 5	
	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth
	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft
23710	4.8	5.0	6.9	3.7	8.4	3.4	8.6	4.3	7.2	4.4	8.3	6.1
23610	7.1	5.0	6.2	4.0	8.4	3.4	8.6	4.3	7.2	4.4	8.1	6.2
23522	6.3	5.7	5.8	4.3	8.2	3.5	8.6	4.3	7.2	4.4	7.9	6.3
23413	7.2	5.0	5.6	4.4	7.9	3.6	8.6	4.3	7.2	4.4	7.7	6.5
23326	6.5	4.8	5.3	4.6	7.5	3.7	8.6	4.3	7.2	4.4	7.5	6.7
23185	5.4	4.8	5.2	4.4	6.7	4.1	8.6	4.3	7.2	4.5	7.1	7.1
23062	4.6	6.0	4.4	5.4	5.9	4.5	8.6	4.3	7.2	4.5	4.8	8.6
22951	5.5	5.6	4.6	5.2	5.3	4.9	8.5	4.3	7.1	4.5	4.1	10.1
22865	10.5	4.9	4.6	5.1	4.9	5.2	8.5	4.4	7.1	4.5	4.1	10.0
22806	9.4	4.7	4.6	5.1	4.7	5.4	8.4	4.4	7.0	4.6	4.1	10.1
22748	9.0	4.5	4.6	5.2	8.3	4.2	8.3	4.4	7.0	4.6	4.1	10.1
22693	8.5	5.1	4.6	5.2	8.1	4.3	8.2	4.5	6.9	4.7	4.1	10.2
22603	9.9	5.6	4.7	5.5	7.6	4.5	8.0	4.6	6.7	4.8	4.0	10.4
22274	3.1	7.5	2.8	7.2	5.7	5.5	6.4	5.6	5.7	5.7	3.9	10.5
22117	7.6	6.8	3.2	7.4	5.0	6.0	5.7	6.3	5.2	6.2	3.9	10.6
21883	5.3	7.2	3.0	7.9	4.2	6.8	4.7	7.3	4.5	7.2	3.9	10.7
21873	4.9	7.5	3.0	8.0	4.1	6.8	4.7	7.4	4.4	7.3	3.9	10.7
21864	4.3	7.5	2.9	8.1	4.1	6.8	4.7	7.4	4.4	7.3	3.9	10.8
21852	3.6	4.7	2.8	8.2	4.1	6.9	4.6	7.5	4.4	7.4	3.9	10.8
21844	3.7	4.8	2.8	8.3	4.1	6.9	4.6	7.5	4.3	7.4	3.9	10.8
21832	4.4	4.7	2.8	8.4	4.0	7.0	4.6	7.6	4.3	7.4	3.9	10.8
21821	7.3	4.8	6.8	12.6	3.7	8.7	9.2	6.5	6.6	7.2	4.4	11.8
Montague Expressway												
21800	7.9	7.2	7.1	12.1	4.9	8.3	10.1	6.0	6.8	7.2	5.5	9.4
21657	4.3	8.8	4.8	7.2	8.4	6.3	7.3	6.1	5.6	7.2	8.5	7.7
21646	4.2	8.0	4.9	7.0	8.4	6.3	7.2	6.2	5.6	7.2	8.5	7.7
21634	4.7	7.0	5.8	6.6	8.4	6.3	7.2	6.2	5.5	7.2	8.4	7.7
21623	6.6	6.7	5.8	6.7	8.4	6.3	7.2	6.2	5.5	7.3	8.4	7.7
21601	9.4	7.3	5.8	6.6	8.3	6.4	7.1	6.2	5.5	7.3	8.4	7.7
21314	7.9	8.5	5.8	6.5	7.4	6.9	6.2	7.1	4.8	8.3	8.2	7.9
21276	6.1	8.6	5.6	6.6	7.3	7.0	6.0	7.2	4.8	8.4	8.2	7.9
21270	5.7	8.6	4.8	8.1	4.5	9.2	5.2	7.2	4.0	9.9	8.2	7.9
UPRR Trestle												
21226	6.9	7.7	6.2	6.6	4.8	8.9	6.5	6.3	5.4	7.4	9.8	6.9
21219	9.7	8.4	9.8	5.9	9.9	5.8	8.6	5.3	7.4	5.4	9.8	6.9
21203	12.3	6.4	12.8	5.1	9.9	5.8	8.6	5.3	7.4	5.4	9.8	6.9
21050	9.8	6.6	9.8	5.5	9.9	5.8	8.6	5.3	7.4	5.4	9.8	6.9
20823	9.7	7.7	9.8	5.5	9.9	5.8	8.6	5.3	7.3	5.5	9.7	6.9
20595	9.4	7.8	9.7	5.6	9.8	5.9	8.4	5.4	7.2	5.6	9.7	7.0
20368	10.5	7.0	12.5	4.8	9.7	5.9	8.0	5.6	7.0	5.7	9.6	7.0
20131	4.4	8.2	7.5	5.5	12.8	5.1	7.4	6.0	6.6	6.1	9.5	7.1
19901	8.9	6.8	6.7	6.0	6.6	5.3	6.7	6.6	6.2	6.5	9.3	7.2
19676	11.0	6.6	5.9	6.5	5.7	5.9	6.0	7.3	5.7	7.1	9.1	7.4
19413	5.2	6.9	4.5	7.7	4.9	6.6	6.5	6.8	5.1	7.9	3.7	12.1
19400	5.9	7.4	4.5	7.7	4.9	6.6	5.3	8.0	5.0	7.9	3.6	12.3
19390	5.5	13.9	7.1	10.8	7.6	9.2	7.4	9.6	7.3	9.6	3.6	12.4
UPRR Triple Box												
19296	5.8	12.7	10.5	7.1	10.4	6.8	8.7	8.0	8.7	8.1	4.5	10.0

Sta	Baseline		Alt 2A		Alt 2B		Alt 3B		Alt 4B		Alt 5	
	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth
	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft	fps	ft
19285	4.9	7.7	6.8	5.8	7.3	4.8	7.3	6.1	6.5	6.2	4.4	10.0
19268	4.0	7.1	6.6	5.7	7.3	4.8	7.1	6.2	6.5	6.2	4.4	10.1
19244	4.2	8.3	7.1	5.7	7.3	4.8	7.1	6.3	6.5	6.2	4.4	10.2
19234	4.2	8.3	7.2	5.7	7.3	4.8	7.1	6.3	6.5	6.2	4.4	10.2
19184	7.0	6.8	7.4	5.6	7.3	4.8	7.1	6.3	6.5	6.1	4.3	10.3
19172	7.4	6.3	7.5	5.6	7.3	4.8	7.1	6.3	6.5	6.1	4.3	10.4
19158	7.6	8.0	7.5	5.5	7.3	4.8	7.1	6.3	6.5	6.1	4.3	10.4
19083	8.9	4.9	8.0	5.3	7.3	4.8	7.1	6.3	6.6	6.1	7.7	8.8
18904	5.7	8.0	7.0	5.8	7.4	4.7	7.1	6.3	6.8	5.9	7.2	9.4
18881	5.0	6.6	6.9	5.8	6.5	5.0	6.7	5.3	6.8	5.9	7.2	9.5
Ames Ave												
18805	7.9	5.8	6.6	5.5	6.3	4.8	7.9	4.7	7.4	5.4	12.0	6.0
18774	10.5	6.9	6.8	5.5	8.9	3.8	8.7	5.2	7.4	5.4	11.0	6.3
18553	10.5	5.1	10.5	3.9	8.9	3.8	8.6	5.3	7.4	5.4	10.8	6.5
18259	6.8	4.9	9.0	4.4	8.8	3.8	8.5	5.3	7.4	5.4	10.2	6.9
18045	2.9	7.1	8.8	4.5	8.8	3.9	8.4	5.4	7.3	5.5	9.5	7.4
17811	2.0	8.6	9.5	4.2	8.5	4.0	8.0	5.6	7.2	5.6	8.6	8.1
17602	2.9	8.3	9.5	4.2	7.7	4.3	7.4	6.0	7.0	5.7	7.8	8.9
17571	7.7	9.9	7.9	5.0	7.0	5.5	6.1	6.1	6.1	6.5	6.9	9.5
Yosemite Dr												
17470	8.6	5.9	9.1	4.5	7.6	5.3	7.5	5.4	6.8	6.3	9.0	7.7
17448	6.5	5.5	8.4	3.7	7.6	4.1	7.8	6.1	6.8	6.3	9.0	7.8
17427	11.5	5.7	8.3	3.7	7.5	4.1	7.8	6.1	6.7	6.3	8.9	7.8
17281	9.1	3.4	7.0	4.3	7.3	4.2	7.5	6.3	6.6	6.5	8.6	8.0
16924	5.4	5.0	5.3	5.4	6.1	4.9	6.6	7.1	5.9	7.2	7.9	8.8
16654	5.1	6.3	6.3	5.9	8.8	4.6	9.4	6.7	8.2	7.0	12.4	7.5
16437	4.3	6.4	5.7	6.3	8.8	4.6	9.4	6.7	8.1	7.1	10.4	8.4
16139	6.3	6.9	6.9	6.1	8.6	4.7	9.3	6.8	7.9	7.2	10.1	8.6
15928	3.1	7.2	3.8	6.7	8.4	4.8	9.2	6.8	7.8	7.4	9.8	8.9
15665	3.0	8.1	6.6	6.8	7.8	5.1	8.9	7.0	7.5	7.7	9.4	9.3
15398	3.9	7.1	5.6	7.0	7.0	5.6	8.4	7.4	7.1	8.1	8.9	9.8
15156	3.9	8.2	4.5	8.1	6.1	6.3	7.8	7.8	6.7	8.6	8.4	10.4
14944	6.0	7.5	4.4	8.7	5.5	7.0	7.3	8.3	6.3	9.1	8.0	10.9
14685	6.1	8.3	3.7	9.4	4.8	7.9	6.6	9.0	5.8	9.8	7.5	11.7
14467	7.9	7.5	4.7	9.6	5.8	8.5	8.4	9.1	7.4	10.0	8.5	13.2
14422	3.8	11.1	3.8	11.2	5.9	7.6	5.1	8.7	7.2	10.1	5.5	14.2
Los Coches St.												
14350	4.4	9.4	5.2	7.5	6.1	7.4	5.4	8.3	8.3	8.8	6.3	12.3
14179	4.2	7.7	5.0	8.9	5.2	8.5	7.9	9.7	7.4	9.9	6.3	12.3
14121	8.6	7.0	4.9	9.1	4.6	9.5	7.0	10.6	6.8	10.8	6.3	12.3
13937	7.4	11.5	4.0	10.6	4.0	10.8	6.1	11.8	6.2	11.9	6.2	12.4
13887	7.0	12.3	3.8	10.9	4.3	11.5	4.1	11.9	6.0	12.2	7.0	12.3
Calaveras Blvd												
13741	7.8	9.1	6.9	6.7	4.4	10.8	4.2	11.1	6.4	11.4	7.9	9.1
13724	6.2	11.6	6.9	6.7	3.4	11.2	6.6	11.2	6.7	11.0	6.5	11.1
13661	3.8	8.4	6.8	6.0	3.4	11.4	6.6	11.1	6.7	10.9	3.9	9.1
13585	3.4	9.5	6.2	6.2	3.3	11.6	6.7	11.0	6.8	10.8	3.8	8.4
13509	4.6	10.8	5.5	6.7	4.6	10.9	4.7	10.8	4.6	10.8	3.4	9.5

CHAPTER 5: FINAL ARRAY OF PROJECT ALTERNATIVES

The final array of project alternatives were analyzed using the revised GRR HEC-RAS unsteady model, described in Section 2.2. Four alternatives were simulated using the revised GRR methodology models. Project features including the hydraulic structure capacities and top of bank/levee elevations for Alternatives 2B and 4 from the preliminary array of alternatives were revised to meet the requirements for FEMA certification using risk and uncertainty principles per Engineering Circular 1110-2-6067, *Certification of Levee Systems for the National Flood Insurance Program* (USACE 2008a) and were based on future improvements by the SCVWD upstream of I-680 constructed on the Berryessa Creek. Alternative 2A was revised to pass the 1% chance exceedance event using the revised GRR unsteady HEC-RAS modeling. No changes were made on project features for Alternative 5. The Berryessa Creek reach upstream of I-680 was removed from each alternative and the hydrologic inputs were developed to allow for unsteady runs to be made. The resulting alternatives are designated as 2A/d, 2B/d, and 4/d to indicate that they only include project features for Berryessa Creek downstream of I-680.

Alternatives 2B/d and 4/d were divided into five sub reaches with representative index cross section assigned to each reach. The Corps HEC-FDA program version 1.2.5a was used to determine the conditional non-exceedance probability (CNP). The hydraulic and hydrologic data developed for the GRR were used as inputs, along with the top of levee elevations to determine the CNP for each reach. Each reach was analyzed to determine if a minimum CNP of 90% for the 1% chance exceedance event (discharge based on future improvements by the SCVWD upstream of I-680) was achieved for entrenched channels. Based on the CNP results the alternatives were refined as needed and the process repeated until the desired minimum CNP of 90% was reached or exceeded (USACE 2008a).

5.1 Alternative descriptions

The alternatives evaluated include the No-action alternative and four project alternatives. Following is a list of features included with each alternative:

Alternative 1 (No Action) Without-project condition, assuming routine maintenance.

Alternative 2A/d (Incised Trapezoidal Channel). The alternative was designed assuming no project upstream of I-680, locally or federally developed, is in place. The primary characteristics of the alternative are as follows:

- Earthen trapezoidal section with varying bottom width and 2H:1V side slopes with a moderate level of containment
- Access road intermittently along top of bank or within channel at approximate level of 4% chance exceedance event
- Cellular bank stabilization with riprap toe protection throughout
- Levees with 2H:1V side slopes and 12’ top width in limited areas, with floodwalls on levees as required

- Montague Expressway, Ames Avenue, Yosemite Avenue, Los Coches Avenue, and Calaveras Boulevard bridges to be modified
- UPRR trestle bridge to be replaced

Alternative 2B/d (Incised Trapezoidal Channel). The alternative was designed assuming a bypass structure, to be developed and constructed along Berryessa Creek upstream of I-680 separately by the SCVWD as a locally funded project, is in place. The bypass will route high flows around the Greenbelt reach reducing flooding in the upper Berryessa watershed. The primary characteristics of the alternative are as follows:

- Earthen trapezoidal section with varying bottom width and 2H:1V side slopes with a FEMA-certifiable level of containment
- Access road intermittently along top of bank or within channel at approximate level of the 10 to 4% chance exceedance event with varying designed level of the maintenance road to suit local maintenance needs
- Cellular bank stabilization with riprap toe protection throughout
- Levees as required with 2H:1V side slopes and 12' top width
- Concrete floodwalls on levees where required
- Montague Expressway, UPRR trestle, Los Coches Avenue, and Calaveras Boulevard bridges to be replaced
- UPRR triple box culvert to be replaced
- Ames Avenue and Yosemite Avenue bridges to be modified.

Alternative 4/d (Walled Trapezoidal Channel). The alternative was designed assuming a bypass structure, to be developed and constructed along Berryessa Creek upstream of I-680 separately by the SCVWD as a locally funded project, is in place. The bypass will route high flows around the Greenbelt reach reducing flooding in the upper Berryessa watershed. The primary characteristics of the alternative are as follows:

- 10' bottom width earthen low-flow channel with 3H:1V side slopes, 3' deep with a FEMA-certifiable level of containment
- Two vegetated floodplain benches, 32' wide on the left bank, and 10' wide on the right bank
- Vertical concrete retaining walls bounding the benches
- Access road location varies along the top of one or both banks or within channel
- Floodwall extensions as required to contain flows
- Montague Expressway, UPRR timber bridge, Los Coches Avenue, and Calaveras Boulevard bridges to be replaced
- UPRR triple box culvert replaced
- Ames Avenue and Yosemite Avenue bridges to be modified

Alternative 5 (Authorized Plan). Alternative 5 is a single-purpose flood risk management project that includes mitigation of adverse effects as authorized by Congress in 1990 as the Berryessa Creek Project. Alternative 5 begins 600 feet upstream of the Old Piedmont Road

and extends to 50 feet downstream of Calaveras Boulevard Bridge. The primary characteristics of the alternative are as follows:

- 500- by 160-foot reinforced-concrete-walled sedimentation basin at upstream end of the Authorized Project transitioning into a new box culvert under Old Piedmont Road
- Trapezoidal concrete-lined channel would be constructed with a bottom width of 8 feet and 2:1 (H:V) bank slopes from Old Piedmont Road to Piedmont Road/Cropley Avenue with service road along the east bank maintained, and with the riparian vegetation along the west bank retained as much as possible.
- Existing 400-foot-long box culvert under the Piedmont Road/Cropley Avenue intersection would be retained
- Existing debris basin downstream of Cropley Avenue would be enlarged and lined with concrete walls to function as a secondary sedimentation basin.
- Existing channel throughout the greenbelt area would be retained as much as possible and the existing levees would be raised to contain the design flood
- Transition area at the downstream end of the greenbelt (approximately 600 feet upstream of Morrill Avenue) leading into trapezoidal concrete-lined channel
- Trapezoidal Concrete channel from transition area until joining the existing concrete-lined channel downstream of Cropley Avenue
- Trapezoidal concrete-lined channel from end of existing concrete-lined channel at I-680 to Calaveras Boulevard
- Rock transition below Calaveras Boulevard to transition flows from the concrete channel into the existing earth-bottomed channel

Bridge and culvert modification and replacement scenarios are generally consistent between Alternatives 2B/d and 4/d. The alternatives differ only in the configuration of the channel reaches between the structures. Alternative 5 is based on the Authorized Project as authorized by Congress in 1990. Plan views and typical sections showing the overall configuration of Alternatives 2A/d, 2B/d and 4/d are presented in *Appendix B, Part IV: Design and Cost of Alternatives*.

5.2 Model Input

5.2.1 Discharge

The Revised Berryessa Creek HEC-RAS model requires hydrographs representing various inflows to the Berryessa Creek Channel. The inflow hydrographs to Berryessa Creek downstream of the I-680 culvert consists of local subarea runoff and tributary creeks. The upstream inflow hydrograph to the HEC-RAS model is the outflow from the I-680 culvert. The outflow used to size Alternative 2A/d was the same hydrograph developed from the Upper Berryessa Creek FLO-2D model for the without-project conditions runs as described in Section 2.2. Alternative 2B/d and 4/d were sized assuming bypass system is constructed by the local sponsor upstream of I-680. The inflow hydrograph at I-680 was therefore developed using a different methodology than for the without-project conditions using the I-680 culvert outflow hydrograph developed from the SCVWD Bypass HEC-HMS model (SCVWD 2011a, 2011b). Economic benefits for Alternatives 2B/d and 4/d were then derived using the

without-project conditions as described in Section 2.2. A separate Upper Berryessa Creek FLO-2D model was created for Alternative 5 to model the portions of the alternative in the Upper Berryessa Reach (upstream of I-680). The Alternative 5 Upper Berryessa FLO-2D model is documented in *Appendix B, Part II: Without-Project Floodplain Development.*

5.2.2 Local and Tributary Inflow Hydrographs

The final array of alternatives includes two sets of local and tributary inflow conditions. Alternatives 2A/d and 5 were run assuming no future improvements are implemented on the Berryessa Creek system upstream of I-680. Alternatives 2B/d and 4/d were designed assuming that future improvements planned by the SCVWD are constructed in the Berryessa Creek system upstream of I-680. In order to compare the economic benefits of Alternatives 2B/d and 4/d on a consistent basis with remaining alternatives, economic benefits for Alternatives 2B/d and 4/d were developed assuming no future improvements are implemented on the Berryessa Creek system upstream of I-680.

5.2.2.1 Future Without Improvements Alternatives 2A/d, 2B/d, 4/d, and 5

Hydrologic inputs were developed for Alternatives 2A/d, 2B/d, 4/d, and 5 assuming that no future improvements planned by the SCVWD are constructed on the Berryessa Creek system upstream of I-680. The local and tributary inflow hydrographs for the future without improvements were taken from the future conditions 2003 HEC-HMS model corresponding to the values published in the NHC hydrology report (NHC 2003). The 2003 report does not include a number of future improvements planned by the SCVWD along the Berryessa Creek system. The 2003 hydrology was used to develop the Federal alternatives and to analyze the benefits of all alternatives. The 2006 NHC hydrology report (NHC 2006) reflects the future with improvements planned by the SCVWD. Since the addition of the SCVWD planned improvements would require a larger conveyance capacity and cost in the study area, the 2006 hydrology was used to develop the locally preferred alternatives and is discussed in the following section. Table 5-1 lists the peak discharges for each inflow hydrograph, HEC-RAS inflow station and HEC-HMS model nodes used to develop the inflow hydrographs. No changes were made to the hydrology for this study. The inflow hydrographs represent the flows entering the Berryessa Creek channel from I-680 downstream to just upstream of the confluence with Penitencia Creek. The unsteady HEC-RAS model allows the flows to escape the channel at the existing breakout locations covered in *Appendix B, Part II: Without-Project Floodplain Development*.

Alternative 2A/d was designed and economic benefits were derived based on the future without improvements hydrologic inputs. The economic benefits for Alternatives 2B/d and 4/d were derived based on the future without improvements hydrologic input with the alternative design based on the future with improvement hydrologic inputs as described in the following section.

Table 5-1 Discharges and Inflow Locations for Future Without Improvements

RAS Sta.	HMS Node	Description	Peak Discharge by Percent Chance Exceedance Event (cfs)							
			50%	20%	10%	4%	2%	1%	0.5%	0.2%
218+32	B13 RM 3.73	Subarea B12	269	382	461	692	811	928	1,073	1,227
174+48	B15 RM 2.96	Subarea B14	96	149	176	245	275	317	361	414
166+54	B17 RM 2.76	Piedmont Creek	244	387	450	715	821	858	900	900
144+67	B17a RM 2.58	Los Coches Creek	264	429	559	833	868	928	911	951
141+21	B19 RM 2.43	Calaveras Blvd Overflow	0	0	0	0	197	400	400	400
123+74	B21 RM 2.21	Tularcitos Creek	208	332	408	595	652	660	678	685
89+53	B23 RM 1.52	Berryessa Pump	107	150	150	150	150	150	150	150
74+86	B25 RM 1.22	Wrigley-Ford Pump	251	378	432	432	432	432	432	432
59+73	B27 RM 0.94	Calera Creek	180	292	367	521	669	869	1,099	1,261
56+27	B29 RM 0.77	Abbot Pump	583	851	1,041	1,330	1,436	1,568	1,676	1,710
51+66	B31 RM 0.14	Jurgens Pump	127	150	150	150	150	150	150	150
49+62	B 33 RM 0.00	Cal Circle Pump	22	30	34	42	48	56	63	71

Source: NHC (2003)

5.2.2.2 Future With Improvements – Alternatives 2B/d and 4/d

Hydrologic inputs were developed for Alternatives 2B/d and 4/d assuming that future improvements planned by the SCVWD upstream of I-680 are constructed on the Berryessa Creek system. The local and tributary inflow hydrographs were taken from the future conditions 2006 HEC-HMS model corresponding to the values published in the NHC hydrology report (NHC 2006). Since the planned SCVWD improvements require additional conveyance capacity in the study area, Alternatives 2B/d and 4/d are locally preferred alternatives. The 2006 hydrology was used to size the alternatives and the 2003 hydrology was used to analyze the resulting benefits. Table 5-2 lists the peak discharges for each inflow hydrograph, HEC-RAS inflow station and HEC-HMS model nodes used to develop the inflow hydrographs. No changes were made to the hydrology for this study. The discharge hydrographs represent the inflows to the Berryessa Creek channel from I-680 downstream to just upstream of the Penitencia Creek confluence. The unsteady HEC-RAS model allows the flows to escape the channel at the existing breakout locations covered in *Appendix B, Part II: Without-Project Floodplain Development*.

Alternatives 2B/d and 4/d were designed based on the future with improvement hydrologic input with the economic benefits for the alternatives based on the future without improvement hydrologic inputs described in the previous section.

Table 5-2 Discharges and Inflow Locations for Future With Improvements

RAS Sta.	HMS Node	Description	Peak Discharge by Percent Chance Exceedance Event (cfs)							
			50%	20%	10%	4%	2%	1%	0.5%	0.2%
218+32	B13 RM 3.73	Subarea B12	269	382	461	692	811	928	1,073	1,227
174+48	B15 RM 2.96	Subarea B14	96	149	176	245	275	317	361	414
166+54	B17 RM 2.76	Piedmont Creek	231	373	444	718	955	1,154	1,378	1,576
144+67	B17a RM 2.58	Los Coches Creek	263	427	556	803	1,015	1,297	1,626	1,898
141+21	B19 RM 2.43	Calaveras Blvd Overflow	0	0	0	0	0	0	0	0
123+74	B21 RM 2.21	Tularcitos Creek	187	294	361	527	653	826	974	1,146
89+53	B23 RM 1.52	Berryessa Pump	107	150	150	150	150	150	150	150
74+86	B25 RM 1.22	Wrigley-Ford Pump	251	378	432	432	432	432	432	432
59+73	B27 RM 0.94	Calera Creek	180	292	367	521	669	869	1,099	1,261
56+27	B29 RM 0.77	Abbot Pump	583	851	1,041	1,330	1,436	1,568	1,676	1,710
51+66	B31 RM 0.14	Jurgens Pump	127	150	150	150	150	150	150	150
49+62	B 33 RM 0.00	Cal Circle Pump	22	30	34	42	48	56	63	71

Note: Rows highlighted in gray represent location where the 2006 HEC-HMS modeling differs from the 2003 modeling as used for the existing conditions modeling described in Section 2.1.1.1. Source: NHC 2006

5.2.3 I-680 Culvert Outflow

Three different conditions were considered upstream of I-680. For the without-project and Alternative 2A/d conditions, the inflow at I-680 assumes that no future project is in place upstream of the interstate and the existing conditions prevail. Alternatives 2B/d and 4B/d assume that a bypass system, designed and built by the SCVWD, is in place above I-680. Alternative 5 assumes that the portion of the Authorized Project above I-680 is constructed at the same time as the portion below I-680. The following sections describe the development of the I-680 inflow hydrograph for use in the final array of alternatives.

5.2.3.1 No Bypass –Alternative 2A/d, 2B/d, and 4/d

The inflow hydrograph at I-680 for the No Bypass is the same as described in Section 2.2.1. Alternative 2A/d was designed and economic benefits were derived based on I-680 outflow hydrographs with no bypass upstream of I-680. The economic benefits for Alternatives 2B/d and 4/d were derived based on I-680 outflow hydrographs with no bypass upstream of I-680 with the alternatives designed based on I-680 outflow hydrographs with an upstream bypass in-place as described in the following section.

5.2.3.2 Upstream Bypass – Alternatives 2B/d and 4/d

Alternative 2B/d and Alternative 4/d were designed with different assumptions for the Berryessa Creek channel upstream of I-680 than those developed for the existing conditions modeling. SCVWD developed hydrologic and hydraulic modeling to analyze a proposed bypass culvert for Berryessa Creek upstream of I-680. The SCVWD bypass hydrology was used only to size the locally preferred alternatives 2/d and 4/d to ensure the alternatives were sized sufficiently to convey the resulting additional flow through study area. The resulting locally preferred alternatives were then analyzed using the Corps-approved 2003 hydrology. The bypass channel would begin at the upstream end of the Piedmont/Cropley Culvert and re-enter Berryessa Creek downstream of the Cropley Avenue Bridge with the bypass culvert alignment running underneath Cropley Avenue.

(a) Bypass Alternative Sizing Methodology

The hydraulic modeling of the bypass culvert was conducted using the Corps existing conditions HEC-RAS model with the baseline geometry used as the basis of the hydraulic analysis. The bypass culvert was modeled as a junction loop with the inlet junction of the bypass culvert located at the upstream end of the Piedmont/Cropley Bridge and the outlet junction located at the downstream end of the Cropley Bridge.

The hydrologic modeling of the bypass culvert was conducted using HEC-HMS model originally developed by Northwest Hydraulic Consultants (NHC 2003) in 2003 and updated in 2006 (NHC 2006). The future conditions basin configurations were used as the basis of the hydrologic analysis. The bypass culvert was added as a diversion card located downstream of node “B5 – Piedmont Road”, a junction card located below node “B11 – Morrill Road”, and a connecting routing reach.

The sizing of the bypass culvert and inlet was developed based on a targeted maximum flow of 400 cfs downstream of the Sweigert Creek confluence for the 0.01 chance exceedance event. The Sweigert Creek confluence is located about 1,000 feet downstream of the Piedmont/Cropley Culvert. The peak flow at Sweigert Creek is 308 cfs for the 0.01 chance exceedance event for Berryessa Creek. This flow results in a maximum release below the Piedmont/Cropley Culvert of 90 to 100 cfs to meet the target discharge of 400 cfs downstream Sweigert Creek.

The bypass culvert was sized using the HEC-RAS and HEC-HMS bypass models. First, the HEC-RAS model was run to develop the split flow rating curve based on a bypass culvert and inlet sizing. The split flow rating curve was then entered in the HEC-HMS model diversion card and the routing reach dimensions adjusted as needed. The HEC HMS model was then run and the discharge at the Sweigert Creek confluence was checked against the target discharge. The process was repeated iteratively until the target discharge downstream of Sweigert Creek was met.

(b) Bypass Alternative Design

The bypass alternative was developed using the methodology stated in the previous section by SCVWD. The bypass alternative was based on available data as of January 10, 2011 and was developed at a feasibility level for planning purposes only. The details of the assumed bypass structure will be fully developed by SCVWD during the design phase, and the resulting bypass rating curves may change.

The bypass culvert consists of 5,730 feet of 15-foot by 6-foot box culvert at a slope of 0.017 feet per feet (ft/ft). The invert of the bypass culvert inlet would be 2.5 feet vertically above the existing Piedmont/Cropley Culvert. The existing Piedmont/Cropley Culvert inlet would be modified to a 6.5-foot by 1.6-foot culvert from the existing 12-foot by 7-foot culvert. Figure 5-1 shows a conceptual layout of the bypass structure inlet. Table 5-3 lists the inflow, diverted bypass, and downstream outflow discharges for the bypass as described by SCVWD (2011a, 2011b).

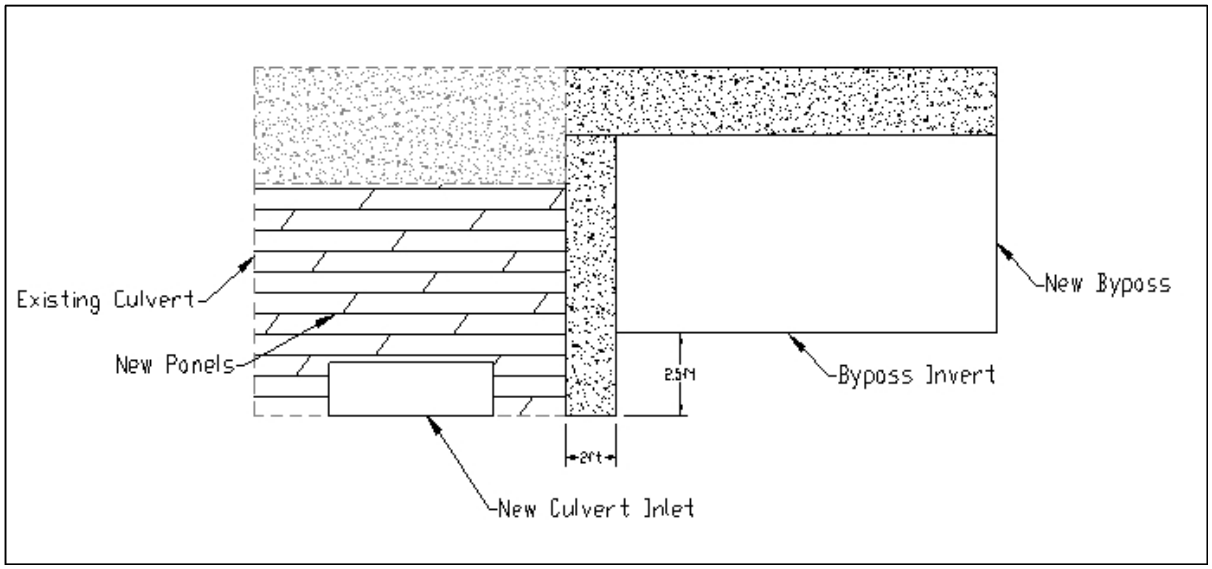

Figure 5-1 Conceptual Bypass Structure Inlet (Source: SCVWD 2011b)

Table 5-3 Inflow, Diverted, and Outflow Discharges at Bypass Structure

Percent Chance Exceedance Event	Berryessa Creek Inflow above Bypass Structure	Flow Diverted to Bypass Culvert	Berryessa Creek Outflow below Bypass Structure
	cfs	cfs	cfs
	0	0	0
	60	0	60
	100	17	83
50%	240	150	90
	340	245	95
20%	420	323	97
10%	560	458	102
4%	830	722	108
2%	1090	978	112
1%	1430	1310	120
0.5%	1820	1692	128
0.2%	2130	1994	136

Source: SCVWD 2011a, 2011b

(c) Bypass Alternative Results

The Berryessa Creek hydrographs at I-680 are used as the upstream input into the Lower Berryessa Creek HEC-RAS model for use in the development of the alternatives with upstream bypass in-place. The hydrographs used at I-680 were taken from node “B11 w Bypass” in the provided SCVWD Bypass HEC-HMS model (SCVWD 2011c). Table 5-4 lists the peak discharge, total volume, and time to peak for each of the flow events. Figure 5-2 shows the hydrographs at I-680 for the 50% to 0.2% chance exceedance events used. The outflow hydrographs from I-680 with the upstream bypass in-place was then used to design Alternatives 2B/d and 4/d. The economic benefits for Alternatives 2B/d and 4/d were then developed based on I-680 outflow hydrographs with no bypass upstream as described in the previous section.

Table 5-4 Peak Flow, Volume and Time to Peak for Bypass Alternative at I-680

Percent Chance Exceedance event	Peak Discharge (cfs)	Hydrograph Volume (ac-ft)	Time to Peak (hr)
50%	467	292.6	14.25
20%	719	437.9	14.25
10%	889	536.6	15.0
4%	1292	765.5	15.0
2%	1687	986.9	15.0
1%	2173	1350.8	15.0
0.5%	2742	1952.0	15.0
0.2%	3415	2387.8	14.0

Source: SCVWD 2011c

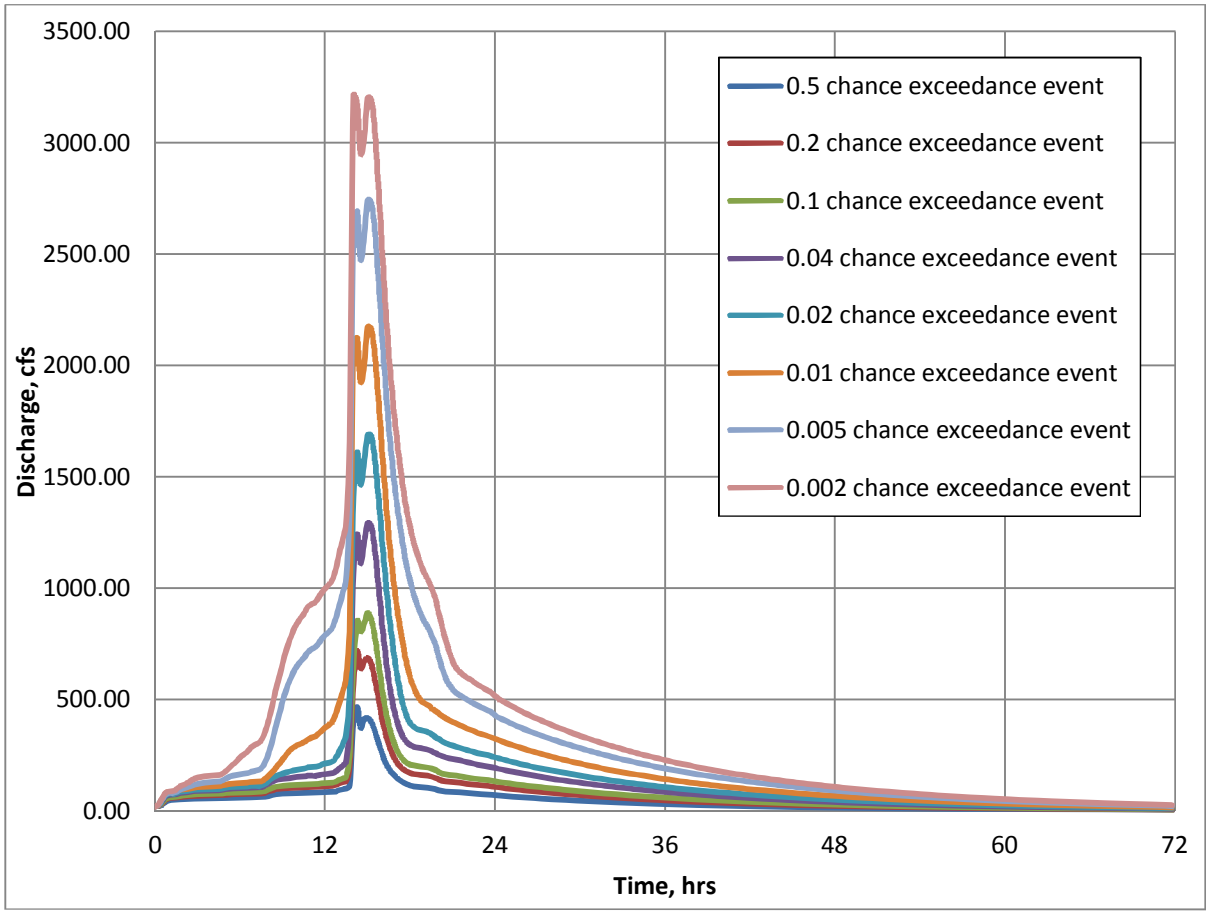

Figure 5-2 Hydrographs at I-680 for 50 to 0.2% Chance Exceedance Events (Source: SCVWD 2011c)

5.2.3.3 Authorized Project – Alternative 5

The I-680 culvert outflow hydrographs for Alternative 5 were developed from the Alternative 5 Upper Berryessa FLO-2D Model (see *Appendix B, Part II: Without-Project Floodplain Development*). Table 5-5 lists the peak discharges for each inflow hydrograph used in the Alternative 5 HEC-RAS model.

Table 5-5 Peak Flow, Volume and Time to Peak for Authorized Project at I-680

Percent Chance Exceedance event	Peak Discharge (cfs)	Hydrograph Volume (ac-ft)	Time to Peak (hr)
50%	482	433.9	14.5
20%	677	679.0	14.5
10%	849	792.6	15.5
4%	1208	941.9	15.5
2%	1526	1091.1	15.5
1%	1988	1339.5	15.5
0.5%	2310	1817.6	15.5
0.2%	2358	2128.2	15.75

5.2.4 Geometry

The geometries for the four alternatives were taken from the geometries developed for the preliminary array of alternatives as described in Chapter 4. The geometry file for each alternative was then modified to eliminate the reach and all associated cross sections above cross section 25471. This cross section represents the outlet of the I-680 culvert and is the upstream end of the revised GRR HEC-RAS model.

Project features, including the hydraulic structure capacities and top of bank/levee elevations, for Alternative 2A from the preliminary array of alternatives were revised to pass the 1% chance exceedance event. The minimum cross section considered was a cross section with a 10-foot bottom width and an in-channel maintenance road. From approximately downstream of Montague Avenue to Yosemite Avenue the minimum cross section was used resulting in a channel that is able to convey more than the 1% chance exceedance event. To reduce the channel cross section to a point where the channel would just convey the 1% chance exceedance event in this section would result in a channel section that does not fulfill the design criteria for Alternative 2A. Therefore Alternative 2A consists of three sections:

- Upstream of Montague Avenue – Designed to pass the 1% chance exceedance event
- Montague Avenue to Yosemite Avenue – Designed using the minimum channel cross section
- Downstream of Yosemite Avenue – Designed to pass the 1% chance exceedance event

A full description of the all of the alternatives in the final array of alternatives is included in *Appendix B, Part IV: Design and Cost of Alternatives*

Project features including the hydraulic structure capacities and top of bank/levee elevations for Alternatives 2B and 4 from the preliminary array of alternatives were revised to meet the requirements for FEMA Certification using risk and uncertainty principles per Engineering Circular 1110-2-6067, *Certification of Levee Systems for the National Flood Insurance Program* (USACE 2008a).

For Alternative 5 no further changes were made to the channel cross sections, bridges, or culverts downstream of station 25471.

The Berryessa Creek reach upstream of I-680 was removed from each alternative and the hydrologic inputs were developed to allow for unsteady runs to be made. The resulting alternatives are designated as 2A/d, 2B/d, and 4/d to indicate that they only include project features for Berryessa Creek downstream of I-680. Alternative 5 remains the same and includes all project elements upstream of I-680.

Alternatives 2B/d and 4/d were divided into five reaches with representative index cross section assigned to each reach. The Corps HEC-FDA program version 1.2.5a was then used to determine the CNP. The hydraulic and hydrologic data developed for the GRR were used as inputs, along with the top of levee elevations to determine the CNP for each reach. Each reach was analyzed to determine if a minimum CNP of 90% for the 1% chance exceedance event was achieved for entrenched channels. Based on the CNP results the alternatives were refined as needed and the process repeated until the desired minimum CNP of 90% was reached or exceeded (USACE 2008a). The following sections describe the development of the project performance for Alternatives 2B/d and 4/d and the results are presented in Section 5.3.6.

5.3 Project Performance

The conditional CNP for the alternatives was used to quantify the project performance for the study alternatives and ensure that each alternative met the minimum project performance criteria specified for the alternative. Each alternative was developed in order to meet a minimum CNP of 90% for the 1% chance exceedance event. The CNP is an index of the likelihood that a specified target stage will not be exceeded, given the occurrence of a hydrometeorological event (USACE 1994). The project performance was developed for this study using USACE' Flood Damage Assessment software, HEC-FDA version 1.2.5a. HEC-FDA requires the following inputs to calculate the CNP:

- Stage-Frequency, Stage-Discharge and Discharge-Probability curves to represent the Water Surface Profile
- Stage-Discharge uncertainty
- Discharge-Probability uncertainty
- Economic Input Data
- Target stage

The following sections describe the inputs into HEC-FDA and the subsequent results.

5.3.1 Water Surface Profiles

The stage-discharge and discharge probability relationships were developed for five reaches along Berryessa Creek downstream of I-680 and six reaches upstream of I-680 for the without-project conditions for each alternative[8]. Table 5-6 lists the index locations and the bounding HEC-RAS cross section stations for each index location. The stage-discharge and discharge-probability relationships for the index sections were developed using the Revised Lower HEC-RAS model as described in Chapter 2 for the reaches downstream of I-680 and from the Upper Berryessa FLO-2D model as described in *Appendix B, Part II: Without-Project Floodplain Development for the reaches upstream of I-680*. Table 5-7 lists the stage-discharge relationships for each index location for the without-project, Alternative 2A/d, and Alternative 5. The stage-discharge and discharge-probability relationships listed assumes future without improvement upstream of I-680 for the without-project, and Alternative 2A/d and for Alternative 5 assume that the upstream components of the alternative are in-place upstream of I-680. Table 5-8 lists the stage-discharge and discharge-probability relationships for Alternative 2B/d and Alternative 4/d for both future without- and with-improvements upstream of I-680. The future with-improvements upstream of I-680 (SCVWD bypass structure in-place and miscellaneous other improvements, see Section 5.2 for details) stage-discharge and discharge probability relationships were used during the design the alternatives. The future without-improvements upstream of I-680 stage-discharge and discharge probability relationships were used to determine the economic benefits of the alternatives.

[8] The hydraulic reaches discussed in this appendix refer to the hydraulic reaches specified in the scope of work to ensure hydraulic performance goals were met. The Economic Appendix discusses the results of the economic analysis on economic reaches developed independently of the hydraulic reaches, based on economic criteria. The reaches referenced in this and the economic appendix are independent and are not meant to correlate between appendices.

Table 5-6 Stage-Discharge Uncertainty Reaches

Reach	HEC-RAS Station/ FLO-2D Gird Location			Watershed Area at Index location (sq mi)
	Downstream	Index	Upstream	
US Extent to Old Piedmont Road	3106	3107	3142	4.4
Old Piedmont Road to Piedmont-Cropley	3038	3039	3075	4.9
Piedmont-Cropley to Drop Structure US of Morrill Ave.	1566	2423	2967	5.8
Drop Structure US of Morrill Ave. to Morrill Ave.	1279	1375	1471	7.7
Morrill Ave. to Cropley Ave.	890	986	1230	7.8
Cropley Ave. to I-680	43	418	840	7.9
I-680 to Montague Blvd	25575	22274	21738	8.83
Montague to UPRR Trestle	21738	21601	21247	8.93
UPRR Trestle to UPRR Triple Box	21274	20131	19333	9.02
UPRR Triple Box to Ames Ave	19333	19158	18843	9.09
Ames Ave to Calaveras Blvd	18843	16924	13803	10.52

Table 5-7 Stage-Discharge and Discharge-Probability Relationship for Lower Berryessa Creek Index locations (Without-Project, Alt 2A/d and Alt 5)

Reach	Index Grid Cell/ Cross Section	Percent Chance Exceedance Event	Without-Project Conditions		Alt 2A/d		Alt 5	
			Stage	Q	Stage	Q	Stage	Q
			ft	Cfs	ft	cfs	ft	Cfs
US Extent to Old Piedmont Road	3107[1]	50%	213.70	240	Same as Without-Project Condition		211.19	240
		20%	214.28	420			212.66	420
		10%	215.12	560			213.80	560
		4%	216.88	830			215.24	830
		2%	219.26	1090			216.70	1090
		1%	220.15	1430			218.51	1421
		0.5%	221.39	1820			219.38	1854
		0.2%	222.31	2130			223.14	2130
Old Piedmont Road to Piedmont-Cropley	3039[1]	50%	190.63	255	Same as Without-Project Condition		196.48	280
		20%	191.64	456			197.30	480
		10%	192.48	614			197.86	642
		4%	193.91	880			198.57	911
		2%	195.66	1147			199.15	1219
		1%	197.27	1468			199.16	1439
		0.5%	197.97	1721			200.87	1880
		0.2%	198.50	1924			202.17	2037
Piedmont-Cropley to Drop Structure US of Morrill Ave.	2423[1]	50%	145.40	265	Same as Without-Project Condition		142.38	260
		20%	146.09	444			146.10	443
		10%	146.34	598			146.36	594
		4%	146.70	860			146.78	854
		2%	146.89	1047			147.02	1109
		1%	146.91	1052			147.27	1433
		0.5%	146.93	1098			147.42	1635
		0.2%	146.94	1114			147.44	1664
Drop Structure US of Morrill Ave. to Morrill Ave.	1375[1]	50%	109.49	306	Same as Without-Project Condition		102.86	378
		20%	110.46	511			103.91	747
		10%	111.16	671			104.34	747
		4%	112.32	897			105.91	951
		2%	113.02	1033			107.47	1284

Reach	Index Grid Cell/ Cross Section	Percent Chance Exceedance Event	Without-Project Conditions		Alt 2A/d		Alt 5	
			Stage	Q	Stage	Q	Stage	Q
			ft	Cfs	ft	cfs	ft	Cfs
		1%	113.44	1133			110.38	1605
		0.5%	113.75	1313			112.49	1876
		0.2%	114.22	1436			112.77	1904
Morrill Ave. to Cropley Ave.	986[1]	50%	99.26	477	Same as Without-Project Condition		96.31	485
		20%	100.23	694			97.16	685
		10%	100.89	852			97.80	863
		4%	103.12	1171			98.94	1211
		2%	104.48	1427			100.79	1541
		1%	104.69	1589			102.51	1999
		0.5%	104.81	1667			104.35	2368
		0.2%	105.03	1790			104.57	2433
Cropley Ave. to I-680	418[1]	50%	87.47	474	Same as Without-Project Condition		84.86	484
		20%	88.31	690			85.60	685
		10%	88.82	845			86.08	853
		4%	89.73	1148			87.12	1220
		2%	90.46	1408			87.83	1538
		1%	90.79	1547			88.86	1996
		0.5%	90.95	1612			89.43	2323
		0.2%	91.23	1724			89.65	2360
I-680 to Montague Blvd	22274[2]	50%	61.63	483	58.20	485	57.67	479
		20%	62.59	692	59.23	695	59.28	675
		10%	63.58	923	60.11	926	60.06	755
		4%	64.50	964	61.07	995	62.06	980
		2%	64.71	1100	61.59	1079	63.12	1148
		1%	64.86	1143	64.15	1184	64.62	1393
		0.5%	65.01	1200	65.28	1425	65.32	1716
		0.2%	65.07	1207	65.48	1452	65.50	1924
Montague to UPRR Trestle	21601[2]	50%	58.58	630	55.84	629	55.76	638
		20%	59.83	962	56.98	961	56.74	947
		10%	60.76	1234	57.85	1246	57.22	1107
		4%	61.57	1442	58.80	1583	58.47	1563

Reach	Index Grid Cell/ Cross Section	Percent Chance Exceedance Event	Without-Project Conditions		Alt 2A/d		Alt 5	
			Stage	Q	Stage	Q	Stage	Q
			ft	Cfs	ft	cfs	ft	Cfs
		2%	61.93	1483	59.31	1771	59.19	1831
		1%	62.17	1505	60.06	2057	60.13	2244
		0.5%	62.38	1554	61.11	2437	60.72	2518
		0.2%	62.51	1592	61.28	2510	60.79	2567
UPRR Trestle to UPRR Triple Box	20131[2]	50%	52.04	629	49.62	629	50.10	637
		20%	53.32	960	50.74	959	50.93	947
		10%	54.14	1231	51.55	1241	51.30	1106
		4%	54.74	1441	52.42	1573	52.31	1561
		2%	54.87	1482	52.89	1763	52.87	1828
		1%	54.93	1505	53.56	2045	53.74	2238
		0.5%	55.07	1553	54.70	2409	55.11	2525
		0.2%	55.17	1589	54.88	2501	55.25	2587
UPRR Triple Box to Ames Ave	19158[2]	50%	47.79	628	46.65	627	45.77	636
		20%	49.10	959	47.86	957	46.91	946
		10%	50.01	1229	48.73	1238	47.41	1105
		4%	50.65	1440	49.64	1569	48.65	1559
		2%	50.82	1481	50.11	1761	49.30	1826
		1%	50.90	1504	50.74	2028	50.33	2231
		0.5%	51.04	1553	52.51	2406	53.24	2525
		0.2%	51.14	1589	52.63	2499	53.37	2584
Ames Ave to Calaveras Blvd	16924[2]	50%	36.80	676	35.01	676	34.14	685
		20%	37.76	923	35.94	1019	34.94	1017
		10%	37.86	1300	36.59	1306	35.32	1193
		4%	38.13	1520	37.53	1690	36.29	1686
		2%	38.21	1543	37.86	1896	36.78	1963
		1%	38.31	1601	38.20	2187	37.35	2339
		0.5%	38.33	1683	38.56	2450	37.75	2621
		0.2%	38.35	1685	38.73	2477	37.99	2819

Note: 1. FLO-2D Grid Cell
2. HEC-RAS Cross Section

Table 5-8 Stage-Discharge and Discharge-Probability Relationship for Lower Berryessa Creek Index locations or Future With and Without Improvements Upstream of I-680 (Alt 2B/d and Alt 4/d)

Reach	Index Section	Percent Chance Exceedance Event	Future No Improvements Upstream of I-680				Future With Improvements Upstream of I-680			
			Alt 2B/d		Alt 4/d		Alt 2B/d		Alt 4/d	
			Stage	Q	Stage	Q	Stage	Q	Stage	Q
			ft	cfs	ft	cfs	ft	cfs	ft	cfs
US Extent to I-680			Same as Without-Project Condition listed in Table 5-13				Hydraulic Analysis not Conducted for Locally Developed Future Upstream Improvements[1]			
I-680 to Montague Blvd	22274	50%	58.97	485	58.42	486	58.84	459	58.36	460
		20%	59.86	695	58.94	697	59.88	705	58.97	707
		10%	60.46	953	59.47	929	60.31	885	59.31	842
		4%	60.86	1143	59.98	1002	61.25	1228	60.41	1230
		2%	61.39	1394	60.36	1095	62.13	1593	61.42	1594
		1%	61.70	1542	61.00	1296	63.39	2110	63.02	2112
		0.5%	62.49	1538	61.97	1600	64.52	2660	64.52	2666
		0.2%	62.95	1607	62.55	1612	65.45	3192	66.19	3178
Montague to UPRR Trestle	21601	50%	55.76	628	55.85	628	55.87	660	55.92	658
		20%	56.89	959	56.66	959	56.97	984	56.72	984
		10%	57.72	1245	57.36	1246	57.52	1173	57.19	1175
		4%	58.57	1579	58.19	1578	59.01	1765	58.68	1761
		2%	59.02	1767	58.68	1761	60.02	2229	59.87	2230
		1%	59.65	2054	59.40	2051	61.41	2939	61.70	2935
		0.5%	60.53	2480	60.53	2477	62.60	3604	63.33	3599
		0.2%	61.01	2724	61.16	2720	63.64	3901	64.58	4135
UPRR Trestle to UPRR Triple Box	20131	50%	49.53	628	49.53	627	49.62	654	49.59	653
		20%	50.57	958	50.22	958	50.62	982	50.26	982
		10%	51.17	1243	50.74	1243	51.02	1171	50.62	1173
		4%	51.81	1577	51.31	1574	52.14	1764	51.62	1758
		2%	52.15	1766	51.62	1758	52.90	2228	52.39	2226
		1%	52.63	2052	52.10	2049	53.84	2937	53.50	2927
		0.5%	53.25	2478	52.83	2469	54.63	3602	54.69	3590
		0.2%	53.57	2722	53.14	2660	55.35	4213	55.66	4121
UPRR	19158	50%	45.80	627	46.26	625	45.88	652	46.32	649

Reach	Index Section	Percent Chance Exceedance Event	Future No Improvements Upstream of I-680				Future With Improvements Upstream of I-680			
			Alt 2B/d		Alt 4/d		Alt 2B/d		Alt 4/d	
			Stage	Q	Stage	Q	Stage	Q	Stage	Q
			ft	cfs	ft	cfs	ft	cfs	ft	cfs
Triple Box to Ames Ave		20%	46.92	957	46.97	956	46.97	980	47.02	979
		10%	47.55	1239	47.49	1239	47.42	1167	47.37	1169
		4%	48.11	1575	48.03	1569	48.39	1763	48.33	1756
		2%	48.39	1764	48.33	1755	49.00	2226	49.00	2222
		1%	48.78	2051	48.75	2047	49.83	2935	49.91	2925
		0.5%	49.31	2476	49.32	2466	50.52	3601	50.69	3589
		0.2%	49.59	2721	49.65	2716	51.72	4203	52.54	4105
Ames Ave to Calaveras Blvd	16924	50%	34.84	676	36.52	674	34.92	722	36.62	716
		20%	35.84	1019	37.37	1016	35.90	1050	37.44	1045
		10%	36.53	1311	37.97	1307	36.42	1246	37.87	1242
		4%	37.45	1695	38.91	1685	37.68	1882	39.18	1869
		2%	37.83	1902	39.36	1886	38.43	2349	40.10	2338
		1%	38.19	2203	39.83	2192	39.35	3097	41.30	3082
		0.5%	38.65	2652	40.43	2626	40.15	3778	42.38	3761
		0.2%	38.93	2937	40.80	2926	41.02	4401	43.22	4271

Note: 1. Locally Developed Future Upstream Improvements are described in Section 5.2.2

5.3.2 Stage-Discharge Uncertainty

The stage-discharge uncertainty accounts for the uncertainty associated with the factors affecting the stage-discharge relationship. These factors can include, but are not limited to, the following:

- bed forms
- water temperature
- debris or other obstructions
- unsteady flow effects
- variation in hydraulic roughness with season, sediment transport, channel scour, or deposition
- changes in channel shape during or as a result of flood events

The procedures specified in EM 1110-2-1619 Risk Based Analysis for Flood Damage Reduction Studies (USACE 1996) were used to develop the stage-discharge uncertainties. In order to develop the stage-discharge uncertainty, two items were calculated. First, the natural uncertainty was developed using the procedure listed in Section 5-4 of EM 1110-2-1619.

Second, the modeling stage-discharge uncertainty from computed water surface elevation (WSEL) profiles was developed using the procedure listed in Section 5-7 of EM 1110-2-1619. The natural and modeling uncertainties are then combined to develop the stage-discharge uncertainty for the index location. The natural stage-discharge uncertainty for ungauged streams correlates stage uncertainty to measurable stream parameters. The equation for developing the stage-discharge uncertainty for ungauged streams is stated in EM 1110-2-1619 Equation 5-5 (COE, 1996) and is as follows:

$$S_{Natural} = [0.07208+0.04936*I_{Bed} - (2.2626*10^{-7})*A_{Basin}+0.02164 * H_{Range}+ (1.4194*10^{-5}) * Q_{100}]^2$$

Where:

$S_{Natural}$ = Standard deviation of natural uncertainty for ungauged stream, meters
I_{Bed} = Stream identifier based on size of bed material based on EM 1110-2-1619 Table 5-1 (COE 1996), dimensionless
A_{Basin} = Basin area at index location, square kilometers
H_{Range} = Maximum expected stage range, in meters
Q_{100} = 1% chance exceedance discharge at index location, cubic meters per second

Each variable was determined at each index location. I_{Bed} was assigned as sands due to the potential of erosion and deposition in the earthen reaches. H_{Range} was determined to be the channel depth at each location since flows in Berryessa Creek can range from no flow to bankfull. Finally, A_{Basin} and Q_{100} were determined from the available HEC-HMS modeling data. Table 5-9 lists the resulting natural uncertainty and related inputs for each of the index locations along Lower Berryessa Creek for each alternative. The stage-discharge uncertainty equation was developed in metric units. For the purposes of the GRR, the stage-discharge uncertainty results were calculated using the metric input values with the final results converted from meters to feet and presented in the table.

Table 5-9 Natural Uncertainty for Lower Berryessa Creek Index Locations

Reach	Index Section	I_{Bed}	A_{Basin} sq mi	H_{Range} Ft	Q_{100} Cfs	$S_{Natural}$ Ft
Without-Project Conditions						
US Extent to Old Piedmont Road	3107	4	4.4	8.5	1,430	0.35
Old Piedmont Road to Piedmont-Cropley	3039	4	4.9	13.0	1,467	0.42
Piedmont-Cropley to Drop Structure US of Morrill Ave.	2423	4	5.8	8.6	969	0.35
Drop Structure US of Morrill Ave. to Morrill Ave.	1375	3	7.7	9.4	1,133	0.36
Morrill Ave. to Cropley Ave.	986	4	7.8	8.6	1,589	0.35
Cropley Ave. to I-680	418	0	7.9	9.5	1,547	0.06
I-680 to Montague Blvd	22274	4	8.8	7.1	1,143	0.33
Montague to UPRR Trestle	21601	4	8.9	11.8	1,505	0.40
UPRR Trestle to UPRR Triple Box	20131	4	9.0	12.0	1,505	0.40
UPRR Triple Box to Ames Ave	19158	4	9.1	12.3	1,505	0.40
Ames Ave to Calaveras Blvd	16924	4	10.5	9.0	1,601	0.36
Alternative 2A/d						
Alternative 2A/d Natural Uncertainty for Reaches Upstream of I-680 same as Existing Conditions						
I-680 to Montague Blvd	22274	4	8.8	10.8	1,132	0.38
Montague to UPRR Trestle	21601	4	8.9	11.0	2,057	0.39
UPRR Trestle to UPRR Triple Box	20131	4	9.0	12.0	2,044	0.40
UPRR Triple Box to Ames Ave	19158	4	9.1	11.0	2,028	0.39
Ames Ave to Calaveras Blvd	16924	4	10.5	7.0	2,187	0.33
Alterative 2B/d						
Alternative 2B/d Natural Uncertainty for Reaches Upstream of I-680 same as Existing Conditions						
I-680 to Montague Blvd	22274	4	8.8	11.3	2,110	0.39
Montague to UPRR Trestle	21601	4	8.9	12.6	2,939	0.41
UPRR Trestle to UPRR Triple Box	20131	4	9.0	12.0	2,936	0.40
UPRR Triple Box to Ames Ave	19158	4	9.1	11.0	2,935	0.39
Ames Ave to Calaveras Blvd	16924	4	10.5	8.9	3,097	0.36
Alternative 4B/d						
Alternative 4/d Natural Uncertainty for Reaches Upstream of I-680 same as Existing Conditions						
I-680 to Montague Blvd	22274	4	8.8	11.1	2,112	0.39
Montague to UPRR Trestle	21601	4	8.9	13.3	2,935	0.42
UPRR Trestle to UPRR Triple Box	20131	4	9.0	12.0	2,925	0.40
UPRR Triple Box to Ames Ave	19158	4	9.1	11.3	2,925	0.39

Reach	Index Section	I_{Bed}	A_{Basin} sq mi	H_{Range} Ft	Q_{100} Cfs	$S_{Natural}$ Ft
Ames Ave to Calaveras Blvd	16924	4	10.5	11.9	3,082	0.40
Alternative 5						
US Extent to Old Piedmont Road	3107	0	4.4	12.5	1421	0.08
Old Piedmont Road to Piedmont-Cropley	3039	0	4.9	7.9	1439	0.05
Piedmont-Cropley to Drop Structure US of Morrill Ave.	2423	4	5.8	8.2	1433	0.34
Drop Structure US of Morrill Ave. to Morrill Ave.	1375	3	7.7	10.4	1604	0.28
Morrill Ave. to Cropley Ave.	986	0	7.8	11.2	1999	0.07
Cropley Ave. to I-680	418	0	7.9	10.0	1996	0.06
I-680 to Montague Blvd	22274	0	8.8	11.4	1393	0.07
Montague to UPRR Trestle	21601	0	8.9	11.4	2244	0.07
UPRR Trestle to UPRR Triple Box	20131	0	9.0	10.9	2238	0.07
UPRR Triple Box to Ames Ave	19158	0	9.1	10	2231	0.06
Ames Ave to Calaveras Blvd	16924	0	10.5	9.4	2338	0.06

The modeling stage-discharge uncertainty was developed using without-project and alternative geometries in the Revised Lower HEC-RAS model for the Berryessa Creek reaches downstream of I-680. The without-project and Alternative 5 Upper Berryessa FLO-2D models were used to develop the modeling stage-discharge uncertainty for the reaches upstream of I-680. The modeling stage-discharge uncertainty is defined as the standard deviation ($S_{Computed}$), which is defined as one-half of the difference between the mean and the upper limit WSEL profiles for each reach. The mean models were based on the Revised Lower HEC-RAS model geometries and Upper Berryessa FLO-2D models. The upper limit models were developed by increasing the Manning's n-values by 20% and adding sediment and pier debris loading.

The sediment loading was based on the average annual volume of sediment removed by SCVWD personel from each of five maintenance zones as described in *Appendix B, Part III: Geomorphic and Sediment Transport Assessment*. The average annual sediment removal volumes were reported for three maintenance reaches downstream of I-680 and two upstream of I-680. Based on the observations of David Adams of the SCVWD, sediment removed in the maintenance reaches upstream of Calaveras Boulevard is approximately uniformly distributed within each channel reach (rather than concentrated at bridge locations). The sediment removal volume for the final maintenance reach downstream of Calaveras was observed to be approximately 90% removed between Calaveras Boulevard and North Able Street with the remaining 10% removed between North Abel Street and the Penitencia Creek confluence. Based on the SCVWD maintenance observations, the average annual sediment removal was distributed over the following five zones with approximately uniform distribution within each zone:

- Zone 1 – Piedmont Sediment Basin – 527 cy
- Zone 2 – Sierra Creek to Cropley Avenue – 525 cy
- Zone 3- I-680 to Montague Boulevard – 440 cy
- Zone 4 - Montague Boulevard to Calaveras Boulevard – 230 cy
- Zone 5a - Calaveras Boulevard to North Abel Street – 4630 cy (90% of 5136 cy)
- Zone 5b - North Abel Street to Penitencia Creek Confluence – 514 cy (10% of 5136 cy)

The sediment deposition volume for each maintenance reach was uniformly distributed using the fixed sediment elevation tool in HEC-RAS and manually adjusting the cross sections in FLO-2D. Table 5-10 lists the average annual sediment deposition volume for each maintenance zone and resulting sediment deposition depth used in the upper limit model. For the reaches upstream of I-680 with no sediment maintenance records available, the following assumptions were made for sediment deposition:

- Upstream of Old Piedmont Road to Piedmont-Cropley Culvert Without-Project - assumes 0.25 feet of uniform deposition over reach
- Upstream of Old Piedmont Road to Piedmont-Cropley Culvert Alternative 5 - assumes 0.25 feet of uniform deposition over reach with the upstream sediment basin full
- Greenbelt Reach – assumes no sediment deposition
- Cropley Avenue to I-680 – assumes same deposition as Zone 2

Floating pier debris of 3 feet wide by 3 feet tall was added to the model at the Montague Blvd and Calaveras Blvd bridge piers based on pier debris removal observations provided by David Adams of the SCVWD. The same floating debris was added to the Morrill Avenue and Cropley Avenue bridges in the FLO-2D models. For the without-project FLO-2D model, the Piedmont-Cropley culvert was assumed to be in the same condition as it exists today, with sediment deposition in the culvert reducing capacity.

Table 5-10 Upper Limit Sediment Deposition Depths

	Maintenance Zone					
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5a**	**Zone 5b**
Length (ft)	120	1194	3,800	8,230	5,900	1,790
Average Annual Sediment Deposition (cy)	527	525	440	230	4,630	514
Without-Project Conditions						
Ave. Bottom Width (ft)	32	25	10	15	76	111
Sediment Deposition Depth (ft)	0.18	0.46	0.31	0.05	0.28	0.05
Alternative 2A/d						
Ave. Bottom Width (ft)	Same as Without-Project Condition		14	12	73	111
Sediment Deposition Depth (ft)			0.13	0.06	0.29	0.07
Alternative 2B/d						
Ave. Bottom Width (ft)	Same as Without-Project Condition		24	38	73	111
Sediment Deposition Depth (ft)			0.13	0.02	0.29	0.07
Alternative 4/d						
Ave. Bottom Width (ft)	Same as Without-Project Condition		12	13	76	111
Sediment Deposition Depth (ft)			0.26	0.06	0.28	0.07
Alternative 5						
Ave. Bottom Width (ft)	32[1]	25[1]	20	15	73	111
Sediment Deposition Depth (ft)	0.18[1]	0.46[1]	0.31	0.05	0.29	0.05

Note: 1. Alternative 5 retains the existing channel configuration in Zones 1 and 2 resulting in the same sediment deposition depths.

The mean and upper limit geometries were run using the 1% chance exceedance event inflow file. The difference in the resulting WSEL profiles was then calculated for each cross section. The average difference for each reach was computed as linearly-weighted average of the cross section differences in each uncertainty reach. The modeling uncertainty standard deviation ($S_{Computed}$) was computed as one-half of the reach average difference. Table 5-11 lists the modeling stage-discharge uncertainty for each index location.

The total stage-discharge uncertainty (S_{Total}) is a combination of the natural and modeling uncertainties and is defined in EM 1110-2-1619 (COE 1996) as follows:

$$S_{Total} = (S_{Natural}^2 + S_{Computed}^2)^{0.5}$$

Where:

S_{Total} = standard deviation of the total uncertainty
$S_{Natural}$ = natural uncertainty
$S_{Computed}$ = modeling uncertainty

Table 5-11 lists the Natural, Computed, and Total stage-discharge uncertainty for each index location.

Table 5-11 Total Stage-Discharge Uncertainty for Lower Berryessa Creek Index Locations

Reach	Index Section	$S_{Natural}$ Ft	$S_{Computed}$ Ft	S_{Total} Ft	S_{Total} Adopted Ft
Without-Project Conditions					
US Extent to Old Piedmont Road	3107	0.35	0.15	0.38	0.9
Old Piedmont Road to Piedmont-Cropley	3039	0.42	0.17	0.45	0.9
Piedmont-Cropley to Drop Structure US of Morrill Ave.	2423	0.35	0.10	0.36	0.9
Drop Structure US of Morrill Ave. to Morrill Ave.	1375	0.36	0.29	0.46	0.9
Morrill Ave. to Cropley Ave.	986	0.35	0.05	0.35	0.9
Cropley Ave. to I-680	418	0.06	0.13	0.15	0.9
I-680 to Montague Blvd	22274	0.33	0.18	0.37	0.9
Montague to UPRR Trestle	21601	0.40	0.07	0.40	0.9
UPRR Trestle to UPRR Triple Box	20131	0.40	0.15	0.43	0.9
UPRR Triple Box to Ames Ave	19158	0.40	0.09	0.41	0.9
Ames Ave to Calaveras Blvd	16924	0.36	0.08	0.37	0.9
Alternative 2A/d					
Alternative 2A/d Natural Uncertainty for Reaches Upstream of I-680 same as Existing Conditions					
I-680 to Montague Blvd	22274	0.38	0.38	0.54	0.9
Montague to UPRR Trestle	21601	0.39	0.61	0.72	0.9
UPRR Trestle to UPRR Triple Box	20131	0.40	0.61	0.73	0.9
UPRR Triple Box to Ames Ave	19158	0.39	0.88	0.96	0.96
Ames Ave to Calaveras Blvd	16924	0.33	0.51	0.61	0.9
Alternative 2B/d					
Alternative 2B/d Natural Uncertainty for Reaches Upstream of I-680 same as Existing Conditions					

Reach	Index Section	$S_{Natural}$ Ft	$S_{Computed}$ Ft	S_{Total} Ft	S_{Total} Adopted Ft
I-680 to Montague Blvd	22274	0.39	0.31	0.50	0.9
Montague to UPRR Trestle	21601	0.41	0.37	0.56	0.9
UPRR Trestle to UPRR Triple Box	20131	0.40	0.34	0.53	0.9
UPRR Triple Box to Ames Ave	19158	0.39	0.30	0.49	0.9
Ames Ave to Calaveras Blvd	16924	0.36	0.31	0.48	0.9
Alternative 4/d					
Alternative 4/d Natural Uncertainty for Reaches Upstream of I-680 same as Existing Conditions					
I-680 to Montague Blvd	22274	0.39	0.28	0.48	0.9
Montague to UPRR Trestle	21601	0.42	0.05	0.42	0.9
UPRR Trestle to UPRR Triple Box	20131	0.40	0.32	0.51	0.9
UPRR Triple Box to Ames Ave	19158	0.39	0.25	0.47	0.9
Ames Ave to Calaveras Blvd	16924	0.40	0.33	0.52	0.9
Alternative 5					
US Extent to Old Piedmont Road	3107	0.08	0.21	0.22	0.9
Old Piedmont Road to Piedmont-Cropley	3039	0.05	0.14	0.15	0.9
Piedmont-Cropley to Drop Structure US of Morrill Ave.	2423	0.34	0.14	0.37	0.9
Drop Structure US of Morrill Ave. to Morrill Ave.	1375	0.28	0.05	0.28	0.9
Morrill Ave. to Cropley Ave.	986	0.07	0.21	0.23	0.9
Cropley Ave. to I-680	418	0.06	0.31	0.31	0.9
I-680 to Montague Blvd	22274	0.07	0.23	0.24	0.9
Montague to UPRR Trestle	21601	0.07	0.10	0.12	0.9
UPRR Trestle to UPRR Triple Box	20131	0.07	0.49	0.49	0.9
UPRR Triple Box to Ames Ave	19158	0.06	1.08	1.08	1.08
Ames Ave to Calaveras Blvd	16924	0.06	0.19	0.19	0.9

As seen in Table 5-11, the total stage-discharge uncertainties range from 0.36 to 1.08 feet. The minimum uncertainty in stage based on a fair Manning's n-value reliability and cross sections based on topographic mapping is 0.9 ft per Table 5-2 from EM 1110-2-1619. All but two of the calculated total stage-discharge uncertainties listed in Table 3.8 are lower than the minimum value and were deemed too low. A total stage-discharge uncertainty of 0.9 was adopted for each index location with a total stage-discharge uncertainty value below 0.9 ft. This increase in the stage-discharge uncertainty was to account for effects that are not explicitly accounted for in the calculations described in this chapter. These effects include:

changes in n-value during the event, unanticipated debris inflow, sediment transport and volume during events among a few. For the two index locations where the total stage-discharge uncertainty was above 0.9 ft the computed total stage-discharge uncertainty was deemed acceptable and used.

5.3.3 Discharge-Probability Uncertainty

The uncertainty of the discharge-probability relationship was developed using the HEC-FDA graphical approach. HEC-FDA computes the uncertainty in terms of confidences limits based on an equivalent period of record for ungauged watersheds. The equivalent period of record used for Berryessa Creek was 35 years for all index sections.

5.3.4 Economic Inputs

HEC-FDA is primarily used as a flood damage analysis tool, of which project performance is one aspect; therefore, economic inputs in the form of stage-damage curves and floodplain structure locations are required. The economic inputs are independent of the project performance results. To use the model for project performance purposes HEC-FDA requires a minimum of one hypothetical damage curve and one hypothetical structure to be entered into the model. The economic data entered into the model consisted of one data point and was used only to allow the calculation of the CNP; it did not affect the performance evaluation or represent any particular structure in the floodplain.

5.3.5 Target Stages

The top of levee ground elevations were used as the target stages for the HEC-FDA program to determine the CNP for each reach of each alternative. The higher of the bank elevation or the top of levee/floodwall elevation was used as the target stage for each section.

5.3.6 Results

The HEC-FDA model was run for Alternatives 2A/d, 2B/d, and 4B/d to determine if the project performance met the requirements for the study. Alternative 2A/d was required to achieve a minimum CNP of 50% for the 1% chance exceedance event for each of the five reaches, and Alternatives 2B/d and 4/d were required to achieve 90%. Alternative 2A/d was run using hydrologic inputs assuming no future improvements upstream of I-680. Alternatives 2B/d and 4/d were run using hydrologic inputs assuming a locally constructed bypass structure is in-place upstream of I-680

If the minimum CNP was not achieved, the alternative was refined as necessary, the inputs recomputed, and the HEC-FDA model rerun. This process was repeated until the minimum CNP requirement was met. Table 3.9 lists the 1% chance exceedance water surface elevation (WSEL), target stage elevation, and resulting CNP for the 1% chance exceedance event for Alternatives 2A/d, 2B/d, and 4/d. As seen in the Table 5-12, all reaches meet or exceed the minimum CNP of 50% for the 1% chance exceedance event required for Alternative 2A/d and 90% for Alternatives 2B/d and 4/d.

Table 5-12 Conditional Non-Exceedance Probability Results

	Reach				
	I-680 to Montague Blvd	**Montague to UPRR Trestle**	**UPRR Trestle to UPRR Triple Box**	**UPRR Triple Box to Ames Ave**	**Ames Ave to Calaveras Blvd**
Index Section	**22274**	**21601**	**20131**	**19158**	**16924**
Alternative 2A/d					
1% Chance Exceedance WSEL	64.15	60.06	53.56	50.74	38.20
Target Stage (ft)	65.27	62.43	57.11	52.55	38.88
Computed CNP for 1% event	76%	82%	99%	97%	79%
Alternative 2B/d					
1% Chance Exceedance WSEL	63.38	61.41	53.84	48.83	39.35
Target Stage (ft)	65.45	63.90	57.15	52.55	41.35
Computed CNP for 1% event	95%	99%	100%	95%	95%
Alternative 4/d					
1% Chance Exceedance WSEL	63.02	61.70	53.50	49.91	41.30
Target Stage (ft)	66.00	64.70	57.11	52.55	43.80
Computed CNP for 1% event	97%	96%	99%	96%	97%

5.4 Results

This section summarizes the hydraulic characteristics for the without-project conditions and alternatives. Further details on cross sections, quantities and costs are included in *Appendix B, Part IV: Design and Cost of Alternatives*. All project features were modeled individually to determine the associated hydraulic effects prior to combining the features into composite with-project alternative models. Summary results of the hydraulic parameters, averaged by reach[9], are presented in Table 5-13. Additional details can be found in Table 5-14 and in the accompanying HEC-RAS model.

[9] The hydraulic reaches discussed in this appendix refer to the hydraulic reaches specified in the scope of work to ensure hydraulic performance goals were met. The Economic Appendix discusses the results of the economic analysis on economic reaches developed independently of the hydraulic reaches, based on economic criteria. The reaches referenced in this and the economic appendix are independent and are not meant to correlate between appendices.

Table 5-13 Summary of Reach Average Hydraulic Results for the 1% Chance Exceedance Event

Reach from	Reach to	Without-Project		Alternative 2A/d		Alternative 5	
		Vel	Depth	Vel	Depth	Vel	Depth
		(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
US Extent	Old Piedmont Road	8.0	6.8	Same as Without-Project Condition		8.2	6.6
Old Piedmont Road	Piedmont-Cropley	10.9	7.4			15.7	7.6
Piedmont-Cropley	Drop Structure US of Morrill Ave.	6.6	6.2			6.6	6.9
Drop Structure US of Morrill Ave.	Morrill Ave.	4.9	12.1			11.3	9.6
Morrill Ave.	Cropley Ave.	5.1	9.8			8.2	9.8
Cropley Ave.	I-680	12.2	6.9			12.9	7.7
I-680	Montague Expy	6.2	4.8	6.9	5.0	10.9	5.0
Montague Expy	UPRR Trestle	6.3	5.7	6.6	5.0	9.6	4.7
UPRR Trestle	UPRR Culvert	8.2	5.3	8.1	5.5	13.7	5.0
UPRR Culvert	Ames Avenue	5.9	5.0	6.5	5.2	7.6	5.5
Ames Avenue	Yosemite Drive	7.4	4.7	9.4	4.8	14.6	4.5
Yosemite Drive	Los Coches Street	5.7	4.1	7.2	4.7	13.3	5.6
Los Coches St	Calaveras Blvd	5.4	6.5	5.2	6.9	6.4	8.6
Calaveras Blvd	Downstream Extent	5.3	4.0	5.3	5.0	6.5	5.2

Table 5-13 Summary of Reach Average Hydraulic Results for the 1% Chance Exceedance Event (cont.)

Reach from	Reach to	Alternative 2B/d without Future Upstream of I-680 Improvements		Alternative 2B/d with Future Upstream of I-680 Improvements	
		Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
US Extent	I-680	Same as Without-Project Condition		Hydraulic Analysis not Conducted for Locally Developed Future Upstream Improvements[1]	
I-680	Montague Expy	8.1	4.0	8.9	4.8
Montague Expy	UPRR Trestle	6.2	4.8	6.6	5.7
UPRR Trestle	UPRR Culvert	9.0	4.7	10.0	5.5
UPRR Culvert	Ames Avenue	7.1	3.7	8.0	4.4
Ames Avenue	Yosemite Drive	8.0	3.6	9.0	4.3
Yosemite Drive	Los Coches Street	7.7	4.2	8.5	5.1
Los Coches St	Calaveras Blvd	9.4	4.4	9.3	5.3
Calaveras Blvd	Downstream Extent	5.2	5.2	4.8	6.2

Note: 1. Locally Developed Future Upstream Improvements are described in Section 5.2.2.

Table 5-13 Summary of Reach Average Hydraulic Results for the 1% Chance Exceedance Event (cont.)

Reach from	Reach to	Alternative 4/d without Future Upstream of I-680 Improvements		Alternative 4/d with Future Upstream of I-680 Improvements	
		Vel	Depth	Vel	Depth
		(ft/s)	(ft)	(ft/s)	(ft)
US Extent	I-680	Same as Without-Project Condition		Hydraulic Analysis not Conducted for Locally Developed Future Upstream Improvements[1]	
I-680	Montague Expy	6.5	4.2	7.3	5.3
Montague Expy	UPRR Trestle	4.8	5.4	5.0	7.4
UPRR Trestle	UPRR Culvert	6.6	5.2	7.4	6.6
UPRR Culvert	Ames Avenue	5.3	4.4	6.2	5.5
Ames Avenue	Yosemite Drive	6.3	4.4	7.1	5.5
Yosemite Drive	Los Coches Street	6.4	5.9	6.9	7.6
Los Coches St	Calaveras Blvd	8.7	5.8	9.3	6.6
Calaveras Blvd	Downstream Extent	5.8	5.0	5.5	6.0

Note: 1. Locally Developed Future Upstream Improvements are described in Section 5.2.2.

These results are for fully contained flows. Comparison to the without-project conditions is therefore hypothetical only; the computed without-project water surface elevation at any point assumes full containment at each upstream section, and flows are restricted to the extent of each cross section in the event of breakout. Results accounting for breakout flows are presented in *Appendix B, Part II: Floodplain Development*, and *Appendix B, Part III: Geomorphology*.

Table 5-14 With-Project Hydraulic Results Summary for the 1% Chance Exceedance Event

FLO-2D Grid Cell / HEC-RAS Station	Without-Project		Alternative 2A/d		Alternative 5	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
US Extent						
3142[1]	5.57	8.31	Same as Without-Project Condition		5.6	8.15
3141[1]	6.59	6.94			6.85	7.36
3140[1]	8.12	5.88			11.06	5.78
3111[1]	8.99	6.09			11.01	4.9
3110[1]	8.99	4.67			8.57	2.67
3109[1]	7.2	6.18			8.91	3.56
3108[1]	8.82	4.89			8.12	7.33
3107[1]	8.82	6.03			6.47	9.01
3106[1]	8.72	12.25			7.04	10.31
Old Piedmont Road						
3075[1]	11.99	4.18	Same as Without-Project Condition		11.1	7.49
3104[1]	11.99	6.25			13.74	7.65
3103[1]	13.72	7.71			17.4	6.81
3072[1]	13.72	5.41			17.4	5.37
3071[1]	8.42	8.36			15.2	8.09
3039[1]	8.29	8.35			17.58	5.64
3038[1]	8.42	11.6			17.58	12.39
Piedmont-Cropley						
2967[1]	5.65	5.9	Same as Without-Project Condition		3.78	5.22
2966[1]	6.24	4.82			3.85	5.63
2930[1]	6.24	5.21			5.43	6.17
2893[1]	5.08	5.55			5.27	6.2
2892[1]	4.59	6.01			4.71	6.52
2891[1]	4.94	5.8			4.45	6.51
2853[1]	6.35	6.1			6.22	6.75
2852[1]	7.98	5.24			7.58	5.61
2851[1]	7.98	5.54			7.87	5.93
2850[1]	6.8	7.58			6.37	8.05
2811[1]	6.8	6.9			6.37	7.45
2771[1]	6.02	7.88			5.68	8.37
2729[1]	6.75	7.46			6.54	7.82
2728[1]	6.93	5.49			6.72	5.74
2727[1]	6.46	6			6.71	6.49
2685[1]	7.51	4.95			7.61	5.42
2642[1]	7.55	6.35			7.63	6.73
2599[1]	7.13	6.25			7.08	6.78
2555[1]	7.17	6.57			7.3	7.32
2512[1]	7.42	7.18			7.27	7.96

FLO-2D Grid Cell / HEC-RAS Station	Without-Project		Alternative 2A/d		Alternative 5	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
2468[1]	7.97	6.53			8.21	7.47
2467[1]	8.36	6.44			9.32	7.03
2423[1]	7.55	6.26			7.45	6.62
2379[1]	7.54	6.29			7.49	6.88
2334[1]	5.5	7.45			5.49	8.26
2291[1]	6.47	6.36			6.47	7.21
2247[1]	7.53	6.73			7.43	7.41
2202[1]	7.52	4.98			7.43	5.73
2158[1]	6.76	5.05			7.22	6.29
2114[1]	6.18	6.52			6.87	7.47
2069[1]	5.02	7.69			5.61	8.35
2024[1]	5.53	7.23			5.77	7.77
1979[1]	6.01	6.17			6.29	6.67
1934[1]	6.04	5.63			6.5	6.19
1888[1]	5.79	5.23			6.5	5.75
1842[1]	5.95	7.39			6.46	7.95
1797[1]	5.95	6.86			6.46	7.51
1751[1]	5.38	6.86			5.97	7.42
1705[1]	5.24	6.08			5.81	6.7
1659[1]	4.67	6.7			5.52	7.19
1613[1]	9.12	6.52			9.71	7
1566[1]	9.12	4.52			9.78	6.45
Drop Structure US of Morrill Ave.						
1471[1]	3.83	11.19	Same as Without-Project Condition		13.18	9.59
1424[1]	5.48	11.5			14.14	6.74
1375[1]	5.48	11.01			14.14	9.38
1326[1]	4.92	13.32			8.72	11.35
1279[1]	4.92	13.36			6.29	10.7
Morrill Ave.						
1230[1]	5.9	8.67	Same as Without-Project Condition		9.94	7.26
1182[1]	5.9	8.23			9.94	9.46
1134[1]	4.55	9.1			7.93	9.99
1085[1]	5.25	9.35			7.51	10.14
1035[1]	5.42	9.57			7.45	10.24
986[1]	4.82	10.24			7.47	10.33
938[1]	4.8	10.09			7.64	10.43
889[1]	4.99	11.17			7.77	10.33
890[1]	4.19	11.9			7.71	10.24
Cropley Ave.						
840[1]	8.34	8.8	Same as Without-		8.04	10.47

FLO-2D Grid Cell / HEC-RAS Station	Without-Project		Alternative 2A/d		Alternative 5	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
788[1]	10.48	7.05	Project Condition		9.22	8.76
736[1]	11.59	6.64			10.01	8.41
683[1]	11.59	6.46			10.25	8.22
630[1]	12.46	7			11.54	8.35
577[1]	12.46	6.46			12.71	7.95
524[1]	11.97	7.22			13.25	7.5
471[1]	10.17	7.57			13.26	7.27
418[1]	10.85	7.26			13.04	7.37
364[1]	13.1	6.6			13.46	7.52
309[1]	13.53	5.96			13.55	7.09
257[1]	13.53	5.84			13.55	6.94
211[1]	10.83	8			12.87	7.91
168[1]	11.85	7.31			12.87	7.82
130[1]	11.86	7.08			12.52	8.08
96[1]	16.51	8.15			18	8.89
68[1]	16.52	2.11			18	1.36
43[1]	12.37	7.86			16.83	9.05
I-680						
25296[2]	5.2	4.7	5.2	4.7	12.9	3.6
25245[2]	5.8	5.1	5.8	5.1	14.5	3.5
25155[2]	6.2	5.0	6.2	5.0	14.5	4.0
24997[2]	7.1	4.9	7.1	5.0	15.3	3.9
24886[2]	6.9	5.6	6.8	5.6	16.1	3.8
24791[2]	7.1	5.0	7.0	4.9	17.1	3.6
24694[2]	7.9	4.6	7.8	4.6	19.1	3.4
24171[2]	7.8	5.1	8.5	4.8	15.4	3.8
24079[2]	7.5	4.8	9.6	4.4	15.3	3.8
23986[2]	6.9	5.0	9.1	4.4	15.2	3.8
23889[2]	4.3	4.6	9.1	4.4	15.1	3.8
23786[2]	4.9	4.1	9.1	4.4	14.8	3.9
23710[2]	5.7	4.2	9.1	4.4	14.6	3.9
23610[2]	6.9	4.6	9.1	4.4	14.2	4.0
23522[2]	5.4	5.2	9.1	4.4	13.8	4.0
23413[2]	5.9	4.4	9.1	4.4	13.2	4.2
23326[2]	7.3	4.2	9.1	4.4	12.7	4.3
23185[2]	5.6	3.5	9.1	4.4	11.7	4.5
23062[2]	5.6	4.9	9.1	4.4	4.9	6.2
22951[2]	7.8	4.3	7.4	4.4	3.9	7.1
22865[2]	9.2	4.4	6.9	4.6	3.8	7.2
22806[2]	8.3	4.6	6.5	4.7	3.8	7.2

FLO-2D Grid Cell / HEC-RAS Station	Without-Project		Alternative 2A/d		Alternative 5	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
22748[2]	8.5	4.8	6.2	4.8	3.8	7.3
22693[2]	8.1	4.1	5.8	4.9	3.8	7.3
22603[2]	8.8	4.8	5.3	5.2	3.7	7.3
22274[2]	3.0	5.4	3.9	6.0	3.5	7.5
22117[2]	4.4	5.3	3.3	6.5	3.5	7.6
21883[2]	2.4	5.9	2.7	7.4	3.4	7.7
21873[2]	2.2	6.2	2.7	7.5	3.4	7.7
21864[2]	1.9	6.2	2.6	7.5	3.4	7.7
21852[2]	1.7	3.4	2.6	7.6	3.4	7.7
21844[2]	1.8	3.5	2.6	7.6	3.3	7.7
21832[2]	1.9	4.6	2.6	7.7	3.3	7.7
21821[2]	5.6	11.4	6.6	8.9	4.7	8.9
Montague Expressway						
21667[2]	6.3	11.0	9.7	6.5	7.8	6.3
21657[2]	4.1	6.6	8.1	5.4	12.5	5.3
21646[2]	3.8	5.8	8.0	5.4	12.5	5.3
21634[2]	4.3	4.9	8.0	5.5	12.5	5.3
21623[2]	6.6	5.5	7.9	5.5	12.5	5.3
21601[2]	8.9	5.6	7.9	5.5	12.4	5.3
21314[2]	7.5	6.2	6.9	5.9	11.8	5.4
21276[2]	5.6	6.9	6.8	5.9	11.7	5.5
21270[2]	5.1	6.7	5.6	8.2	6.4	8.4
UPRR Trestle						
21226[2]	6.5	6.5	6.5	8.0	7.9	7.0
21219[2]	7.4	6.1	9.1	5.1	15.4	4.7
21203[2]	8.4	5.7	9.1	5.1	15.4	4.7
21050[2]	10.3	4.8	9.1	5.1	15.4	4.7
20823[2]	10.1	5.3	9.2	5.1	15.4	4.7
20595[2]	7.6	5.5	9.2	5.1	15.3	4.7
20368[2]	8.7	5.0	8.7	5.2	15.1	4.8
20131[2]	5.9	5.8	8.1	5.4	14.9	4.8
19901[2]	8.2	5.1	7.9	5.5	14.6	4.9
19676[2]	10.1	4.9	7.1	5.8	14.1	4.9
19413[2]	5.7	5.2	6.2	6.3	5.0	7.3
19400[2]	6.3	5.1	6.1	6.3	4.8	7.4
19390[2]	4.0	10.1	5.3	10.4	4.6	7.7
UPRR Triple Box						
19285[2]	4.4	5.3	7.3	5.7	6.0	6.5
19268[2]	3.7	5.8	7.3	5.7	5.9	6.5
19244[2]	3.6	6.1	7.3	5.7	5.8	6.6

FLO-2D Grid Cell / HEC-RAS Station	Without-Project		Alternative 2A/d		Alternative 5	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
19234[2]	3.6	6.0	7.3	5.7	5.8	6.6
19184[2]	6.3	5.4	7.3	5.7	5.7	6.7
19172[2]	6.8	5.6	7.3	5.7	5.6	6.7
19158[2]	7.0	5.9	7.3	5.7	5.6	6.8
19083[2]	8.6	5.6	7.2	5.7	11.1	5.5
18904[2]	6.5	5.2	7.3	5.7	9.6	5.9
18881[2]	5.7	5.1	7.4	6.2	9.4	6.0
Ames Ave						
18805[2]	8.8	5.7	10.6	5.1	18.7	4.1
18774[2]	11.7	4.8	9.7	5.0	17.2	4.3
18553[2]	9.2	4.7	9.6	5.0	16.8	4.3
18259[2]	7.5	4.7	9.6	4.9	15.8	4.5
18045[2]	7.7	4.4	9.6	4.9	14.6	4.7
17811[2]	4.1	4.5	9.9	4.8	13.0	5.0
17602[2]	6.5	6.0	10.4	4.7	11.3	5.4
17571[2]	6.2	6.3	6.3	5.5	9.4	5.8
Yosemite Dr						
17470[2]	5.7	5.4	7.2	5.1	14.6	4.5
17448[2]	6.9	5.1	7.0	4.1	14.5	4.5
17427[2]	10.6	4.9	8.1	3.9	15.6	4.5
17281[2]	8.5	3.3	8.1	3.9	15.5	4.5
16924[2]	7.1	4.6	8.2	3.9	15.1	4.6
16654[2]	5.8	4.7	5.6	4.8	14.5	4.7
16437[2]	4.7	4.4	8.5	4.3	16.3	5.2
16139[2]	9.5	4.3	8.5	4.3	15.8	5.3
15928[2]	5.3	3.7	8.5	4.3	15.3	5.4
15665[2]	3.6	4.4	8.3	4.4	14.6	5.5
15398[2]	4.4	3.3	7.6	4.7	13.6	5.8
15156[2]	3.4	4.3	6.8	5.2	12.5	6.0
14944[2]	5.4	3.5	6.1	5.8	11.5	6.3
14685[2]	4.7	4.3	5.3	6.6	8.2	7.8
14467[2]	4.3	4.3	4.7	7.4	5.0	10.5
14422[2]	2.5	7.2	4.4	7.9	5.9	10.2
Los Coches St.						
14350[2]	2.8	7.3	6.1	7.3	6.9	8.8
14179[2]	6.0	5.9	6.2	6.5	6.8	8.9
14121[2]	7.0	6.5	5.3	7.3	6.6	9.1
13937[2]	6.3	8.2	4.8	8.3	7.0	9.1
13887[2]	5.7	9.0	4.0	9.4	7.3	12.0
Calaveras Blvd						

FLO-2D Grid Cell / HEC-RAS Station	Without-Project		Alternative 2A/d		Alternative 5	
	Vel	Depth	Vel	Depth	Vel	Depth
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
13741[2]	12.4	4.4	8.0	5.7	15.1	6.0
13653[2]	5.1	5.4	6.9	6.4	6.3	6.9
13603[2]	5.0	5.5	6.2	6.9	6.2	7.0
13553[2]	5.0	5.5	6.1	6.9	6.1	7.0
13503[2]	4.7	5.8	5.8	7.2	5.9	7.3

Note: 1. FLO-2D Grid Cell
2. HEC-RAS Cross Section Station

Table 5-14 With-Project Hydraulic Results Summary for the 1% Chance Exceedance Event (cont.)

Station	Alternative 2B/d without Future Upstream of I-680 Improvements		Alternative 2B/d 5 with Future Upstream of I-680 Improvements		Alternative 4/d 5 without Future Upstream of I-680 Improvements		Alternative 4/d 5 with Future Upstream of I-680 Improvements	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
US Extent to I-680								
	Same as Without-Project Condition listed in Table 5-13		Hydraulic Analysis not Conducted for Locally Developed Future Upstream Improvements[1]		Same as Without-Project Condition listed in Table 5-13		Hydraulic Analysis not Conducted for Locally Developed Future Upstream Improvements[1]	
I-680								
25296	3.8	5.4	4.3	6.5	6.3	4.5	6.6	4.8
25245	9.3	5.0	10.3	5.7	8.2	5.0	9.3	6.1
25155	9.4	5.0	10.5	5.6	8.2	5.0	9.4	6.1
24997	9.9	4.9	11.0	5.5	8.3	4.9	9.5	6.0
24886	10.5	4.7	11.6	5.3	8.4	4.8	9.7	5.9
24791	11.0	4.6	12.2	5.2	8.5	4.8	9.9	5.8
24694	12.2	4.4	13.4	5.0	8.8	4.6	10.3	5.5
24171	9.5	4.0	10.6	4.6	6.9	3.9	8.0	4.7
24079	7.9	4.3	9.3	4.8	7.2	3.7	8.4	4.5
23986	9.3	3.4	10.5	3.9	6.5	3.7	7.4	4.5
23889	9.6	3.3	10.8	3.9	6.5	3.7	7.4	4.5
23786	10.3	3.1	11.5	3.7	6.5	3.7	7.4	4.5
23710	11.3	2.9	12.4	3.5	6.5	3.7	7.4	4.5
23610	9.1	3.1	10.0	3.7	6.5	3.7	7.4	4.5
23522	8.0	3.2	8.9	3.8	6.5	3.7	7.4	4.5
23413	7.8	3.3	8.6	3.9	6.5	3.7	7.4	4.5
23326	7.4	3.4	8.2	4.1	6.5	3.7	7.4	4.5
23185	7.9	3.2	8.6	3.9	6.5	3.7	7.4	4.5
23062	7.6	3.3	7.8	4.1	6.5	3.7	7.2	4.5
22951	7.0	3.5	7.1	4.4	6.5	3.7	7.0	4.6
22865	6.4	3.7	6.6	4.6	6.4	3.7	6.9	4.7
22806	6.0	3.9	6.2	4.8	6.4	3.7	6.7	4.8
22748	5.6	4.1	5.9	5.0	6.4	3.7	6.6	4.9
22693	6.3	4.0	6.5	4.9	6.4	3.7	6.4	5.1
22603	7.2	4.0	7.4	4.9	6.5	3.7	6.3	5.3
22274	7.3	4.1	6.9	5.2	4.6	4.4	5.2	6.4
22117	6.3	4.1	7.2	5.2	4.0	5.1	4.7	7.1
21883	5.0	4.7	6.0	5.8	3.3	6.1	4.1	8.2
21873	4.9	4.8	5.9	5.9	3.2	6.2	4.0	8.3
21864	4.9	4.8	5.9	5.9	3.2	6.2	4.0	8.3

Station	Alternative 2B/d without Future Upstream of I-680 Improvements		Alternative 2B/d 5 with Future Upstream of I-680 Improvements		Alternative 4/d 5 without Future Upstream of I-680 Improvements		Alternative 4/d 5 with Future Upstream of I-680 Improvements	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
21852	4.8	4.8	5.8	5.9	3.2	6.3	4.0	8.4
21844	4.8	4.9	5.8	6.0	3.2	6.3	4.0	8.4
21832	4.7	4.9	5.7	6.0	3.1	6.4	3.9	8.5
21821	3.7	6.9	4.2	8.2	5.9	5.8	6.1	8.0
Montague Expressway								
21667	5.2	6.3	5.7	7.4	6.2	5.8	6.4	8.0
21657	8.3	5.3	8.8	6.2	6.1	5.8	6.3	8.1
21646	8.3	5.3	8.8	6.2	6.0	5.8	6.2	8.1
21634	8.3	5.3	8.7	6.3	6.0	5.9	6.2	8.1
21623	8.2	5.3	8.7	6.3	6.0	5.9	6.2	8.2
21601	8.2	5.3	8.7	6.3	5.9	5.9	6.1	8.2
21314	7.3	5.7	7.7	6.7	5.2	6.8	5.5	9.2
21276	7.2	5.7	7.6	6.7	5.1	6.9	5.4	9.3
21270	4.3	7.9	4.9	9.0	3.5	8.4	3.8	10.9
UPRR Trestle								
21226	4.5	7.6	5.3	8.6	4.4	6.7	5.2	8.0
21219	9.2	5.1	10.1	5.9	7.2	4.9	8.3	6.1
21203	9.2	5.1	10.1	5.9	7.2	4.9	8.3	6.1
21050	9.2	5.1	10.1	5.9	7.2	4.9	8.2	6.1
20823	9.2	5.1	10.2	5.9	7.2	4.9	8.2	6.1
20595	9.4	5.1	10.5	5.8	7.2	4.9	8.2	6.2
20368	9.9	4.9	11.1	5.6	7.2	4.9	8.1	6.2
20131	11.0	4.7	12.3	5.3	7.1	5.0	7.9	6.4
19901	8.6	4.0	9.5	4.8	7.0	5.0	7.6	6.6
19676	8.5	4.0	9.2	4.9	5.4	5.5	5.8	7.2
19413	8.0	4.2	8.6	5.2	4.7	6.2	5.2	8.0
19400	8.0	4.2	8.5	5.2	4.7	6.3	5.2	8.1
19390	4.7	7.3	5.7	8.6	6.2	8.2	7.4	9.9
UPRR Triple Box								
19285	7.4	4.3	8.4	5.1	5.7	5.1	6.7	6.3
19268	7.5	4.3	8.5	5.1	5.8	5.1	6.7	6.2
19244	7.5	4.3	8.5	5.0	5.8	5.1	6.7	6.2
19234	7.5	4.3	8.5	5.0	5.8	5.1	6.7	6.2
19184	7.6	4.2	8.6	5.0	5.8	5.0	6.7	6.2
19172	7.6	4.2	8.7	5.0	5.8	5.0	6.8	6.2
19158	7.7	4.2	8.7	5.0	5.8	5.0	6.8	6.2
19083	7.9	4.1	9.0	4.9	5.9	5.0	6.8	6.1

Station	Alternative 2B/d without Future Upstream of I-680 Improvements		Alternative 2B/d 5 with Future Upstream of I-680 Improvements		Alternative 4/d 5 without Future Upstream of I-680 Improvements		Alternative 4/d 5 with Future Upstream of I-680 Improvements	
	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)	Vel (ft/s)	Depth (ft)
18904	8.9	3.7	10.0	4.5	6.1	4.8	7.1	5.9
18881	4.9	4.8	5.8	5.6	6.1	4.7	7.1	5.9
Ames Ave								
18805	4.6	4.8	5.5	5.5	6.9	4.2	7.9	5.3
18774	8.6	3.6	9.6	4.3	6.8	4.3	7.8	5.3
18553	8.6	3.6	9.6	4.3	6.8	4.3	7.8	5.4
18259	8.5	3.6	9.6	4.3	6.7	4.4	7.6	5.5
18045	8.5	3.6	9.6	4.3	6.5	4.5	7.3	5.7
17811	8.5	3.6	9.5	4.4	6.1	4.8	6.8	6.1
17602	8.2	3.7	9.1	4.5	5.5	5.4	6.2	6.7
17571	4.9	5.7	5.8	6.7	5.3	5.5	6.1	6.8
Yosemite Dr								
17470	4.6	5.7	5.8	6.8	5.6	5.1	6.4	6.5
17448	6.2	4.0	7.3	4.7	5.6	5.2	6.4	6.5
17427	7.5	3.7	8.2	4.5	6.2	5.0	6.9	6.4
17281	7.3	3.8	8.0	4.6	6.0	5.2	6.7	6.6
16924	6.3	4.3	6.9	5.3	5.4	5.8	6.1	7.2
16654	5.3	4.9	6.0	6.0	4.9	6.4	5.6	7.9
16437	8.6	4.3	9.6	5.2	7.4	5.8	8.4	7.1
16139	8.6	4.3	9.6	5.2	7.4	5.9	8.3	7.2
15928	8.6	4.3	9.6	5.2	7.4	5.9	8.1	7.3
15665	8.6	4.3	9.6	5.2	7.3	5.9	7.9	7.5
15398	8.6	4.3	9.6	5.2	7.2	6.1	7.6	7.8
15156	8.5	4.3	9.6	5.2	6.9	6.2	7.2	8.3
14944	8.6	4.3	9.7	5.1	6.7	6.5	6.8	8.7
14685	8.6	4.3	9.7	5.0	6.2	7.0	6.3	9.4
14467	8.5	4.3	7.3	5.0	5.7	7.5	5.9	10.0
14422	7.4	5.4	8.0	6.2	8.4	6.6	7.6	9.5
Los Coches St.								
14350	7.7	5.2	8.3	6.0	10.3	5.4	11.4	6.3
14179	11.1	4.3	11.4	5.1	9.4	5.9	10.0	6.8
14121	10.6	4.5	10.7	5.4	8.8	6.4	9.7	7.0
13937	10.5	4.7	8.9	6.2	8.8	6.7	8.7	7.8
13887	7.5	6.2	6.6	7.8	8.5	6.9	8.2	8.1
Calaveras Blvd								
13741	8.0	5.8	7.5	7.1	11.4	5.2	11.6	6.2
13653	6.3	6.9	5.9	8.3	6.3	6.9	5.8	8.3

Station	Alternative 2B/d without Future Upstream of I-680 Improvements		Alternative 2B/d 5 with Future Upstream of I-680 Improvements		Alternative 4/d 5 without Future Upstream of I-680 Improvements		Alternative 4/d 5 with Future Upstream of I-680 Improvements	
	Vel	Depth	Vel	Depth	Vel	Depth	Vel	Depth
	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)	(ft/s)	(ft)
13603	6.2	7.0	5.8	8.4	6.2	7.0	5.7	8.4
13553	6.1	7.0	5.7	8.5	6.1	7.0	5.6	8.4
13503	5.9	7.3	5.5	8.8	5.8	7.3	5.4	8.7

Note: 1. Locally Developed Future Upstream Improvements are described in Section 5.2.2.

CHAPTER 6: SUMMARY

This appendix (*Appendix B, Part I: Hydraulic Analysis of Alternatives*) presents the modeling input and results for the without-project and project alternatives hydraulics. Modeling in this portion of the engineering appendix is based both on steady-state, 1-dimensional flow for the original modeling (retained for continuity) and unsteady, 1-dimensional flow for the revised GRR modeling. The total stage-discharge uncertainties for six index reaches upstream of I-680 and five index reaches downstream of I-680 were developed for the without-project and project alternatives for use in Economic analysis as presented in *Appendix C: Economics.* In addition, the stage-discharge uncertainties were used to size project alternatives 2A/d, 2B/d, and 4/d using risk-based principles.

The hydraulic results documented in this appendix were applied to the development of the floodplain mapping for the without-project and project alternatives. Details on the 2-dimensional modeling and mapping of overflows are presented in *Appendix B, Part II: Floodplain Development*.

Readers are referred to HDR, Inc.'s Technical Memorandum, *Berryessa Creek Hydraulic Analysis,* (HDR 2004) for details on the initial development and calibration of the without-project HEC-RAS steady-state model. Tetra Tech Inc.'s Technical Memorandum to U.S. Army Corps of Engineers, *Changes to without-project Hydraulic Modeling* (Tetra Tech 2005) details the changes made by Tetra Tech to the HDR HEC-RAS model which serve as the basis for the modeling reported in this document.

The following refinements for the selected plan during the detailed design phase are routinely carried out:

- Obtain updated topographic data to ensure that all channel breaklines are properly identified.
- Conduct detailed survey of bridge and culvert crossings.
- Model calibration is recommended if high water events occur and high water marks can be measured during the peak flow event.

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Berryessa Creek Project

Santa Clara County, California

Appendix B

Engineering and Design

Part II: Floodplain Development

TETRA TECH

FEBRUARY 2013

BERRYESSA CREEK PROJECT

APPENDIX B, Part II: Floodplain Development

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CHAPTER 1: FLOODPLAIN DEVELOPMENT METHODOLOGY

1.1 Study Methodology

Floodplains for Berryessa Creek were developed for the 20, 10, 4, 2, 1, 0.5, and 0.2 percent chance exceedance flood events. The project study reach for Berryessa Creek extends from upstream of the Old Piedmont Road in the City of San Jose to just upstream of the Calaveras Boulevard in the City of Milpitas. The study area watershed is divided into two distinct sub-areas by the Interstate 680 (I-680) embankment located approximately midway through the study reach. The I-680 embankment forces breakout flow upstream of the I-680 embankment to either pond in low areas along the embankment or return to the creek channel. Therefore, the embankment was used to divide the study area into two separate floodplains, each modeled with a separate FLO-2D model. The first floodplain encompasses the study area from Old Piedmont Bridge to the I-680 embankment and is referred to as the Upper Model. The second floodplain encompasses the study area downstream of the I-680 embankment to Calaveras Boulevard (with the modeling extending to Penitencia Creek) and is referred to as the Lower Model. In this appendix, “Lower” Berryessa Creek refers to the portion of the authorized Federal project downstream from I-680, rather than to the SCVWD’s Lower Berryessa Creek Project, which is located downstream from the Federal project.

The methodology used for modeling Berryessa Creek overflows was determined through discussions with the Sacramento District of the U.S. Army Corps (SPK) and the Santa Clara Valley Water District. The original GRR methodology was built on the premise of using the available F3 pre-Feasibility Scoping Meeting without-project conditions (pre-FSM) report steady state HEC-RAS channel (HDR 2004b) and HEC-HMS watershed modeling (NHC, 2003, 2006) coupled with FLO-2D for overbank modeling. The study methodology was extensively revised in 2010 to account for the effects of upstream attenuation on breakout flows. It was determined that the Upper FLO-2D model should be extended to encompasses the urban channelized portions of Sierra Creek, a major tributary to Berryessa Creek. The study methodology was revised to use FLO-2D to model both the channel and overbank flows in the Upper Model and use an unsteady HEC-RAS model coupled with FLO-2D for overbank flow in the Lower Model.

The following sections describe the Original 2004 and Revised 2010 GRR Methodologies. The original GRR methodology is included to provide continuity for floodplain development used in the incremental analysis and preliminary array of alternatives development in 2009. The revised 2010 GRR Methodology was used for evaluation of the final array of alternatives.

1.1.1 Original 2004 GRR Floodplain Development Methodology

The following steps were used in the development of a one storm event floodplain for any given alternative/increment:

1. A steady state HEC-RAS model of Berryessa Creek, extending from downstream of Calaveras Boulevard to upstream of Old Piedmont Road, was constructed to reflect the alternative being investigated (see *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*).
2. The appropriate peak storm event discharges were input into the HEC-RAS model. Using the methodology developed by HDR, Inc. (HDR 2004b) for the January 2004 Feasibility Scoping Meeting (FSM) document, peak breakout discharges at the upstream bridge crossings were manually removed from the flow input file (see Section 1.2.1.1).
3. The Berryessa Creek HEC-RAS model was run with the peak breakout discharge modified flow input file to determine the lateral peak breakout discharges.
4. The bridge and lateral peak breakout discharges were input into a modified HEC-HMS model based on the original developed by NHC, Inc. (NHC 2003, 2006) for the FSM document. The peak breakout discharges were added to the model using diversion cards to develop diversion hydrographs (see Section 1.3.1).
5. The diversion hydrographs were converted to unit hydrographs (see Section 1.3.1).
6. The HEC-RAS output was used to determine the incremental breakout discharges from the channel for individual cross sections along the lateral weir (see Section 1.3.1).
7. The incremental lateral breakout discharges were multiplied by the unit hydrographs to develop inflow hydrographs for the FLO-2D Grid Cells along the lateral weirs (see Section 1.3.1).
8. The upstream bridge breakout hydrographs were assigned to the appropriate FLO-2D grid cell (see Section 1.3.1).
9. The lateral breakout hydrographs and bridge breakout hydrographs were combined into FLO-2D format inflow input files for the Upper and Lower Models.
10. The Upper and Lower FLO-2D Models were run using the event inflow files.
11. The Upper and Lower FLO-2D output files were processed using the FLO-2D post-processor program MAPPER to create water surface elevation and flow depth ArcMap shapefiles based on the FLO-2D grid system.
12. The water surface elevations grids were overlain on the structure shapefiles and the water surface elevation for the impacted structures were assigned in ArcMap. This data was then supplied to the study economist.
13. The flow depth output from the Upper and Lower FLO-2D models were overlain on the aerial photographs to create the floodplain mapping.

1.1.2 Revised 2010 GRR Floodplain Development Methodology

The 2010 revisions to the GRR methodology allowed for simplifying the workflow needed to develop a floodplain for a given alternative. The following steps describe the development of a one-storm-event floodplain using the revised GRR methodology.

1. A FLO-2D model of the Upper Berryessa Creek and overbanks extending from Old Piedmont Road to I-680 was constructed to reflect the existing without-project conditions.
2. An unsteady HEC-RAS model was developed for Berryessa Creek downstream of I-680 (see *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*).
3. The inflow for Berryessa Creek upstream of Old Piedmont Road was taken from the HEC-HMS model developed by NHC, Inc. (NHC, 2003, 2006) for the FSM document.
4. The inflow hydrographs for the three Upper Model tributaries, Sierra, Crosley, and Sweigert Creeks, were determined from the HEC-HMS model. The tributary inflow hydrographs were adjusted to account for the culvert inlets capacity based on full inlet flow control (see Section 1.3.2.1).
5. The inflow hydrographs were formatted into a FLO-2D format inflow file for the Upper Model, and the Upper Berryessa Creek FLO-2D model was run.
6. The I-680 outflow hydrograph from the Upper FLO-2D Model was then used as the inflow at the upstream boundary of the unsteady Lower Berryessa Creek HEC-RAS Model. Hydrographs for subareas and tributaries entering Berryessa Creek downstream of I-680 were taken from the HEC-HMS model developed by NHC, Inc. and input in the Lower HEC-RAS model.
7. The Lower HEC-RAS model was then run to determine the breakout flows along the creek.
8. The lateral weir output was used to determine the incremental breakout discharge from the channel between individual cross sections as well as the overall lateral weir outflow hydrograph and the incremental lateral breakout discharges were used to distribute the breakout hydrograph along the lateral weirs extent (see Section 1.3.2.2).
9. The lateral breakout hydrographs were combined into a FLO-2D format inflow file for the Lower FLO-2D Model (see Section 1.3.2.2).
10. The Lower FLO-2D Model was run using the event inflow files.
11. The Upper and Lower Model FLO-2D output files were processed using the FLO-2D post-processor program MAPPER to create water surface elevation and flow depth ArcMap shapefiles based on the FLO-2D grid system.
12. The water surface elevations grids were overlain on the structure shapefiles and the water surface elevation for the impacted structures were assigned in ArcMap. This data was then supplied to the study economist.
13. The flow depth output from the Upper and Lower FLO-2D Models were overlain on the aerial photographs for the study area to create the floodplain mapping.

1.2 HEC-RAS Outflow Breakout Discharge Development

Breakout flows from the HEC-RAS models were used as inputs into the Upper and Lower FLO-2D Models for the original GRR methodology. For the revised GRR methodology, the HEC-RAS breakout flows were only used for the Lower FLO-2D model. The following sections describe the original and revised GRR methodologies for developing the breakout discharges from the Berryessa Creek HEC-RAS model.

1.2.1 Original GRR HEC-RAS Breakout Discharge Development Methodology

The without-project Berryessa Creek HEC-RAS model was originally developed by HDR, Inc. (HDR 2004a) in support of the F3 (pre-FSM) phase of the GRR. During the F4 pre-Alternative Formulation Briefing with-project conditions (pre-AFB) phase of the GRR from 2005-2009, the HEC-RAS model was further refined by Tetra Tech, Inc. and the refined baseline model was then used to determine the without-project breakout discharges from Berryessa Creek.

The without-project HEC-RAS model developed by HDR, Inc. simulated breakout discharges using the lateral weir routine. The routine automatically determines the breakout discharge over a lateral weir between each cross section within the lateral weir. The lateral weir routine removes the breakout discharge from further downstream computation in the model and they were permanently removed from the system. A new version of the HEC-RAS software was released by HEC between the F3 (pre-FSM) and F4 (pre-AFB) phases of the GRR containing improvements to the lateral weir routines. Due to changes in the software, without-project breakout discharges were recomputed using the updated HEC-RAS software.

Another crucial part of the Upper Model modeling effort was to quantify the breakout discharges at the three crossings of concern over Berryessa Creek upstream of I-680. The crossing breakout discharges occur at Old Piedmont Road Bridge, Piedmont-Cropley Culvert, and Morrill Avenue Culvert. The lateral weir routine does not support usage at bridge and culvert crossings. In order to determine the breakouts at the bridges, HDR, Inc. developed a methodology to iteratively determine the breakout discharges and remove them from the input flow file. This same method was used for the F4 (pre-AFB) phase of the GRR to determine the breakout discharges at the three crossings for this model.

1.2.1.1 Bridge Breakouts

The major source of flooding for the Upper FLO-2D model upstream of I-680 is breakout flows originating at bridge and culvert crossings. The breakouts occur at Old Piedmont Road Bridge, Piedmont-Cropley Culvert, and Morrill Avenue Culvert. Using the methodology developed by HDR, Inc. during the F3 (pre-FSM) phase of the GRR, the breakout discharges were determined starting at the Old Piedmont Bridge working downstream (HDR 2004a).

Tetra Tech, Inc. refined baseline and alternative HEC-RAS models were used to determine the bridge/culvert breakout discharges. The initial steady flow data file was prepared using the peak discharges from the F3 (pre-FSM) hydrology prepared by NHC, Inc. (NHC 2006). The following methodology, as developed for the F3 (pre-FSM) portion of the GRR, was

used to determine and account for the bridge/culvert breakout discharges at the three crossings.

1. The initial steady flow data run, developed using the F3 (pre-FSM) hydrology, was run in the alternative HEC-RAS model.
2. The HEC-RAS model output was used to determine the breakout discharge flow at Old Piedmont Road (see Section 1.2.2.1).
3. The peak breakout discharge for the Old Piedmont Road Bridge was subtracted from the flow steady flow data for all flow change locations downstream of Old Piedmont Road to create the first interim steady flow data set.
4. The model was then run using the first interim steady flow data set. The breakout discharge for the Piedmont-Cropley Culvert was then determined from the HEC-RAS output (see Section 1.2.2.1).
5. The Piedmont-Cropley Culvert breakout discharge was subtracted from the steady flow data set for all locations downstream of the Piedmont-Cropley flow change location to create the second interim steady flow data set.
6. The model was run using the second interim steady flow data set. The breakout discharge from Morrill Avenue Culvert was then determined from the HEC-RAS output (see Section 1.2.2.1).
7. The Morrill Avenue breakout discharge was then subtracted from the steady flow data set for all flow change locations downstream of Morrill Avenue to create the final steady flow data set for the model.
8. The HEC-RAS model was run using the final steady flow data set to determine the lateral weir breakout discharges for Berryessa Creek upstream of I-680.

It should be noted that this method was used to determine the breakout discharges and steady flow data sets only for the locations above I-680. The primary assumption of this methodology is that all breakout flows returns to Berryessa Creek at the I-680 culvert, negating the need to continue modeling the breakout flow deletion downstream of the I-680 culvert. This assumption negates the need to actually model the return of the breakout flows to the channel and the hydrology downstream of the I-680 culvert is taken directly from without-project hydrology as reported by NHC, Inc. (NHC 2003, 2006). This method is described in more detail in the Hydraulic Modeling Berryessa Creek Floodplain Development (HDR 2004a).

1.2.1.2 HEC-RAS Steady Flow Data Set Development

The HEC-RAS Berryessa Creek model contains numerous tributary inflows, bridge/culvert breakouts, and lateral weir breakouts in the study area. The without-project hydrology for Berryessa Creek produced by NHC, Inc. was used as the initial HEC-RAS steady flow data set. Since the breakout discharges at the bridges could not be handled internal to the HEC-RAS program, the breakout discharges were manually removed from the initial HEC-RAS steady flow data set. This iterative process was completed for each frequency event run.

The bridge/culvert breakout discharges were removed from the steady flow data set by subtracting the bridge/culvert breakout discharge from each flow change location downstream of the breakout to the I-680 culvert. The process created an interim steady flow

data set that was then used to determine the breakout discharge at the next downstream bridge. Once all bridges/culverts breakout discharges were determined, the final steady flow data set for the frequency event was completed for the Upper Model.

The bridge breakouts are located upstream of I-680. The primary assumptions of the methodology was that the overland flow in the Upper Model returned to the channel at the I-680 culvert and no change in the flows downstream of the culvert would occur. This assumption was used to develop the F3 (pre-FSM) hydrology (NHC 2003) and floodplain development (HDR 2004a) and was continued to this phase for continuity. Therefore the steady flow data for the HEC-RAS downstream of I-680 was taken directly from the without-project hydrology peak flows.

Old Piedmont Road

Old Piedmont Road at the Berryessa Creek Bridge slopes away from the channel and connects to a number of adjacent streets that continue to slope away from Berryessa Creek channel. Flows escaping in this area will continue away from the creek until returning to the channel near the I-680 culvert. In general, a majority of the flow overtopping Old Piedmont Bridge will be simple weir flow across the bridge deck and re-enter the creek channel on the downstream side of the bridge. A small portion of the weir flow though, will follow the road slope and flow away from the channel.

The Old Piedmont Road Bridge breakout discharges were developed using the method developed by HDR, Inc. for the F3 (pre-FSM) condition HEC-RAS model (HDR 2004b). This approach uses the flow depth over the bridge deck as the energy grade elevation for flows escaping down Old Piedmont Road. A simple Old Piedmont Road HEC-RAS model was constructed based on the road dimensions and slope and was used to develop a discharge versus energy grade elevation rating curve for the flows down Old Piedmont Road. The Old Piedmont Bridge deck elevation was subtracted from the water surface elevation from Berryessa Creek HEC-RAS model to determine the Old Piedmont Road energy grade elevation. The energy grade elevation and the rating curve were then used to determine Old Piedmont Road breakout discharge.

Piedmont-Cropley Culvert

The culvert under Piedmont road and Cropley Avenue is a major point source of flooding upstream of I-680 due to the limited culvert capacity. The breakout discharge at the Piedmont-Cropley Culvert was determined by using the culvert weir flow as computed by the HEC-RAS model. The entire weir flow was assumed to escape and not return to the channel downstream of the culvert for the following reasons:

(a) The culvert is over 407 feet long.
(b) The breakout spills onto Cropley Avenue which slopes away from Berryessa Creek.
(c) The culvert alignment crosses two major roads, a number of raised curbs, and traffic islands between the culvert inlet and outlet that prevent the flow from continuing down the creek at end of the culvert.

Morrill Avenue Culvert

The Morrill Avenue culvert was the last remaining point breakout location in the Upper Model that required manual correction. The breakout discharge at this culvert was assumed to not re-enter the creek downstream of the culvert for the following reasons:

1. The headwall at Morrill Avenue is raised approximately 3 feet for the width of the culvert both upstream and downstream of the culvert, does not tie into any flow barrier, and prevents flow from continuing downstream. The upstream headwall is shown in Figure 1-1.
2. The roads adjacent to Morrill Avenue paralleling either side of Berryessa Creek slope away from the channel and into residential subdivisions areas.

Due to the headwall disruption and flow paths away from the creek, the Morrill Avenue breakout was based on the weir flow as determined by the HEC-RAS model.

Figure 1-1 Morrill Avenue Culvert Headwall looking Downstream

Lateral Overflows

The remaining source of flooding from Berryessa Creek for the Upper Model and all of the flooding for the Lower Model is overflow from low areas along the creek banks. All lateral overflows in the Upper Model were assumed to break from the creek and flow independently overland due to the alluvial fan nature of the upper creek. In the Lower Model the channel alignment has been re-routed in the past, so that the channel is now nearly perpendicular to the general topographic slope. Therefore, breakout flows in the Lower Model would flow away from the creek following the general topographic slope. Breakout flows would be forced to re-enter the creek only once they meet a barrier that redirects flow back towards the channel. The barriers for the Lower Model watershed include the I-680 embankment, the Penitencia Creek floodwall, and levees downstream of the study area along the lower Berryessa Creek.

The channel reaches with lateral flooding potential were modeled in the Berryessa Creek HEC-RAS model using the lateral weir routine. The lateral weir routine in HEC-RAS calculates a peak overbank discharge between each cross section based on the water surface elevations and the lateral weir elevation at each cross section for the specified lateral weir reach. The lateral weir routine accounted for the breakout discharge loss from the channel by reducing the channel flow for the next downstream cross section. The lateral weir breakout flow was coded to leave the modeling system and not return later to a downstream cross section.

Three lateral weirs were modeled in the HEC-RAS model for the reach upstream of I-680 for the baseline, two along the left bank and one along the right bank. Four lateral weirs were modeled along the left bank of the baseline HEC-RAS model downstream of I-680. Table 1-1 lists the lateral breakout locations and stations as coded in the HEC-RAS model. The lateral weir lengths were taken from the lateral structure embankment stationing in the HEC-RAS model as developed by HDR (HDR, 2004b).

Table 1-1 Lateral Weir Locations

Weir Location (Upstream To Downstream)	Upstream Station	Downstream Location	Length, Ft
Upstream of Crosley Creek Parkhaven to Messina (Right Bank)[1]	31,895	31,026	869
Upstream of Morrill Street –Crosley to US of Morrill (left bank)[1]	30,468	29,993	475
Upstream of Cropley Ave. – Downstream of Morrill Street to Cropley Ave (Left Bank)[1]	28,161	27,642	519
Upstream of Montague Ave. - I-680 to Montague (Left Bank)[1]	25,295	21,821	3,474
Downstream of Montague – Downstream of Montague to UPRR Bridge (Left Bank)[2]	21,666	21,270	396
Upstream of Yosemite Avenue – Downstream of Ames Avenue to Yosemite Avenue (Left Bank)[2]	18,543	17,602	941
Downstream of Yosemite Street –Yosemite to Piedmont Creek (Left Bank)[2,3]	17,460	16,654	806
Downstream of Piedmont Creek – Piedmont Creek to Los Coches Ave (Left Bank)[2,3]	16,654	14,467	2,187

Notes:
1. Lateral weirs included in the Lower Model.
2. Lateral weirs included in the Upper Model.
3. The Yosemite to Los Coches lateral weir was modeled as one lateral weir in the HEC-RAS model, but treated as two in the inflow input due to additional inflow from Piedmont Creek

The total breakout discharge for each lateral weir reach was determined by subtracting the downstream most weir cross section channel flow from the upstream most weir channel cross section. The incremental lateral weir breakout discharge is the overflow between individual cross sections in a lateral weir reach and was determined by subtracting adjoining cross sections along the lateral weir length. The sum of the incremental lateral weir breakout discharges equals the total breakout discharge. The peak incremental lateral weir breakout

discharge was then used to apportion the lateral weir breakout hydrographs along the respective FLO-2D grid nodes along the lateral weir.

1.2.2 Revised GRR HEC-RAS Breakout Discharge Development Methodology

The revised GRR methodology modified the HEC-RAS model for the Lower Model. The without-project Berryessa Creek HEC-RAS model, originally developed by HDR, Inc. (HDR 2004a) in support of the F3 (pre-FSM) phase of the GRR, was modified to eliminate the reach upstream of the I-680 culvert. In addition, the 60 percent design for the Santa Clara Valley Water District's Lower Berryessa Project (starting just downstream of Calaveras Bridge) was incorporated in the HEC-RAS geometry. The HEC-RAS model inflow inputs were then modified to allow the model to run in the unsteady mode. The Upper FLO-2D model was modified to include the Berryessa Creek and Lower Sierra Creek channels and extended south to the boundary with the Penitencia Creek watershed. The Upper FLO-2D model was used to develop the channel outflow hydrograph at the I-680 culvert eliminating the need for HEC-RAS modeling upstream of the I-680 culvert. The revised HEC-RAS model was then used to determine the without-project breakout discharges from Berryessa Creek for the Lower Model.

The without-project HEC-RAS model simulated breakout discharges using the lateral weir routine. The routine automatically determines the breakout discharge hydrograph over each lateral weir. The lateral weir routine removes the breakout discharge from further downstream computation in the model unless coded to return to the channel.

1.2.2.1 Lower Model HEC-RAS Unsteady Flow Data Set Development

The lower HEC-RAS Berryessa Creek model contains numerous tributary inflows in the study area and for the reach downstream of the Calaveras Boulevard. The results of the without-project HEC-HMS model developed for the F3 (pre-FSM) portion of the GRR (NHC 2003) were used to generate the inflow hydrographs to the Lower Model. Hydrographs for each inflow location to Berryessa Creek were taken from the HEC-HMS model and added as lateral inflow hydrographs. The upstream boundary inflow hydrograph was developed from the Upper Model FLO-2D outflow at the I-680 culvert.

Downstream of I-680, flow breaks out of the channel from low areas along the creek banks. The lateral overflows for the Lower Models were modeled using the lateral weir routine for the unsteady HEC-RAS model. The assumptions associated with the lateral weir overflows for the Lower Model from the original GRR methodology were kept in the revised GRR methodology. These assumptions include:

- Breakout flows in the Lower Model will flow away from the creek and follow the general topographic slope.
- Breakout flows will be re-directed back to the channel only once they meet a barrier. For the Lower Model, the Penitencia Creek floodwall and levees on Berryessa Creek downstream of the study area served as the barriers.

The four lateral weirs were modeled along the left bank of the baseline HEC-RAS model downstream of I-680. The associated lateral weir locations and crest elevations from the baseline HEC-RAS model were retained. Table 1-1 lists the lateral breakout locations for the Lower Model (indicated by notation 2) and the weir lengths used in the HEC-RAS model.

By applying the lateral weir routine in an unsteady HEC-RAS model, the outflow hydrograph for each lateral weir was directly computed. The peak incremental breakout discharge for each lateral weir reach was determined by sequentially subtracting the channel discharge associated with the maximum water surface for adjoining cross sections along the lateral weirs. The peak incremental lateral weir breakout discharge was then used to apportion the lateral weir breakout hydrographs along the respective FLO-2D grid nodes along the lateral weir.

1.3 FLO-2D Inflow Development

FLO-2D requires inflow hydrographs to simulate the flooding over the grid system. Inflow hydrographs were therefore developed for input into the Upper and Lower FLO-2D models from the baseline HEC-RAS and HEC-HMS modeling. The following sections describe the original and revised GRR methodologies for developing the inflow hydrographs to the Upper and Lower FLO-2D Models.

1.3.1 Original GRR FLO-2D Inflow Methodology

The updated without-project HEC-HMS model developed for the F3 (pre-FSM) portion of the GRR (NHC 2006) was used to develop the shape of the hydrographs for the breakouts from the bridges, culverts, and lateral weirs. The without-project hydrology does not route breakout flows separately through the study area and therefore does not include any attenuation for breakouts that flow overland and later return to Berryessa Creek at the I-680 culvert. The assumption of no attenuation of breakout flows was maintained throughout the GRR as described in the without-project hydraulics (HDR 2004a, NHC 2003, 2006).

The assumption of no attenuation for breakout flow was used in the development of the breakout hydrographs to maintain consistency with the F3 (pre-FSM) hydrology. The without-project HEC-HMS model was modified to create two breakout diversion HEC-HMS models, one for Berryessa Creek above I-680 and one for the Berryessa Creek below I-680. The upstream HEC-HMS models contains the breakouts at the three bridge/culvert crossings and the three lateral weirs located upstream of I-680. No separate routing of these breakout flows above I-680 was done to remain consistent with the without-project hydrology. The downstream HEC-HMS model contains the breakouts for the four lateral weirs downstream of I-680 with no diversions upstream of I-680.

To modify the without-project HEC-HMS model, diversion cards were inserted into the HEC-HMS model at the locations of the breakouts. The diversion cards were used to specify a rating curve relating the total channel inflow to diverted outflow. Flow remained in the channel until the channel capacity was exceeded. Once the channel capacity was exceeded, all excess flow was diverted. The channel capacity was determined from the HEC-RAS model output to be the bridge/culvert capacity at the bridge breakout locations and the

channel flow at the downstream most cross section of the lateral weirs. The overflow hydrographs were created from the HEC-HMS output from the diversion nodes.

Since the FLO-2D model is a volume conserving, two-dimensional flood routing model, the area of inundation is primarily a function of the flood volume in the hydrograph. The flood hydrograph in Berryessa Creek is relatively steep and narrow, see Figure 1-2, with the peak discharge associated with a flood volume. In Berryessa Creek upstream of I-680, the 1% chance exceedance flood event at the Cropley-Piedmont Culvert has a volume of 686 acre-feet and peak discharge of 1,370 cfs over a total duration of 72 hours. The majority of the flood flow occurs over a seven hour duration. The without-project culvert capacity is 1,016 cfs resulting in an ability to pass 96% of the total 1% chance exceedance flood volume. The resulting breakout flow volume is 28 acre-ft with a peak discharge of 354 cfs accounting for 4% of the total volume of the flood hydrograph and occurs for less than a two hour duration.

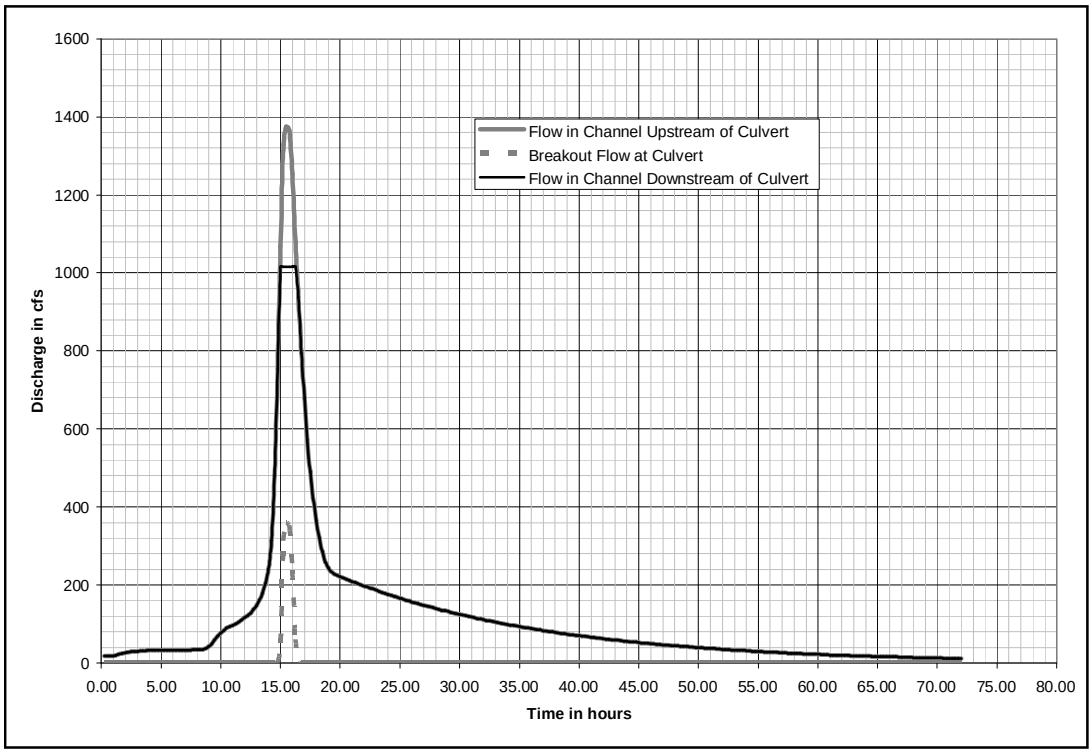

Figure 1-2 1% Chance Exceedance Flood Event Hydrograph Upstream and Downstream of Piedmont-Cropley Breakout for the Without-Project Condition

Figure 1-3 shows the inflow, outflow, and breakout hydrographs for the lateral breakout from the I-680 culvert to Montague Avenue on Berryessa Creek downstream of I-680 for the 1% chance exceedance flood event. The double peak seen in the figure is the result of a difference in timing of Sierra Creek which enters Berryessa Creek just upstream of Morrill Avenue. The resulting hydrograph has a 1% chance exceedance storm volume of 1,351 acre-ft with a peak discharge of 2,140 cfs. The lateral breakout upstream of Montague Avenue results in a total flood volume of 199 acre-ft escaping into the floodplain over the length of the reach with a peak discharge of 1,170 cfs. The breakout is approximately 15% of the total flood volume. The channel downstream of the breakout contains a total of 970 cfs and passes a flood volume of 1,152 acre-ft.

The diversion hydrographs developed with the modified HEC-HMS model were converted to unit hydrographs by dividing the diversion hydrograph discharge at each time step by the peak hydrograph discharge. The incremental lateral breakout discharge was used along with the diversion unit hydrograph to create a breakout hydrograph for each cross section in the lateral weir. The breakout hydrographs were then used in the creation of the FLO-2D flow input files. The details of the creation of these FLO-2D inflow files are discussed in Section 2.1.8.

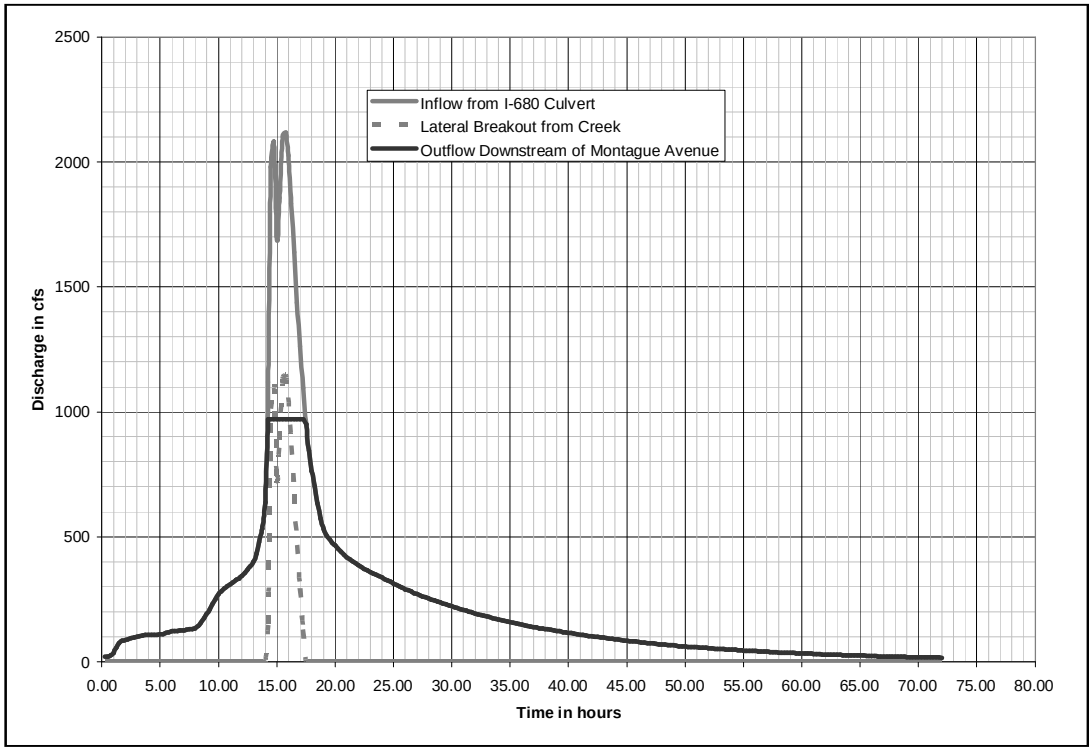

Figure 1-3 1% Chance Exceedance Flood Event Hydrograph for Lateral Weir Breakout between I-680 Culvert and Montague Avenue for the Without-Project Condition

1.3.2 Revised GRR FLO-2D Inflow Methodology

Due to the 2010 revisions to the Upper Model, the development of the FLO-2D inflow files differs for the Upper and Lower Models. The Upper Model inflows are based on inflow to the Berryessa and Sierra Creek channels. The Lower Model inflows are based on the lateral weir breakout discharges as in the original GRR methodology with minor changes in the development process. The following sections describe the process for developing the inflows for the Upper and Lower FLO-2D Models

1.3.2.1 Upper Model

The major revision to the original GRR was the modification of the Upper FLO-2D model to include the Berryessa and Sierra Creek channels. This modification allowed for the Upper FLO-2D Model to compute both the in-channel and overbank flows for Berryessa Creek, eliminating the need to manually transfer the breakouts between the HEC-RAS and FLO-2D models. In addition, the attenuation of overland flow and storage in low areas is accounted for in the revised GRR methodology.

The Upper FLO-2D Model routed the flows from upstream of Old Piedmont Road to the I-680 culvert. The outflow hydrograph at the I-680 culvert was then used as the inflow hydrograph to the Lower HEC-RAS model.
The results from the without-project HEC-HMS model developed for the F3 (pre-FSM) portion of the GRR (NHC 2003) were used for the inflow hydrographs to the Upper Models. Inflow hydrographs were developed for the upstream end of Berryessa Creek and three tributary inflows entering the creek upstream of I-680. The locations of the four inflow points to the Upper Model were:

- Berryessa Creek above Old Piedmont Road
- Sweigert Creek culvert outlet at Berryessa Creek
- Crosley Creek culvert outlet at Berryessa Creek
- Sierra Creek culvert outlet at upstream end of Sierra Creek urban channel

The inflow hydrograph for Berryessa Creek above Old Piedmont Road was taken directly from the HEC-HMS model results.

The three tributary inflows are conveyed fully—or partially, in the case of Sierra Creek—to the Berryessa Creek Channel. The HEC-HMS modeling did not incorporate the effects of the culvert capacity on the inflow to Berryessa Creek. In order to include the limitations of the culvert's capacity, the inflow hydrographs for each tributary were modified to account for the inlet capacity at the upstream end of the storm drain culverts where the flows from the undeveloped areas were captured and routed beneath the residential areas to Berryessa Creek. The limiting capacity of the storm drain system in the residential areas between the culvert upstream inlet and outlet at Berryessa Creek were not addressed. This was due to complexity of the residential culvert networks with a multitude of storm drain inlets in the residential areas. Addressing this issue would require a level of modeling beyond the scope of the GRR. The hydrologic modeling conveyed the entirety of the flow from tributary creeks to

Berryessa Creek without accounting for conveyance limitations in the interior drainage system. Hence, the inflow to Berryessa Creek, especially for the larger events is likely to be overestimated. The overestimation of the flows in Berryessa Creek leads to a conservative design and therefore it was deemed acceptable not to model the interior drainage system,

Each of the three creeks was modeled in the HEC-HMS model by two subbasins. The upper subbasin represented the undeveloped watershed above the culvert inlet and the lower subbasin represented the developed area downstream of the culvert inlet. The tributary inflow hydrographs were developed using the following steps:

1. The outflow hydrographs for the upper and lower subbasins for each tributary creek were taken from the HEC-HMS model and entered into an Excel spreadsheet.
2. The upper outflow hydrograph was subtracted from the lower outflow hydrograph to produce the hydrograph for the lower subbasin contribution at Berryessa Creek.
3. The capacity of the culvert inlets, assuming full inlet control, was determined for each culvert to the top of the inlet headwall.
4. The upper watershed hydrograph was truncated for flows above the culvert inlet capacity assuming all flows greater than the inlet capacity was lost.
5. The truncated upper and lower hydrographs were combined to create the inflow hydrograph to the Upper FLO-2D model.

The Berryessa Creek hydrograph and the three tributary hydrographs were then compiled into a FLO-2D inflow file for each storm event.

1.3.2.2 Lower Model

The Lower Model used the unsteady Berryessa Creek HEC-RAS model to route in-channel flows and develop the breakout flows. The resulting breakouts were then routed overland using FLO-2D. The resulting breakout hydrograph for each of the four lateral weirs in the HEC-RAS model was used as the basis for the inflow hydrographs to the Lower FLO-2D Model. The unsteady HEC-RAS model results were apportioned to the FLO-2D grid cell along the lateral weirs and then converted to a FLO-2D model compatible inflow file. The Lower FLO-2D Model inflow file was developed using the following steps:

1. The lateral weir breakout hydrographs and peak channel discharges corresponding to the maximum water surface for all Berryessa Creek cross sections were entered into an Excel spreadsheet.
2. The cross sections along the lateral weirs were assigned to corresponding FLO-2D nodes in the Lower Model. Due to the spacing of the cross sections and grid cell size, some cross sections were assigned to multiple grid nodes.
3. The incremental peak breakout discharges were determined by subtracting the peak channel flow of adjoining cross sections along each lateral weir.
4. The incremental peak breakouts for each lateral weir were then converted to a percentage of the total peak lateral weir breakout, and the percentage of breakout flow discharging at each FLO-2D grid was determined. For cross sections assigned to multiple FLO-2D grid nodes, the cross section percentage was divided equally among the FLO-2D grids.

5. The lateral weir outflow hydrographs were apportioned along the FLO-2D lateral weir grid cells by multiplying the lateral breakout hydrograph by the breakout flow percentages determined in Step 4 for each grid cell. Individual breakout hydrographs for each grid were developed.
6. The individual grid hydrographs were combined into a FLO-2D inflow file.

CHAPTER 2: FLO-2D MODEL DEVELOPMENT

Separate FLO-2D models were developed by Tetra Tech for the Upper Model and Lower Model. In 2010, the Upper FLO-2D Model was revised by adding the Berryessa and Sierra Creek channels to the FLO-2D model and expanding the overall coverage of the Upper Model. The following sections discuss the development of the original Upper and Lower FLO-2D Model and the revisions made to the Upper FLO-2D Model in 2010.

2.1 Original GRR FLO-2D Model

Version 2004.6.1 of FLO-2D was used to model the Berryessa Creek Overflow Floodplains. The creation of the FLO-2D model required for the analysis included the following steps:

(a) Creation of the FLO-2D grid system
(b) Graphical spatial editing of streets, levees and hydraulic structure model components
(c) Preparation of the inflow hydrographs

The FLO-2D model and each of the model features above will be discussed in the following sections.

2.1.2 FLO-2D Description

FLO-2D is a volume conservation model that distributes a flood hydrograph over a system of square grid elements (tiles). It is a two-dimensional flood routing model that numerically routes a flood hydrograph while predicting the area of inundation and simulating floodwave attenuation. Two dimensional flood routing is accomplished using a finite difference numerical integration of the equations of motion and the conservation of fluid volume (full dynamic wave equation) for either a water flood or a hyperconcentrated sediment flow. The FLO-2D model is able to account for rainfall, infiltration, levees, hydraulic structures, streets, hyperconcentrated sediment flows, and the effects of buildings or flow obstructions.

The solution domain is discretized into uniform, square grid elements. The computational procedure for overland flows involves calculating the discharge across each of the boundaries in eight potential flow directions. FLO-2D is on FEMA's list of approved hydraulic models for riverine and unconfined alluvial fan flood studies. Further model information can be found at the following website: www.flo-2d.com.

Since the FLO-2D model is a volume conserving, two-dimensional flood routing model, the area of inundation is primarily a function of the flood volume in the hydrograph. FLO-2D was selected for this project because it is an effective tool for analyzing unconfined flows over complex topography such as alluvial fans and floodplains, split flows, and urban flooding, all of which are present in the study area. In addition, FLO-2D has options for unlimited channel and floodplain hydrographs.

2.1.3 FLO-2D Grid Development

FLO-2D uses a finite difference grid system to represent the topography and to simulate unconfined flow over the floodplain. The grid system consists of square grid elements covering the study area. The grid element elevation data was based on a triangulated irregular network (TIN) supplied by the Corps of Engineers Sacramento District (SPK) and on topographic surveying conducted for the Santa Clara Valley Water District (SCVWD). The Berryessa Creek TIN was sampled at a 5-foot interval to create an elevation grid points (points) file. The files were then input into the FLO-2D Grid Developer System (GDS) program which filtered the data, defined the model boundary cells and assigned the grid cell elevation. Both the Upper and Lower models use a grid element of 100-foot square.

The study area watershed was divided into two distinct sub areas by I-680. The interstate is located approximately midway through the study reach. The interstate creates a barrier across the watershed which has only one flow path through it, the Berryessa Creek culvert. Using the interstate embankment to divide the study area, two FLO-2D models were created to simulate the overbank flooding that occurs upstream of the Calaveras Boulevard Bridge in the City of Milpitas to the vicinity of the Old Piedmont Bridge in the City of San Jose. One FLO-2D model was developed for the area upstream of I-680 (referred to as the Upper Model) and the other for the area downstream of I-680 (referred to as the Lower Model). Figure II-1 shows the location of the model boundaries for both the Upper and Lower Model area used for the analysis.

The Upper FLO-2D Model encompasses the floodplain of Berryessa Creek extending from just above Old Piedmont Road to the I-680 culvert (see Figure 2-1). The boundary of the Upper FLO-2D model extends from approximately one quarter of a mile upstream of the Old Piedmont Road Bridge to the east, I-680 to the west, Hostetter Road on the south, and a line parallel running approximately 1000 ft south of Landess Road. The grid system consists of 3,418 100-foot square cells.

The Lower FLO-2D model encompasses the floodplain of Berryessa Creek extending from the I-680 culvert to just downstream of Calaveras Boulevard (see Figure 2-1). The Lower Model is bounded by I-680 to the West, Capital Avenue to the South, Abel Street (Penitencia Creek Floodwall) to the east, and extends along Berryessa Creek from Calaveras Boulevard to the confluence with Penitencia Creek. The grid system consisted of 8,428 100-foot square cells.

The downstream study limit for the Berryessa Creek flood control project is approximately 50 feet below Calaveras Boulevard. The Lower model grid system continues along Berryessa Creek to the confluence with Penitencia Creek, which is north of the study limits. The unconfined overland flow breaking out along the creek above Calaveras Boulevard will continue to flow north beyond the limits of flood control project until encountering the downstream levees of the Berryessa and Penitencia Creeks. Therefore the Lower model area was constructed to encompass the entire possible flow area of the creek overflows.

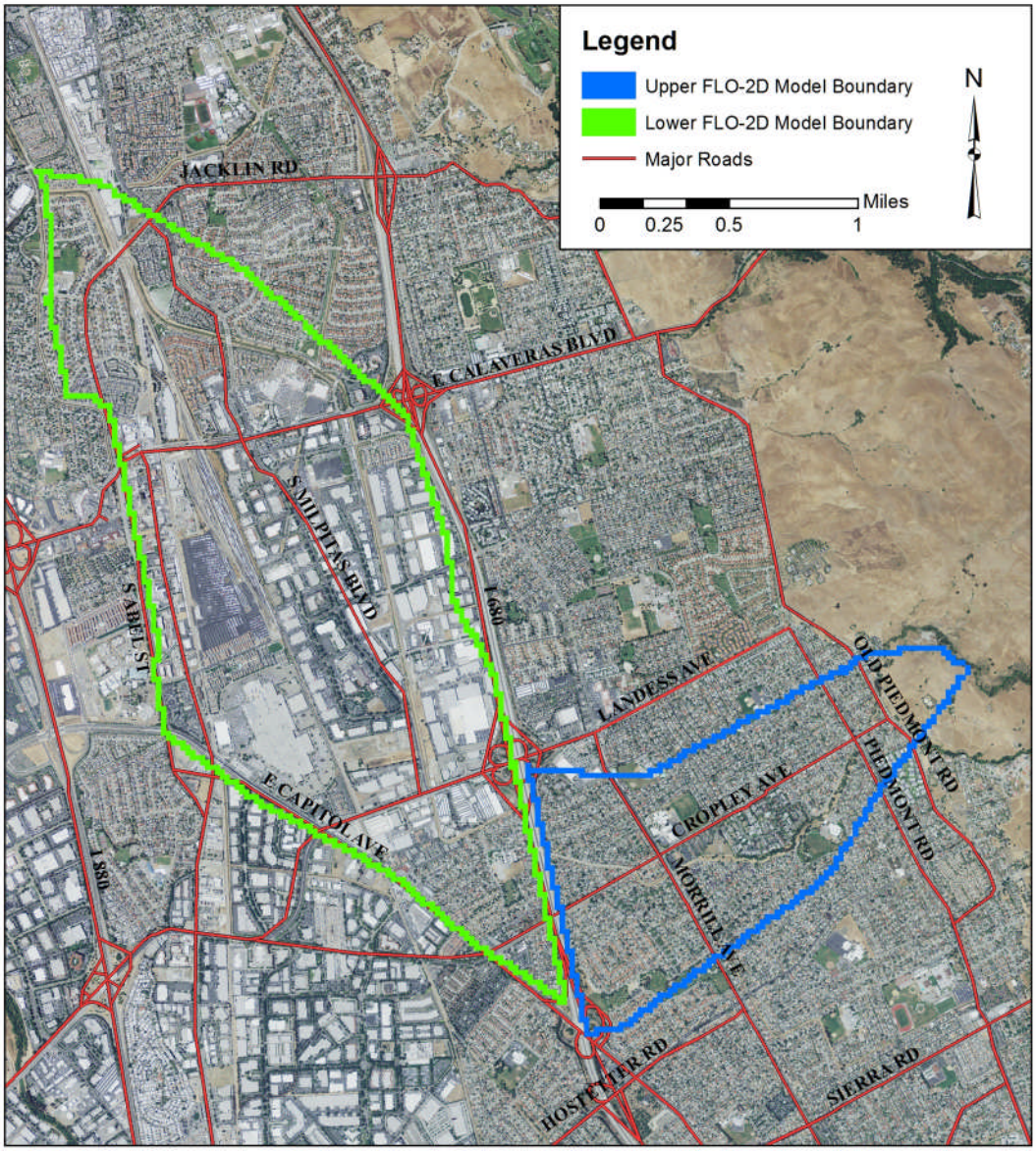

Figure 2-1 Upper and Lower FLO-2D Model Boundaries

2.1.4 Overland Manning's n and Area Reduction Factors

To simulate hydraulic flow resistance related to variable topography, vegetation, and other roughness attributes, FLO-2D uses a Manning's n-value roughness factor. To account for loss of storage due to buildings or other obstruction, an area reduction factor can be applied to each grid element. The GDS program was used to spatially edit the overland Manning's n-value and the area reduction factors for the grid system.

2.1.4.1 Manning's n

Overland Manning's n-values assigned by the GDS were based on land use, vegetation, and other roughness considerations. The overland Manning's n-values were established in ArcMap GIS by assigning n-values to the study area parcel shapefiles based on land use and other roughness factors. The overland Manning's n-values assigned to the parcels are listed in Table 2-1.

Table 2-1 Overland Manning's n-Values Based on Landuse

Land Use	Overland Manning's n-Value
Residential	0.09
Industrial	0.08
Open Areas	0.035
Paved Areas	0.025

The shapefile with the assigned Manning's n-values was imported into the GDS program. The GDS program overlays the parcel shapefile with the model grid system and computes a composite overland Manning's value for each grid cell.

A small number of grid cell's Manning's n-values were further modified to improve the hydraulic results of the FLO-2D model using the limiting Froude number criteria. Increasing the n-values for some grid elements improves stability and reduces computer model run time. A limiting Froude number of 0.9 was applied to adjust the n-values. When the limiting Froude number was exceeded during the model simulation, the n-value was increased by an incremental value. This reduces high velocities and surging which limits the timestep.

2.1.4.2 Area Reduction Factors (ARFs)

Area Reduction Factors (ARFs) were used to simulate the loss of storage related to structures and other obstacles in the individual grid elements. Completely blocked elements were also used as flow path obstructions where appropriate. To account for the spatial footprint of a structure in a grid cell, the ARFs reduce the amount of surface area in a grid element that is available for flood storage. Width reduction factors (WRFs) account for directional flow blockage that eliminate or partially reduce the flow width in a given flow direction. Directional flow blockage was assigned as a percentage of flow width in eight potential flow directions. Aerial photos were imported to the GDS as background images to assign ARFs for the Upper and Lower models.

The primary obstructions in the Upper Model were homes located in dense residential developments. The homes are generally smaller than the 100-foot square cell size. Some structures represented in the Upper Model (near the north bank of the greenbelt area) include larger apartment/condo buildings. WRFs and ARFs were used extensively in the Upper Model to replicate the effects of building patterns on the floodplain.

The primary flow obstructions in the Lower Model were large areas of large industrial buildings and a small number of areas with residential structures. In general, the industrial building footprints are much larger than the 100-foot square cell size. Completely blocking a grid cell from receiving flow was avoided to ensure flow depth around buildings for the study damage assessment. To account for storage loss in locations where building footprint encompass the entire grid element, ARF values of 95% were assigned.

2.1.5 Streets

In the Upper Model study area, the street networks in the dense residential neighborhoods were important to distributing overland flow. The FLO-2D street component utilizes curb height, street width and n-value. The global assignment of street parameters included a 6-inch curb depth and a Manning's n-value of 0.02. Street widths were determined from aerial photos of the study area. The overall street profile was checked against the TIN and survey data and individual grid elevations being adjusted where necessary. Portions of 36 different streets were added to the Upper Model. The streets included major thoroughfares such as Cropley Avenue, Morrill Avenue, and Old Piedmont Road. The remaining streets were smaller residential streets located in the many subdivisions of the study area. The emphasis on street flow simulation was on those streets within the network that would be effective in distributing the floodplain flow. Figure 2-2 shows the street network modeled in the Upper Model.

2.1.6 Levees

The levee option was used to confine floodplain flow due to obstructions, levees, or embankments (such as a highway or railroad). Levee crest elevations and levee flow obstruction directions were assigned for the FLO-2D levee component. When the floodplain water surface exceeds the levee crest, broadcrested weir flow is simulated until the tailwater is 85% of the headwater at which point the model reverts to overland flow simulation. The levee failure option was not used in either the Upper or Lower models. The Upper model study area does not contain any engineered levees. Figure 2-3 shows the embankments that were modeled in the Upper FLO-2D model. The Lower model study area contains both constructed levees along lower Berryessa Creek and some embankments. Figure 2-3 shows the levees that were modeled in the Lower FLO-2D model.

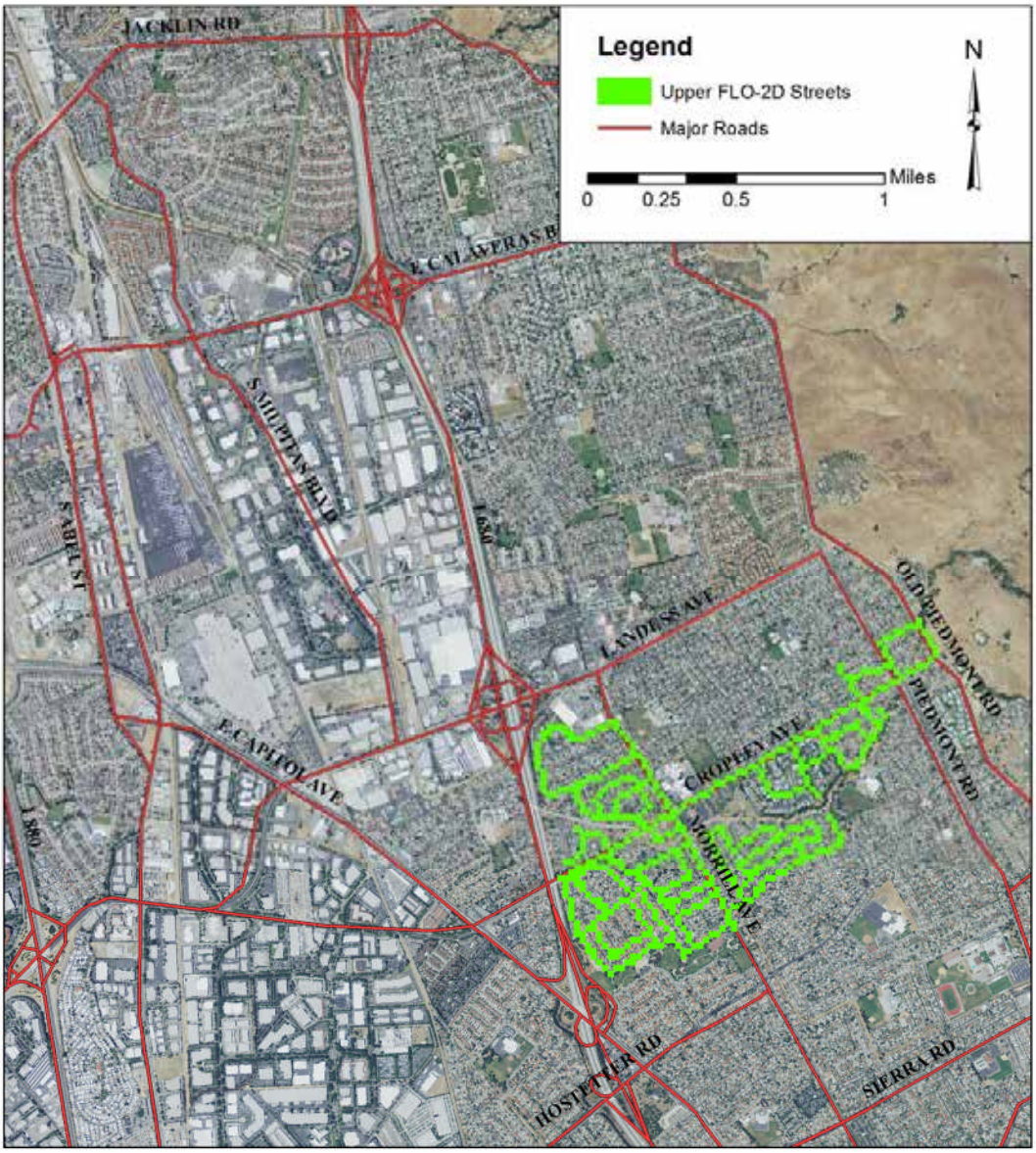

Figure 2-2 Street Network in the Upper FLO-2D Model

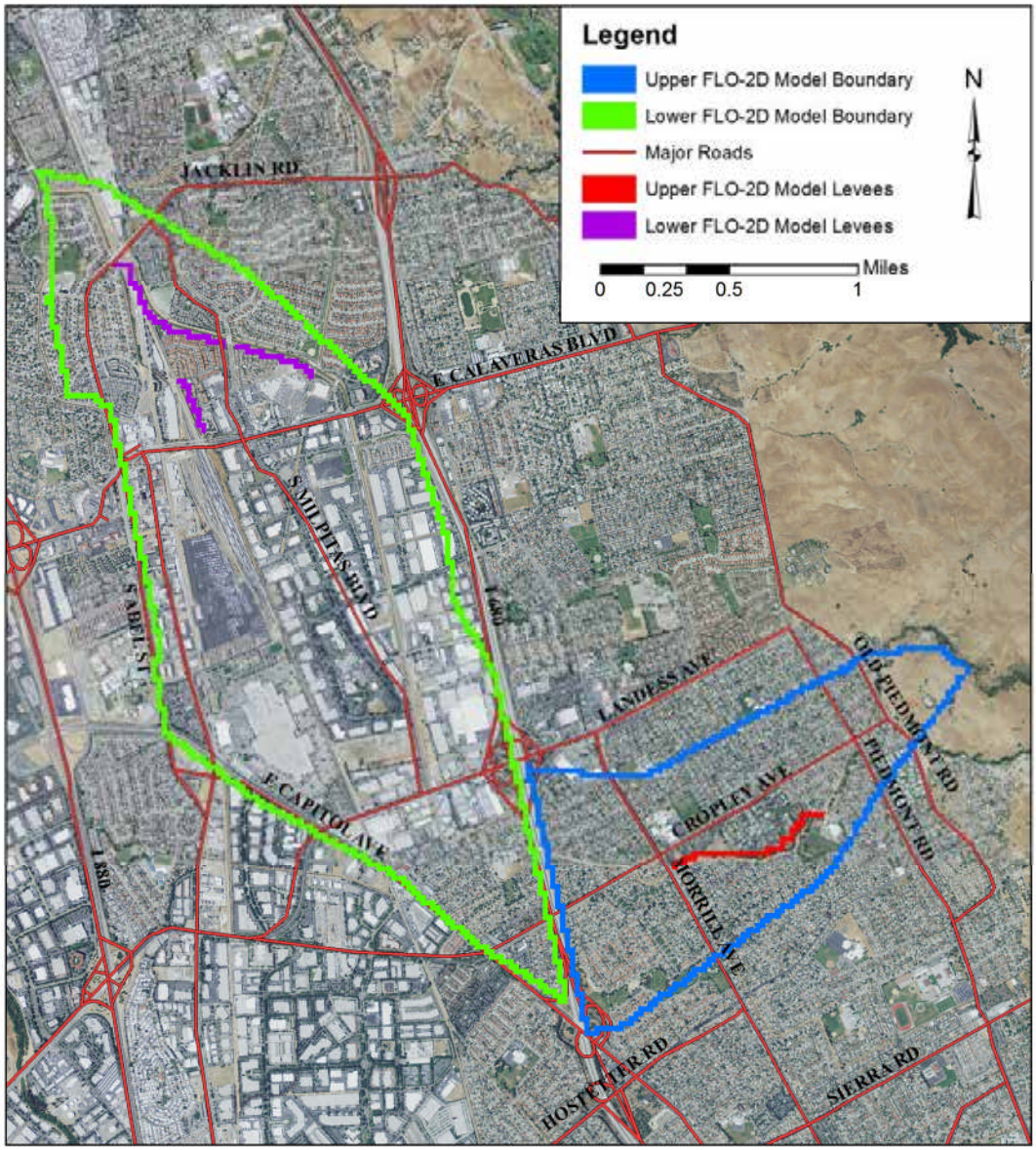

Figure 2-3 Levees in the Upper and Lower FLO-2D Models

2.1.7 Channels

The FLO-2D channel routine was used to model two reaches of the Berryessa Creek channel. The entire Berryessa Creek was not simulated in either the Upper or Lower FLO-2D models because the breakouts occur at specific locations and once flows leave the channel they do not immediately return to the channel. The HEC-RAS model was used to determine the breakouts from the channel as described in detail in Section 1.2. This approach assumes that overbank breakout discharges flow independent of the channel.

Breakouts flow along the alluvial fan spreading out from the creek until forced to return to the creek by a physical barrier. In the Upper FLO-2D model this barrier is the raised I-680 embankment and sound walls. For the Lower FLO-2D model the barrier is the Penitencia Creek Floodwall and levees along Berryessa Creek downstream of the study reach. The channelization of Berryessa Creek has resulted in the construction of levees along Berryessa Creek below Calaveras Boulevard. Levees and floodwalls that meet at the confluence of the Penitencia and Berryessa Creeks force the escaped overbank flow to return to Berryessa Creek near the confluence. The channel option was used in the FLO-2D model to allow flows to return to the channel and exit the model system.

Trapezoidal channel sections were assigned for the FLO-2D channel components in both the Upper and Lower Models. Top of bank elevations were taken from the available TIN, taking into account any levees or high banks that might not otherwise be represented in grid elements. The channel profile was reviewed and varied to ensure a consistent downstream gradient. The channel in the Upper Model had a 38-foot bottom width and a depth of 10 to 11.5 feet. A Manning's n-value of 0.035 was used. Berryessa Creek was modeled from downstream of Cropley Avenue to I-680 at the western end of the Upper model grid for approximately 0.4 miles. The Lower Model channel consisted of a 32-foot bottom width and a depth of 10 to15 feet. A Manning's n-value of 0.035 was used for the entire channel. Berryessa Creek was modeled from downstream of Calaveras Boulevard to the confluence of Berryessa Creek and Penitencia Creek at the northern end of the Lower Model grid, a distance of approximately 1.5 miles.

2.1.8 FLO-2D Inflow File

The FLO-2D input file was used to introduce the inflow hydrographs to the model grid system. A unique FLO-2D inflow data file was developed for each frequency event modeled. The input data file is comprised of a series floodplain inflow hydrographs. Each inflow grid element has an inflow hydrograph assignment.

The bridge/culvert and lateral breakout hydrographs (see Section 1.3.1) were assigned to appropriate grid elements in the system. The lateral weir cross sections were assigned to the grid cell(s) located along the creek channel between cross sections. In locations where the distance between individual lateral weir cross sections span more than one grid cell, the incremental discharge was divided equally between all associated grid cells.

2.2 Revised Without-Project Upper Berryessa GRR FLO-2D Model

The Original GRR Upper and Lower FLO-2D Models were updated from Version 2004.6.1 to the most recent FLO-2D release, Version 2009.06. Updating models from one FLO-2D version to another generally involves a number of minor changes to the input files. The changes to the input files do not affect the overall FLO-2D inputs or results. The steps required to update the FLO-2D model files to the latest FLO-2D version are not unique to the GRR and are documented on the FLO-2D website. Therefore the steps to update the FLO-2D model are not documented in this report.

Revisions to the 2009 Upper FLO-2D model were made for the 2010 GRR. No further changes were necessary for the Lower Model. The modifications to the Upper Model included the following:

(a) Expansion of the Upper FLO-2D grid system south to the Penitencia Creek watershed border
(b) Graphical spatial editing of streets, Manning's n-values, area reduction values, and hydraulic structure model components for the expanded area
(c) Developing the Berryessa Creek and Sierra Creek channels
(d) Calibrating the Berryessa Creek and Sierra Creek channels to the respective HEC-RAS models

The following sections discuss in more detail the revisions made to the Upper FLO-2D Model.

2.2.2 FLO-2D Grid Expansion

The Upper FLO-2D Model was expanded to the south to include the area up to the Penitencia Creek watershed boundary. This resulted in an Upper FLO-2D Model that encompassed the floodplain of Berryessa Creek with the following boundaries:

- East to approximately one quarter of a mile upstream of the Old Piedmont Road Bridge
- West to the I-680 embankment
- South to Penitencia Creek
- North to a line running approximately parallel to 1000 feet south of Landess Road

The revisions to the model added 9,930 grids cells to the existing 3,418 100-foot square cells in the Upper Model resulting in a total of 13,348 grid cells.

The Upper FLO-2D Model was expanded by developing a grid system adjacent to the existing Upper FLO-2D model that encompasses the desired new area. The grid system was developed in the same coordinate system and projection as used in the previous model - California State Plane 3 - NAD 83 feet and NAVD 88 feet. LIDAR data provided by the Santa Clara Valley Water District (SCVWD) was used to develop the grid cell elevations for the new grid system.

The LIDAR data provided by SCVWD covered the entire Berryessa Creek study area. The LIDAR was developed by MDA Geospatial Services and Optimal Geomatics, Inc. in 2006 for the City of San Jose, the County of Santa Clara, and the SCVWD. The LIDAR data was provided as point data in XYZ format text files with associated 2-foot contours by SCVWD. The LIDAR data was provided with both the raw data and the cleaned bare earth data files. The raw data contained all of the data points collected and included elevations for buildings and tree canopy. This made the raw data unsuitable for developing grid cell data in the model. The bare earth LIDAR data contained the post-processed raw LIDAR data with the tree canopy and building points removed. The bare earth LIDAR data was used in the FLO-2D model development.

The LIDAR data was provided as a number of individual flight line tiles, each covering an approximately 2,500 feet square section. The tiles had an average point spacing of 5 feet resulting in approximately 250,000 LIDAR data points per files. Due to the immense amount of LIDAR tiles and data points involved, the LIDAR data was combined into more manageable regional point files. Four regional files were developed for the expanded area of the Upper Model. The individual LIDAR files for each regional file were merged using the UltraEdit-32 version 12.20b text editor.

Once the regional files covering the study area had been completed, the FLO-2D grid system for the expansion area was constructed. The expansion FLO-2D grid system was developed using the FLO-2D preprocessor GDS (Grid Developer System) program version 2009.01. The grid system was based on the same 100-by-100-foot square grid cell as in the original GRR. The Upper Model grid system was imported as a shapefile to act as a reference for creating the expansion grid system. The regional LIDAR files were then imported into the GDS and used to assign grid elevation data for the expansion area. The original FLO-2D grid system and the expansion grid system were then “stitched” together to form one overall grid system. The revised Upper FLO-2D Model grid system was then visually inspected to ensure that the grid system was an accurate reflection of the floodplain. The resulting floodplain grid systems are then used as a basis for the FLO-2D modeling. Figure 2-4 shows the original and the added Upper FLO-2D Model grid system.

Elevations for some of the original FLO-2D grid were compared to elevations developed using the LIDAR data. The elevations for approximately 1,000 of the 3,418 original grids elements were developed using the same techniques discussed previously using the LIDAR data. The size of the area of LIDAR comparison was limited to the LIDAR data that was processed to support the development of the extended grid that overlapped onto the original grid system. This was done to reduce the time consuming task of the processing the LIDAR data. Overall, the difference between the original grid elevation and the LIDAR elevations for 75 percent of the grids were within plus or minus 1.5 feet and with 98 percent falling within plus or minus 3 feet. Overall, the original versus LIDAR grid elevation compared favorably for a majority of the grids compared. No general trend was observed of the original data being higher or lower than the LIDAR data. Positive and negative differences were scattered throughout the compared area, sometimes in close proximity. Since the differences were scattered and both positive and negative, replacing the original data with the LIDAR data would likely cause localized changes in flood depths with the overall floodplain remaining essentially the same.

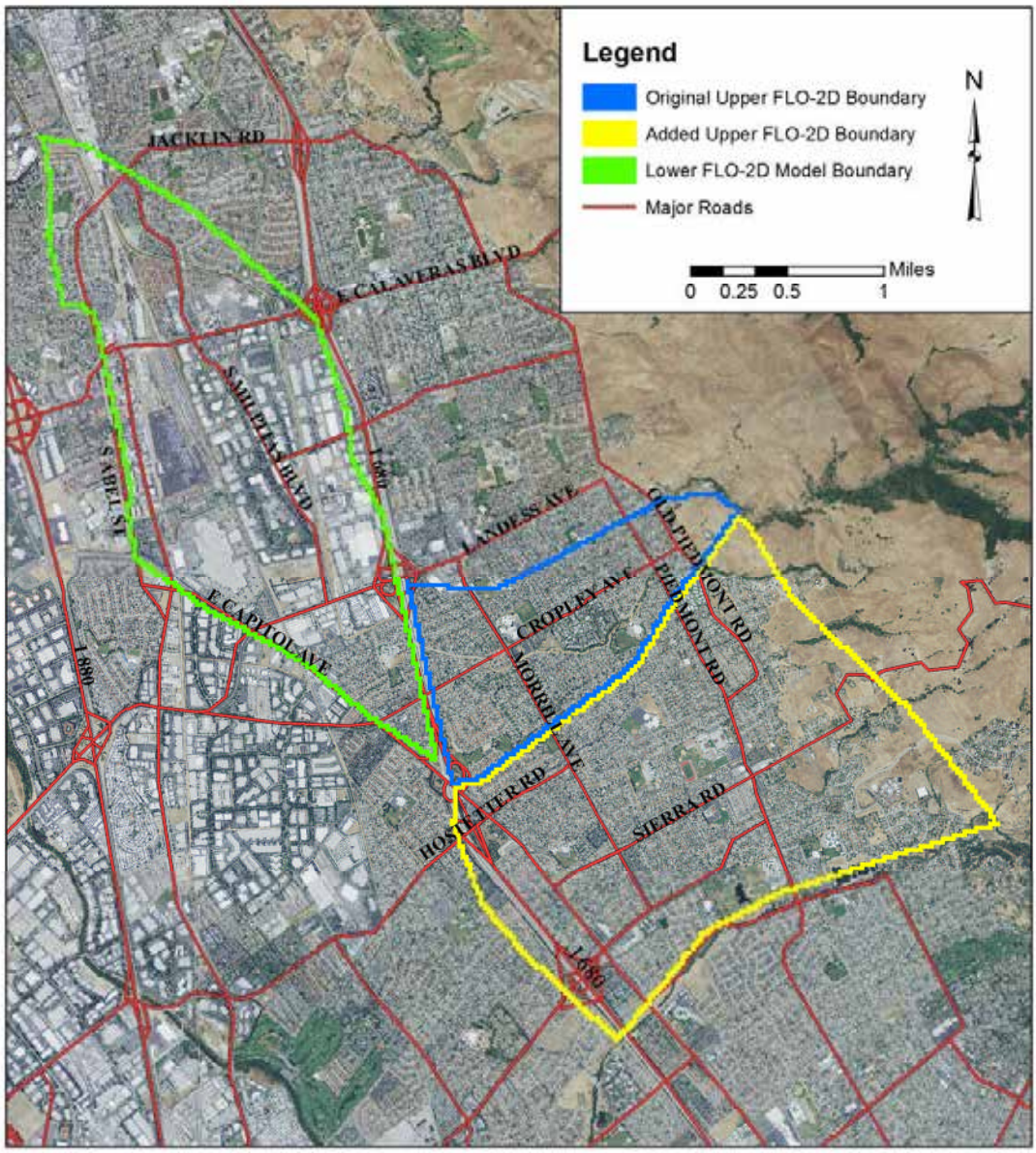

Figure 2-4 Upper FLO-2D Model Boundary

2.2.3 Overland Manning's n and Area Reduction Factors

The Manning's n-values and Area Reduction Factors were applied to the Upper FLO-2D Model expanded area in the same process as described in Section 2.1.4.

2.2.4 Streets

Major thoroughfares such as Morrill Avenue and Old Piedmont Road were modeled in the expanded areas. Smaller residential streets were not modeled, since the primary flooding in the Upper Model is contained in the original grid system, and the original emphasis for the street flow simulation was on those streets within the network that would be effective in distributing the breakout floodplain flow.

The FLO-2D street component utilizes curb height, street width, and n-value. The global assignment of street parameters included a 6-inch curb depth and a Manning's n-value of 0.02. Street widths were determined from aerial photos of the study area. The overall street profile was checked against the LIDAR and survey data and individual grid elevations being adjusted where necessary. Figure 2-5 shows the revised street network modeled in the Upper Model.

2.2.5 Channels

The FLO-2D channel routine was used to model Berryessa Creek and its primary tributary in the Upper Model, Sierra Creek, in the revised Upper FLO-2D Model. The following section describes the addition of the channels to the model.

The Berryessa Creek channel in the original Upper FLO-2D Model consisted of a small segment of the channel extending from downstream of Cropley Avenue to the I-680 culvert. The channel segment was included only to allow breakout flows to return to the creek and then allow the return flow to leave the model system. The channels, developed using the original methodology, were not intended to accurately model the in-channel flows. For the revised Upper FLO-2D Model, the Berryessa Creek channel was extended from Cropley Avenue to upstream of Old Piedmont Road. The baseline HEC-RAS model (*Appendix B, Part I, "Hydraulic Analysis of Alternatives"*) was used as the basis for the Berryessa Creek channel geometry.

The Sierra Creek channel was not included in the original FLO-2D model. A channel segment representing the Sierra Creek channel was added to Upper Model based on the alignment of the creek taken from available aerial photography. The Sierra Creek channel extended from the confluence with Berryessa Creek to the Sierra Creek culvert outlet at Mauna Kea Lane near Piedmont Hills High School. The channel section geometry was based on a HEC-RAS model of the Sierra Creek channel developed and provided by Santa Clara Valley Water District.

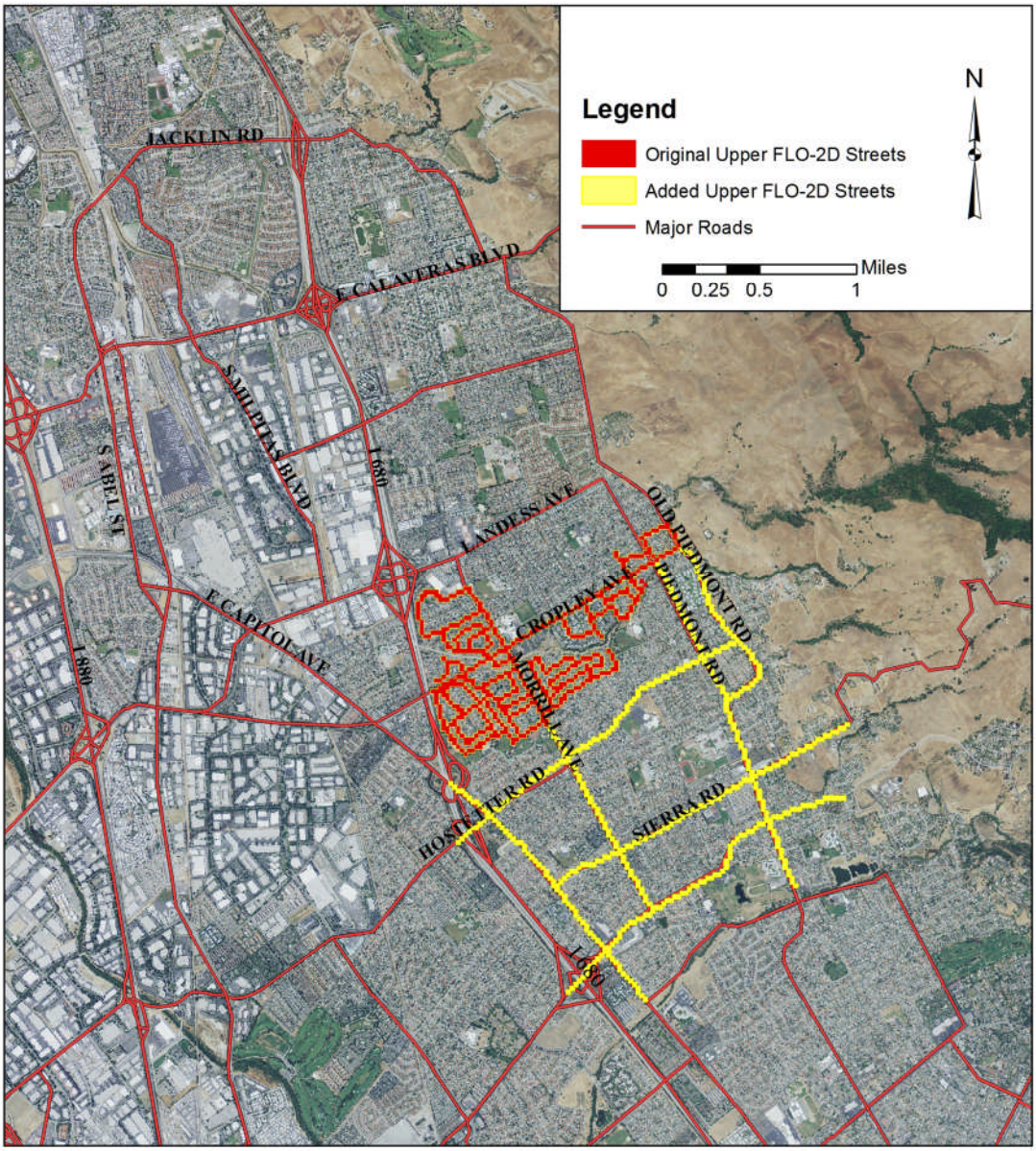

Figure 2-5 Upper FLO-2D Model Streets

In FLO-2D, channel elements represent only the main channel, with the overbanks modeled by the grid system. HEC-RAS cross sections generally include both the main channel and overbanks for each cross section. In order to use the HEC-RAS cross sections in the FLO-2D model, the cross sections were reviewed and edited to include only the main channel. This was completed for both the Berryessa and Sierra Creek HEC-RAS model using the graphical cross section editor in HEC-RAS.

Once the main channel cross sections were completed, the cross sections were assigned to the FLO-2D channel grids using the GDS HEC-RAS geometry import routine. After the cross sections were assigned, they were reviewed to ensure that the most representative cross section was chosen for each channel grid. The right bank channel extensions for each channel grid was then created and reviewed in GDS. Finally, the channel slope profile was reviewed and cross section elevations modified to ensure that the representative channel slope was maintained throughout the FLO-2D channel system.

The initial Manning's n-value for each cross section was taken from the channel Manning's n-value in the HEC-RAS model. The Manning's n-values were then adjusted using the suggested Manning's n-values contained in the FLO-2D (chan.rgh) file. The (chan.rgh) file contains results of the FLO-2D model's adjustments to the channel Manning's n-value to meet the limiting Froude number criteria. The resulting channel Manning's n-values were then further adjusted during calibration of the channel. Section 2.2.8 describes the calibration of the Berryessa and Sierra Creek channels.

Figure 2-6 shows the location of the Revised Upper FLO-2D Model Berryessa and Sierra Creek channels.

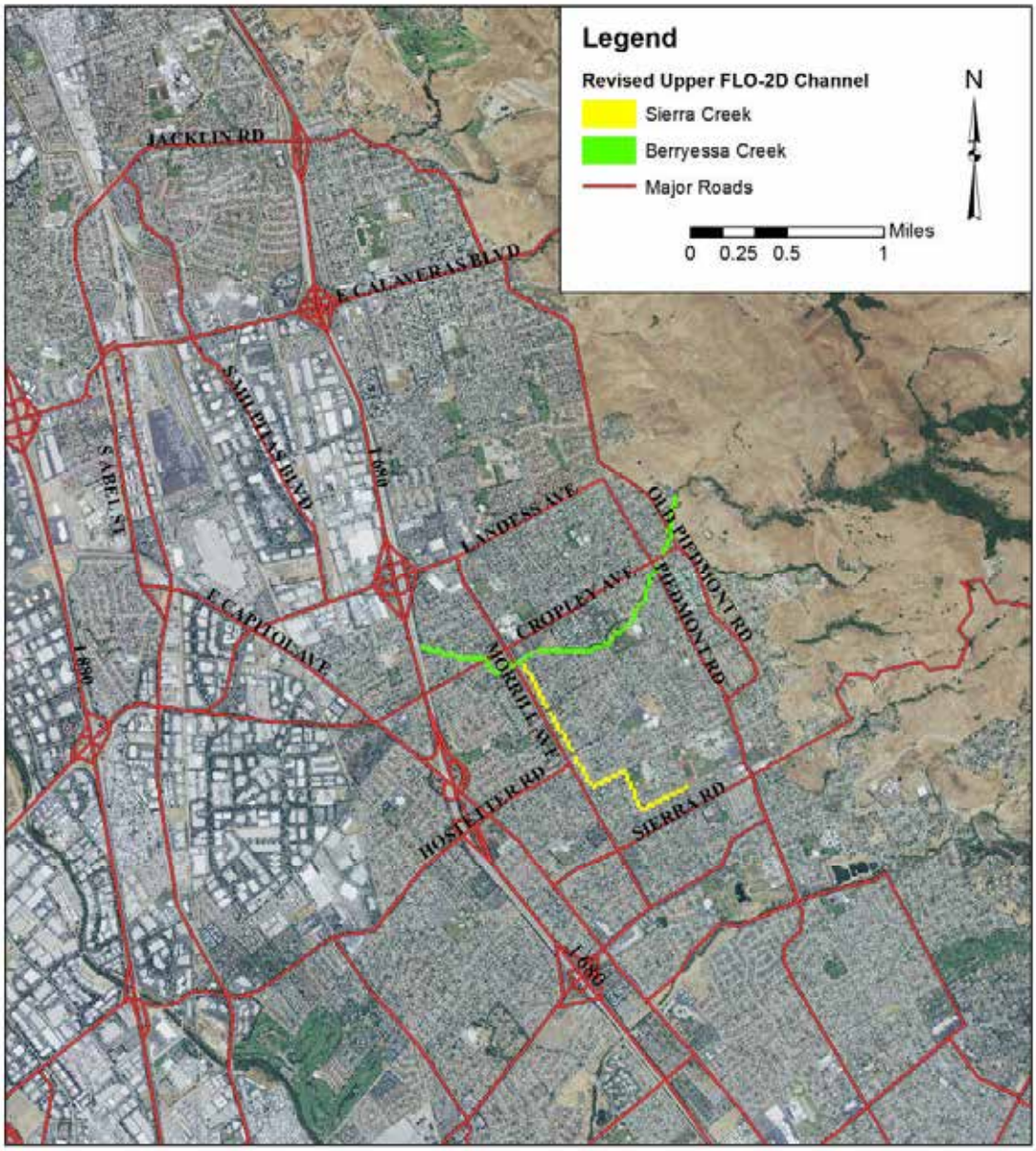

Figure 2-6 Revised Upper FLO-2D Model Berryessa and Sierra Creek Channels

2.2.6 Hydraulic Structures

Hydraulic structures, such as bridges and drop structures were used in FLO-2D to model any conveyance that would affect the flow between two grids that could not be modeled using the channel components. Due to the limit of one cross section per channel grid cell, it is difficult to model drop structures and other sudden changes in channel geometry. In the Upper FLO-2D Model hydraulic structures were used to model the bridges, culverts, and hydraulic drops in the Berryessa/Sierra Creek system. The hydraulic structures were developed as rating tables describing the flow between two channel grid cells. The rating tables were derived from the Berryessa and Sierra Creek HEC-RAS models. The bridge/culvert rating table reflected the flow through the bridge/culvert only and did not include the HEC-RAS computed weir flow. The weir flow was excluded from the rating curve since the breakout flow at the bridge/culverts was found to be primarily redirected weir flow and is a major source of overland flooding. The FLO-2D model then determined the weir flow based on the surrounding grid cells and the weir flow was allowed to flow overland or return to the channel as the topography dictated. Table 2-2 lists the hydraulic structures in the Upper FLO-2D Model.

Table 2-2 Hydraulic Structures in Upper FLO-2D Model

Structure Name	Description	Inlet Node	Outlet Node
OldPied	Old Piedmont Road Bridge over Berryessa Creek	3106	3075
PiedCrop	Berryessa Creek culvert under Piedmont and Cropley Streets	3038	2967
DropStructure	Drop structure on Berryessa Creek upstream of Morrill Avenue and the Sierra Creek confluence	1566	1471
Morrill	Berryessa Creek culvert under Morrill Avenue	1279	1230
Cropley	Berryessa Creek Culvert under Cropley Street	890	840
SierraPedBrdg	Sierra Creek Pedestrian Bridge	7616	7485
HostetterRd	Hostetter Road bridge	6973	6735
KnightsBridge	Knights Bridge Road bridge over Sierra Creek	1688	1644
SierraDrop	Sierra Creek Drop Structure at confluence with Berryessa Creek	1373	1326

2.2.7 FLO-2D Inflow File

The FLO-2D input file was used to introduce the inflow hydrographs to the model grid system. A unique FLO-2D inflow data file was developed for each frequency flow event combination modeled. The input data file for the Upper Model consisted of four discreet inflow hydrographs to the channel system. The inflow hydrographs were introduced to the system at the following locations:

- Grid 3142 - upstream end of the Berryessa Creek channel above Old Piedmont Road
- Grid 2850 - Sweigert Creek culvert outlet to Berryessa Creek located in the upper portion of the Greenbelt

- Grid 2334 - Crosley Creek culvert outlet to Berryessa Creek located in the lower portion of the Greenbelt
- Grid 8044 - Sierra Creek culvert outlet at upstream end of the Sierra Creek channel at Mauna Kea Lane

The inflow hydrographs were developed for each of the locations as described in Section 1.3.2.1 and compiled into a FLO-2D inflow data files. Rainfall was not added to the FLO-2D model since precipitation was accounted for in the development of the hydrology (NHC 2003, 2006).

2.2.8 Upper Model FLO-2D Calibration

HEC-RAS models for the Berryessa and Sierra Creeks were used to calibrate the Upper FLO-2D Model to ensure that the FLO-2D channel system was accurately simulating the in-channel flows. First the Upper FLO-2D model Berryessa Creek channel segments was calibrated to the 1% chance exceedance steady state baseline without-project Berryessa Creek HEC-RAS model (see *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*). Then the Sierra Creek channel was calibrated to the 10% chance exceedance steady state Sierra Creek HEC-RAS model provided by the Santa Clara Valley Water District (SCVWD). The final input data files from the Berryessa and Sierra Creek calibration effort runs were then used as the final Upper FLO-2D Model.

2.2.8.1 Berryessa Creek Channel

The Berryessa Creek channel was calibrated to the 1% chance exceedance Berryessa Creek HEC-RAS model used to develop the breakout flow for the original GRR methodology, as detailed in Section 1.2.1. The calibration was completed to ensure that FLO-2D channels accurately reflect the Berryessa Creek channel. Two primary goals were established for the calibration:

1. Calibrate the water surface elevations to plus/minus 0.25 feet
2. Calibrate the bridge capacities and overflow characteristics at the three major breakout points in the Upper Model: Old Piedmont Bridge, Piedmont-Cropley Culvert, and Morrill Avenue Culvert

A steady state FLO-2D inflow file was developed to replicate the flow conditions in the HEC-RAS model. Inflow hydrographs were developed for each of the four inflow locations. The inflow hydrographs ramped up quickly to the steady flow values and were then held steady for the duration of the run. The Upper FLO-2D Model was then run for a six hour duration to ensure that the entire channel system was operating at the full steady flow values.

The Upper Model was calibrated, working from upstream to downstream. The primary methods used to adjust the model during calibration included:

- Raising/lowering cross section inverts
- Replacing HEC-RAS cross section used for a grid section with a representative cross section

- Removing HEC-RAS cross sections and interpolating between the upstream and downstream cross sections
- Raising/lowering cross section end point (channel bank elevations)
- Revision of Manning's n-values

The water surface elevations at 44 cross section locations were compared to the FLO-2D grid water surface elevations. Table 2-3 lists the 1% chance exceedance HEC-RAS and FLO-2D water surface elevations at the calibration locations along with the difference.

As shown in the table, the calibration to the water surface elevation was fairly successful with 39 out of 44 calibration points within 0.25 feet of the HEC-RAS model results. Of the five remaining points, four are within 0.35 feet of the HEC-RAS locations with the last being 0.54 feet lower that the HEC-RAS WSEL. The locations with difference are at locations such as upstream of bridges or upstream of a grade break, both which are difficult for FLO-2D to model.

Table 2-3 Calibration Results for Berryessa Creek Channel Upper FLO-2D Model

Point	HEC-RAS Cross Section	FLO-2D Grid Cell	1% Chance Exceedance HEC-RAS Elevation(ft)	1% Chance Exceedance FLO-2D Elevation (ft)	Difference (ft)
1	36242	3142	243.1	242.97	-0.13
2	36126	3141	240.56	240.57	0.01
3	36032	3140	238.36	238.29	-0.07
4	35191	3106	220.21	220.2	-0.01
5	35139	3075	216.3	216.29	-0.01
6	34989	3104	207.32	207.47	0.15
7	34694	3071	198.24	198.27	0.03
8	34566	3039	197.22	197.36	0.14
9	34467	3038	195.13	195.46	0.33
10	34032	2967	188.9	188.81	-0.09
11	33804	2930	185.55	185.51	-0.04
12	33485	2891	181.66	181.72	0.06
13	33207	2852	176.34	176.28	-0.06
14	32976	2850	171.95	171.87	-0.08
15	32721	2771	168.15	168.04	-0.11
16	32436	2728	163	163.07	0.07
17	32333	2727	160.67	160.69	0.02
18	31969	2642	155.59	155.7	0.11
19	31905	2599	154.56	154.59	0.03
20	31559	2468	150.23	150.12	-0.11
21	31440	2467	147.72	147.77	0.05
22	31168	2334	144.32	144.4	0.08
23	30978	2291	141.76	141.75	-0.01
24	30808	2247	139.31	139.34	0.03
25	30701	2202	137.4	137.35	-0.05
26	30478	2114	133.82	133.68	-0.14
27	30327	2069	132.71	132.71	0
28	30195	1979	131.27	131.3	0.03
29	29983	1842	127.62	127.77	0.15
30	29873	1797	126.19	126.26	0.07
31	29571	1659	123.05	122.95	-0.1
32	29433	1613	121.71	121.66	-0.05
33	29093	1375	113.12	113.24	0.12
34	28699	1326	112.94	112.99	0.05
35	28447	1182	105.46	105.8	0.34
36	27895	938	104.96	104.42	-0.54
37	27642	890	103.73	103.73	0
38	27380	788	95.19	95.22	0.03
39	27108	630	93.22	93.4	0.18
40	26889	524	91.41	91.7	0.29
41	26695	418	90.73	90.99	0.26
42	26577	364	89.64	89.87	0.23
43	26419	257	86.14	86.22	0.08
44	25688	43	78.34	78.38	0.04

The second goal of the calibration was to ensure that the three bridges that are sources of breakout flow are accurately represented. Table 2-4 lists the FLO-2D and HEC-RAS WSEL upstream of the bridge and culverts. The discharge through the bridge and culverts is also listed. As shown in the table the calibration of the bridge and culverts matches well with the HEC-RAS model. The Piedmont-Cropley Culvert WSEL is higher than the desired 0.25 ft difference, but the culvert discharge matches well. During the calibration, it was determined that matching the WSEL resulted in the discharge through the culvert to increase. Since the breakout flow is driven by the amount of discharge leaving the channel, it was decided that matching the bridge discharge was a higher priority than matching the WSEL.

Table 2-4 Upper FLO-2D Model Bridge and Culvert Calibration Results

Bridge	WSEL Upstream (ft)			Bridge Discharge (cfs)		
	HEC-RAS	FLO-2D	Difference	HEC-RAS	FLO-2D	Difference
Old Piedmont Road	220.21	220.20	-0.01	1160	1172	-12
Piedmont Cropley Culvert	195.13	195.46	0.33	1028	1063	-35
Morrill Avenue Culvert	112.94	112.99	0.05	1599	1607	-10

Table 2-5 lists the average reach discharges for the HEC-RAS model and the calibrated Upper FLO-2D model as well as the difference. As seen in the table, the reach discharges compare well between the Upper FLO-2D and the HEC-RAS results for most reaches. The reach between Crosley Creek and Sierra Creek shows a large difference between the two models. The large difference results from the differences in the modeling of Berryessa Creek in the FLO-2D model versus the HEC-RAS model. The channel in FLO-2D is modeled by the main channel handled by the channel routine with overbanks flow handled by the grid system. The discharge reported in the table is the flow in the FLO-2D model channel and does not include the flow in overbank for this reach.

Table 2-5 Upper FLO-2D Model Berryessa Creek Flow Calibration Results

Reach	Average HEC-RAS Discharge (cfs)	Average FLO-2D Discharge (cfs)	Difference (cfs)	% Difference
Upstream to Old Piedmont Rd	1430	1430	0	0
Old Piedmont Rd to Piedmont-Cropley Blvd	1385	1378	-7	-1%
Piedmont-Cropley Blvd to Sweigert Ck	1028	1060	32	3%
Sweigert Ck to Crosley Ck	1128	1100	-28	-2%
Crosley Ck to Sierra Ck	1011	1204	193	19%
Sierra Ck to Morrill Ave	1621	1635	14	1%
Morrill Ave to Cropley Rd	1600	1660	60	4%
Cropley Rd to I-680	1600	1640	40	3%

2.2.8.2 Sierra Creek Channel

The Sierra Creek channel was calibrated to the 10% chance exceedance event of the SCVWD Sierra Creek HEC-RAS model. The 10% chance exceedance discharge was chosen since it was the largest event that did not overflow the channel banks. The SCVWD Sierra Creek HEC-RAS model was developed independently of the GRR and is based on an "infinite wall" geometry, meaning that breakouts along the channel are not modeled and the HEC-RAS program automatically raises the elevation of the ends of channel cross sections to contain the flow. Since breakouts were not modeled, it is impossible to calibrate to any event higher than the channel banks, since the HEC-RAS model's "infinite walls" artificially raised the WSEL and do not account for flow loss to the floodplain. As with the Berryessa Creek channel, the calibration was completed to calibrate the water surface elevations to plus/minus 0.25 feet.

A steady state FLO-2D inflow file was developed to replicate the flow conditions in the HEC-RAS model. Inflow hydrographs were developed for the upstream inflow to Sierra Creek with placeholder values created for the remaining Berryessa Creek inflow locations. The inflow hydrographs ramped up quickly to the steady flow values and were then held steady for the duration of the run. The Upper FLO-2D Model was then run for a six hour duration to ensure that the entire channel system was operating at the full steady flow values.

The Upper Model was calibrated, working from upstream to the downstream. The primary methods used to adjust the model during calibration included:

- Raising/lowering cross section inverts
- Replacing HEC-RAS cross section used for a grid section with a representative cross section
- Removing HEC-RAS cross sections and interpolating between the upstream and downstream cross sections
- Raising/lowering cross section end point (channel bank elevations)
- Revision of Manning's n-values

The water surface elevations at 35 cross sections locations were compared to the FLO-2D grid water surface elevations. Table 2-6 lists the 10% chance exceedance HEC-RAS and FLO-2D water surface elevations at the calibration locations along with the difference.

Table 2-6 Calibration Results for Sierra Creek Channel Upper FLO-2D Model

Point	HEC-RAS Cross Section	FLO-2D Grid Cell	1% Chance Exceedance HEC-RAS Elevation(ft)	1% Chance Exceedance FLO-2D Elevation (ft)	Difference (ft)
1	7266	8044	159.63	160.02	0.39
2	7226	8185	158.18	158.09	-0.09
3	7061	8184	157.76	157.82	0.06
4	6868	8326	156.56	156.57	0.01
5	6694	8325	156.16	156.04	-0.12
6	6500	8466	155.24	155.13	-0.11
7	6295	8608	154.77	154.86	0.09
8	6098	8751	154.1	154.19	0.09
9	5964	8896	153.91	153.91	0
10	5628	8748	151.93	151.86	-0.07
11	5434	8458	146.84	146.73	-0.11
12	5300	8315	146.41	146.43	0.02
13	5241	8172	145.98	146.03	0.05
14	5043	8029	145.56	145.69	0.13
15	4942	7888	145.47	145.49	0.02
16	4937	7616	145.01	145.26	0.25
17	4925	7485	144.06	144.43	0.37
18	4723	7613	143.23	143.13	-0.1
19	4352	7743	135.94	136.06	0.12
20	4152	7879	133.87	133.97	0.1
21	3973	7877	133.49	133.38	-0.11
22	3794	7738	132.67	132.57	-0.1
23	3589	7605	131.69	131.79	0.1
24	3382	7346	130.91	130.89	-0.02
25	3202	7219	130.38	130.26	-0.12
26	2980	6973	129.02	129.03	0.01
27	2547	6395	121.26	121.12	-0.14
28	2344	6286	120.03	120.09	0.06
29	1939	5971	117.76	117.72	-0.04
30	1739	1733	117.15	117.2	0.05
31	1323	1600	114.81	114.77	-0.04
32	939	1509	113.1	113.01	-0.09
33	743	1464	112.33	112.19	-0.14
34	347	1372	110.51	110.48	-0.03
35	155	1373	109.89	110.2	0.31

As shown in the table, the calibration to the water surface elevation was fairly successful with 32 out of 35 calibration points within 0.25 feet of the HEC-RAS model results. All three remaining points are within 0.40 feet of the HEC-RAS WSEL. Two of the points are located at the upstream and downstream end of the channel reach. In similar situations to this, there is difficulty in calibrating the boundary of the channel due to the differences in how HEC-RAS and FLO-2D handle channel boundary conditions. The final point is located upstream of a pedestrian bridge. Using a rating table to simulate the HEC-RAS bridge routine can similarly cause calibration issues.

2.3 Alternative 5 Upper Berryessa GRR FLO-2D Model

Alternative 5 is the only alternative in the final array of alternatives with a project component upstream of the I-680 culvert. The Upper Berryessa Alternative 5 FLO-2D model was developed by modifying the without-project Upper Berryessa FLO-2D model to include the proposed Alternative 5 channel improvements.

Alternative 5 (also referred to as the Authorized Project) includes channel improvements along the existing alignment with new levees proposed in the greenbelt reach. The modifications to the Without-Project Upper FLO-2D Model include the following:

- Modifying the channel elements to reflect the Alternative 5 configuration
- Adding levees to the Greenbelt Reach
- Updating the rating tables for the bridges and culverts modified in Alternative 5
- Calibrating Berryessa Creek to the Alternative 5 HEC-RAS model

The following sections discuss in more detail the revisions made to the Alternative 5 Upper FLO-2D Model.

2.3.1 Channel

The Berryessa Creek channel in the Alternative 5 Upper Berryessa Flo-2D model was updated to reflect the Alternative 5 design. The Alternative 5 channel follows the same alignment as the without-project Berryessa Creek alignment as shown in Figure 2-6.

2.3.2 Levees

Levees were added to the FLO-2D models to represent the proposed levees in the Greenbelt Reach for Alternative 5. The levees were coded using the crest elevations from the Authorized Project profile sheets using the Levee Express tool in the GDS preprocessor program. The levees in the Alternative 5 Upper Berryessa Creek FLO-2D Model extend from upstream of the drop structure near Morrill Avenue to the Piedmont Cropley Culvert. A set of parallel levees were coded into the Alternative 5 Upper FLO-2D Model to represent the levees located on each side of the Berryessa Creek channel along the greenbelt reach. Figure 2-7 shows the extent of the levees in the model.

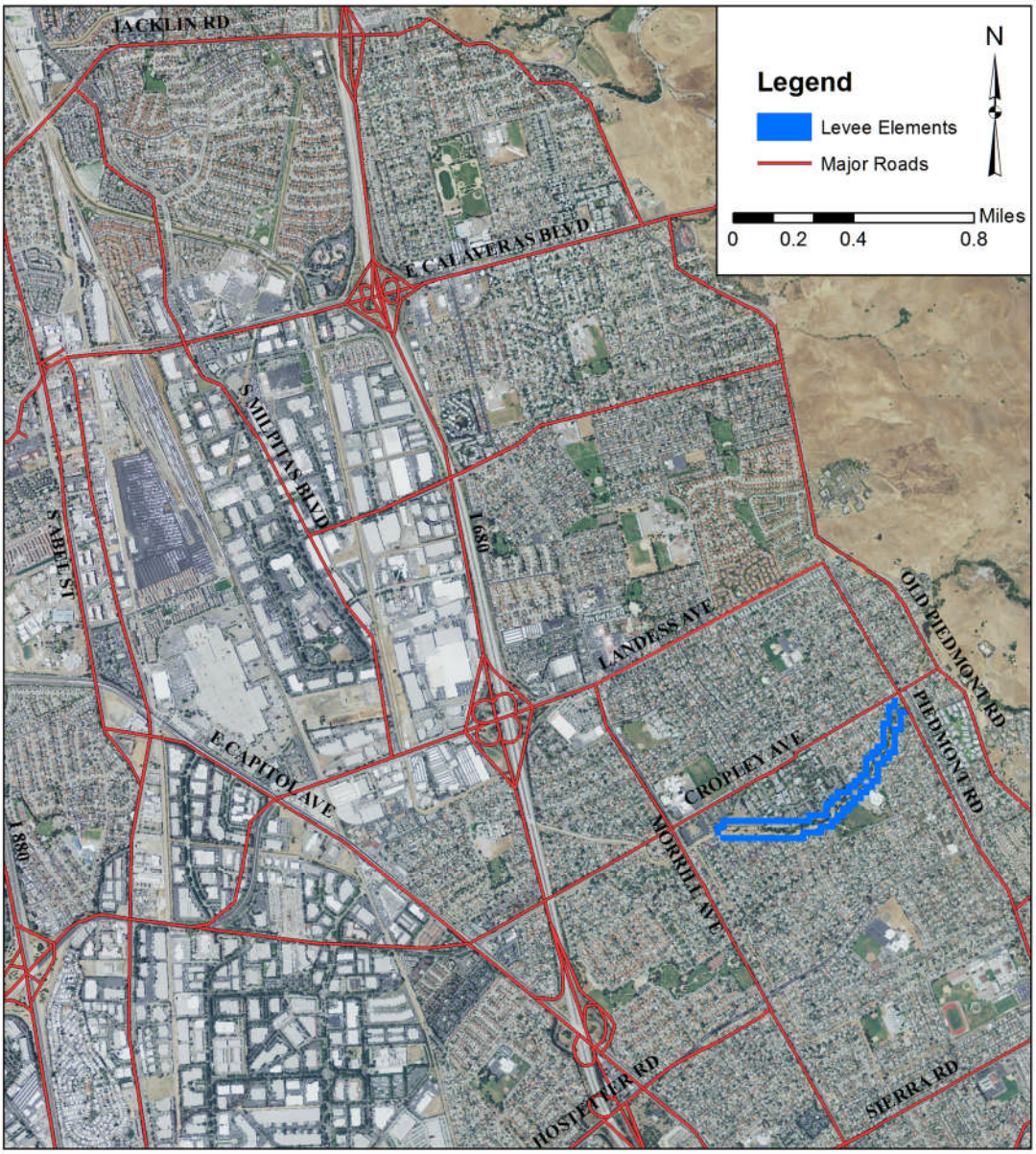

Figure 2-7 Levees in Upper FLO-2D Model

2.3.3 Hydraulic Structures

The Upper Berryessa FLO-2D model contains five hydraulic structures along the Berryessa Creek channel consisting of four bridges and one drop structure. The rating tables for each of the bridges were revised using rating tables derived from the Alternative 5 HEC-RAS model. Since the existing drop structure is to remain in the Alternative 5 design, the associated rating table was not updated.

Table 2-7 lists the hydraulic structures which were updated for the Alternative 5 Upper Berryessa FLO-2D Model.

Table 2-7 Hydraulic Structures Updated for Alternative 5 Upper Berryessa FLO-2D Model

Structure Name	Description	Inlet Node	Outlet Node
OldPied	Old Piedmont Road Bridge over Berryessa Creek	3106	3075
PiedCrop	Berryessa Creek culvert under Piedmont and Cropley Streets	3038	2967
Morrill	Berryessa Creek culvert under Morrill Avenue	1279	1230
Cropley	Berryessa Creek Culvert under Cropley Street	890	840

2.3.4 FLO-2D Inflow File

The FLO-2D input file was used to introduce the inflow hydrographs to the model grid system. A unique FLO-2D inflow data file was developed for each frequency flow event combination modeled. The input data file for the Upper Model consisted of four discreet inflow hydrographs to the channel system. The inflow hydrographs were introduced to the system at the following locations:

- Grid 3142 - upstream end of the Berryessa Creek channel above Old Piedmont Road
- Grid 2850 - Sweigert Creek culvert outlet to Berryessa Creek located in the upper portion of the Greenbelt
- Grid 2334 - Crosley Creek culvert outlet to Berryessa Creek located in the lower portion of the Greenbelt
- Grid 8044 - Sierra Creek culvert outlet at upstream end of the Sierra Creek channel at Mauna Kea Lane

The inflow hydrographs were developed for each of the locations as described in Section 1.3.2.1 and compiled into a FLO-2D inflow data files.

2.3.5 Upper Model FLO-2D Calibration

The Alternative 5 Berryessa Creek HEC-RAS model was used to calibrate the modified Berryessa Creek channel to ensure that the FLO-2D channel system was accurately simulating the in-channel flows. The Berryessa Creek channel segments in the Alternative 5 Upper FLO-2D Model were calibrated to the 1% chance exceedance steady state baseline Alternative 5 Berryessa Creek HEC-RAS model (see *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*). The calibration was completed to ensure that FLO-2D channels accurately reflect the Berryessa Creek channel. Two primary goals were established for the calibration:

1. Calibrate the water surface elevations to plus/minus 0.25 feet
2. Calibrate the bridge capacities and overflow characteristics at the three major breakout points in the Upper Model: Old Piedmont Bridge, Piedmont-Cropley Culvert, and Morrill Avenue Culvert

A steady state FLO-2D inflow file was developed to replicate the flow conditions in the HEC-RAS model. Inflow hydrographs were developed for each of the four inflow locations. The inflow hydrographs ramped up quickly to the steady flow values and were then held steady for the duration of the run. The Upper FLO-2D Model was run for a five hour duration to ensure that the entire channel system was at a steady state condition.

The Upper Model was calibrated using the following methods:

- Raising/lowering cross section inverts
- Replacing HEC-RAS cross section used for a grid section with a more representative cross section
- Removing HEC-RAS cross sections and interpolating between the upstream and downstream cross sections
- Raising/lowering cross section end point (channel bank elevations)
- Revision of Manning's n-values

The water surface elevations at 39 cross section locations were compared to the FLO-2D grid water surface elevations. Table 2-8 lists the 1% chance exceedance HEC-RAS and FLO-2D water surface elevations at the calibration locations along with the difference.

As shown in the table, the FLO-2D model calibrates well with 36 out of 39 calibration points within 0.25 feet of the HEC-RAS model results. Of the three remaining points, two are within .35 feet of the HEC-RAS locations with the last point being 0.72 feet higher than the HEC-RAS WSEL. The locations with difference greater than 0.25 ft are at locations such as upstream of bridges or a grade break and at the beginning and end of the channel system.

Table 2-8 Calibration Results for Berryessa Creek Channel Upper FLO-2D Model

Point	HEC-RAS Cross Section	FLO-2D Grid Cell	1% Chance Exceedance HEC-RAS Elevation(ft)	1% Chance Exceedance FLO-2D Elevation (ft)	Difference (ft)
1	36242	3142	243.09	242.81	-0.28
2	36126	3141	240.37	240.61	0.22
3	36032	3140	238.01	238.2	0.19
4	35476	3110	220.69	220.48	-0.22
5	35191	3106	218.13	218.08	-0.07
6	35139	3075	212.19	212.22	0.21
7	34989	3104	208.74	208.65	0.02
8	34694	3071	202.29	202.63	0.07
9	34467	3038	197.64	197.46	-0.04
10	34032	2967	186.85	187.04	0.21
11	33804	2930	186.55	186.45	-0.08
12	33485	2891	182.58	182.44	-0.14
13	33207	2852	176.78	176.67	-0.12
14	32976	2850	172.47	172.38	-0.09
15	32721	2771	168.64	168.56	-0.08
16	32436	2728	163.45	163.39	-0.08
17	32333	2727	161.2	161.21	0
18	31969	2642	156.17	156.11	-0.07
19	31559	2468	151.21	151.11	-0.09
20	31168	2334	145.07	145	-0.05
21	30978	2291	142.49	142.37	-0.11
22	30808	2247	139.84	140.01	0.19
23	30701	2202	137.98	138.02	0.07
24	30478	2114	134.71	134.64	-0.05
25	30327	2069	133.32	133.36	0.09
26	30195	1979	131.87	131.78	-0.04
27	29983	1842	128.39	128.29	-0.08
28	29873	1797	126.75	126.83	0.09
29	29433	1613	122.28	122.26	0.04
30	28758	1375	111.56	111.43	-0.33
31	28699	1326	111.56	111.68	-0.06
32	28307	1182	102.95	102.97	-0.02
33	27895	938	102.89	102.72	-0.14
34	27642	890	102.4	102.36	0
35	27380	788	95.59	96.57	0.11
36	26889	524	90.9	91.3	0.03
37	26695	418	89.24	89.25	-0.14
38	26419	168	84.86	83.17	0.72
39	25688	43	72.91	73.18	0.01

The second goal of the calibration was to ensure that the three bridges where flow breakouts occur are accurately modeled. Table 2-9 lists the FLO-2D and HEC-RAS WSEL upstream of the bridge and culverts as well as the discharge through the bridge and culverts. As shown in the table, the discharges predicted by the FLO-2D model and the HEC-RAS match, except at the Old Piedmont Road Bridge. The Piedmont-Cropley Culvert WSEL is higher than the desired 0.25 foot difference, but the culvert discharge matches well. During the calibration, it was determined that matching the WSEL resulted in the discharge through the culvert to increase. Since the breakout flow is driven by the amount of discharge leaving the channel, it was decided that matching the bridge discharge was a higher priority than matching the WSEL.

Table 2-9 Upper FLO-2D Model Bridge and Culvert Calibration Results

Bridge	WSEL Upstream (ft)			Bridge Discharge (cfs)		
	HEC-RAS	FLO-2D	Difference	HEC-RAS	FLO-2D	Difference
Old Piedmont Road	218.13	218.07	-0.05	1376	1434	+58
Piedmont Cropley Culvert	197.64	197.45	-0.19	1430	1432	-8
Morrill Avenue Culvert	110.51	110.91	+.40	2140	2156	+16

Table 2-10 lists the average reach discharges for the HEC-RAS model and the calibrated Upper FLO-2D model as well as the difference. As shown in the table, the reach discharges compare well between the Upper FLO-2D and the HEC-RAS results for most reaches.

Table 2-10 Upper FLO-2D Model Berryessa Creek Flow Calibration Results

Reach	Average HEC-RAS Discharge (cfs)	Average FLO-2D Discharge (cfs)	Difference (cfs)	% Difference
Upstream to Old Piedmont Rd	1394	1435	+41	2.9%
Old Piedmont Rd to Piedmont-Cropley Blvd	1421	1485	+64	4.5%
Piedmont-Cropley Blvd to Sweigert Ck	1420	1433	+13	1.0%
Sweigert Ck to Sierra Ck	1530	1512	-18	1.1%
Sierra Ck to Morrill Ave	2140	2139	-1	0.0%
Morrill Ave to Cropley Rd	2140	2140	0	0.0%
Cropley Rd to I-680	2140	2140	0	0.0%

CHAPTER 3: WITHOUT-PROJECT FLOODPLAINS

Without-project floodplains were developed for the Berryessa Creek study area using the Upper and Lower FLO-2D models (as described in Chapter 2) and the HEC-RAS without-project model results (as described in *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*) using both the Original GRR and Revised GRR methodologies.

3.1 Original GRR Modeling Results

3.1.1 FLO-2D Flow Inputs

The input to the Upper and Lower FLO-2D models was created using the original GRR methodology discussed in Chapters 1 and 2. Only the inflow hydrographs were adjusted for the various FLO-2D simulations, the same data files for the physical features and channel geometry were applied for all alternatives and events. Table 3-1 to Table 3-7 list the resulting channel flow and breakout flows for each of the flow change locations used in the without-project HEC-RAS model. The original input into the HEC-RAS model is listed in *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*.

Table 3-1 Original GRR Model Results for Without-Project Conditions – 20% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	420		
Breakout at Old Piedmont Road Bridge	35249	420		0
Sweigert Creek - Old Location	35029	420		
Breakout at Cropley/Piedmont Culvert	34041	420		0
Inflow at Sweigert Creek – Corrected Location	33136	450	98	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	450		0
Inflow at Crosley Creek	30478	450	123	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	450		0
Inflow at Sierra Creek	28656	710	442	
Breakout at Morrill Avenue Culvert	28447	710		0
Downstream Cropley Avenue	25744	710		
I-680 Culvert	25296	710		
Lateral Weir Breakout Upstream of Montague	25295-21832	710		0
Inflow at Montague Avenue	21821	960	375	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	960		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	960		0
Inflow at Yosemite Avenue	17465	960	138	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	960		0
Inflow from Piedmont Creek	16437	1350	286	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1197		153
Inflow from Los Coches Creek	14422	1566	392	
Calaveras Boulevard	13887	1566		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 3-2 Original GRR Model Results for Without-Project Conditions - 10% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	560		
Breakout at Old Piedmont Road Bridge	35249	560		0
Sweigert Creek - Old Location	35029	560		
Breakout at Cropley/Piedmont Culvert	34041	560		0
Inflow at Sweigert Creek – Corrected Location	33136	600	118	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	598		2
Inflow at Crosley Creek	30478	598	148	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	598		0
Inflow at Sierra Creek	28656	827	495	
Breakout at Morrill Avenue Culvert	28447	827		0
Downstream Cropley Avenue	25744	827		
I-680 Culvert	25296	827		
Lateral Weir Breakout Upstream of Montague	25295-21832	830		0
Inflow at Montague Avenue	21821	1120	451	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1120		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1120		0
Inflow at Yosemite Avenue	17465	1170	162	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1170		0
Inflow from Piedmont Creek	16437	1600	501	
560Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1265		335
Inflow from Los Coches Creek	14422	1725	518	
Calaveras Boulevard	13887	1725		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 3-3 Original GRR Model Results for Without-Project Conditions - 4% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	830		
Breakout at Old Piedmont Road Bridge	35249	830		0
Sweigert Creek - Old Location	35029	830		
Breakout at Cropley/Piedmont Culvert	34041	830		0
Inflow at Sweigert Creek – Corrected Location	33136	890	212	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	786		104
Inflow at Crosley Creek	30478	786	245	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	786		0
Inflow at Sierra Creek	28656	1155	778	
Breakout at Morrill Avenue Culvert	28447	1155		0
Downstream Cropley Avenue	25744	1155		
I-680 Culvert	25296	1155		
Lateral Weir Breakout Upstream of Montague	25295-21832	1260		0
Inflow at Montague Avenue	21821	1620	684	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1515		171
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1515		0
Inflow at Yosemite Avenue	17465	1664	2236	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1664		0
Inflow from Piedmont Creek	16437	2335	861	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1361		974
Inflow from Los Coches Creek	14422	1981	757	
Calaveras Boulevard	13887	1981		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 3-4 Original GRR Model Results for Without-Project Conditions - 2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1090		
Breakout at Old Piedmont Road Bridge	35249	1082		8
Sweigert Creek - Old Location	35029	1082		
Breakout at Cropley/Piedmont Culvert	34041	1023		59
Inflow at Sweigert Creek – Corrected Location	33136	1113	250	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1000		113
Inflow at Crosley Creek	30478	1000	277	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1000		0
Inflow at Sierra Creek	28656	1450	968	
Breakout at Morrill Avenue Culvert	28447	1450		0
Downstream Cropley Avenue	25744	1450		
I-680 Culvert	25296	1630		
Lateral Weir Breakout Upstream of Montague	25295-21832	1103		460
Inflow at Montague Avenue	21821	1492	791	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1417		79
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1417		0
Inflow at Yosemite Avenue	17465	1597	265	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1597		0
Inflow from Piedmont Creek	16437	2245	1049	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1287		1146
Inflow from Los Coches Creek	14422	2127	972	
Calaveras Boulevard	13887	2127		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 3-5 Original GRR Model Results for Without-Project Conditions - 1% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1430		
Breakout at Old Piedmont Road Bridge	35249	1385		45
Sweigert Creek - Old Location	35029	1385		
Breakout at Cropley/Piedmont Culvert	34041	1028		357
Inflow at Sweigert Creek – Corrected Location	33136	1128	308	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1011		117
Inflow at Crosley Creek	30478	1011	372	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1011		0
Inflow at Sierra Creek	28656	1621	1458	
Breakout at Morrill Avenue Culvert	28447	1599		22
Downstream Cropley Avenue	25744	1599		
I-680 Culvert	25296	1716		
Lateral Weir Breakout Upstream of Montague	25295-21832	898		818
Inflow at Montague Avenue	21821	1535	922	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1812		170
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1812		0
Inflow at Yosemite Avenue	17465	1941	302	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1917		24
Inflow from Piedmont Creek	16437	2881	1338	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1214		1667
Inflow from Los Coches Creek	14422	2315	1253	
Calaveras Boulevard	13887	2315		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 3-6 Original GRR Model Results for Without-Project Conditions - 0.5% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1820		
Breakout at Old Piedmont Road Bridge	35249	1662		158
Sweigert Creek - Old Location	35029	1662		
Breakout at Cropley/Piedmont Culvert	34041	1054		608
Inflow at Sweigert Creek – Corrected Location	33136	1194	365	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1059		135
Inflow at Crosley Creek	30478	1319	477	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1306		13
Inflow at Sierra Creek	28656	1746	1493	
Breakout at Morrill Avenue Culvert	28447	1505		241
Downstream Cropley Avenue	25744	1505		
I-680 Culvert	25296	2660		
Lateral Weir Breakout Upstream of Montague	25295-21832	835		1825
Inflow at Montague Avenue	21821	1662	1077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1546		204
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1546		0
Inflow at Yosemite Avenue	17465	1636	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1636		0
Inflow from Piedmont Creek	16437	2628	1691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1079		1757
Inflow from Los Coches Creek	14422	2360	1583	
Calaveras Boulevard	13887	2325		35

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 3-7 Original GRR Model Results for Without-Project Conditions - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	1848		283
Sweigert Creek - Old Location	35029	1848		
Breakout at Cropley/Piedmont Culvert	34041	1068		782
Inflow at Sweigert Creek – Corrected Location	33136	1238	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1090		145
Inflow at Crosley Creek	30478	1392	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1372		19
Inflow at Sierra Creek	28656	1913	1848	
Breakout at Morrill Avenue Culvert	28447	1496		416
Downstream Cropley Avenue	25744	1469		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	689		2451
Inflow at Montague Avenue	21821	1764	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1604		250
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1604		0
Inflow at Yosemite Avenue	17465	1547	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1547		0
Inflow from Piedmont Creek	16437	2487	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	993		2032
Inflow from Los Coches Creek	14422	2297	1848	
Calaveras Boulevard	13887	2444		97

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

3.1.2 FLO-2D Model Results

The without-project Upper and Lower FLO-2D models were run for the 20, 4, 2, 1, 0.5, and 0.2 percent chance exceedance flood events developed using the original GRR methodology. Each run had a total simulation time of 32 hours. Following the completion of the flood simulations, the FLO-2D post-processor program Mapper was used to develop ArcMap flood depth and flood water surface elevation shapefiles from the Upper and Lower FLO-2D model results. The flood depth shapefiles were used to create floodplain maps for each simulated event using standard ArcMap tools. The flood depth shapefiles for the Upper and Lower FLO-2D models were combined for each simulated event to create a complete study area floodplain. Figure 3-1 to Figure 3-7 show the resulting without-project floodplains for the 20% to 0.2% chance exceedance flood events for the Berryessa Creek study area. Since there are no breakouts for the 50% chance exceedance event, the FLO-2D models were not run for this event.

The FLO-2D floodplain water surface elevation shapefiles were used to assign water surface elevations to the parcel economic data. Using the geoprocessing tools in ArcMap, the floodplain water surface elevations were assigned to the parcel map shapefile representing the structures in the floodplain. The parcel data amended with the structure water surface elevations was used in the subsequent economic analysis.

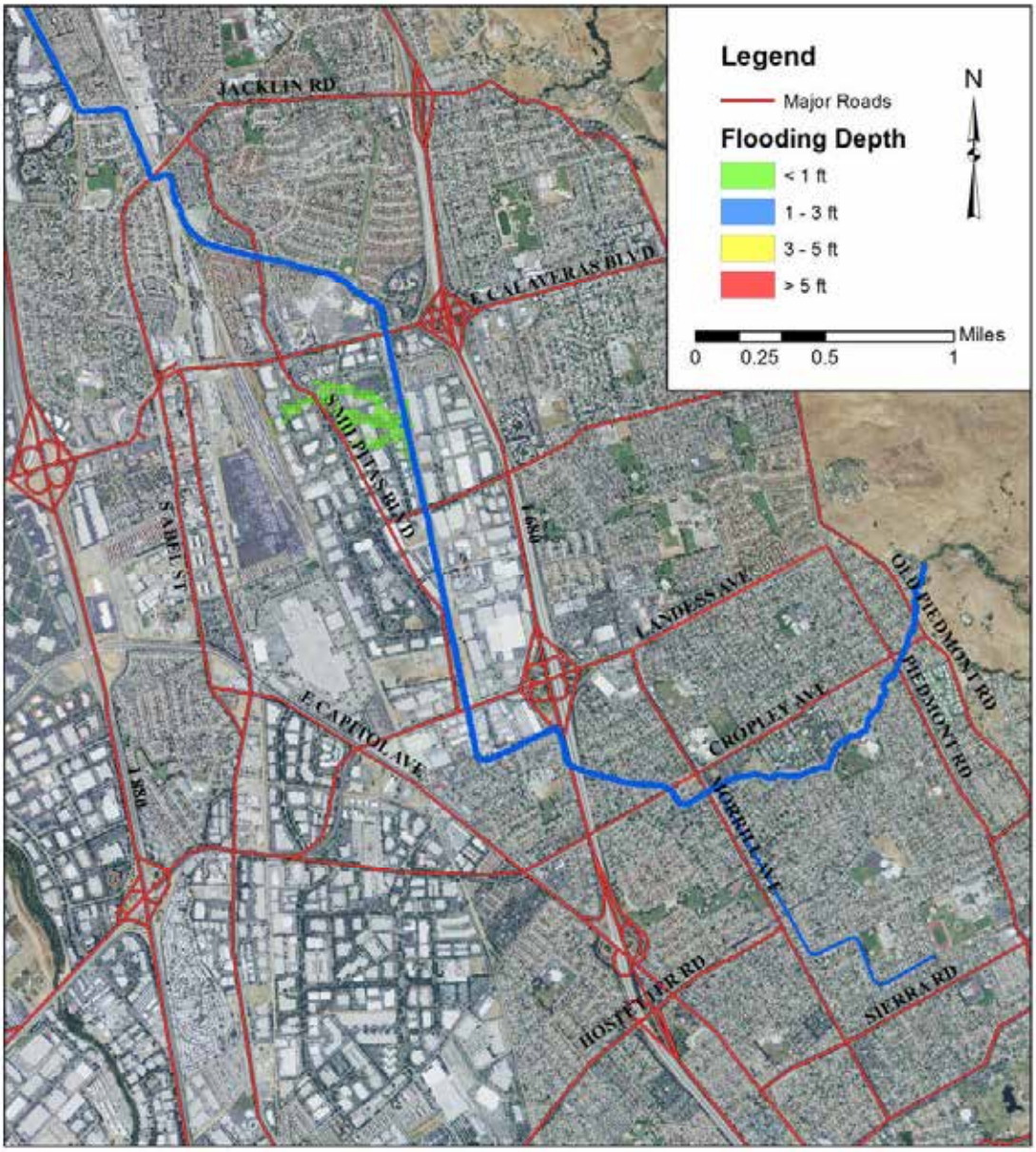

Figure 3-1 20% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without-Project Condition

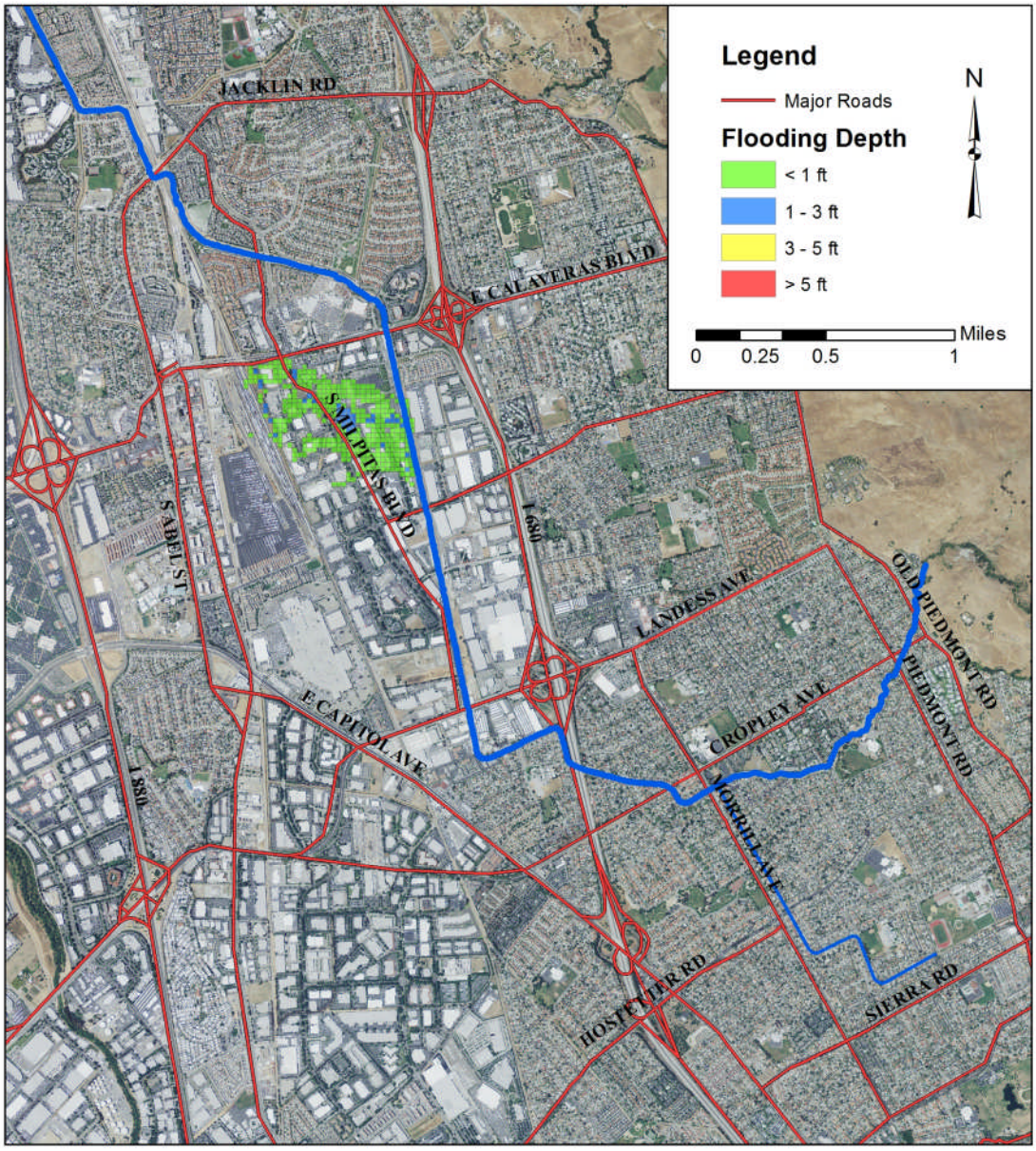

Figure 3-2 10% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without-Project Condition

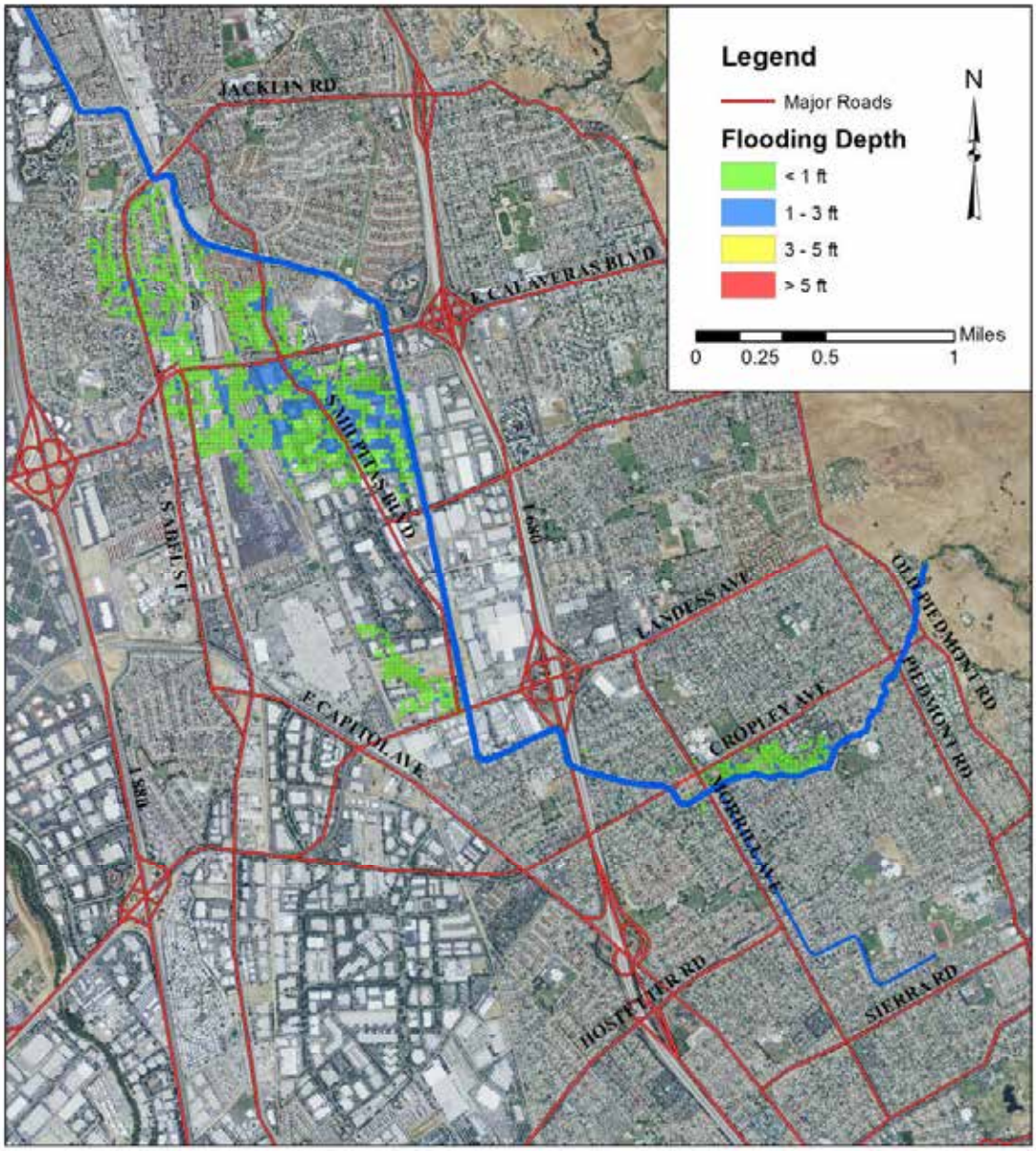

Figure 3-3 4% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without Project Condition

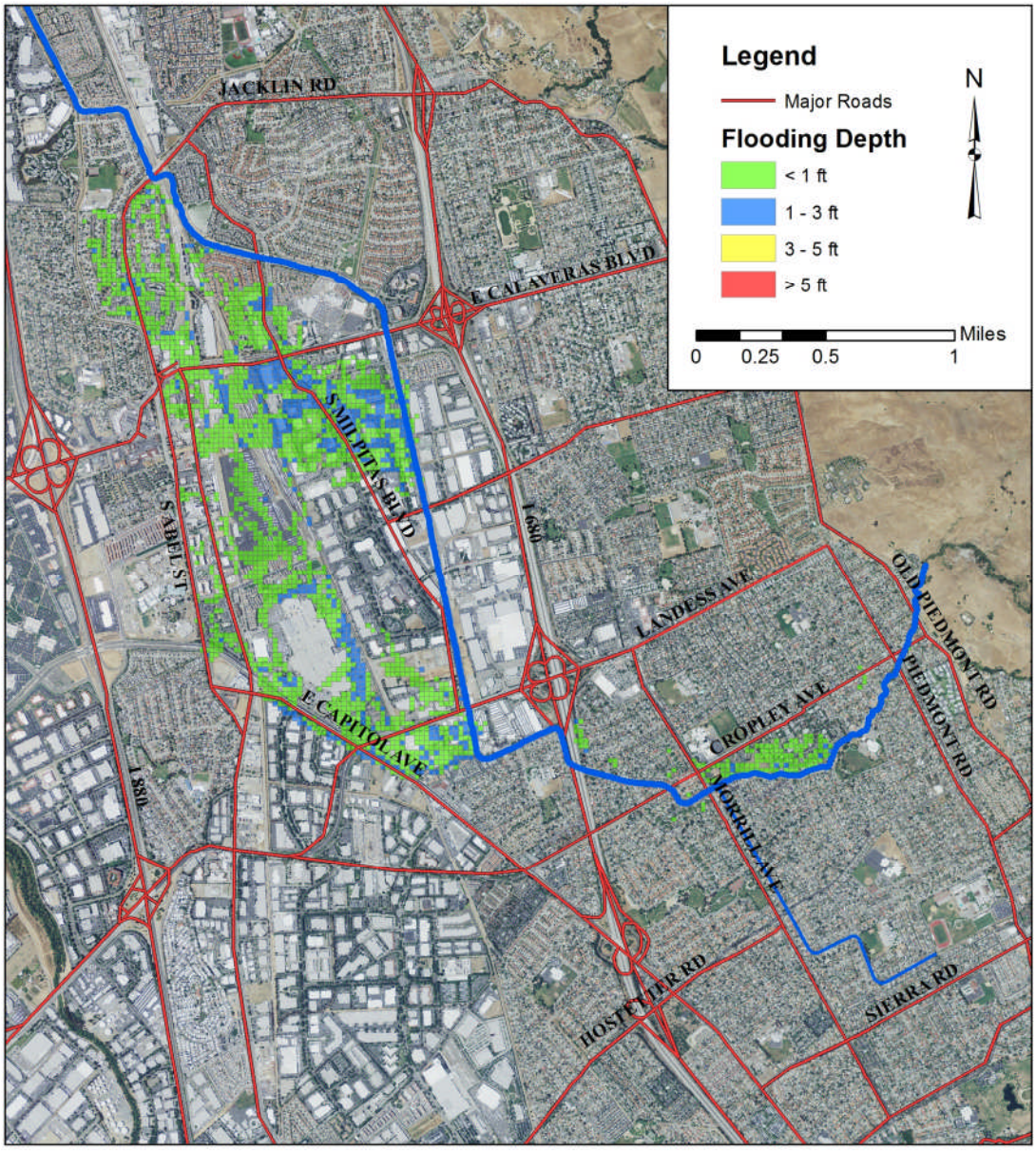

Figure 3-4 2% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without-Project Condition

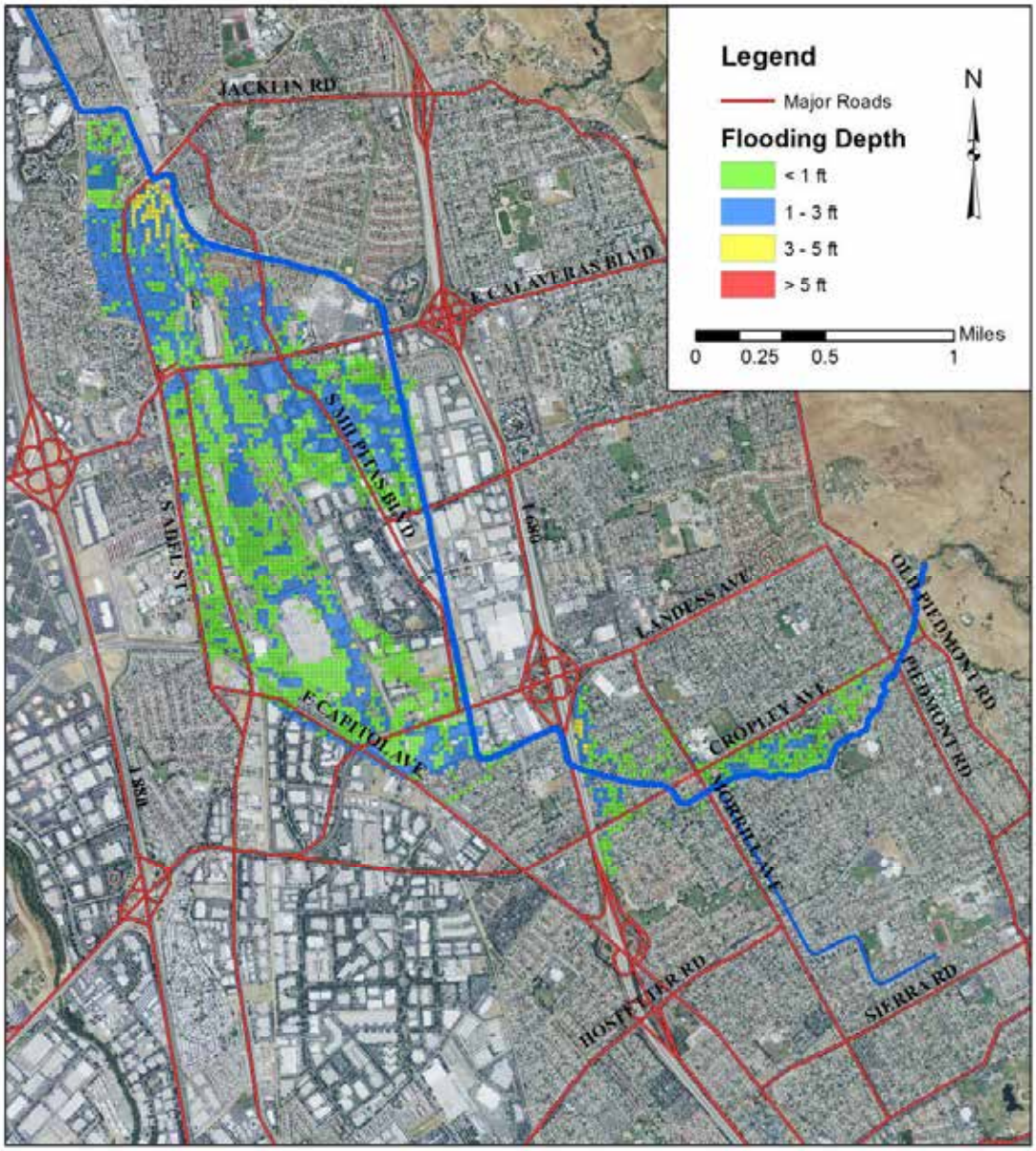

Figure 3-5 1% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without-Project Condition

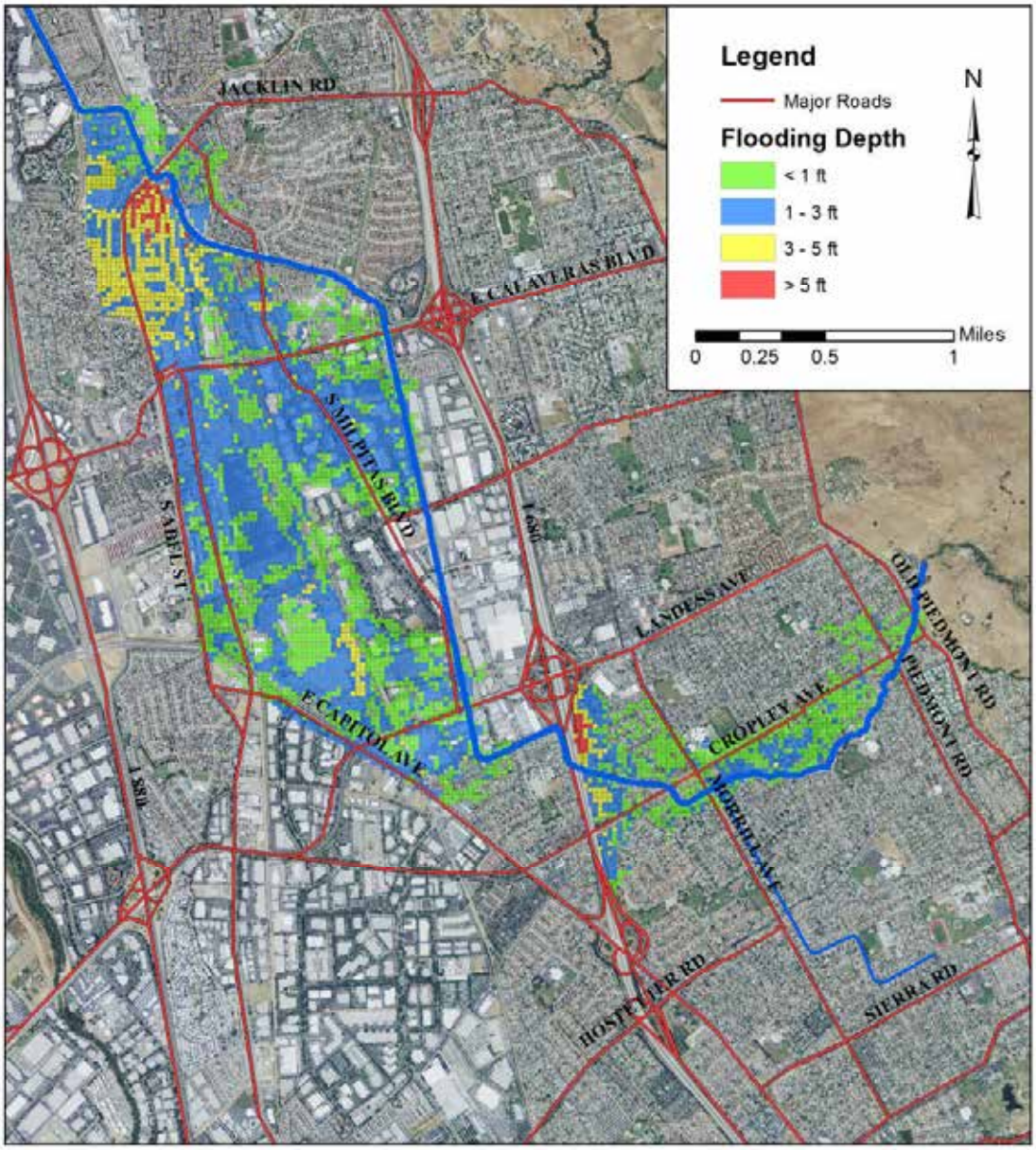

Figure 3-6 0.5% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without-Project Condition

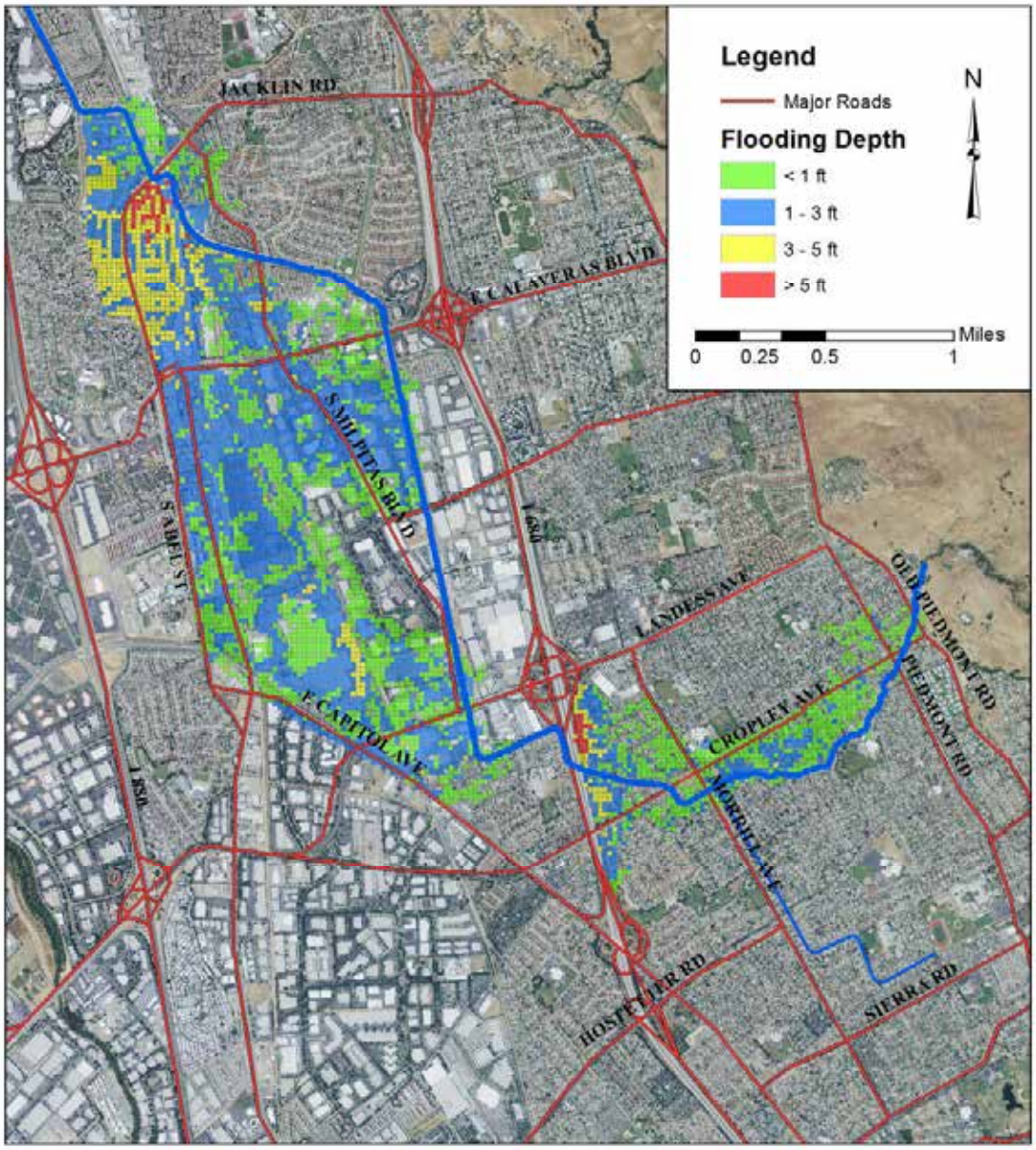

Figure 3-7 0.2% Chance Exceedance Flood Event Floodplain for the Original GRR Model Without-Project Condition

3.1.3 Original GRR Model Results Comparison to FEMA Floodplain

The FEMA 1 percent (100-year) floodplain was compared to the Original GRR Model Without-Project 1% chance exceedance flood event floodplain. Figure 3-8 compares the 1% chance exceedance without-project floodplain with the currently accepted FEMA 1 percent (100-year) floodplain. The FEMA floodplain is mapped on the following FEMA map panels.

- Panel 9 of 64 of City of San Jose, Santa Clara County California FIRM, Community Panel Number 060349 0009G revised August 17, 1998
- Panel 10 of 64 of City of San Jose, Santa Clara County California FIRM, Community Panel Number 060349 0010E revised August 17, 1998
- Panel 1 of 4 of the City of Milpitas, Santa Clara County, California FIRM, County Panel Number 060344 0001G revised June 22, 1998
- Panel 3 of 4 of the City of Milpitas, Santa Clara County, California FIRM, County Panel Number 060344 0003G revised June 22, 1998

The FEMA floodplain shows the results of a commingled floodplain resulting from Berryessa Creek overflows plus a number of other contributing flood sources in the study area including Sweigert Creek, Sierra Creek, and Penitencia Creek. (The Penitencia Creek floodplain no longer occurs due to the Penitencia Creek Project.) Floodplains specific to these flows were not part of the current GRR, although the hydrology and design have always considered that discharges associated with Sweigert and Sierra Creeks are conveyed to Berryessa Creek.

Upstream of I-680, as seen in Figure 3-8, the without-project and FEMA floodplains generally agree considering that the majority of the flooding to the south of the creek upstream of Morrill Avenue is the result of Sierra and Sweigert Creek breakouts. However, the following differences were observed between the two floodplains. Except as noted above (commingling and independent tributary floodplains) and in the individual items below, the differences are due to the increased accuracy of the FLO-2D model as well as where the breakouts were assumed to occur in the older HEC-2 model.

- The current without-project floodplain shows a small amount of additional flooding from the Old Piedmont Road Bridge breakout to the northwest that is not present in the FEMA floodplain.

- The current without-project floodplain shows a small amount of flooding to the north of Cropley Avenue upstream of Morrill Avenue.

- A small breakout from Berryessa Creek is present in the current without-project floodplain just downstream of the I-680 culvert.

- The breakout from upstream of Montague Expressway in the current without-project floodplain shows flooding to the northwest that is not in the FEMA floodplain. This flow follows the prevailing topography and is considered more accurate.

- The current without-project floodplain shows the area just north of Montague and east of Capitol Avenue to be flooded where the FEMA floodplain contains areas that are not flooded. The FEMA floodplain assumed that a railroad embankment contained flows in this area, whereas the area actually consists of low-lying land that receives water from surrounding and adjacent overflow areas.

- The current without-project floodplain shows breakouts near Yosemite flowing to the northwest and west, compared to the FEMA floodplain. This flow follows the prevailing topography and is considered more accurate.

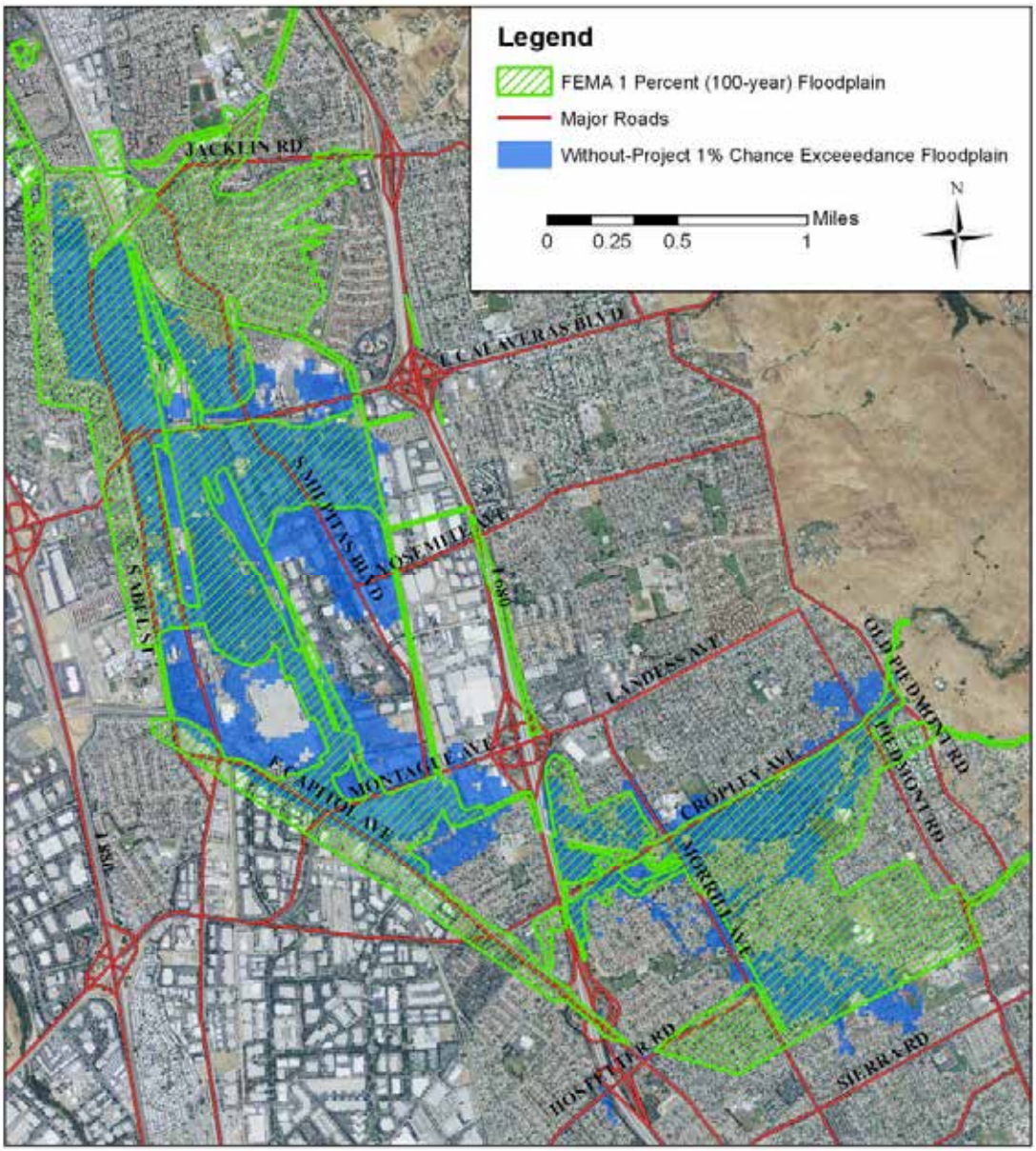

Figure 3-8 Comparison of the FEMA Floodplain and the Original GRR Model Without-Project 1% Chance Exceedance Flood Event Floodplain

3.2 Revised GRR Modeling Results

3.2.1 FLO-2D Flow Inputs

The input to the Upper and Lower FLO-2D models was created using the Revised GRR Methodology as discussed in Chapters 1 and 2. Only the inflow hydrographs were adjusted for the various FLO-2D simulations, the same data files for the physical features and channel geometry were applied for all frequency events. Table 3-8 to Table 3-14 list the resulting channel flow and breakout flows for each of the flow change locations used in the without-project HEC-RAS model. The original input into the HEC-RAS model is listed in *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*. Since the 50% chance exceedance event did not incur breakouts from the channel, no breakout table was developed for this report.

Table 3-8 Revised GRR Model Results for Without-Project Conditions - 20% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	420		
Breakout at Old Piedmont Road Bridge	3106[2]	420		
Sweigert Creek - Old Location	3072[2]	420		
Breakout at Cropley/Piedmont Culvert	3038[2]	420		
Inflow at Sweigert Creek – Corrected Location	2850[2]	445	100	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	445		
Inflow at Crosley Creek	2334[2]	510	126	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	510		
Inflow at Sierra Creek	1326[2]	695	140	
Breakout at Morrill Avenue Culvert	1279[2]	692		3
Downstream Cropley Avenue	788[2]	692		
I-680 Culvert	25296[3]	698		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	689		0
Inflow at Montague Avenue	21821[3]	963	382	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	963		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	960		0
Inflow at Yosemite Avenue	17448[3]	960	149	
Inflow from Piedmont Creek	16437[3]	1374	387	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1196		153
Inflow from Los Coches Creek	14422[3]	1623	429	
Calaveras Boulevard	13887[3]	1625		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 3-9 Revised GRR Model Results for Without-Project Conditions - 10% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	564		
Breakout at Old Piedmont Road Bridge	3106[2]	564		0
Sweigert Creek - Old Location	3072[2]	564		
Breakout at Cropley/Piedmont Culvert	3038[2]	564		0
Inflow at Sweigert Creek – Corrected Location	2850[2]	604	129	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	590		14
Inflow at Crosley Creek	2334[2]	662	163	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	662		0
Inflow at Sierra Creek	1326[2]	847	492	
Breakout at Morrill Avenue Culvert	1279[2]	846		0
Downstream Cropley Avenue	788[2]	953		
I-680 Culvert	25296[3]	953		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	913		40
Inflow at Montague Avenue	21821[3]	1234	461	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	1233		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	1228		0
Inflow at Yosemite Avenue	17448[3]	1300	175	
Inflow from Piedmont Creek	16437[3]	1714	450	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1327		387
Inflow from Los Coches Creek	14422[3]	1880	559	
Calaveras Boulevard	13887[3]	1880		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 3-10 Revised GRR Model Results for Without-Project Conditions - 4% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	829		
Breakout at Old Piedmont Road Bridge	3106[2]	829		0
Sweigert Creek - Old Location	3072[2]	829		
Breakout at Cropley/Piedmont Culvert	3038[2]	829		0
Inflow at Sweigert Creek – Corrected Location	2850[2]	890	212	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	808		82
Inflow at Crosley Creek	2334[2]	896	225	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	895		0
Inflow at Sierra Creek	1326[2]	1156	778	
Breakout at Morrill Avenue Culvert	1279[2]	1149		0
Downstream Cropley Avenue	788[2]	1145		
I-680 Culvert	25296[3]	1145		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	912		78
Inflow at Montague Avenue	21821[3]	1471	692	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	1443		26
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	1407		27
Inflow at Yosemite Avenue	17448[3]	1520	244	
Inflow from Piedmont Creek	16437[3]	2181	715	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1376		696
Inflow from Los Coches Creek	14422[3]	2205	833	
Calaveras Boulevard	13887[3]	2203		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 3-11 Revised GRR Model Results for Without-Project Conditions - 2% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	1094		
Breakout at Old Piedmont Road Bridge	3106[2]	1037		57
Sweigert Creek - Old Location	3072[2]	1090		
Breakout at Cropley/Piedmont Culvert	3038[2]	1049		41
Inflow at Sweigert Creek – Corrected Location	2850[2]	1118	257	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	932		186
Inflow at Crosley Creek	2334[2]	1032	275	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1032		0
Inflow at Sierra Creek	1326[2]	1429	968	
Breakout at Morrill Avenue Culvert	1279[2]	1418		10
Downstream Cropley Avenue	788[2]	1405		
I-680 Culvert	25296[3]	1398		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	834		252
Inflow at Montague Avenue	21821[3]	1535	811	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	1484		50
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	1358		46
Inflow at Yosemite Avenue	17448[3]	1550	275	
Inflow from Piedmont Creek	16437[3]	2305	821	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1325		859
Inflow from Los Coches Creek	14422[3]	2346	868	
Calaveras Boulevard	13887[3]	2345		39

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 3-12 Revised GRR Model Results for Without-Project Conditions - 1% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	1428		
Breakout at Old Piedmont Road Bridge	3106[2]	1170		258
Sweigert Creek - Old Location	3072[2]	1462		
Breakout at Cropley/Piedmont Culvert	3038[2]	1063		399
Inflow at Sweigert Creek – Corrected Location	2850[2]	1174	308	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	966		208
Inflow at Crosley Creek	2334[2]	1083	329	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1088		0
Inflow at Sierra Creek	1326[2]	1605	1421	
Breakout at Morrill Avenue Culvert	1279[2]	1560		45
Downstream Cropley Avenue	788[2]	1540		
I-680 Culvert	25296[3]	1544		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	700		484
Inflow at Montague Avenue	21821[3]	1579	928	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	1506		68
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	1416		73
Inflow at Yosemite Avenue	17448[3]	1611	317	
Inflow from Piedmont Creek	16437[3]	2393	858	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1295		1065
Inflow from Los Coches Creek	14422[3]	2534	928	
Calaveras Boulevard	13887[3]	2373		163

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 3-13 Revised GRR Model Results for Without-Project Conditions - 0.5% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	1818		
Breakout at Old Piedmont Road Bridge	3106[2]	1180		738
Sweigert Creek - Old Location	3072[2]	1726		
Breakout at Cropley/Piedmont Culvert	3038[2]	1098		628
Inflow at Sweigert Creek – Corrected Location	2850[2]	1230	379	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	1013		217
Inflow at Crosley Creek	2334[2]	1171	375	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1227		0
Inflow at Sierra Creek	1326[2]	1688	1493	0
Breakout at Morrill Avenue Culvert	1279[2]	1630		58
Downstream Cropley Avenue	788[2]	1608		
I-680 Culvert	25296[3]	1611		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	626		822
Inflow at Montague Avenue	21821[3]	1646	1072	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	1554		91
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	1269		132
Inflow at Yosemite Avenue	17448[3]	1639	361	
Inflow from Piedmont Creek	16437[3]	2452	901	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1345		1157
Inflow from Los Coches Creek	14422[3]	2625	911	
Calaveras Boulevard	13887[3]	2383		228

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 3-14 Revised GRR Model Results for Without-Project Conditions - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	2129		
Breakout at Old Piedmont Road Bridge	3106[2]	1183		946
Sweigert Creek - Old Location	3072[2]	1868		
Breakout at Cropley/Piedmont Culvert	3038[2]	1098		770
Inflow at Sweigert Creek – Corrected Location	2850[2]	1249	438	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	1029		220
Inflow at Crosley Creek	2334[2]	1334	435	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1332		0
Inflow at Sierra Creek	1326[2]	1865	1835	
Breakout at Morrill Avenue Culvert	1279[2]	1719		142
Downstream Cropley Avenue	788[2]	1713		
I-680 Culvert	25296[3]	1770		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	520		1029
Inflow at Montague Avenue	21821[3]	1699	1227	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	1592		106
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	1210		206
Inflow at Yosemite Avenue	17448[3]	1924	401	
Inflow from Piedmont Creek	16437[3]	2520	900	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	1362		1215
Inflow from Los Coches Creek	14422[3]	2622	951	
Calaveras Boulevard	13887[3]	2387		226

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

3.2.2 Revised GRR FLO-2D Model Results

The Revised without-project Upper and Lower FLO-2D models were run for the 20, 4, 2, 1, 0.5, and 0.2% chance exceedance flood events. In addition, the 50% chance exceedance event was run for the Upper FLO-2D model. Each run had a total simulation time of 40 hours. Following the completion of the flood simulations, the FLO-2D post-processor program Mapper was used to develop ArcMap flood depth and flood water surface elevation shapefiles from the Upper and Lower FLO-2D model results. The flood depth shapefiles were used to create floodplain maps for each simulated event using standard ArcMap tools. The flood depth shapefiles for the Upper and Lower FLO-2D models were combined for each simulated event to create a complete study area floodplain. Figure 3-9 to Figure 3-15 show the without-project floodplains for the 20% to 0.2% chance exceedance flood events for the Berryessa Creek study area. Since the 50% chance exceedance event did not incur breakouts from the channel, no floodplain figure was developed.

The FLO-2D floodplain water surface elevation shapefiles were used to assign water surface elevations to the parcel economic data. Using the geoprocessing tools in ArcMap, the floodplain water surface elevations were assigned to the parcel map shapefile representing the structures in the floodplain. The parcel data amended with the structure water surface elevations was used in the subsequent economic analysis.

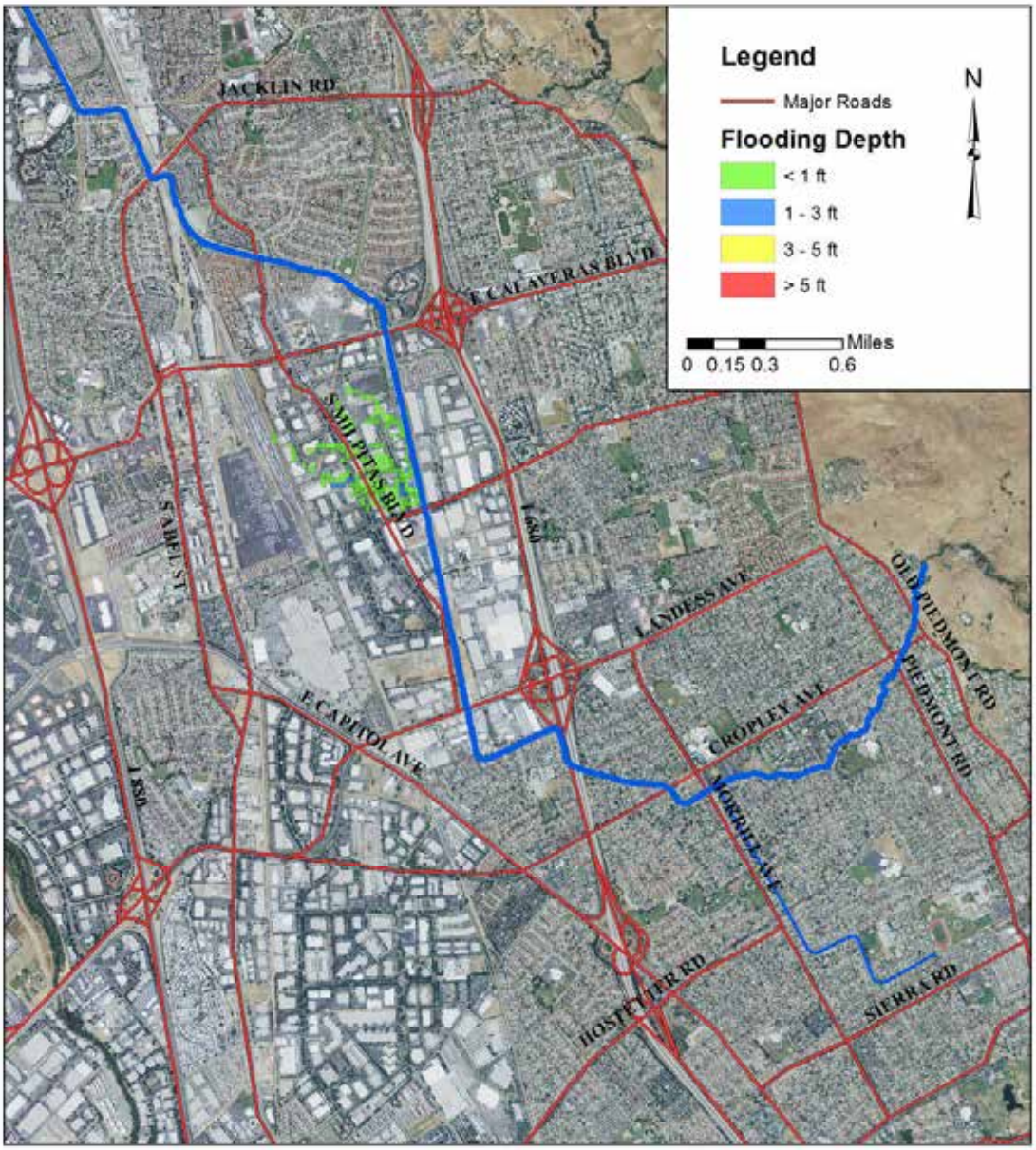

Figure 3-9 20% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

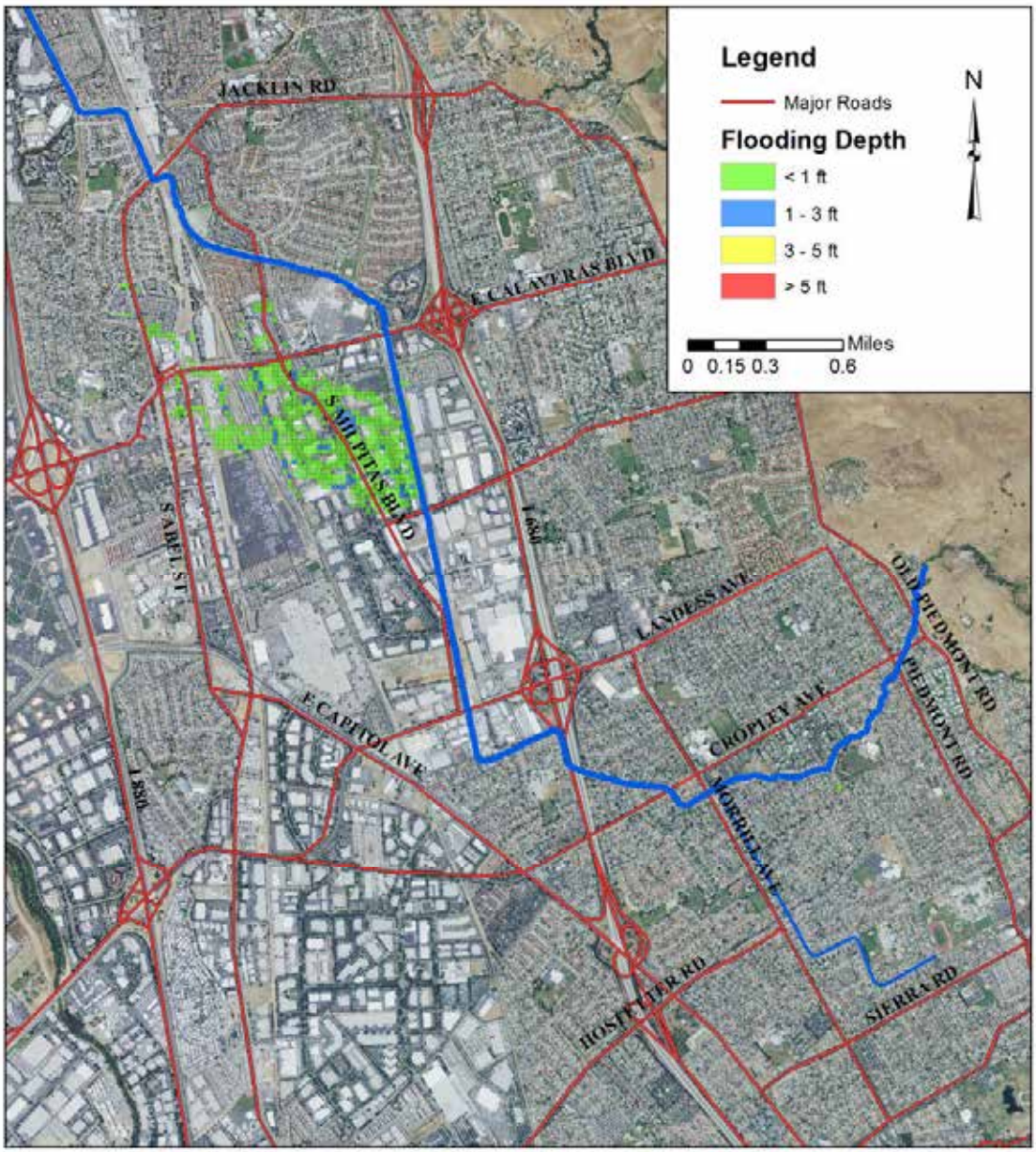

Figure 3-10 10% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

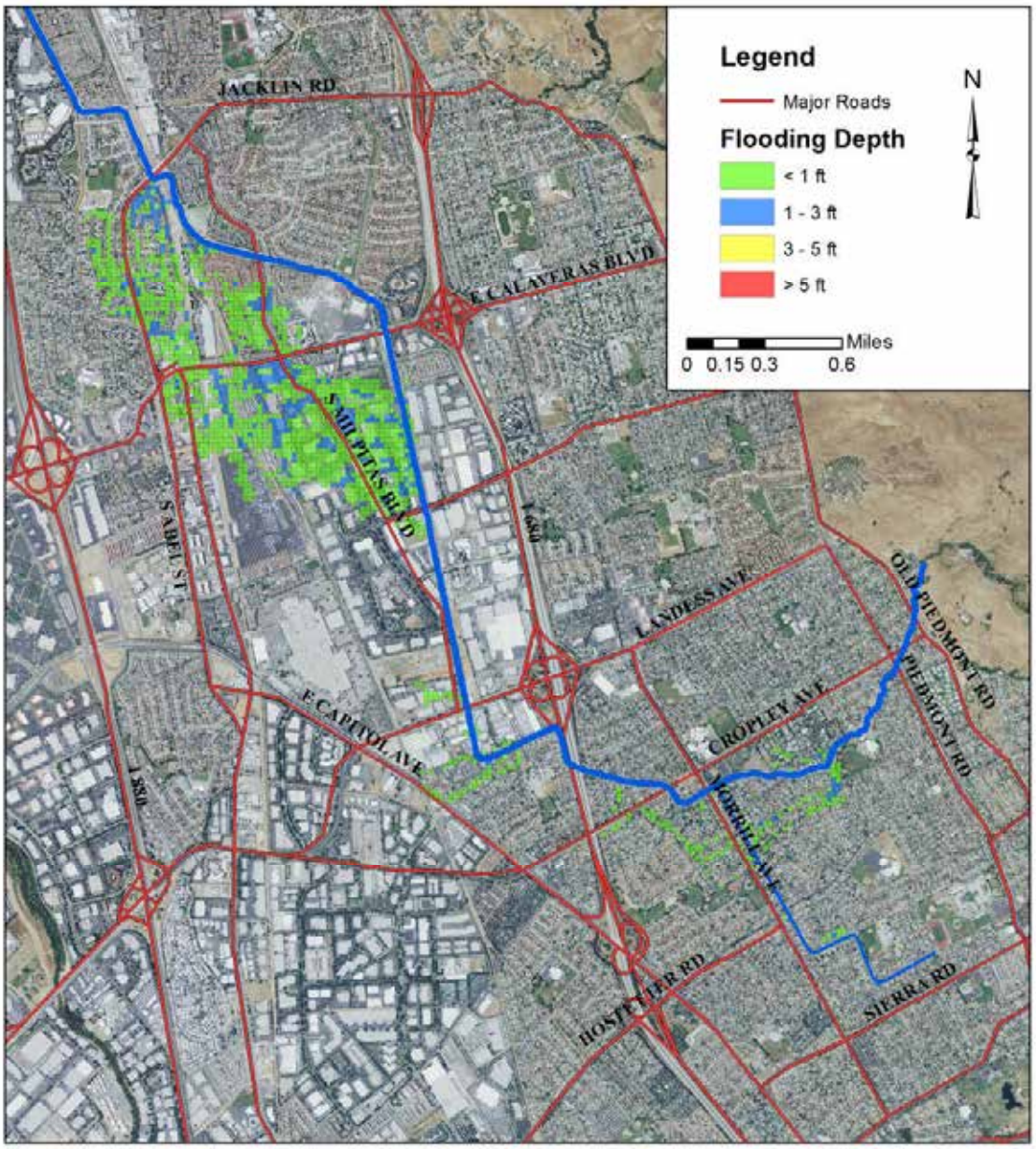

Figure 3-11 4% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

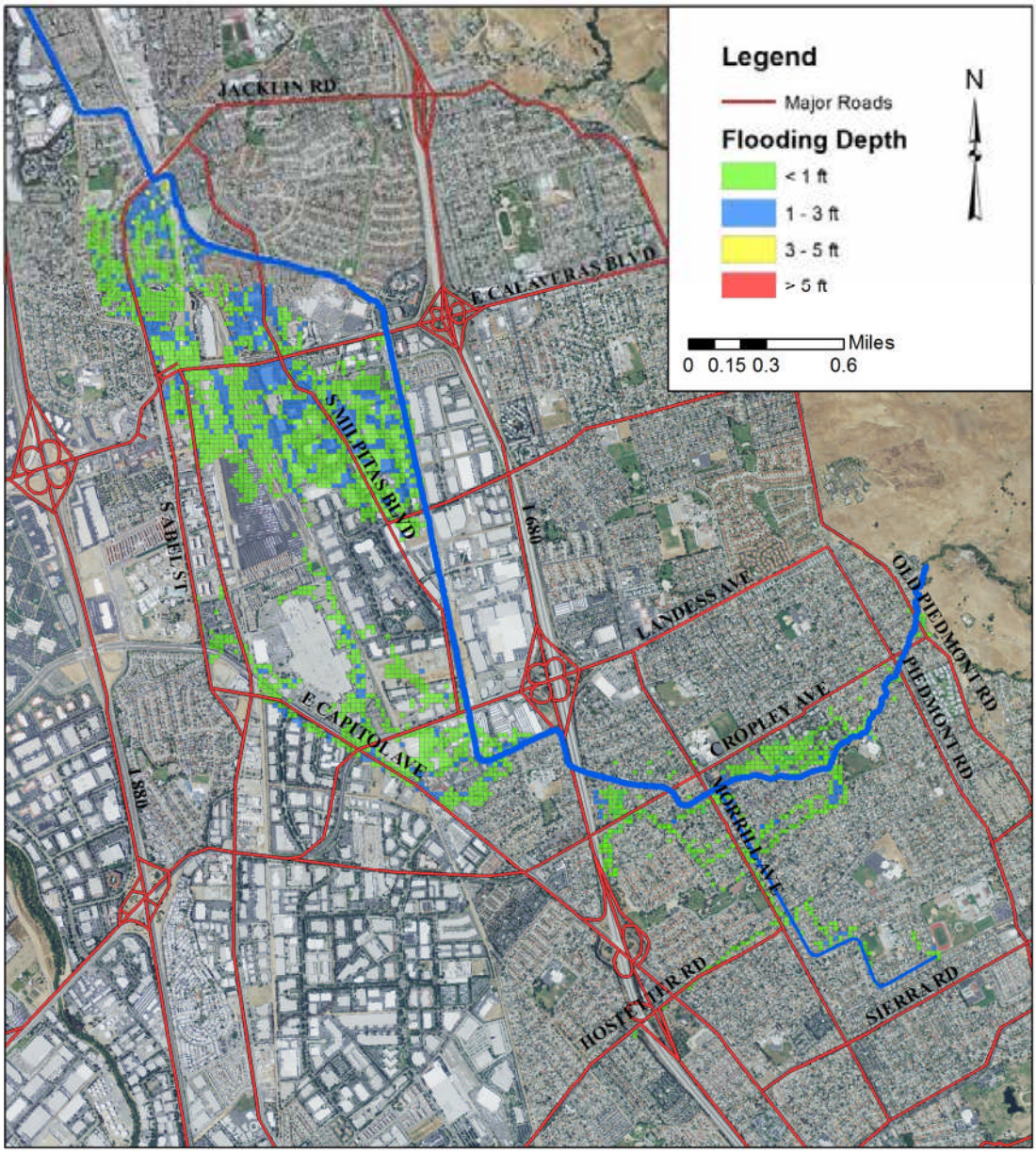

Figure 3-12 2% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

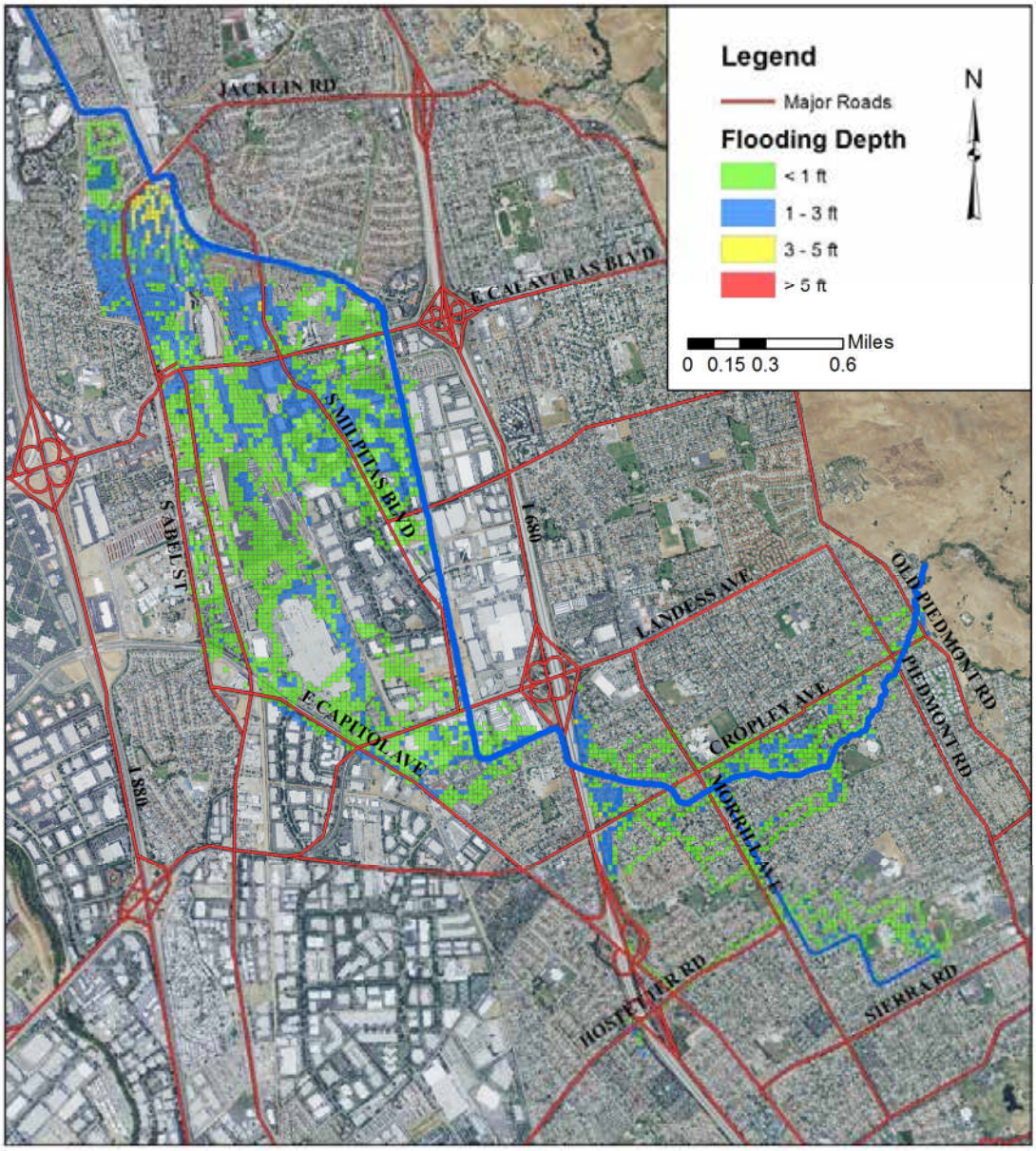

Figure 3-13 1% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

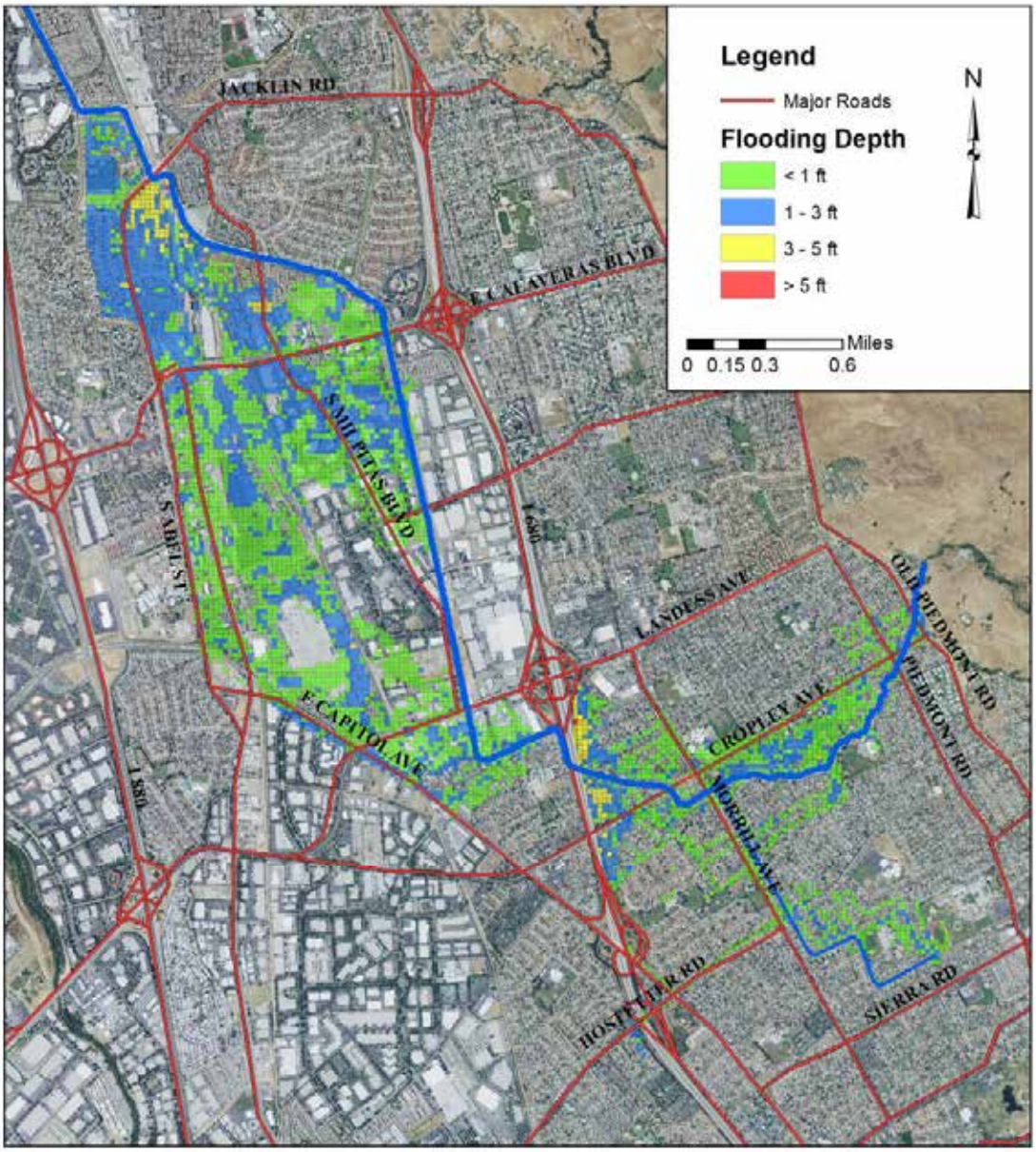

Figure 3-14 0.5% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

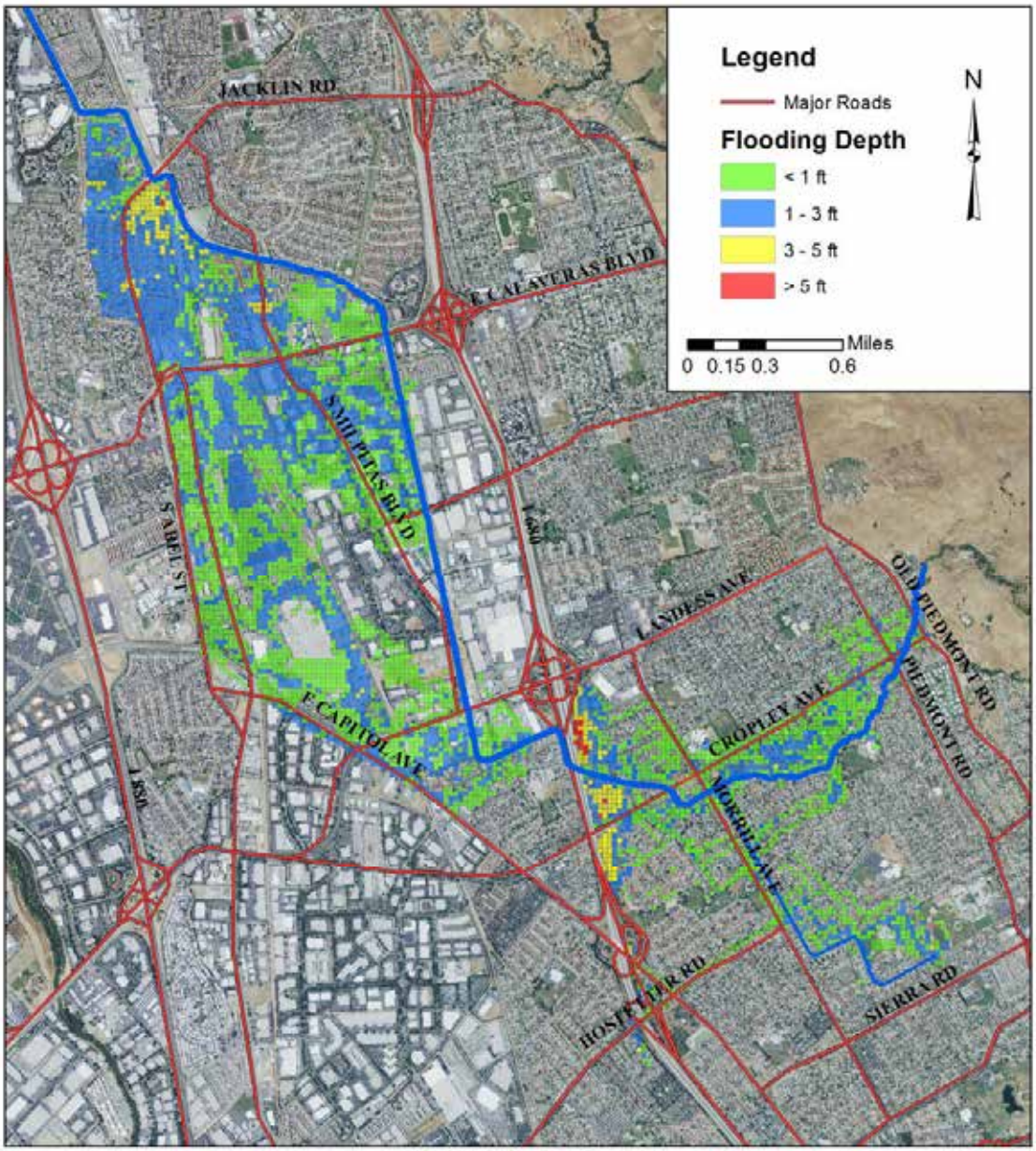

Figure 3-15 0.2% Chance Exceedance Flood Event Floodplain for the Revised GRR Model Without-Project Condition

3.2.3 Comparison of Revised GRR Model to FEMA Floodplain

The FEMA 1 percent (100-year) floodplain was compared to the Revised GRR Model Without-Project 1% Chance exceedance flood event floodplain. Figure 3-16 compares the 1% chance exceedance without-project floodplain with the currently accepted FEMA 1 percent (100-year) floodplain. The FEMA floodplain is mapped on the following FEMA map panels.

- Panel 9 of 64 of City of San Jose, Santa Clara County California FIRM, Community Panel Number 060349 0009G revised August 17, 1998
- Panel 10 of 64 of City of San Jose, Santa Clara County California FIRM, Community Panel Number 060349 0010E revised August 17, 1998
- Panel 1 of 4 of the City of Milpitas, Santa Clara County, California FIRM, County Panel Number 060344 0001G revised June 22, 1998
- Panel 3 of 4 of the City of Milpitas, Santa Clara County, California FIRM, County Panel Number 060344 0003G revised June 22, 1998

The FEMA floodplain shows the results of a commingled floodplain resulting from Berryessa Creek overflows plus a number of other contributing flood sources in the study area including Sweigert Creek, Sierra Creek, and Penitencia Creek. (The Penitencia Creek floodplain no longer occurs due to the Penitencia Creek Project.) Floodplains specific to the Upper Sweigert and Sierra Creeks are not part of the current GRR, although consideration was made to the capacity of the culvert inlets for the discharges associated with Sweigert and Sierra Creeks that are conveyed to the Revised Berryessa Creek FLO-2D Model.

Upstream of I-680, as seen in Figure 3-16, the without-project and FEMA floodplains generally agree considering that the majority of the flooding to the southeast of the creek upstream of Morrill Avenue is the result of Upper Sierra and Sweigert Creek flooding. However, the following differences were observed between the two floodplains. Except as noted above (commingling and independent tributary floodplains) and in the individual items below, the differences are due to the increased accuracy of the FLO-2D model as well as where the breakouts were assumed to occur in the older HEC-2 model.

- The Revised Without-Project floodplain shows a small amount of additional flooding from the Old Piedmont Road Bridge breakout to the northwest that is not present in the FEMA floodplain.

- The Revised Without-Project floodplain shows a small amount of flooding to the north of Cropley Avenue upstream of Morrill Avenue.

- A small breakout from Berryessa Creek is present in the Revised Without-Project floodplain just downstream of the I-680 culvert.

- The breakout from upstream of Montague Expressway in the Revised Without-Project floodplain shows flooding to the northwest that is not in the FEMA

floodplain. This flow follows the prevailing topography and is considered more accurate.

- The Revised Without-Project floodplain shows the area just north of Montague and east of Capitol Avenue to be flooded where the FEMA floodplain contains areas that are not flooded. The FEMA floodplain assumed that a railroad embankment contained flows in this area, whereas the area actually consists of low-lying land that receives water from surrounding and adjacent overflow areas.

- The Revised Without-Project floodplain shows breakouts near Yosemite flowing to the northwest and west, compared to the FEMA floodplain. This flow follows the prevailing topography and is considered more accurate.

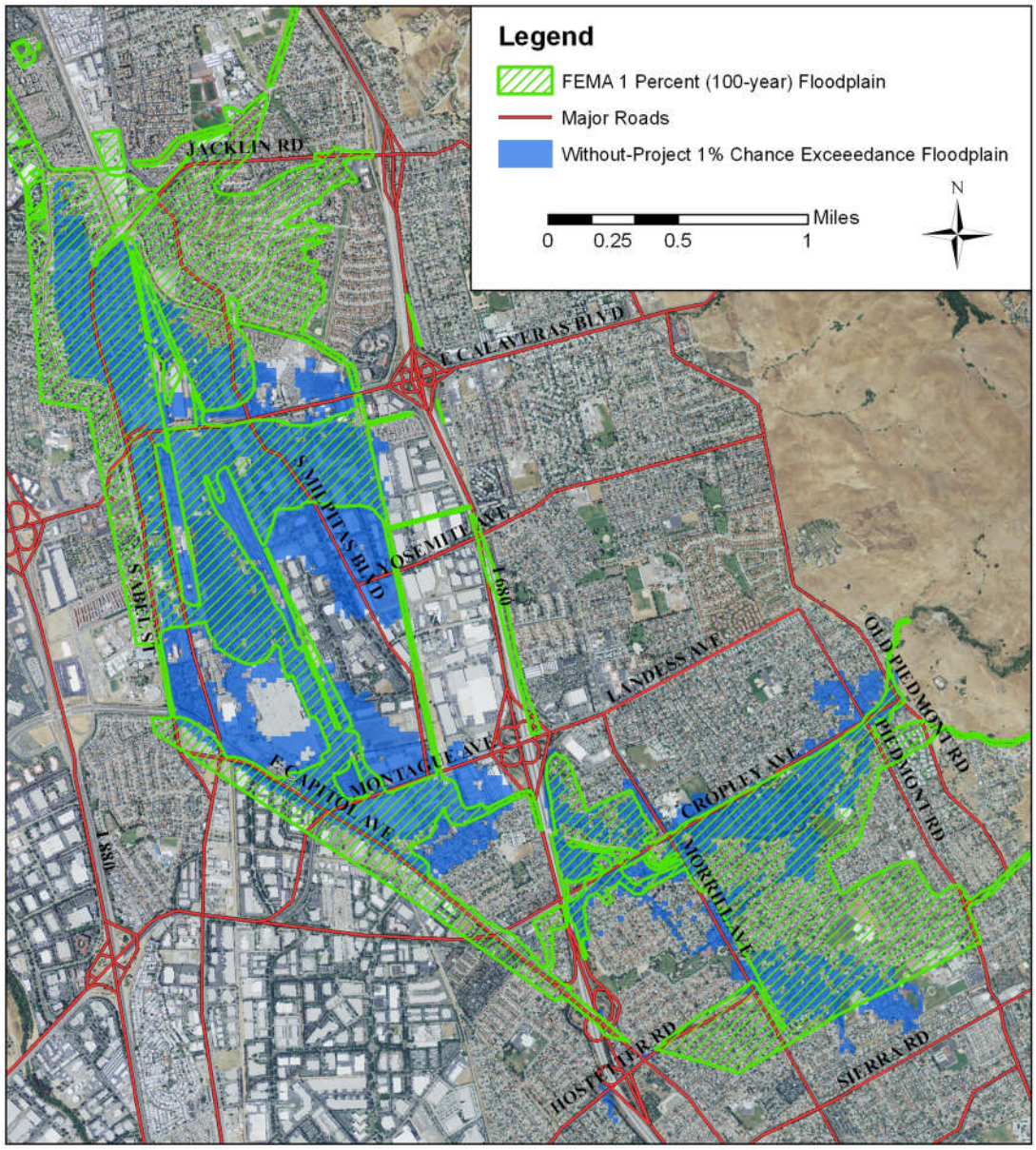

Figure 3-16 Comparison of the FEMA Floodplain and the Revised GRR Model Without-Project 1% Chance Exceedance Flood Event Floodplain

CHAPTER 4: INCREMENTAL ANALYSIS

The incremental analysis was conducted using the original GRR methodology. An incremental analysis of the flood damage reduction components for the Berryessa Creek study was conducted to determine the level of protection that is economically justified for both the Upper and Lower Berryessa study areas. Increment plans for different levels of protection, based on the channel capacity, were developed for the Upper and Lower areas based on an earthen trapezoidal channel cross section, as shown in Figure 4-1, for reaches along Berryessa Creek where channel modification were warranted and feasible. The flood damage reduction component incremental plans were sized such that a new and distinct plan was developed when a major change in cost, for example bridge reconstruction/replacement, was necessary to obtain the next desired level of protection. Table 4-1 lists the four increments used in the analysis. Further rationale for each level of protection increment studied is included in the *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*.

The 2, 1, 0.5, and 0.2 percent chance exceedance event floodplains were developed for each of the four increments where applicable. No floodplains were developed for events smaller than the level of protection provided by the increment (i.e. the 1% chance exceedance level of protection plan did not generate a 2 or 1 percent chance exceedance floodplain since both would be contained in channel). Table 4-1 lists the floodplains developed in support of the flood damage reduction component incremental analysis.

Table 4-1 Floodplains Developed in Support of Flood Damage Reduction Component Incremental Analysis

Level of Protection (Median flow)	Upper Model Floodplains	Lower Model Floodplains
Increment A – Pass 3% Chance Exceedance Event	2, 1, 0.5, and 0.2 Percent Chance Exceedance Events	2, 1, 0.5, and 0.2 Percent Chance Exceedance Events
Increment B – Pass 2% Chance Exceedance Event	1, 0.5, and 0.2 Percent Chance Exceedance Events	1, 0.5, and 0.2 Percent Chance Exceedance Events
Increment C – Pass 1% Chance Exceedance Event	0.5, and 0.2 Percent Chance Exceedance Events	0.5, and 0.2 Percent Chance Exceedance Events
Increment D – Pass 0.5% Chance Exceedance Event	0.2% Chance Exceedance Events	0.2% Chance Exceedance Events

The increment A-D FLO-2D Upper and Lower models were each run for the 2, 1, 0.5, and 0.2 percent chance exceedance events as indicated in Table 4-1. The design storm was of 24 hour duration, in order to allow for sufficient time to complete the flood routing. The models were run for a total simulation time of 32 hours. After the flood simulations were completed, the FLO-2D post-processor program Mapper was used to develop ArcMap flood depth and flood water surface elevation shapefiles from the Upper and Lower FLO-2D model results.

The flood depth shapefiles were used to create floodplain maps for each simulated event using standard ArcMap tools. The flood depth shapefiles for the Upper and Lower FLO-2D models were combined for each simulated event to generate a total area of flood inundation.

The FLO-2D floodplain water surface elevation shapefiles were used to assign water surface elevations to the parcel economic data as described in the Economic Appendix.

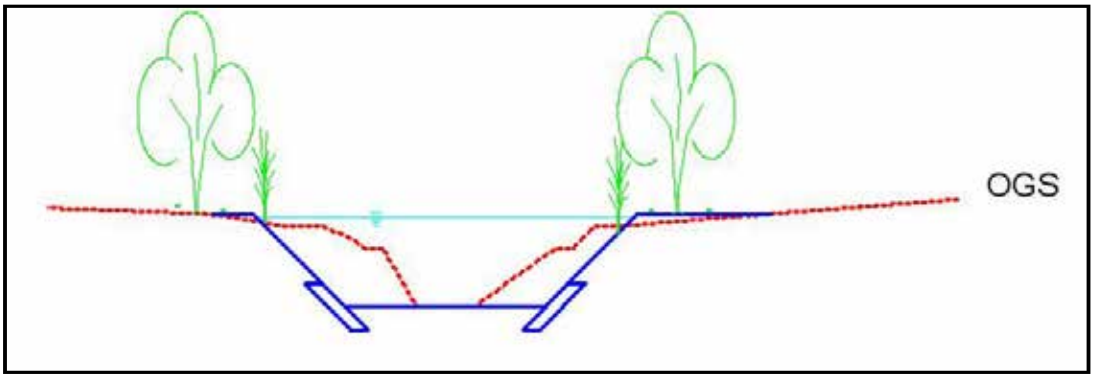

Figure 4-1 Earthen Trapezoidal Cross Section

4.1 Increment A – Pass 3% Chance Exceedance Event

Increment A provides a protection from the 3% chance exceedance event for Berryessa Creek through the entire study reach. Increment A consists of the following project features:

- A 2-foot levee upstream of Old Piedmont Road
- Armoring of bed and Banks between Old Piedmont Road and Cropley Avenue
- A one-half foot headwall extension at the Piedmont-Cropley Culvert
- Levees of up to 1.5 feet in the Greenbelt Reach
- Removal of existing dragons teeth and channel invert smoothing at Cropley Avenue Culvert
- Levees of up to 1.7 feet from Montague Avenue to the I-680 Culvert
- A 0.7-foot headwall extension at the Montague Culvert
- Channel Excavation and levees of up to 0.6 feet from Montague Avenue to the UPRR Trestle
- Channel Excavation and levees of up to 3.9 feet from the UPRR Culvert to just downstream of Calaveras Boulevard
- Extension of existing wing-walls at the UPRR Culvert
- A one foot headwall extension at the Los Coches Bridge
- Installation of a transition structure at Calaveras Boulevard bridge

Table 4-2 to Table 4-5 list the channel flow and breakout for the Increment A HEC-RAS model. Figure 4-2 to Figure 4-5 show the resulting 2, 1, 0.5 and 0.2 percent chance exceedance floodplains for Increment A.

Table 4-2 Original GRR Model Results for Increment A - 2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1090		
Breakout at Old Piedmont Road Bridge	35249	1081		9
Sweigert Creek - Old Location	35029	1081		
Breakout at Cropley/Piedmont Culvert	34041	1030		51
Inflow at Sweigert Creek – Corrected Location	33136	1120	250	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1120		0
Inflow at Crosley Creek	30478	1280	277	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1280		0
Inflow at Sierra Creek	28656	1570	968	
Breakout at Morrill Avenue Culvert	28447	1550		20
Downstream Cropley Avenue	25744	1630		
I-680 Culvert	25296	1630		
Lateral Weir Breakout Upstream of Montague	25295-21832	1099		531
Inflow at Montague Avenue	21821	1488	791	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1419		69
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1353		66
Inflow at Yosemite Avenue	17465	1533	265	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1510		23
Inflow from Piedmont Creek	16437	2116	1049	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1135		981
Inflow from Los Coches Creek	14422	1885	972	
Calaveras Boulevard	13887	1885		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 4-3 Original GRR Model Results Results for Increment A - 1% Chance ExceedanceFlood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1430		
Breakout at Old Piedmont Road Bridge	35249	1350		80
Sweigert Creek - Old Location	35029	1350		
Breakout at Cropley/Piedmont Culvert	34041	1100		250
Inflow at Sweigert Creek – Corrected Location	33136	1200	308	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1184		16
Inflow at Crosley Creek	30478	1394	372	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1394		0
Inflow at Sierra Creek	28656	1794	1458	
Breakout at Morrill Avenue Culvert	28447	1700		94
Downstream Cropley Avenue	25744	2124		
I-680 Culvert	25296	2140		
Lateral Weir Breakout Upstream of Montague	25295-21832	1034		1106
Inflow at Montague Avenue	21821	1671	922	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1559		112
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1439		120
Inflow at Yosemite Avenue	17465	1569	302	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1535		34
Inflow from Piedmont Creek	16437	2201	1338	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1103		1097
Inflow from Los Coches Creek	14422	2003	1253	
Calaveras Boulevard	13887	2003		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 4-4 Original GRR Model Results for Increment A - 0.5% Chance ExceedanceFlood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1820		
Breakout at Old Piedmont Road Bridge	35249	1610		210
Sweigert Creek - Old Location	35029	1610		
Breakout at Cropley/Piedmont Culvert	34041	1143		467
Inflow at Sweigert Creek – Corrected Location	33136	1283	365	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1227		56
Inflow at Crosley Creek	30478	1487	477	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1483		4
Inflow at Sierra Creek	28656	1923	1493	
Breakout at Morrill Avenue Culvert	28447	1753		170
Downstream Cropley Avenue	25744	2600		
I-680 Culvert	25296	2660		
Lateral Weir Breakout Upstream of Montague	25295-21832	935		1725
Inflow at Montague Avenue	21821	1760	1077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1622		137
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1484		138
Inflow at Yosemite Avenue	17465	1574	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1527		47
Inflow from Piedmont Creek	16437	2219	1691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1082		1137
Inflow from Los Coches Creek	14422	2052	1583	
Calaveras Boulevard	13887	2052		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 4-5 Original GRR Model Results for Increment A - 0.2% Chance ExceedanceFlood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	1820		340
Sweigert Creek - Old Location	35029	1820		
Breakout at Cropley/Piedmont Culvert	34041	1168		652
Inflow at Sweigert Creek – Corrected Location	33136	1420	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1297		123
Inflow at Crosley Creek	30478	1637	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1614		24
Inflow at Sierra Creek	28656	2994	1848	
Breakout at Morrill Avenue Culvert	28447	1407		1587
Downstream Cropley Avenue	25744	2994		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	799		2341
Inflow at Montague Avenue	21821	1851	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1684		167
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1684		
Inflow at Yosemite Avenue	17465	1774	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1701		73
Inflow from Piedmont Creek	16437	2366	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	963		1403
Inflow from Los Coches Creek	14422	2206	1848	
Calaveras Boulevard	13887	2206		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

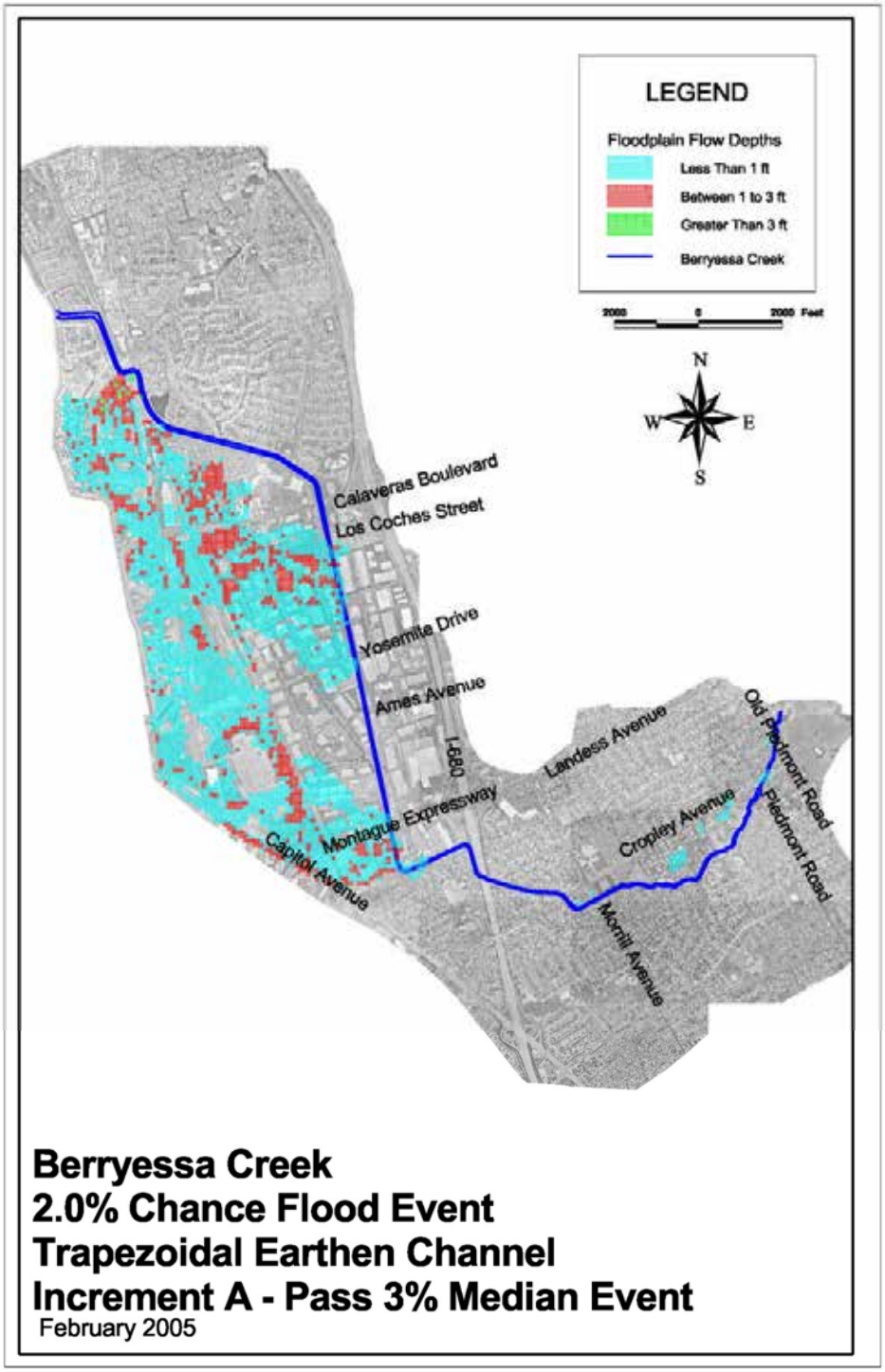

Figure 4-2 2% Chance Exceedance Event Floodplain for Original GRR Model Increment A

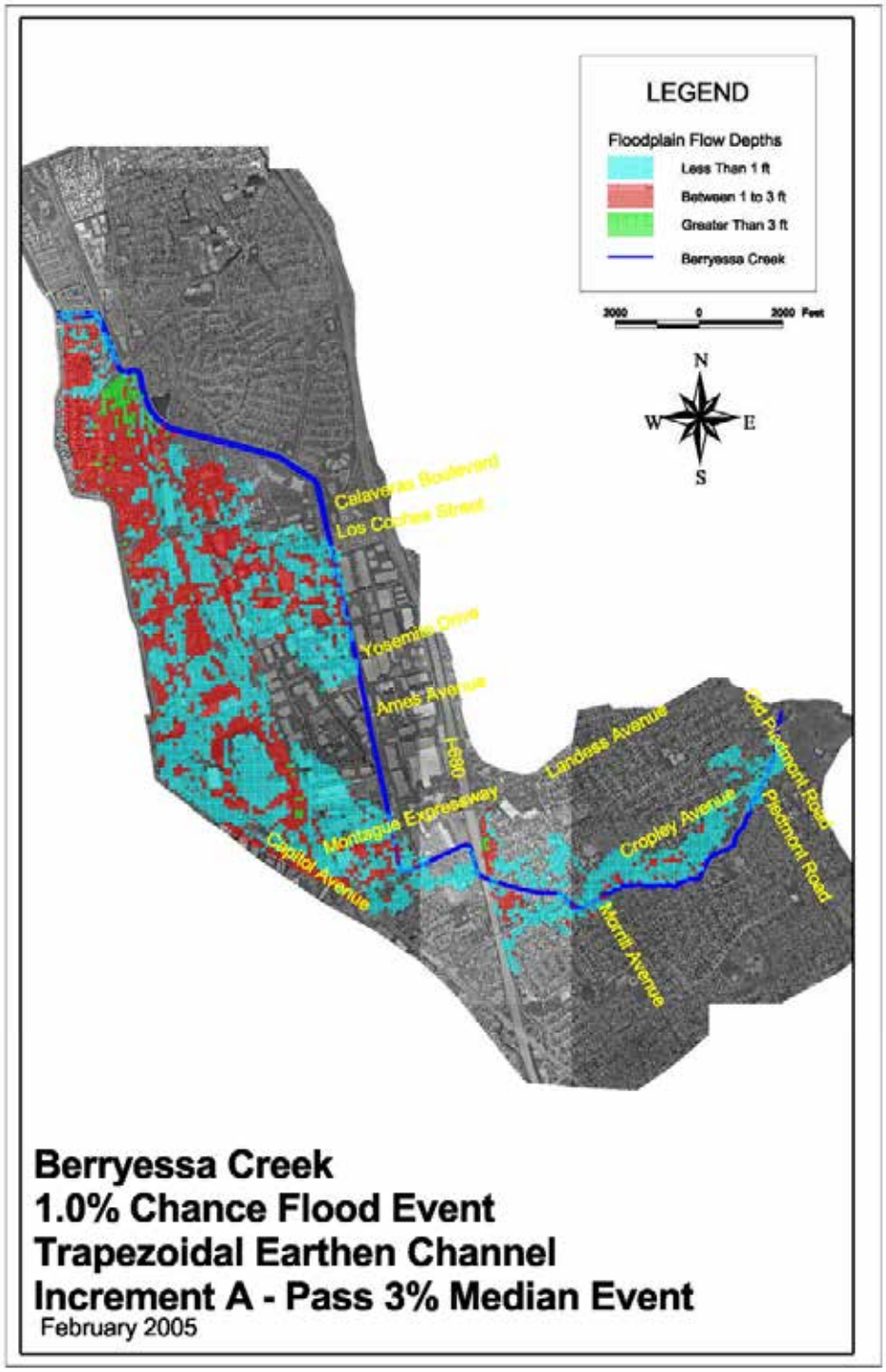

Figure 4-3 1% Chance Exceedance Event Floodplain for Original GRR Model Increment A

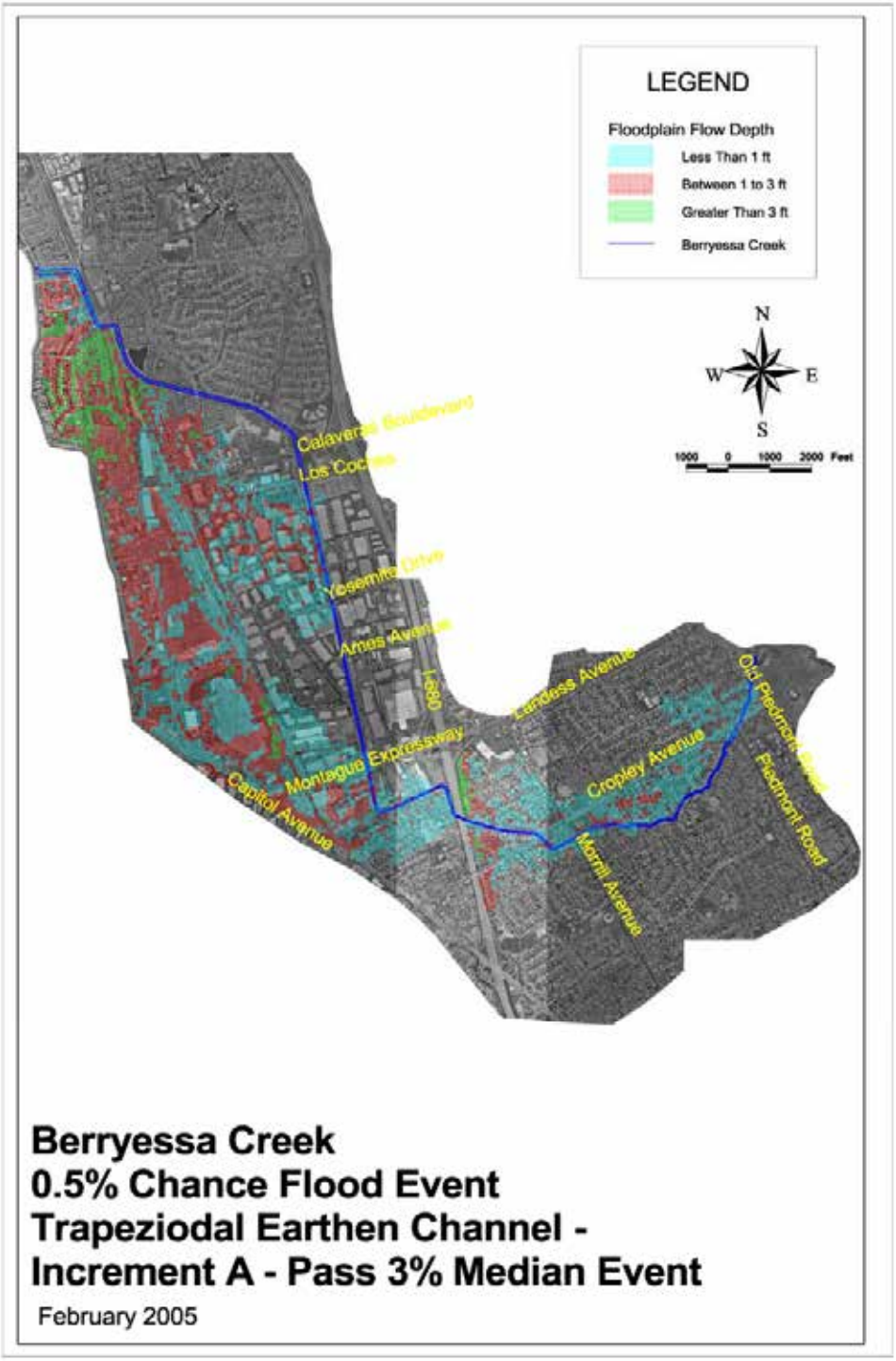

Figure 4-4 0.5% Chance Exceedance Event Floodplain for Increment A

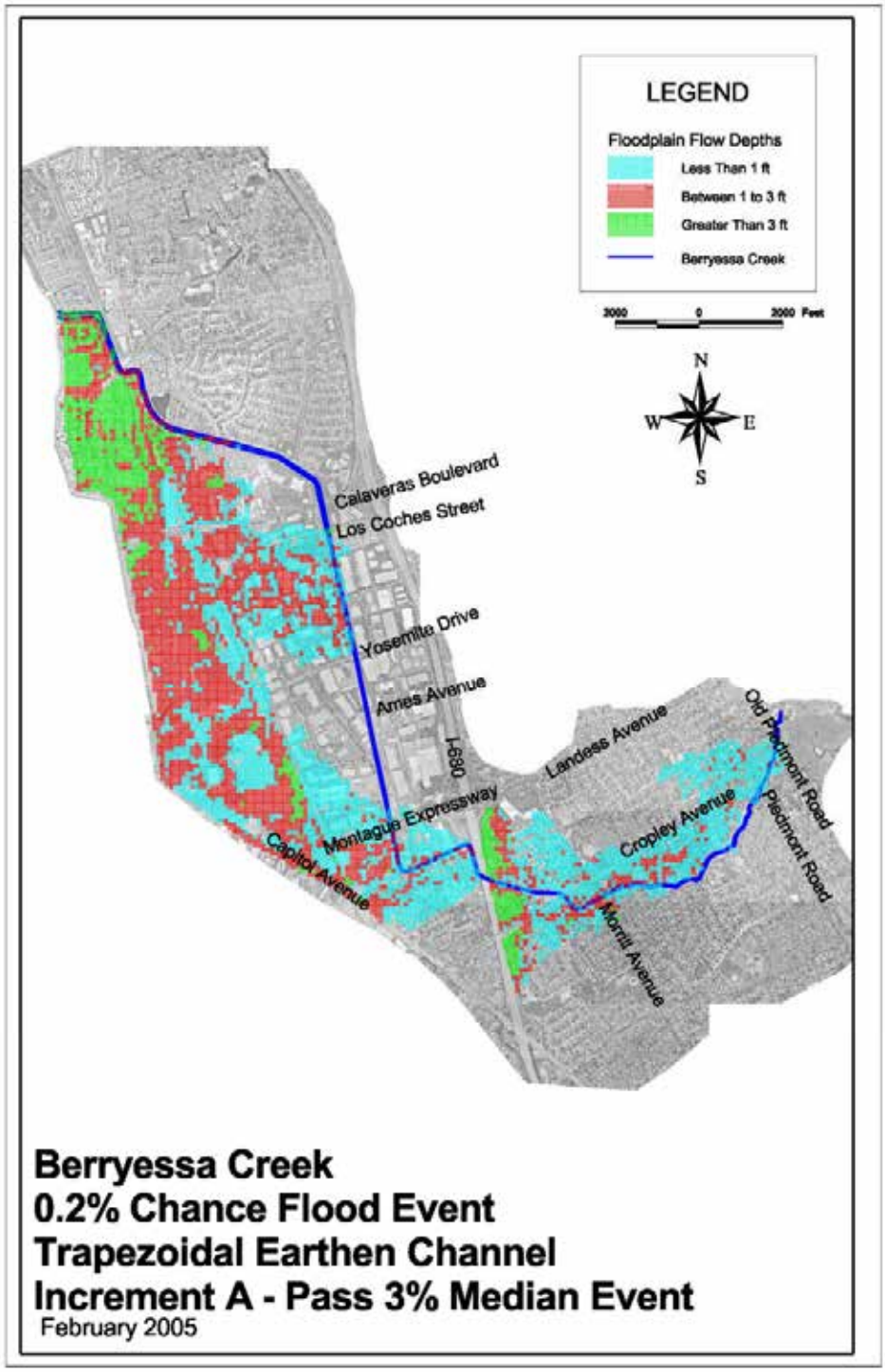

Figure 4-5 0.2% Chance Exceedance Event Floodplain for Original GRR Model Increment A

As seen in Table 4-6, the areal extent of the Increment A floodplain slightly increases for the 2, 1, and 0.5% chance exceedance events. This occurs because Increment A was designed to eliminate the flooding from the 3% chance exceedance (approximately 33-year) flood event. Downstream of I- 680, the left bank of Berryessa Creek is along the creek channel in the lowest points. Increasing the bank elevation in these areas does not significantly increase the channel conveyance capacity. The increased bank heights force more water downstream resulting in more areas of shallow flooding.

A similar event occurs for the 0.2% chance exceedance flood event upstream of the 680 Interstate. Upstream of highway 680 for the 0.5% chance exceedance event, the highest overbank discharges are located at the bridges and culverts. The Increment A flood mitigation measures increase the channel conveyance capacity until the tributary inflow causes overflow at the lateral weir representing the banks. An increase in channel flood conveyance upstream will result in overbank flooding downstream by forcing more water volume downstream in the channel.

Figure 4-6 graphically displays the results in Table 4-6, showing the resulting areas of increased flooding for the 2% chance exceedance flood event as well as the areas of decreased flooding.

Table 4-6 Original GRR Model Results - Increment A versus Without Project Floodplain Area Comparison

Increment	Floodplain Area in Acres (percent reduction from Without Project Floodplain)			
	2% Chance Exceedance Event	1% Chance Exceedance Event	0.5% Chance Exceedance Event	0.2% Chance Exceedance Event
Upstream of I-680 (Upper FLO-2D Model Results)				
Without Project	100 (N/A)	196 (N/A)	254 (N/A)	322 (N/A)
Increment A	12 (88%)	180 (8%)	246 (3%)	324 (-1%)
Downstream of I-680 (Lower FLO-2D Model Results)				
Without Project	809 (N/A)	998 (N/A)	1083 (N/A)	1172 (N/A)
Increment A	821 (-2%)	1033 (-3%)	1101 (-2%)	1127 (4%)
Total Study Area (Upper plus Lower FLO-2D Model Results)				
Without Project	909 (N/A)	1194 (N/A)	1337 (N/A)	1493 (N/A)
Increment A	834 (8%)	1213 (-2%)	1347 (-1%)	1451 (3%)

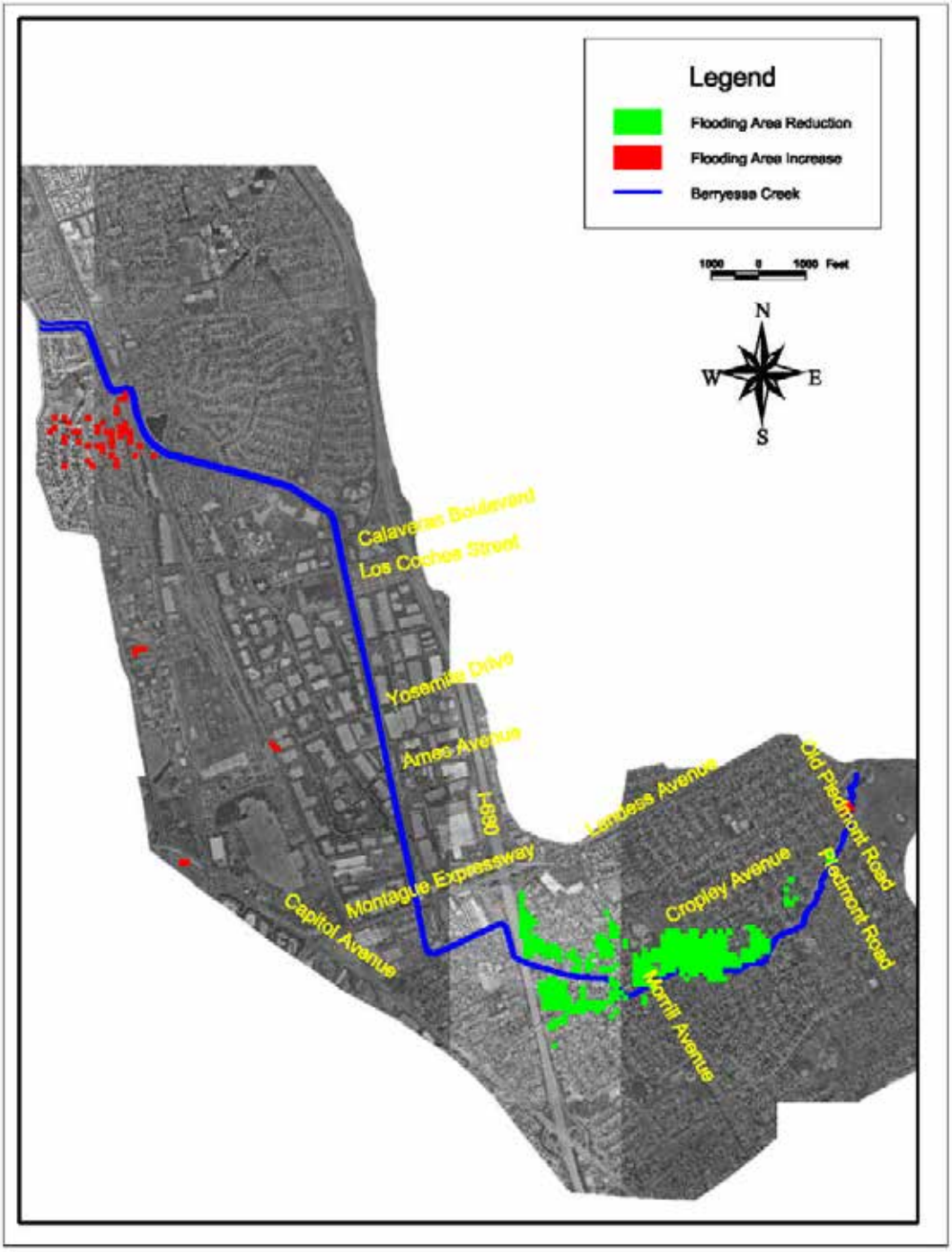

Figure 4-6 Change in Floodplain Area between the Original GRR Model Without Project and Increment A 2% Chance Exceedance Event Floodplains

4.2 Increment B – Pass 2% Chance Exceedance Event

Increment B provides a protection from up to the 2% chance exceedance event for Berryessa Creek for the study area reach.

Increment B consists of the following project features:

- A 2.5-foot levee upstream of Old Piedmont Road
- A 1.5-foot headwall extension at the Old Piedmont Bridge
- Armoring of bed and Banks between Old Piedmont Road and Cropley Avenue
- A 1.5-foot headwall extension at the Piedmont-Cropley Culvert
- Levees of up to 2.2 feet in the Greenbelt Reach
- Tie in of the Morrill Avenue headwall to the channel levees
- Removal of existing dragons teeth and channel invert smoothing at Cropley Avenue Culvert
- Levees of up to 2.0 feet from Montague Avenue to the I-680 Culvert
- A 0.7-foot headwall extension at the Montague Culvert
- Channel Excavation and levees of up to 0.6 feet from Montague Avenue to the UPRR Trestle
- Replacement of the UPRR Trestle with a triple 11ft x 11ft box culvert (same design as the existing UPRR Culvert located downstream of the trestle)
- Channel Excavation and levees of up to 4.4 feet from the UPRR Culvert to just downstream of Calaveras Boulevard
- Extension of existing wing-walls at the UPRR Culvert
- A 1.5-foot headwall extension at the Los Coches Bridge
- Installation of a transition structure at Calaveras Boulevard bridge

Table 4-7 to Table 4-9 list the resulting channel and breakout flows for the Increment B HEC-RAS model. Figure 4-7 to Figure 4-9 show the 1, 0.5, and 0.2% chance exceedance event Increment B floodplains.

Table 4-7 Original GRR Model Results for Increment B – 1% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1430		
Breakout at Old Piedmont Road Bridge	35249	1420		10
Sweigert Creek - Old Location	35029	1420		
Breakout at Cropley/Piedmont Culvert	34041	1172		248
Inflow at Sweigert Creek – Corrected Location	33136	1272	308	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1272		0
Inflow at Crosley Creek	30478	1482	372	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1482		0
Inflow at Sierra Creek	28656	1882	1458	
Breakout at Morrill Avenue Culvert	28447	1769		113
Downstream Cropley Avenue	25744	2140		
I-680 Culvert	25296	2140		
Lateral Weir Breakout Upstream of Montague	25295-21832	1364		776
Inflow at Montague Avenue	21821	2002	922	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1969		33
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1664		304
Inflow at Yosemite Avenue	17465	1794	302	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1700		94
Inflow from Piedmont Creek	16437	2403	1338	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1310		1094
Inflow from Los Coches Creek	14422	2210	1253	
Calaveras Boulevard	13887	2210		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 4-8 Original GRR Model Results for Increment B - 0.5% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1820		
Breakout at Old Piedmont Road Bridge	35249	1730		90
Sweigert Creek - Old Location	35029	1730		
Breakout at Cropley/Piedmont Culvert	34041	1356		374
Inflow at Sweigert Creek – Corrected Location	33136	1496	365	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1421		75
Inflow at Crosley Creek	30478	1681	477	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1677		4
Inflow at Sierra Creek	28656	2117	1493	
Breakout at Morrill Avenue Culvert	28447	1797		320
Downstream Cropley Avenue	25744	2581		
I-680 Culvert	25296	2660		
Lateral Weir Breakout Upstream of Montague	25295-21832	1225		1435
Inflow at Montague Avenue	21821	2051	1077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	2006		45
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1698		308
Inflow at Yosemite Avenue	17465	1788	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1672		116
Inflow from Piedmont Creek	16437	2437	1691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1288		1149
Inflow from Los Coches Creek	14422	2258	1583	
Calaveras Boulevard	13887	2258		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 4-9 Original GRR Model Results for Increment B - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	1820		320
Sweigert Creek - Old Location	35029	1820		
Breakout at Cropley/Piedmont Culvert	34041	1365		455
Inflow at Sweigert Creek – Corrected Location	33136	1617	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1513		104
Inflow at Crosley Creek	30478	1853	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1827		27
Inflow at Sierra Creek	28656	3010	1848	
Breakout at Morrill Avenue Culvert	28447	1617		1393
Downstream Cropley Avenue	25744	3010		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	1035		2105
Inflow at Montague Avenue	21821	2089	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	2032		58
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1701		331
Inflow at Yosemite Avenue	17465	1791	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1675		115
Inflow from Piedmont Creek	16437	2390	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1183		1207
Inflow from Los Coches Creek	14422	2431	1848	
Calaveras Boulevard	13887	2431		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

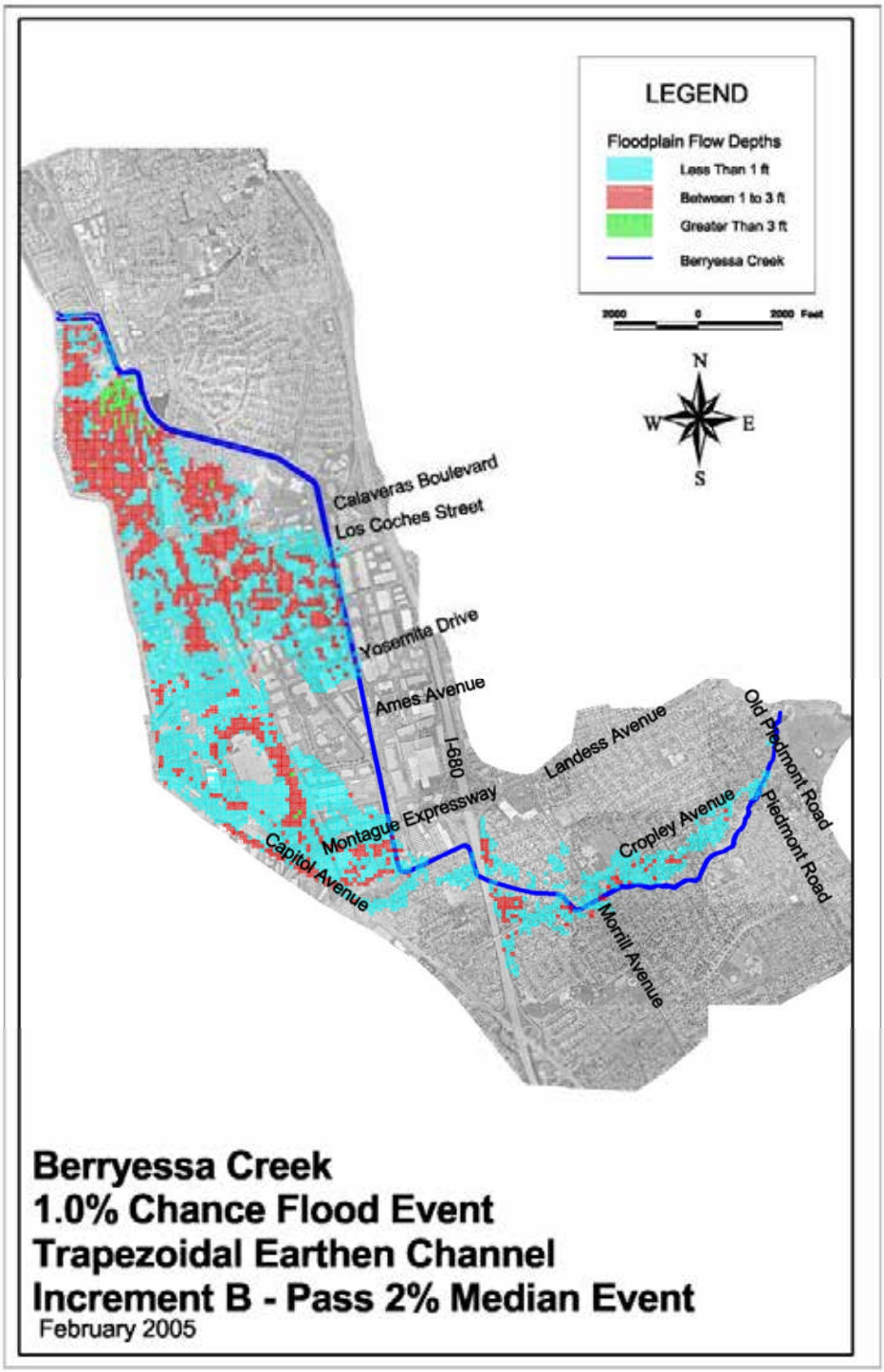

Figure 4-7 1% Chance Exceedance Event Floodplain for Original GRR Model Increment B

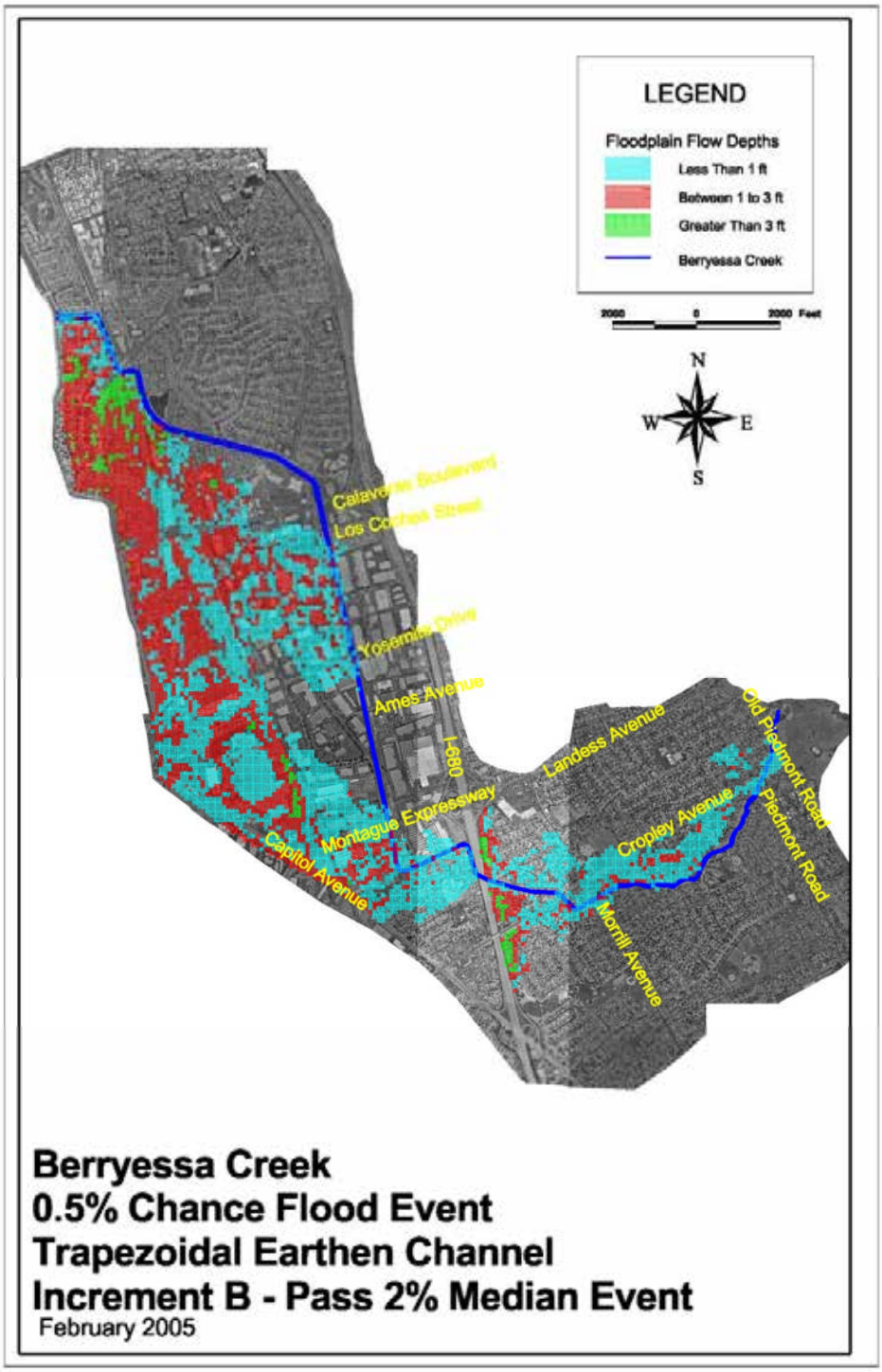

Figure 4-8 0.5% Chance Exceedance Event Floodplain for Original GRR Model Increment B

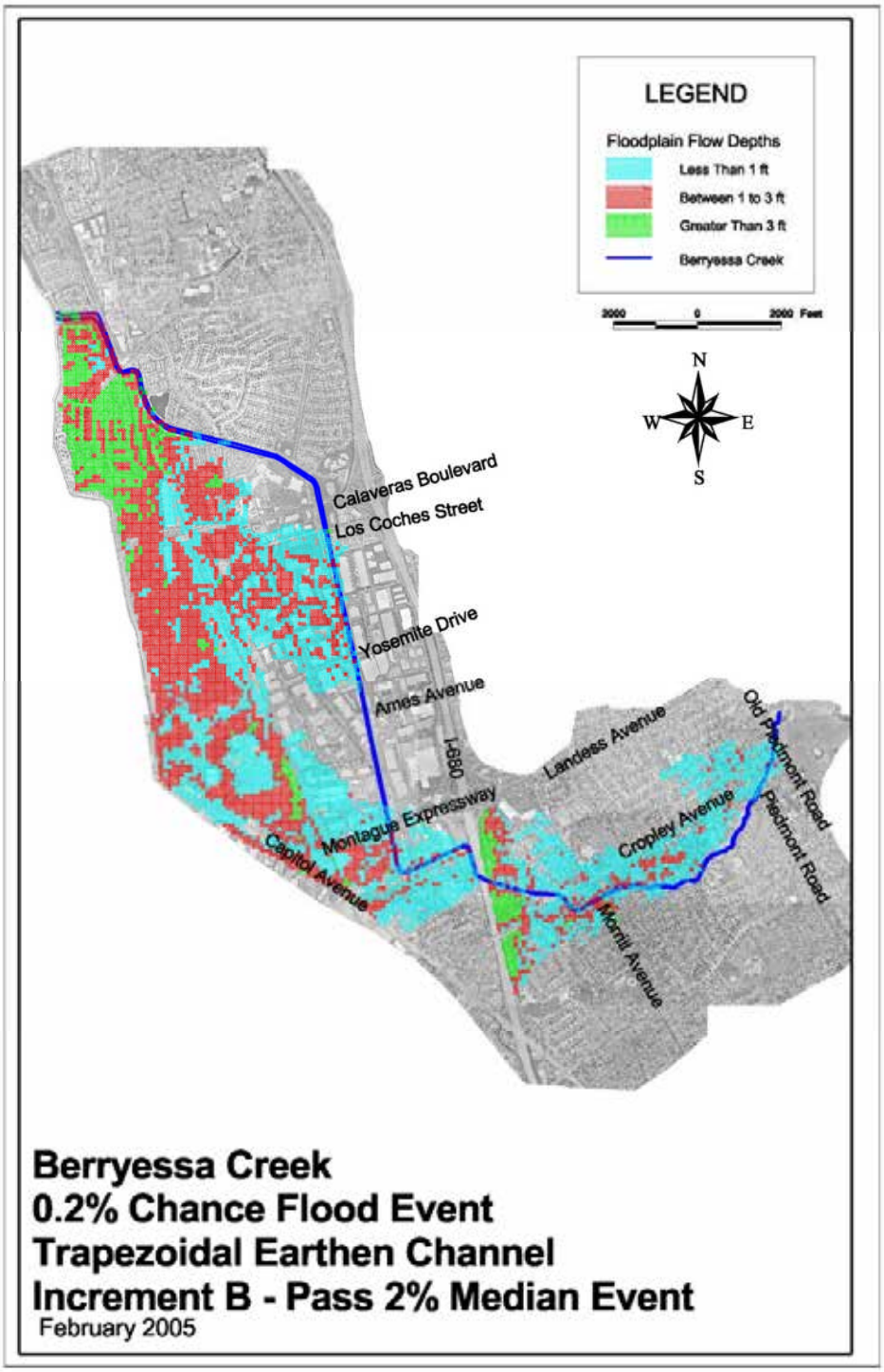

Figure 4-9 0.2% Chance Exceedance Event Floodplain for Original GRR Model Increment B

Figure 4-10 shows the resulting increase and decrease areas of flooding between the Increment B and without project for the 1% chance exceedance flood event. As seen in Table 4-10, Increment B results in a small reduction in the flooded area of approximately 73 acres.

As seen in Table 4-10 and Figure 4-10, the areal extent of the Increment B floodplain slightly increases for the 1 and 0.5% chance exceedance flood event. Upstream of highway 680 for the 0.5% chance exceedance event, the highest overbank discharges are located at the bridges and culverts. The Increment A flood mitigation measures increase the channel conveyance capacity until the tributary inflow causes overflow at the lateral weir representing the banks. An increase in channel flood conveyance upstream will result in overbank flooding downstream by forcing more water volume downstream in the channel. This increase is due to the same phenomenon as described for Increment A. The higher level of design for the 2% chance exceedance flood event affects a larger portion of the left bank of Berryessa Creek downstream of Interstate 680, increasing the overall channel capacity. The increased channel capacity allows for a longer shallower overflow weir than in the without condition resulting in an increase in the floodplain.

Table 4-10 Original GRR Model Results - Increment B versus Without Project Floodplain Area Comparison

Increment	Floodplain Area in Acres (percent reduction from Without Project Floodplain)			
	2% Chance Exceedance Event	1% Chance Exceedance Event	0.5% Chance Exceedance Event	0.2% Chance Exceedance Event
Upstream of I-680 (Upper FLO-2D Model Results)				
Without Project	100 (N/A)	196 (N/A)	254 (N/A)	322 (N/A)
Increment B	0 (100%)	131 (33%)	208 (18%)	315 (2%)
Downstream of I-680 (Lower FLO-2D Model Results)				
Without Project	809 (N/A)	998 (N/A)	1083 (N/A)	1172 (N/A)
Increment B	0 (100%)	989 (1%)	1103 (-2%)	1148 (2%)
Total Study Area (Upper plus Lower FLO-2D Model Results)				
Without Project	909 (N/A)	1194 (N/A)	1337 (N/A)	1493 (N/A)
Increment B	0 (100%)	1121 (6%)	1311 (2%)	1463 (2%)

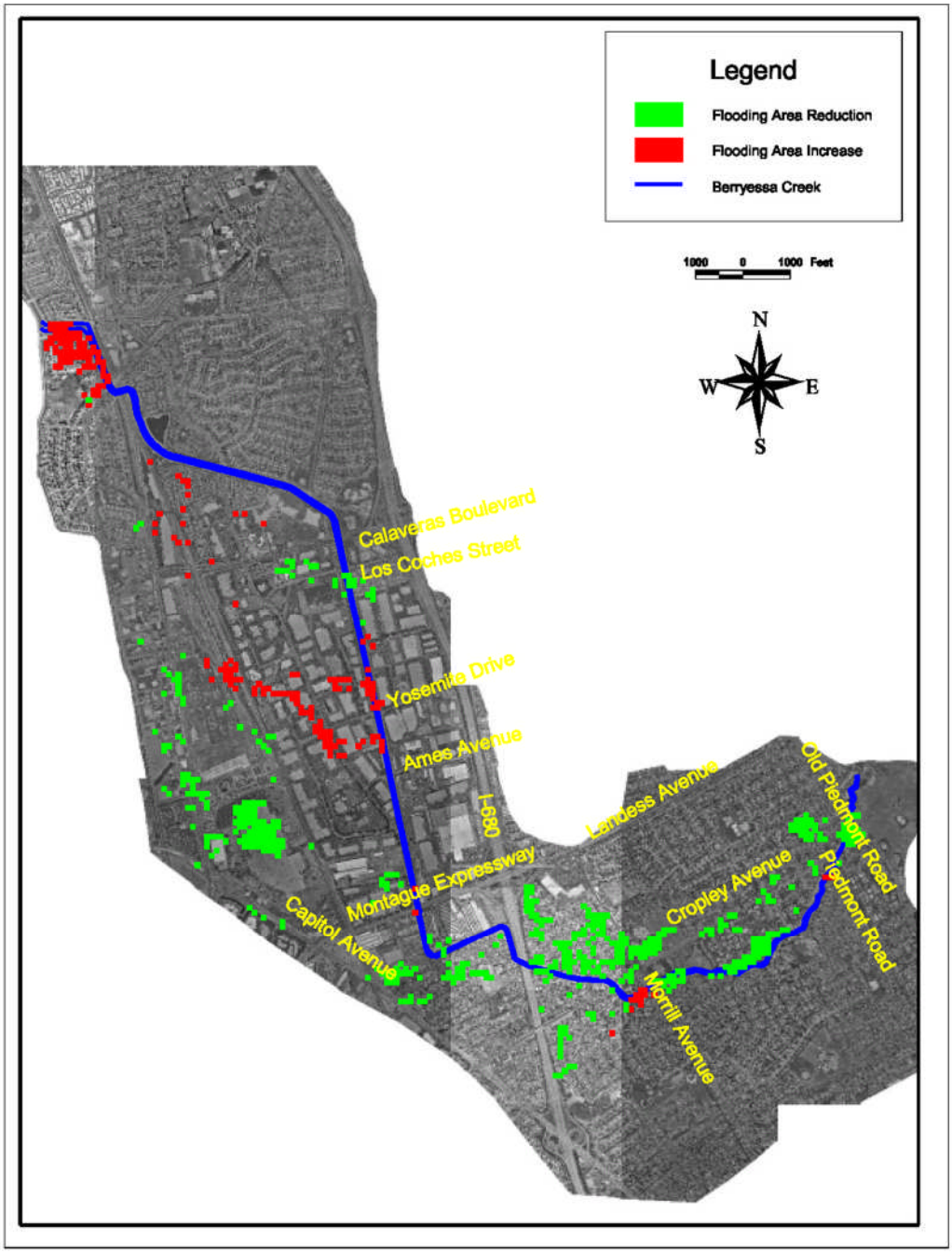

Figure 4-10 Change in Floodplain Area between the Original GRR Model Without Project and Increment B 1% Chance Exceedance Event Floodplains

4.3 Increment C – Pass 1% Chance Exceedance Event

Increment C provides protection from the 1% chance exceedance event for Berryessa Creek through the entire study reach. Increment C consists of the following project features:

- A 3-foot levee upstream of Old Piedmont Road
- Replacement of the Old Piedmont Bridge with a 22-foot span
- Armoring of bed and Banks between Old Piedmont Road and Cropley Avenue
- Replacement of the Piedmont-Cropley Culvert with a 20’ x 7’ culvert
- Levees of up to 3.1 feet in the Greenbelt Reach
- Replace the Morrill Avenue culvert with 26-foot span
- Removal of existing dragons teeth, channel invert smoothing and replacement of the Cropley Avenue Culvert with 24-foot span
- Levees of up to 2.1 feet from Montague Avenue to the I-680 Culvert
- Replacement of the Montague Culvert with 26-foot span with 1.5 foot headwall
- Replacement of the UPRR Trestle with a triple 11’ x 12’ box culvert (same design as the existing UPRR Culvert located downstream of the trestle)
- Channel Excavation and levees of up to 2.3 feet from the Montague Avenue to just downstream of Calaveras Boulevard
- Extension of existing wing-walls at the UPRR Culvert
- Installation of a transition structure at the Los Coches Bridge
- Installation of a transition structure at Calaveras Boulevard bridge

Table 4-11 and Table 4-12 list the resulting channel and breakout flows for the Increment C HEC-RAS model. Figure 4-11 and Figure 4-12 show the 0.5 and 0.2% chance exceedance event floodplains for Increment C.

Table 4-11 Original GRR Model Results for Increment C - 0.5% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1820		
Breakout at Old Piedmont Road Bridge	35249	1820		0
Sweigert Creek - Old Location	35029	1820		
Breakout at Cropley/Piedmont Culvert	34041	1710		110
Inflow at Sweigert Creek – Corrected Location	33136	1850	365	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1845		5
Inflow at Crosley Creek	30478	2105	477	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2098		7
Inflow at Sierra Creek	28656	2538	1493	
Breakout at Morrill Avenue Culvert	28447	2426		92
Downstream Cropley Avenue	25744	2648		
I-680 Culvert	25296	2660		
Lateral Weir Breakout Upstream of Montague	25295-21832	2219		441
Inflow at Montague Avenue	21821	3048	1077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	3011		38
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	3011		
Inflow at Yosemite Avenue	17465	3101	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	3101		
Inflow from Piedmont Creek	16437	4041	1691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	3849		192
Inflow from Los Coches Creek	14422	4659	1583	
Calaveras Boulevard	13887	4659		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 4-12 Original GRR Model Results for Increment C - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	2130		0
Sweigert Creek - Old Location	35029	2130		
Breakout at Cropley/Piedmont Culvert	34041	1806		324
Inflow at Sweigert Creek – Corrected Location	33136	2058	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1946		112
Inflow at Crosley Creek	30478	2286	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2252		35
Inflow at Sierra Creek	28656	2994	1848	
Breakout at Morrill Avenue Culvert	28447	2694		300
Downstream Cropley Avenue	25744	2994		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	2107		1033
Inflow at Montague Avenue	21821	3165	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	3067		99
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	3067		0
Inflow at Yosemite Avenue	17465	3157	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	3157		0
Inflow from Piedmont Creek	16437	4097	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	3636		461
Inflow from Los Coches Creek	14422	4670	1848	
Calaveras Boulevard	13887	4670		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

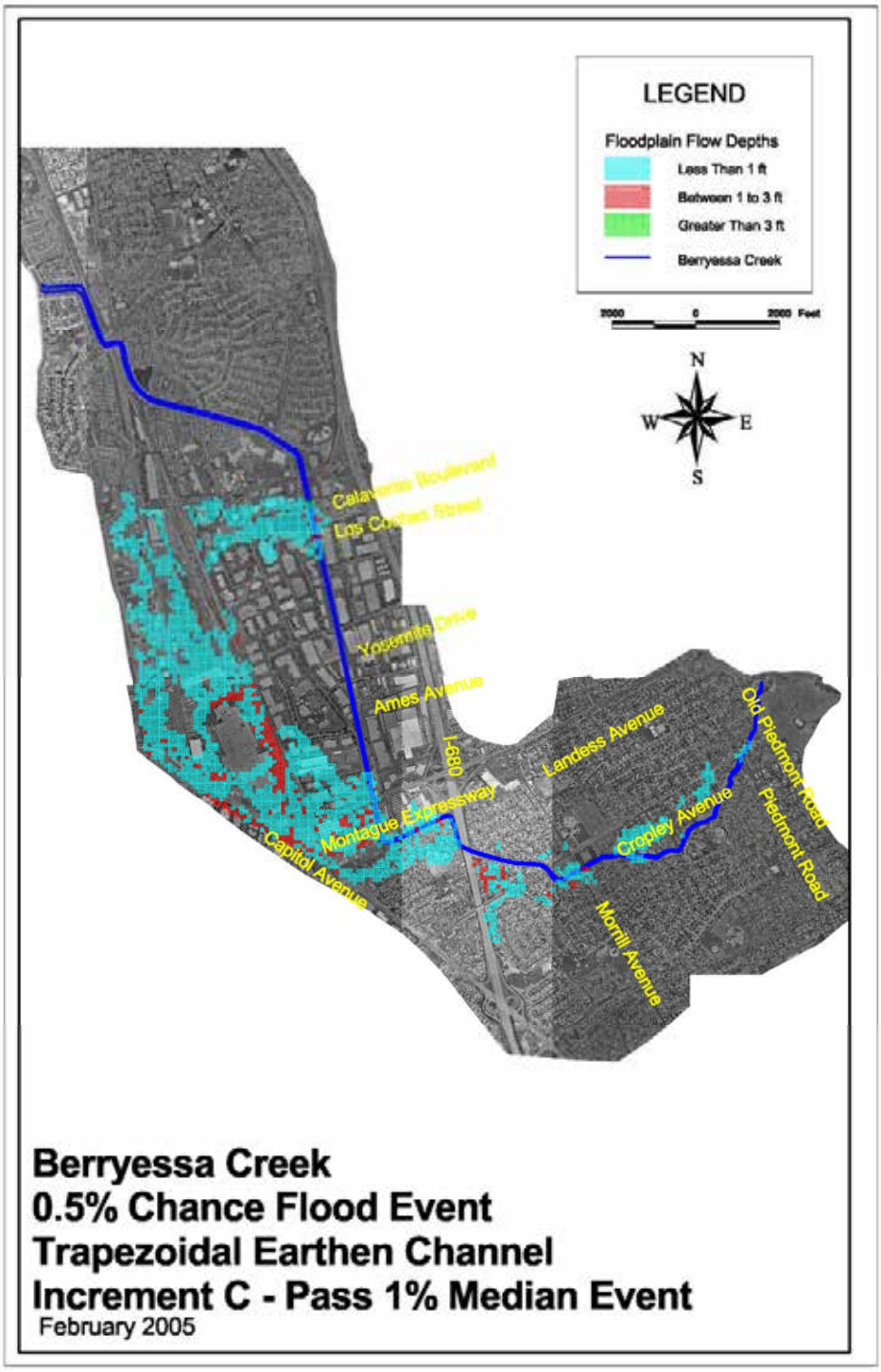

Figure 4-11 0.5% Chance Exceedance Event Floodplain for Original GRR Model Increment C

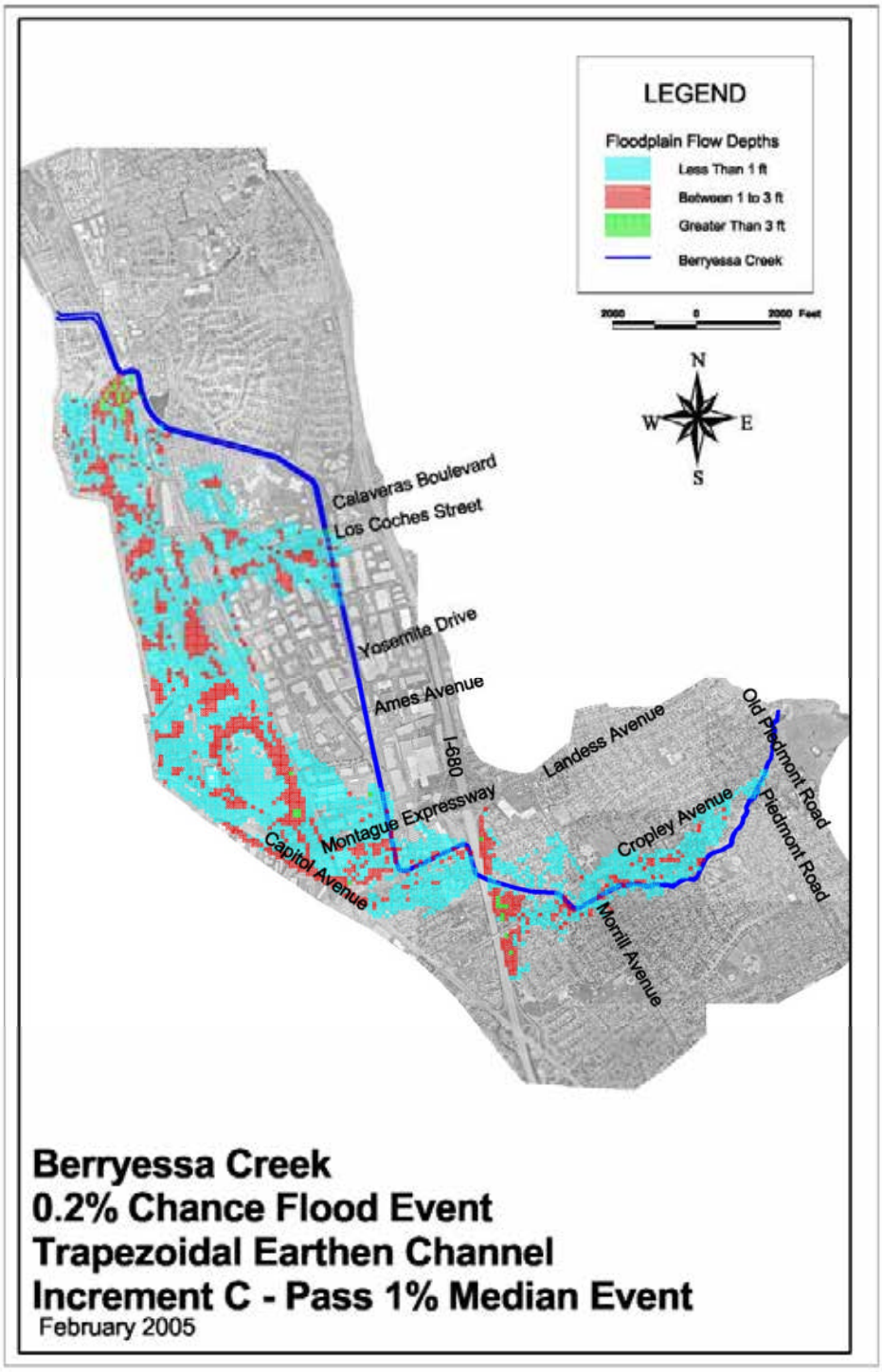

Figure 4-12 0.2% Chance Exceedance Event Floodplain for Original GRR Model Increment C

Figure 4-13 shows the resulting reduction and increases between Increment C and the without project 0.5% chance exceedance flood event. As seen in Figure 4-13, Increment C results in a small increase in the flooded area which is offset by the large areas of flooding reduction. Table 4-13 shows that Increment C results in a large reduction in floodplain extent for both the 0.2 and 0.5% chance exceedance flood events. This is primarily due to the greatly increased channel capacity that Increment C provides. The increased capacity allows the channel to convey a significantly larger portion of the flow volume that would escape into the floodplain in the without project conditions.

Table 4-13 Original GRR Model Results - Increment C versus Without Project Floodplain Area Comparison

Increment	Floodplain Area in Acres (percent reduction from Without Project Floodplain)			
	2% Chance Exceedance Event	1% Chance Exceedance Event	0.5% Chance Exceedance Event	0.2% Chance Exceedance Event
Upstream of I-680 (Upper FLO-2D Model Results)				
Without Project	100 (N/A)	196 (N/A)	254 (N/A)	322 (N/A)
Increment C	0 (100%)	0 (100%)	65 (75%)	177 (45%)
Downstream of I-680 (Lower FLO-2D Model Results)				
Without Project	809 (N/A)	998 (N/A)	1083 (N/A)	1172 (N/A)
Increment C	0 (100%)	0 (100%)	503 (54%)	865 (26%)
Total Study Area (Upper plus Lower FLO-2D Model Results)				
Without Project	909 (N/A)	1194 (N/A)	1337 (N/A)	1493 (N/A)
Increment C	0 (100%)	0 (100%)	567 (58%)	1041 (30%)

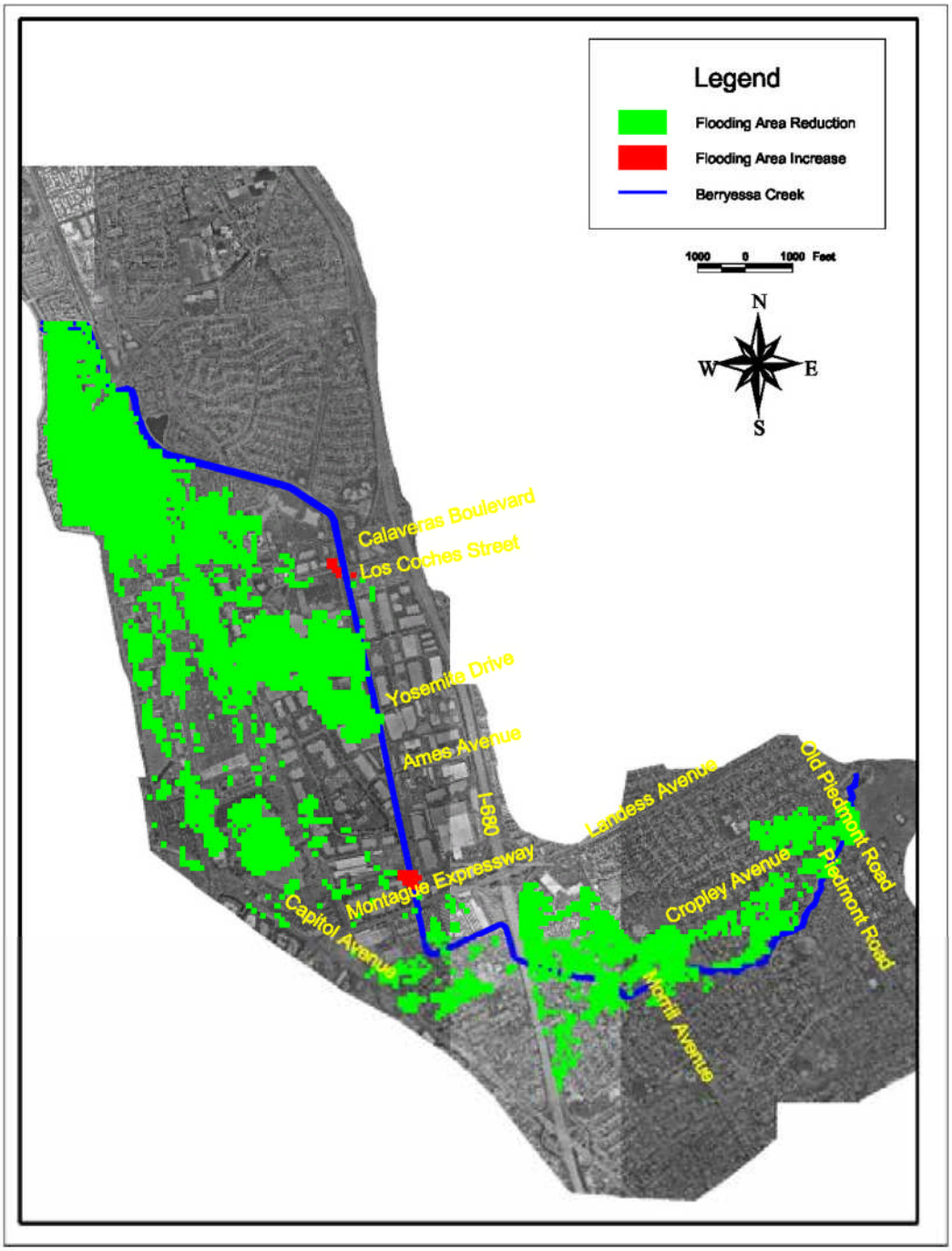

Figure 4-13 Change in Floodplain Area between the Original GRR Model Without Project and Increment C 0.5% Chance Exceedance Event Floodplains

4.4 Increment D - 0.5% Chance Exceedance Event

Increment D provides protection from a 0.5% chance exceedance event for Berryessa Creek through the study reach. Increment D consists of the following project features:

- A 3.5-foot levee upstream of Old Piedmont Road
- Replacement of the Old Piedmont Bridge with a 30 foot span
- Armoring of bed and Banks between Old Piedmont Road and Cropley Avenue
- Replacement of the Piedmont-Cropley Culvert with a 24’ x 7’ culvert
- Levees of up to 3.2 feet in the Greenbelt Reach
- Replace the Morrill Avenue culvert with 30-foot span
- Removal of existing dragons teeth, channel invert smoothing and replacement of the Cropley Avenue Culvert with 24-foot span
- Levees of up to 0.2 feet from Cropley Avenue to I-680 Culvert
- Levees of up to 3.2 feet from Montague Avenue to the I-680 Culvert
- Replacement of the Montague Culvert with 36-foot span with 2.5 foot headwall
- Replacement of the UPRR Trestle with a triple 11’ x 12’ box culvert
- Channel Excavation and levees of up to 2.7 feet from the Montague Avenue to just downstream of Calaveras Boulevard
- Extension of existing wing-walls at the UPRR Culvert
- Installation of a transition structure at the Los Coches Bridge
- Replace the Calaveras Boulevard bridge with 46 foot span

Table 4-14 lists the resulting channel and breakout flows for the Increment D HEC-RAS model. Figure 4-14 shows the 0.2% chance exceedance event floodplain for Increment D.

Table 4-14 Original GRR Model Results for Increment D - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1430		
Breakout at Old Piedmont Road Bridge	35249	2130		0
Sweigert Creek - Old Location	35029	2130		
Breakout at Cropley/Piedmont Culvert	34041	2039		90
Inflow at Sweigert Creek – Corrected Location	33136	2130	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	2130		
Inflow at Crosley Creek	30478	2600	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2596		4
Inflow at Sierra Creek	28656	3136	1848	
Breakout at Morrill Avenue Culvert	28447	3116		20
Downstream Cropley Avenue	25744	3136		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	2780		360
Inflow at Montague Avenue	21821	3840	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	3743		97
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	3743		
Inflow at Yosemite Avenue	17465	3833	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	3833		
Inflow from Piedmont Creek	16437	4773	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	4506		267
Inflow from Los Coches Creek	14422	5660	1848	
Calaveras Boulevard	13887	5660		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

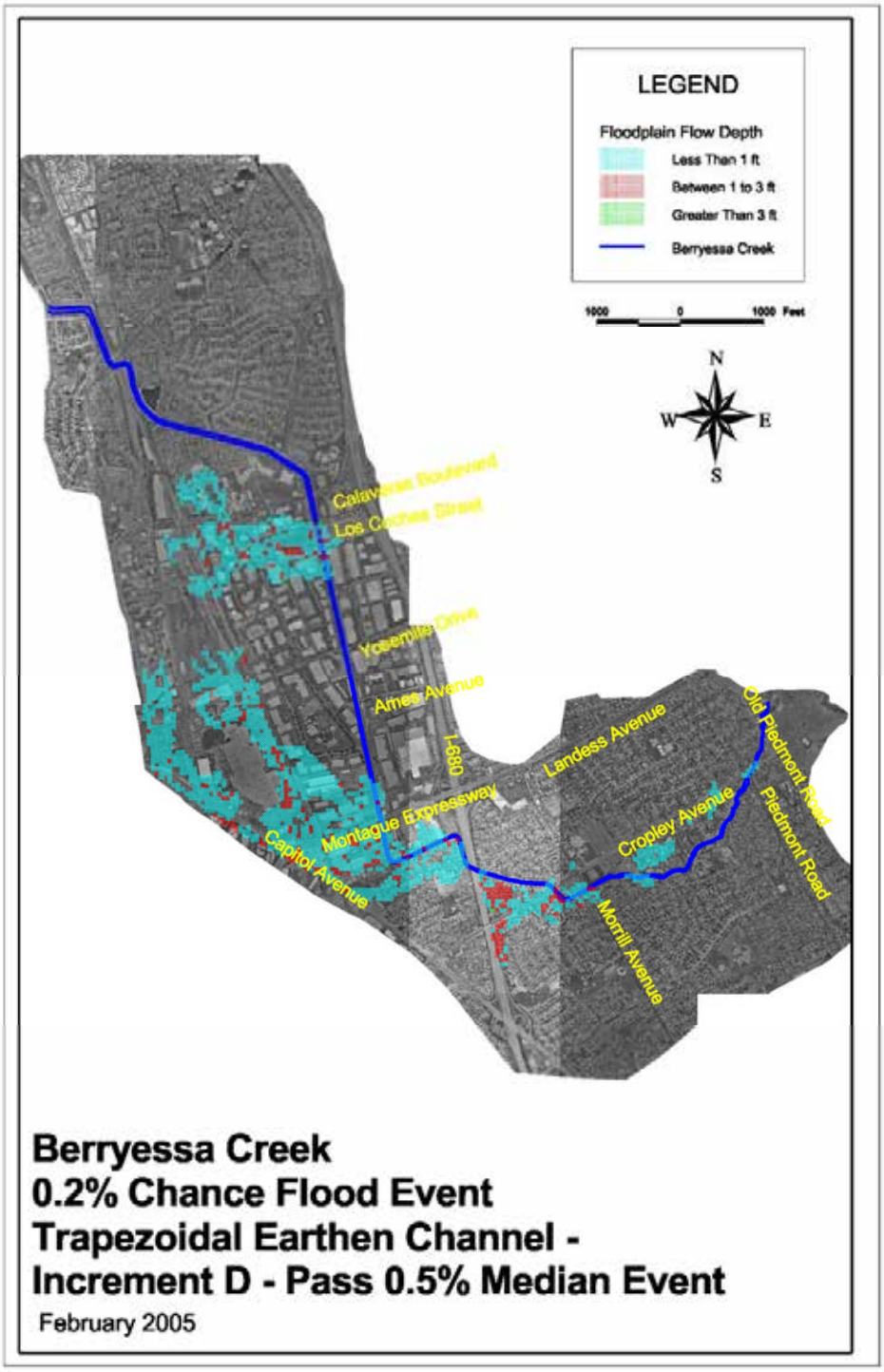

Figure 4-14 0.2% Chance Exceedance Event Floodplain for Original GRR Model Increment D

Figure 4-15 shows the resulting reduction between the Increment D and without project 0.2% chance exceedance flood event. The small areas of increased flooding are due to the bridge and bank improvements which allow a larger amount of flow to pass down the channel which were previously limited. The Increment D Plan encompasses a number of significant flood mitigation alternatives that increase the channel conveyance capacity and substantially reduce the area of inundation (Table 4-15).

Table 4-15 Original GRR Model Results Increment D versus Without Project Floodplain Floodplain Area Comparison

Increment	Floodplain Area in Acres (percent reduction from Without Project Floodplain)			
	2% Chance Exceedance Event	1% Chance Exceedance Event	0.5% Chance Exceedance Event	0.2% Chance Exceedance Event
Upstream of I-680 (Upper FLO-2D Model Results)				
Without Project	100 (N/A)	196 (N/A)	254 (N/A)	322 (N/A)
Increment D	0 (100%)	0 (100%)	0 (100%)	72 (78%)
Downstream of I-680 (Lower FLO-2D Model Results)				
Without Project	809 (N/A)	998 (N/A)	1083 (N/A)	1172 (N/A)
Increment D	0 (100%)	0 (100%)	0 (100%)	457 (61%)
Total Study Area (Upper plus Lower FLO-2D Model Results)				
Without Project	909 (N/A)	1194 (N/A)	1337 (N/A)	1493 (N/A)
Increment D	0 (100%)	0 (100%)	0 (100%)	529 (65%)

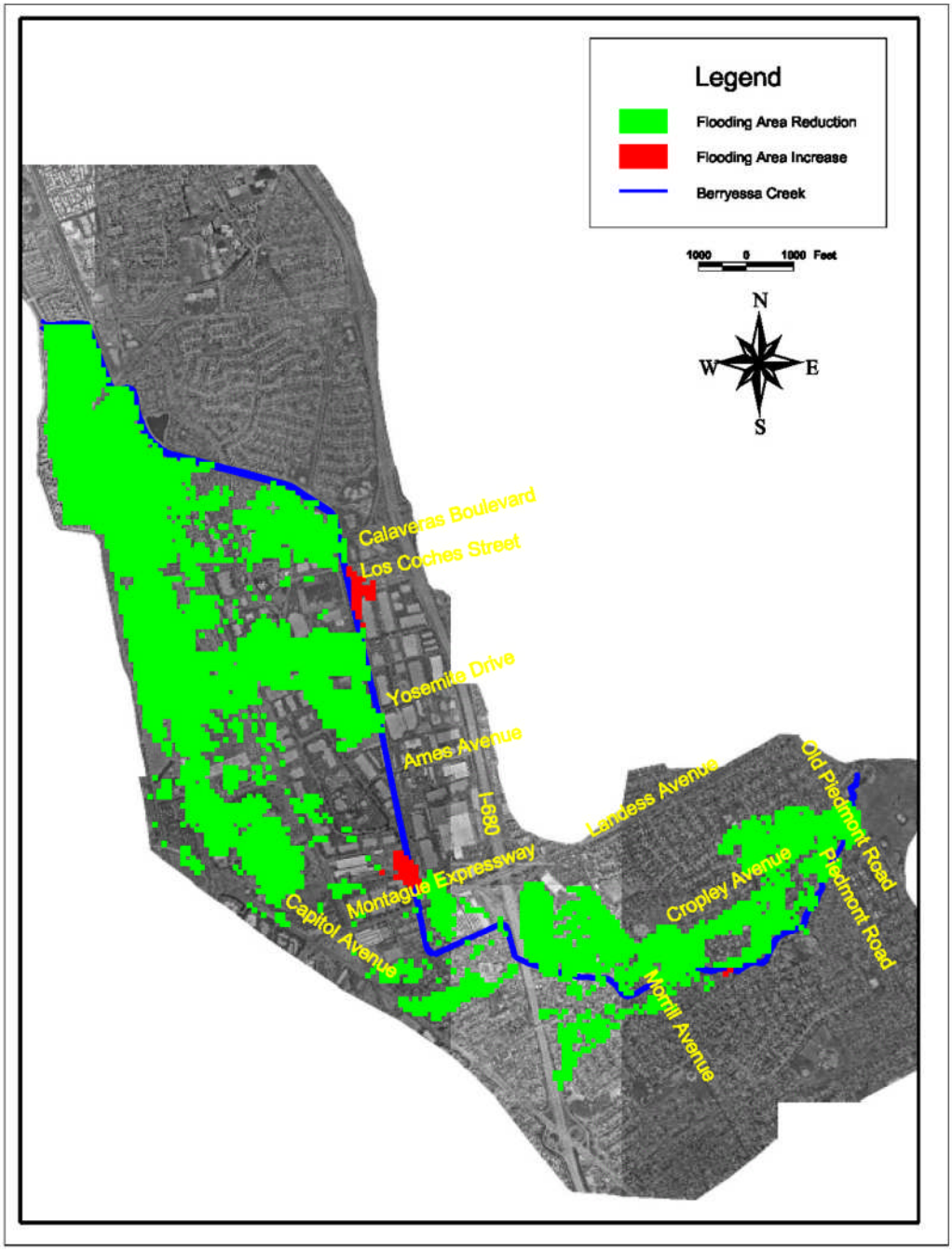

Figure 4-15 Change in Floodplain Area between the Original GRR Model Without Project and Increment D 0.2% Chance Exceedance Event Floodplains

4.5 Flood Damage Reduction Component Incremental Analysis Results Summary

The Flood Damage Reduction Component Incremental Plan analysis for flood mitigation of Berryessa Creek is summarized in Table 4-16. The reduced area of inundations for each plan was used to determine the NED analysis (Economics Appendix).

Table 4-16 Flood Damage Reduction Component Incremental Analysis Floodplain Area Results Summary

Increment	Floodplain Area in Acres (percent reduction from Without Project Floodplain)			
	2% Chance Exceedance Event	1% Chance Exceedance Event	0.5% Chance Exceedance Event	0.2% Chance Exceedance Event
Upstream of I-680 (Upper FLO-2D Model Results)				
Without Project	100 (N/A)	196 (N/A)	254 (N/A)	322 (N/A)
Increment A	12 (88%)	180 (8%)	246 (3%)	324 (-1%)
Increment B	0 (100%)	131 (33%)	208 (18%)	315 (2%)
Increment C	0 (100%)	0 (100%)	65 (75%)	177 (45%)
Increment D	0 (100%)	0 (100%)	0 (100%)	72 (78%)
Downstream of I-680 (Lower FLO-2D Model Results)				
Without Project	809 (N/A)	998 (N/A)	1083 (N/A)	1172 (N/A)
Increment A	821 (-2%)	1033 (-3%)	1101 (-2%)	1127 (4%)
Increment B	0 (100%)	989 (1%)	1103 (-2%)	1148 (2%)
Increment C	0 (100%)	0 (100%)	503 (54%)	865 (26%)
Increment D	0 (100%)	0 (100%)	0 (100%)	457 (61%)
Total Study Area (Upper plus Lower FLO-2D Model Results)				
Without Project	909 (N/A)	1194 (N/A)	1337 (N/A)	1493 (N/A)
Increment A	834 (8%)	1213 (-2%)	1347 (-1%)	1451 (3%)
Increment B	0 (100%)	1121 (6%)	1311 (2%)	1463 (2%)
Increment C	0 (100%)	0 (100%)	567 (58%)	1041 (30%)
Increment D	0 (100%)	0 (100%)	0 (100%)	529 (65%)

CHAPTER 5: PRELIMINARY ARRAY OF ALTERNATIVES

The preliminary array of alternatives was developed from 2006 to 2009 with the help of the information developed in the incremental analysis. The GRR with-project scenarios are built on the original GRR without-project HEC-RAS model and associated assumptions as described in Section 1.1. Floodplains for the preliminary array of alternatives were developed for the Berryessa Creek study area using the Original GRR Upper and Lower FLO-2D models (as described in Chapter 2) and the Original GRR HEC-RAS without-project model results (as described in *Appendix B, Part I, Hydraulic Analysis of Alternatives*).

The Authorized Plan, the NED plan, and three FEMA-certifiable alternatives were developed in support of this study. A HEC-RAS model was developed for each alternative and FLO-2D routing of breakout flows was performed. The FLO-2D output was developed into floodplains for each breakout event for all alternatives. Table 5-1 list the alternatives, short description of each, and the floodplain event developed.

Table 5-1 Berryessa Creek Alternatives

Alternative	Name	Floodplains
Alternative 1	No Action (Without Project as described in Chapter 2)	5-, 10-, 25-, 50-, 100-, 200-, and 500-yr
Authorized Plan	Authorized Plan	25-, 50-, 100-, 200-, and 500-yr
Alternative 2A	Incised Trapezoidal Channel	200- and 500-yr
Alternative 2B	Incised Trapezoidal Channel	500-yr
Alternative 3B	Terraced Trapezoidal Channel	200- and 500-yr
Alternative 4B	Walled Trapezoidal Channel	200- and 500-yr

The authorized plan, as presented in the 1987 feasibility study, was modeled in HEC-RAS for the current analysis. The authorized plan was modeled as described in the feasibility study with no updates to the design based on the revised 2006 hydrology.

The flood damage reduction component incremental floodplains (described in Chapter 4) were developed to aid in the determination of the optimal National Economic Development (NED) plan. The NED analysis is described in depth in the Economics Appendix. The Berryessa Creek Incremental Plan analysis for the flood damage reduction component resulted in the selection of a plan that passes median discharge associated with the 1% chance exceedance event for both the reach downstream of I-680 and upstream of I-680. One alternatives was developed to NED sizing (denoted as Moderate Protection below).

Three additional alternatives were developed to FEMA certifiable levels as described by Corps guidelines (denoted as FEMA-Certification Protection below). The design were done in compliance with criteria developed by the U.S. Army Corps as outlined in the Engineering Circular No. 1110-2-6067 “Certification of Levee Systems for the National Flood Insurance Program” dated September 30, 2008. EC 1110-2-6067 stated that the criteria for certification of a riverine levee system area as follow:

- The conditional non-exceedance probability (CNP) must be greater than 90% from overtopping of the base flood event for all reaches of the levee system.
- If the top of levee elevation if less than three feet above the FEMA base flood elevation, the levee can only be certified if the CNP is greater than 95%.
- The top of levee elevation shall not be less than 2 feet above the FEMA base flood elevation in any event, regardless is the CNP is 95% or greater.

For reaches within the study area consisting of entrenched channels, the criterion was a 90% CNP at the bank elevation for the FEMA base flood events per conversations with the Corps (COE 2008a). No minimum elevation above the base flood was specified for the entrenched channel.

For the purposes of this study, the 0.9% chance exceedance event was selected as the base flood event instead of the standard 1% event. The use of the 0.9% chance exceedance event was selected to provide for robust alternative designs with respect to FEMA certification, against possible future changes in the hydrology or hydraulics.

5.1 Alternative 1- No Action Alternative

Alternative 1 is the no action alternative. The no action alternative is the without project floodplains described as described in Chapter 2.

5.2 Authorized Project

The Authorized Plan is the plan authorized by Congress in 1990. The Authorized Project is a primarily a concrete-lined channel with a natural greenbelt. (Note that the Authorized Project was modeled without updating the plan due to hydrologic changes.)

The Authorized Project consists of the following project features:

- Concrete Primary Sediment Basin upstream of Old Piedmont Road
- Lower invert and construct inlet transition structure at Old Piedmont Bridge
- Construct concrete-line channel with 5-foot bottom width and 1.5H:1V side slopes from Old Piedmont to Piedmont Cropley.
- Construct secondary stilling basin downstream of Piedmont Cropley Culvert.
- Construct earthen levees with maximum height of 3 feet from Piedmont Cropley to Morrill Avenue.
- Construct concrete lined channel with 14-foot bottom width and 1.5H:1V side slopes from Morrill Avenue to Cropley Blvd.
- Construct inlet transition at Cropley Ave. Bridge.
- Extend Lining of existing concrete channel 0.06 feet from Cropley to I-680.
- Construct trapezoidal concrete lined channel with 20-foot bottom width and 1.5H:1V side slopes from I-680 to Montague Expressway.
- Construct sloping wingwall structure at Montague Expressway Bridge.
- Construct trapezoidal concrete lined channel with 9-foot bottom width and 1.5H:1V side slopes from Montague Expressway to UPRR Culvert.

- Replace UPRR trestle with triple 11-ft by 9-ft RCB.
- Construct inlet transition at UPRR Trestle.
- Construct trapezoidal concrete lined channel with 12-foot bottom width and 1.5H:1V side slopes from UPRR Trestle to Yosemite Drive.
- Excavate and extend concrete lining below Ames Ave. Bridge.
- Excavate and extend concrete lining below Yosemite Drive Bridge.
- Construct trapezoidal concrete lined channel with 16-foot bottom width and 1.5H:1V side slopes from Yosemite Drive to Los Coches Street.
- Tie in concrete lining to existing concrete bed and reconstruct Los Coches Creek confluence at Los Coches Street Bridge.
- Construct trapezoidal concrete lined channel with 30-foot bottom width and 1.5H:1V side slopes from Los Coches Street to Calaveras Blvd.
- Construct sloping wingwall transition structure at Calaveras Blvd. Bridge
- Re-grade from Transition structure to existing channel downstream of Calaveras Blvd.

Table 5-2 to Table 5-6 list the resulting channel and breakout flows for the Authorized Project HEC-RAS model. Figure 5-1 to Figure 5-5 show the area of inundation for the Authorized Project.

Table 5-2 Original GRR Model Results for the Authorized Project – 4% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	830		
Breakout at Old Piedmont Road Bridge	35249	830		0
Sweigert Creek - Old Location	35029	830		
Breakout at Cropley/Piedmont Culvert	34041	830		0
Inflow at Sweigert Creek – Corrected Location	33136	890	212	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	769		121
Inflow at Crosley Creek	30478	879	245	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	879		0
Inflow at Sierra Creek	28656	1139	778	
Breakout at Morrill Avenue Culvert	28447	1139		0
Downstream Cropley Avenue	25744	1139		
I-680 Culvert	25296	1260		
Lateral Weir Breakout Upstream of Montague	25295-21832	1257		3
Inflow at Montague Avenue	21821	1616	684	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1616		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1616		0
Inflow at Yosemite Avenue	17465	1766	236	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1583		183
Inflow from Piedmont Creek	16437	2126	861	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1877		250
Inflow from Los Coches Creek	14422	2497	757	
Calaveras Boulevard	13887	2473		24

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 5-3 Original GRR Model Results for the Authorized Project - 2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1090		
Breakout at Old Piedmont Road Bridge	35249	1082		8
Sweigert Creek - Old Location	35029	1082		
Breakout at Cropley/Piedmont Culvert	34041	1023		59
Inflow at Sweigert Creek – Corrected Location	33136	1113	250	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1000		113
Inflow at Crosley Creek	30478	1000	277	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1000		0
Inflow at Sierra Creek	28656	1449	968	
Breakout at Morrill Avenue Culvert	28447	1449		0
Downstream Cropley Avenue	25744	1449		
I-680 Culvert	25296	1563		
Lateral Weir Breakout Upstream of Montague	25295-21832	1102		460
Inflow at Montague Avenue	21821	1492	791	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1411		80
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1478		0
Inflow at Yosemite Avenue	17465	1658	265	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1658		0
Inflow from Piedmont Creek	16437	2448	1049	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1302		1146
Inflow from Los Coches Creek	14422	2142	972	
Calaveras Boulevard	13887	2142		

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek

Table 5-4 Original GRR Model Results for the Authorized Project - 1% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1430		
Breakout at Old Piedmont Road Bridge	35249	1385		45
Sweigert Creek - Old Location	35029	1385		
Breakout at Cropley/Piedmont Culvert	34041	1028		357
Inflow at Sweigert Creek – Corrected Location	33136	1128	308	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1011		117
Inflow at Crosley Creek	30478	1011	372	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1011		0
Inflow at Sierra Creek	28656	1621	1458	
Breakout at Morrill Avenue Culvert	28447	1599		22
Downstream Cropley Avenue	25744	1599		
I-680 Culvert	25296	1716		
Lateral Weir Breakout Upstream of Montague	25295-21832	898		818
Inflow at Montague Avenue	21821	1535	922	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1387		170
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	1811		0
Inflow at Yosemite Avenue	17465	1942	302	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1917		24
Inflow from Piedmont Creek	16437	1881	1338	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1214		1667
Inflow from Los Coches Creek	14422	2315	1253	
Calaveras Boulevard	13887	2315		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 5-5 Original GRR Model Results for the Authorized Project – 0.5% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1820		
Breakout at Old Piedmont Road Bridge	35249	1662		158
Sweigert Creek - Old Location	35029	1662		
Breakout at Cropley/Piedmont Culvert	34041	1054		608
Inflow at Sweigert Creek – Corrected Location	33136	1194	365	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1059		135
Inflow at Crosley Creek	30478	1319	477	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1306		13
Inflow at Sierra Creek	28656	1746	1493	
Breakout at Morrill Avenue Culvert	28447	1505		241
Downstream Cropley Avenue	25744	1505		
I-680 Culvert	25296	2233		
Lateral Weir Breakout Upstream of Montague	25295-21832	921		1312
Inflow at Montague Avenue	21821	1735	1077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1716		19
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	2143		0
Inflow at Yosemite Avenue	17465	2233	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1700		533
Inflow from Piedmont Creek	16437	2469	1691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1677		792
Inflow from Los Coches Creek	14422	2987	1583	
Calaveras Boulevard	13887	2614		374

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 5-6 Original GRR Model Results for the Authorized Project - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	1848		283
Sweigert Creek - Old Location	35029	1848		
Breakout at Cropley/Piedmont Culvert	34041	1068		782
Inflow at Sweigert Creek – Corrected Location	33136	1238	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1092		146
Inflow at Crosley Creek	30478	1392	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	1372		19
Inflow at Sierra Creek	28656	1913	1848	
Breakout at Morrill Avenue Culvert	28447	1496		416
Downstream Cropley Avenue	25744	1496		
I-680 Culvert	25296	2472		
Lateral Weir Breakout Upstream of Montague	25295-21832	700		1772
Inflow at Montague Avenue	21821	1739	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	1604		423
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	2272		0
Inflow at Yosemite Avenue	17465	2362	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	1692		670
Inflow from Piedmont Creek	16437	2558	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	1588		970
Inflow from Los Coches Creek	14422	3106	1848	
Calaveras Boulevard	13887	2630		477

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

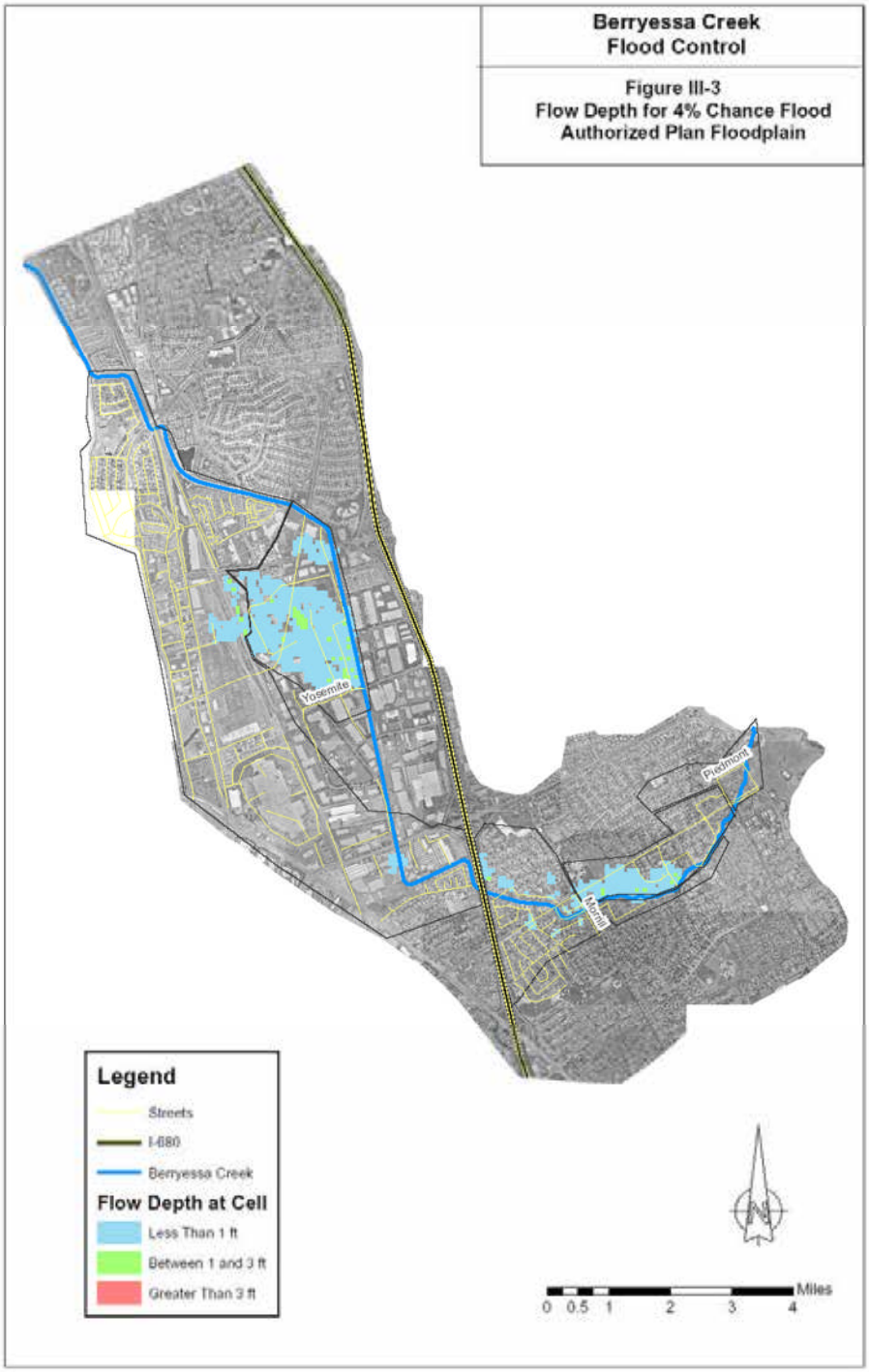

Figure 5-1 4% Chance Exceedance Event Floodplain for the Original GRR Model Authorized Project

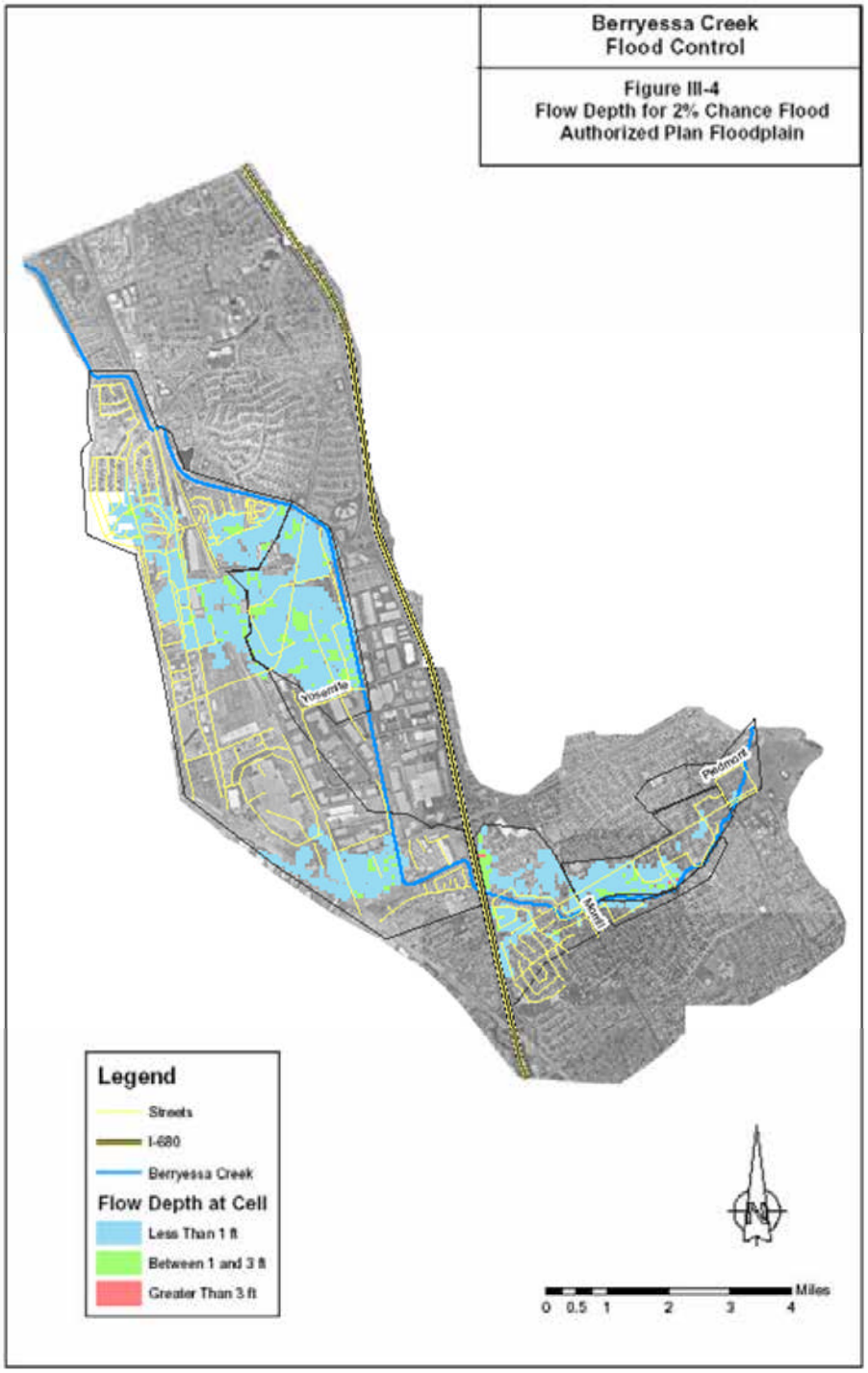

Figure 5-2 2% Chance Exceedance Event Floodplain for the Original GRR Model Authorized Project

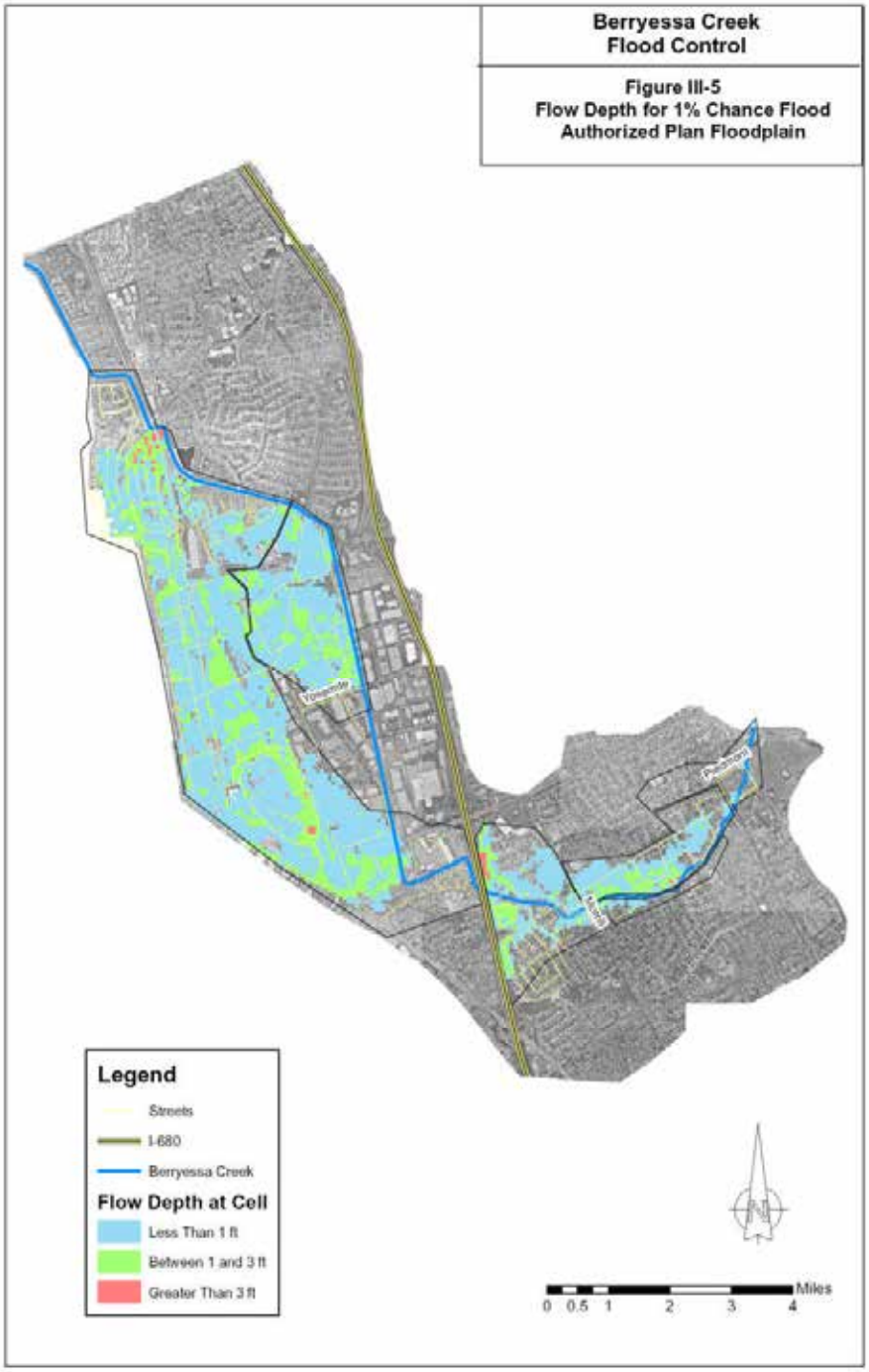

Figure 5-3 1% Chance Exceedance Event Floodplain for the Original GRR Model Authorized Project

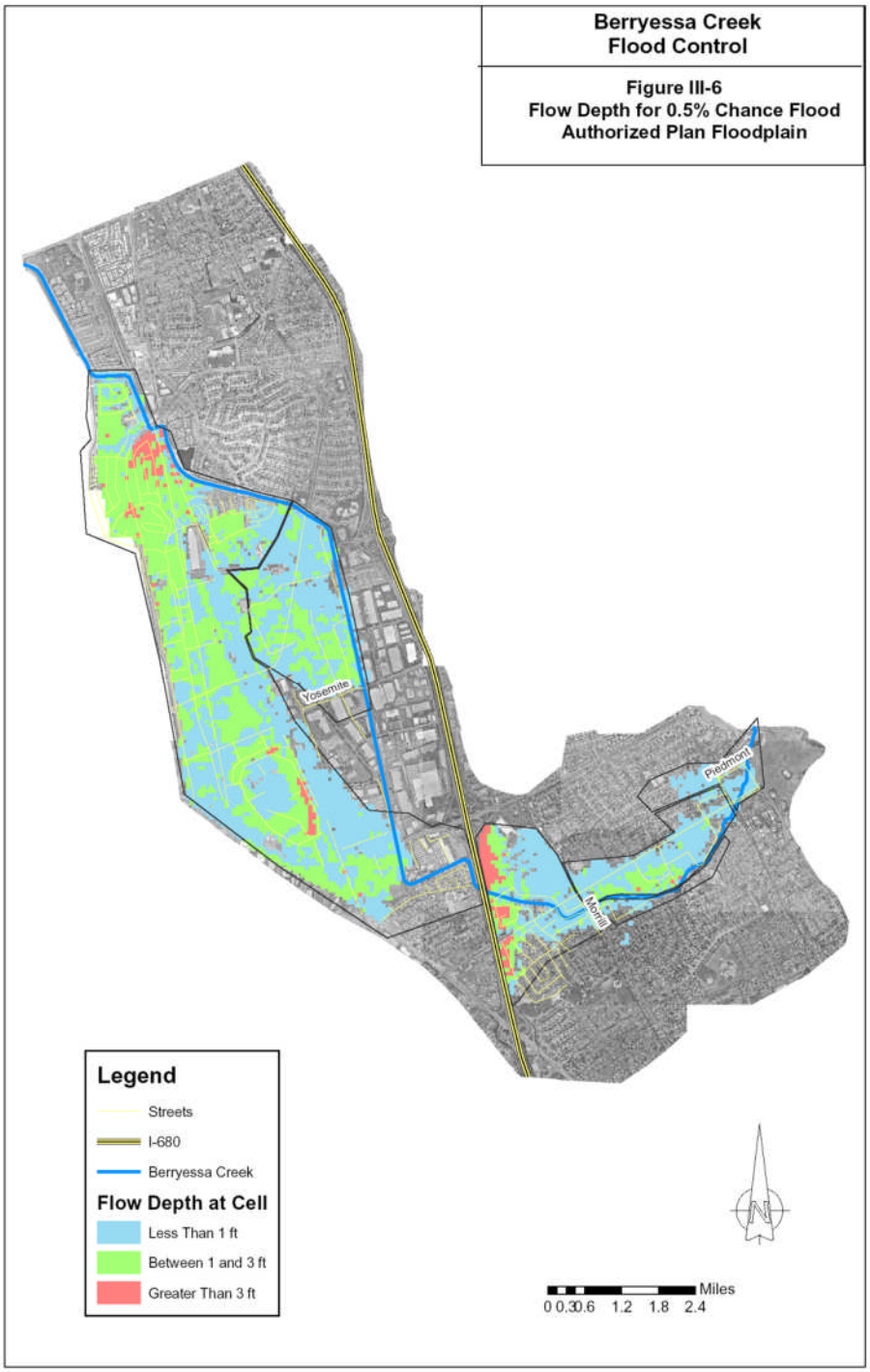

Figure 5-4 0.5% Chance Exceedance Event Floodplain for the Original GRR Model Authorized Project

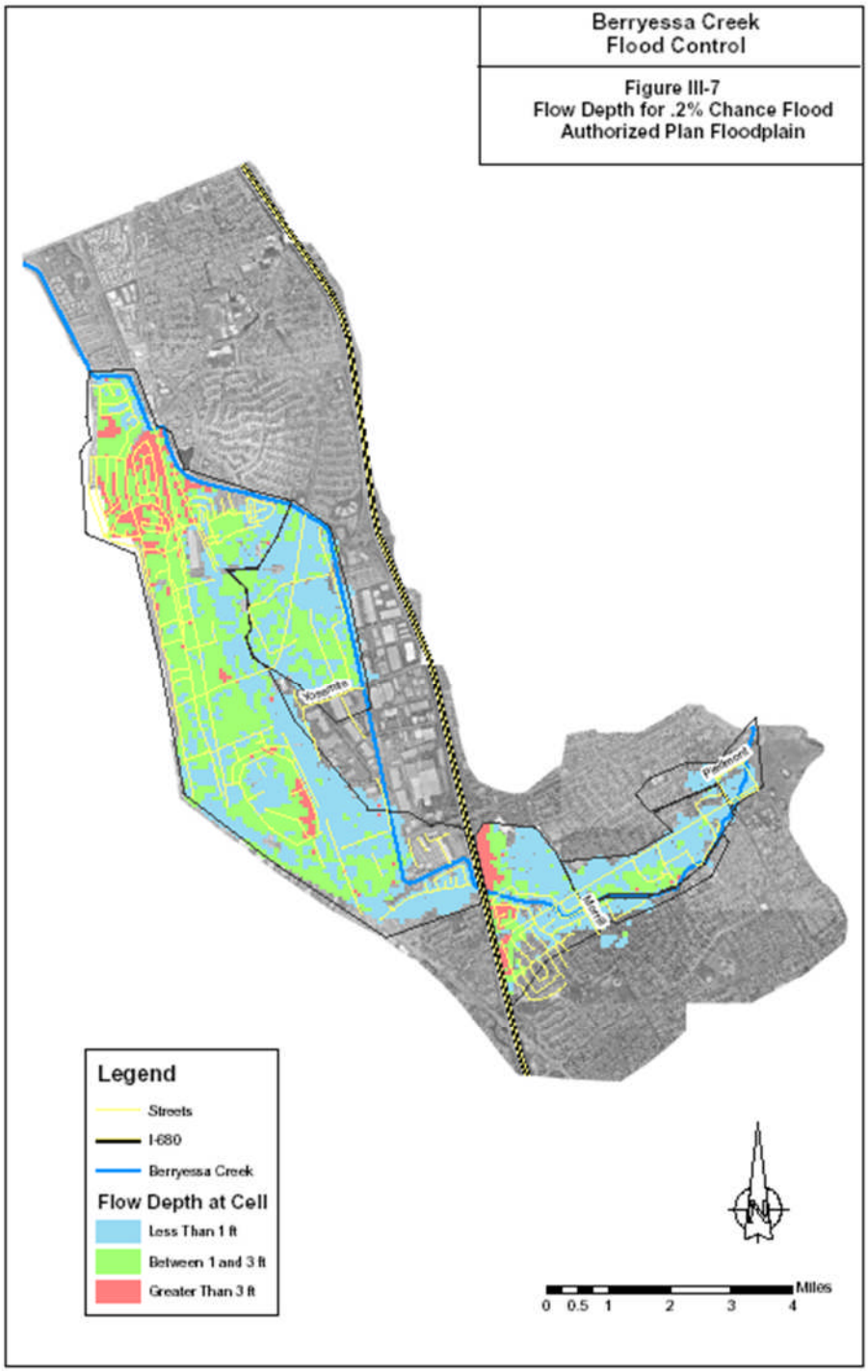

Figure 5-5 0.2% Chance Exceedance Event Floodplain for the Original GRR Model Authorized Project

5.3 Alternative 2A – Incised Trapezoidal Channel - Moderate Protection

Alternative 2A consists of a 1% chance exceedance event level of protection upstream and downstream of the I-680 culvert. The formulation of Alternative 2A was based on the results of the flood damage reduction component incremental analysis projects and the conceptual design developed in the F3 phase of the study. A complete description of the alternative formulation process is included in *Appendix B, Part I, "Hydraulic Analysis of Alternatives"*.

Alternative 2A consists of the following project features:

- A 1 ft parapet wall upstream of Old Piedmont Road
- Replace Old Piedmont Bridge with a 22ft span bridge
- Construct riffle and pools with boulder weirs between Old Piedmont Road and Cropley Avenue
- Replace Piedmont-Cropley Culvert with 20 ft box
- Lower sediment basin bed by 4 feet.
- Excavate floodplain terra and construct floodwall with maximum 1 ft height in the Greenbelt Reach.
- Replace Morrill Avenue with 26 ft span
- Removal of existing dragons teeth
- Excavate channel thalweg and replace Cropley Avenue culvert with 24-foot span bridge.
- Excavate 30-foot bottom width earthen channel with cellular bank protection and construct levees of up to 1.8 feet from Montague Avenue to the I-680 Culvert
- Replacement of the Montague Culvert with 30-foot span with 1.5 foot headwall
- Excavate 10-foot bottom width earthen channel with cellular bank protection and construct levees of up to 1.8 feet from Montague Avenue to UPRR Trestle
- Replacement of the UPRR Trestle with a triple 11ft x 12ft box culvert (same design as the existing UPRR Culvert located downstream of the trestle)
- Excavate 40-foot bottom width earthen channel with cellular bank protection from Montague Avenue to the Yosemite Drive
- Excavate 50-foot bottom width earthen channel with cellular bank protection and earthen levees to 4 feet from Yosemite Drive to downstream of Calaveras Blvd.
- Extension of existing wing-walls at the UPRR Culvert
- Installation of a transition structure and 3-foot headwall and reconstruct confluence at the Los Coches Bridge
- Installation of a transition structure and 3-foot headwall at Calaveras Boulevard bridge

Note that channel excavation/modifications downstream of the I-680 culvert were based on an earthen trapezoidal cross section as shown in Figure 5-1. The project attempts to balance the cut and fill by using levees along the tops of the channel banks. A 2:1 side slope was maintained were possible, but was steepened as necessary to keep the footprint within the existing right of way.

An Alternative 2A HEC-RAS model was developed from the baseline HEC-RAS model. Table 5-7 and Table 5-8 list the resulting channel and breakout flows for the Alternative 2A HEC-RAS model. The 0.5 and 0.2 percent chance exceedance floodplains were developed for Alternative 2A using the methods outlined in Chapter 1. Figure 5-6 and Figure 5-7 show the area of inundation for Alternative 2A.

Table 5-7 Original GRR Model Results for Alternative 2A Incised Trapezoidal Channel – Moderate Protection - 0.5% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	1820		
Breakout at Old Piedmont Road Bridge	35249	1776		43
Sweigert Creek - Old Location	35029	1776		
Breakout at Cropley/Piedmont Culvert	34041	1729		47
Inflow at Sweigert Creek – Corrected Location	33136	1869	365	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1868		1
Inflow at Crosley Creek	30478	2127	477	
Lateral Weir Breakout Upstream Morrill Avenue	30468-28656	2012		114
Inflow at Sierra Creek	28656	2453	1493	
Breakout at Morrill Avenue Culvert	28447	2452		0
Breakout Downstream Cropley Avenue	25744	2315		138
I-680 Culvert	25296	2660		
Lateral Weir Breakout Upstream of Montague	25295-21832	2161		499
Inflow at Montague Avenue	21821	2990	1077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	2930		60
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	2930		0
Inflow at Yosemite Avenue	17465	3020	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	3020		0
Inflow from Piedmont Creek	16437	4220	1691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	3899		398
Inflow from Los Coches Creek	14422	5132	1583	
Calaveras Boulevard	13887	5103		29

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 5-8 Original GRR Model Results for Alternative 2A Incised Trapezoidal Channel – Moderate Protection - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	2080		50
Sweigert Creek - Old Location	35029	2080		
Breakout at Cropley/Piedmont Culvert	34041	1818		262
Inflow at Sweigert Creek – Corrected Location	33136	1988	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	1979		9
Inflow at Crosley Creek	30478	2275	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2069		206
Inflow at Sierra Creek	28656	2610	1848	
Breakout at Morrill Avenue Culvert	28447	2610		0
Breakout Downstream Cropley Avenue	25744	2378		232
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	2058		1082
Inflow at Montague Avenue	21821	3115	1230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	2976		139
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	2976		0
Inflow at Yosemite Avenue	17465	3066	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	3066		0
Inflow from Piedmont Creek	16437	4406	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	3795		763
Inflow from Los Coches Creek	14422	5163	1848	
Calaveras Boulevard	13887	5095		68

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

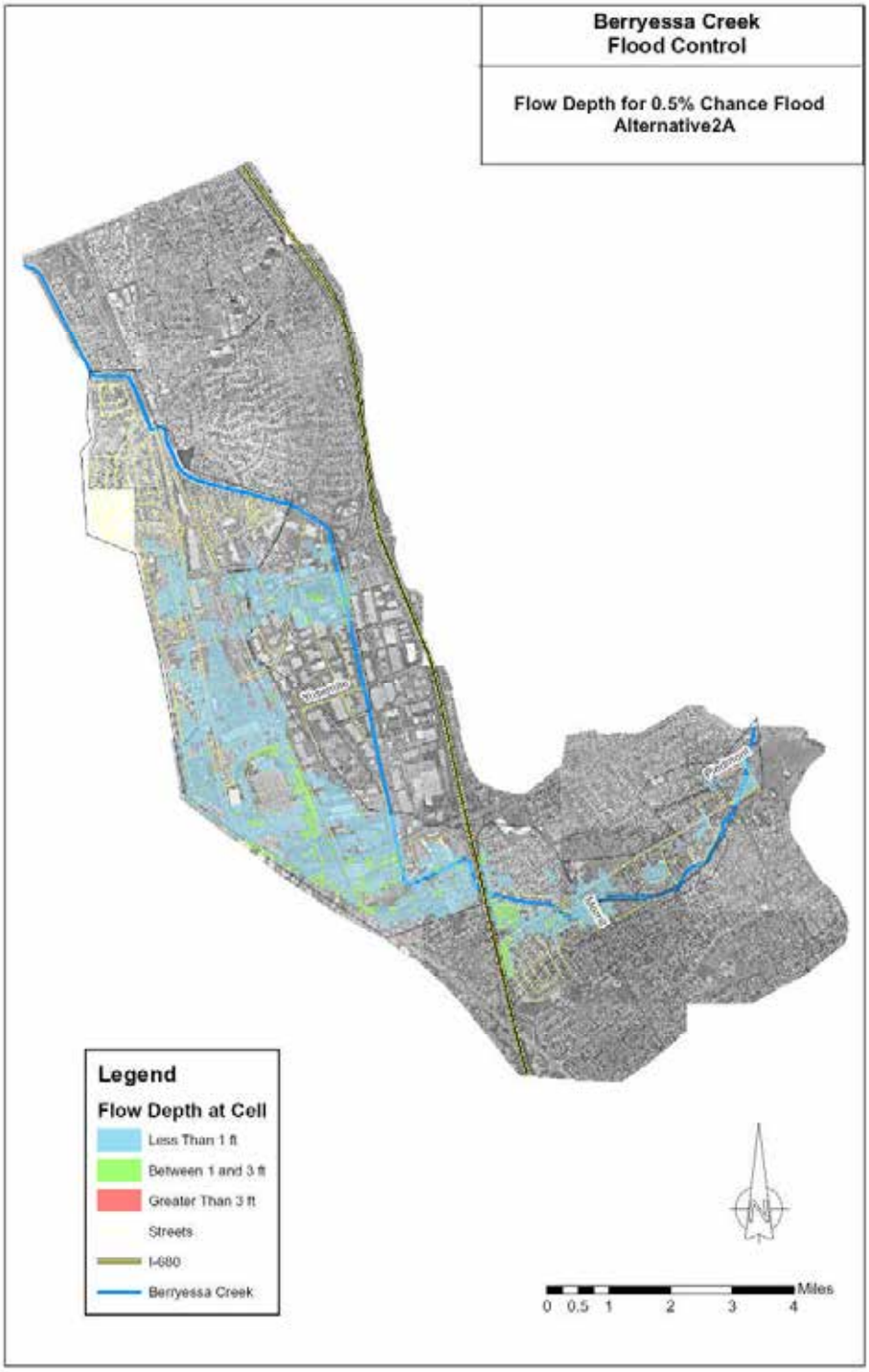

Figure 5-6 0.5% Chance Exceedance Event Floodplain for Original GRR Model Alternative 2A

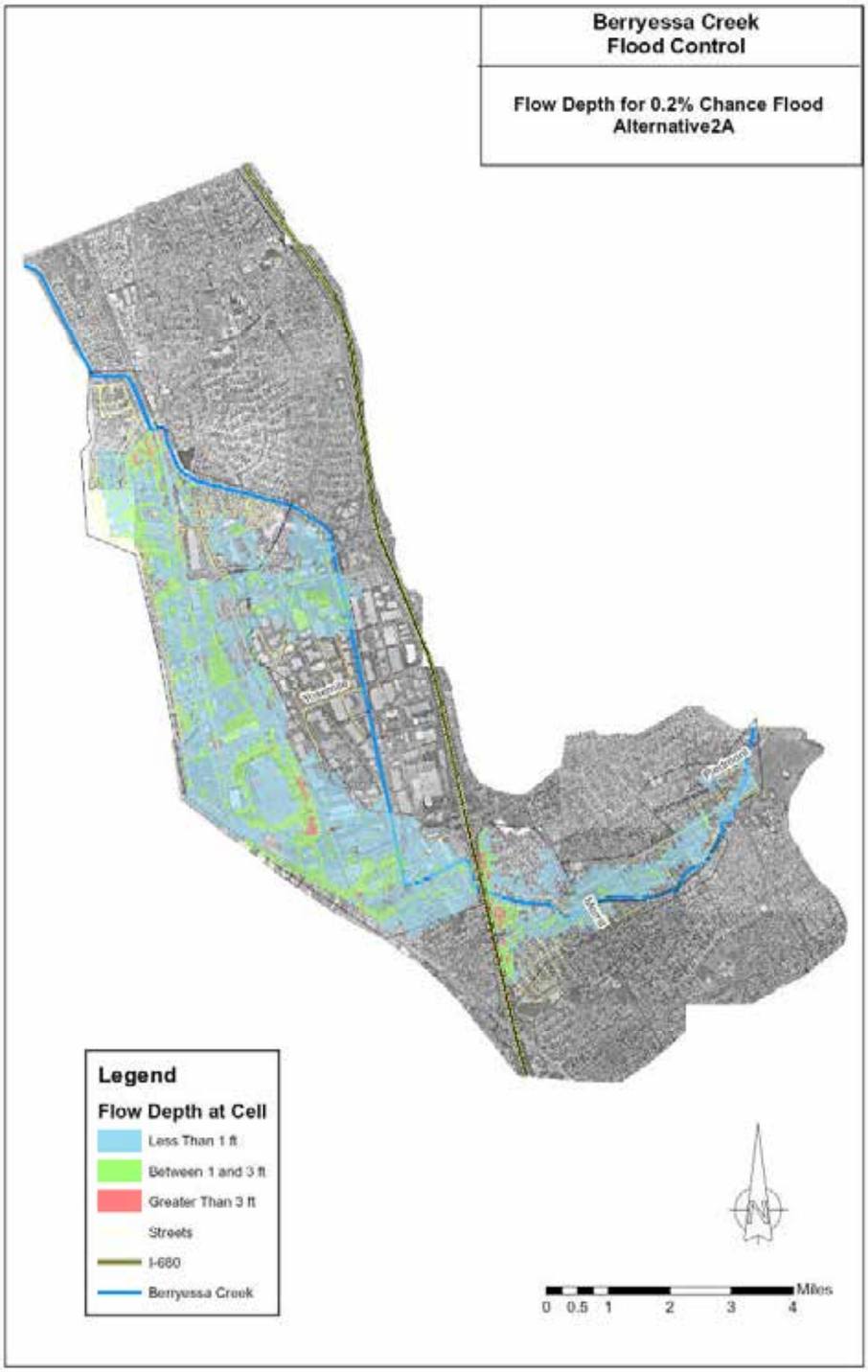

Figure 5-7 0.2% Chance Exceedance Event Floodplain for Original GRR Model Alternative 2A

5.4 Alternative 2B – Incised Trapezoidal Channel - FEMA-Certification Protection

Alternative 2B consists of a FEMA certifiable level of protection upstream and downstream of the I-680 culvert. Alternative 2B is fundamentally the same as Alternative 2A with the features modified to provide a FEMA certifiable design.

Alternative 2B consists of the following project features:

- A 3-ft parapet wall and debris trap upstream of Old Piedmont Road
- Replace Old Piedmont Bridge with a 36-ft span bridge
- Construct riffle and pools with boulder weirs between Old Piedmont Road and Cropley Avenue
- Replace Piedmont-Cropley Culvert with 28-ft box
- Lower sediment basin bed by 4 feet.
- Excavate floodplain terrace and construct floodwall with maximum 2-ft height in the Greenbelt Reach.
- Replace Morrill Avenue with 32-ft span
- Removal of existing dragons teeth, channel invert smoothing, bridge replacement at Cropley Avenue Culvert with 24 ft span
- Construct up to 3-ft concrete parapet wall from Morrill Ave. to I-680.
- Excavate 10- to 40-foot bottom width earthen channel with cellular bank protection and construct levees of up to 3 feet from I-680 to UPRR Trestle.
- Replacement of the Montague Culvert with 60-foot span with 3-foot headwall
- Replacement of the UPRR Trestle with a triple 15ft x 12ft box culvert.
- Excavate 10- to 40-foot bottom width earthen channel with cellular bank protection from UPRR Trestle to Yosemite Drive
- Replacement of the UPRR Culvert with a triple 40-ft bridge
- Excavate 55-foot bottom width earthen channel with cellular bank protection and concrete parapet walls up to 6 feet from Yosemite Drive to Calaveras Blvd.
- Construct 100-ft bridge with 4-ft headwall at Los Coches Street
- Construct 100-ft raised deck bridge with 6-ft headwall at Calaveras Blvd.
- Excavate 70-foot bottom width earthen channel with cellular bank protection and concrete parapet walls up to 6 feet downstream of Calaveras Blvd.

Note that channel excavation/modifications downstream of the I-680 culvert were based on an earthen trapezoidal cross section as shown in Figure 5-1. A 2:1 side slope was maintained were possible, but was steepened as necessary to keep the footprint within the existing right of way.

A HEC-RAS model for Alternative 2B was developed from the baseline HEC-RAS model. Table 5-9 lists the resulting channel and breakout flow for the Alternative 2B HEC-RAS model. The 0.2% chance exceedance floodplain was developed for Alternative B using the methods outlined in Chapter 1. Figure 5-8 shows the area of inundation for Alternative 2B.

Table 5-9 Original GRR Model Results for Alternative 2B Incised Trapezoidal Channel – FEMA Certifiable Protection - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	2125		22
Sweigert Creek - Old Location	35029	2125		
Breakout at Cropley/Piedmont Culvert	34041	2125		0
Inflow at Sweigert Creek – Corrected Location	33136	2277	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	2276		1
Inflow at Crosley Creek	30478	2577	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2573		4
Inflow at Sierra Creek	28656	3113	1848	
Breakout at Morrill Avenue Culvert	28447	3113		0
Downstream Cropley Avenue	25744	3113		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	3140		0
Inflow at Montague Avenue	21821	4200	1230	
Lateral Weir Breakout Downstream of UPPR Trestle	20838-19390	4127		73
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	4127		0
Inflow at Yosemite Avenue	17465	4217	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	4217		0
Inflow from Piedmont Creek	16437	5557	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	5188		563
Inflow from Los Coches Creek	14422	6517	1848	
Calaveras Boulevard	13887	6517		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

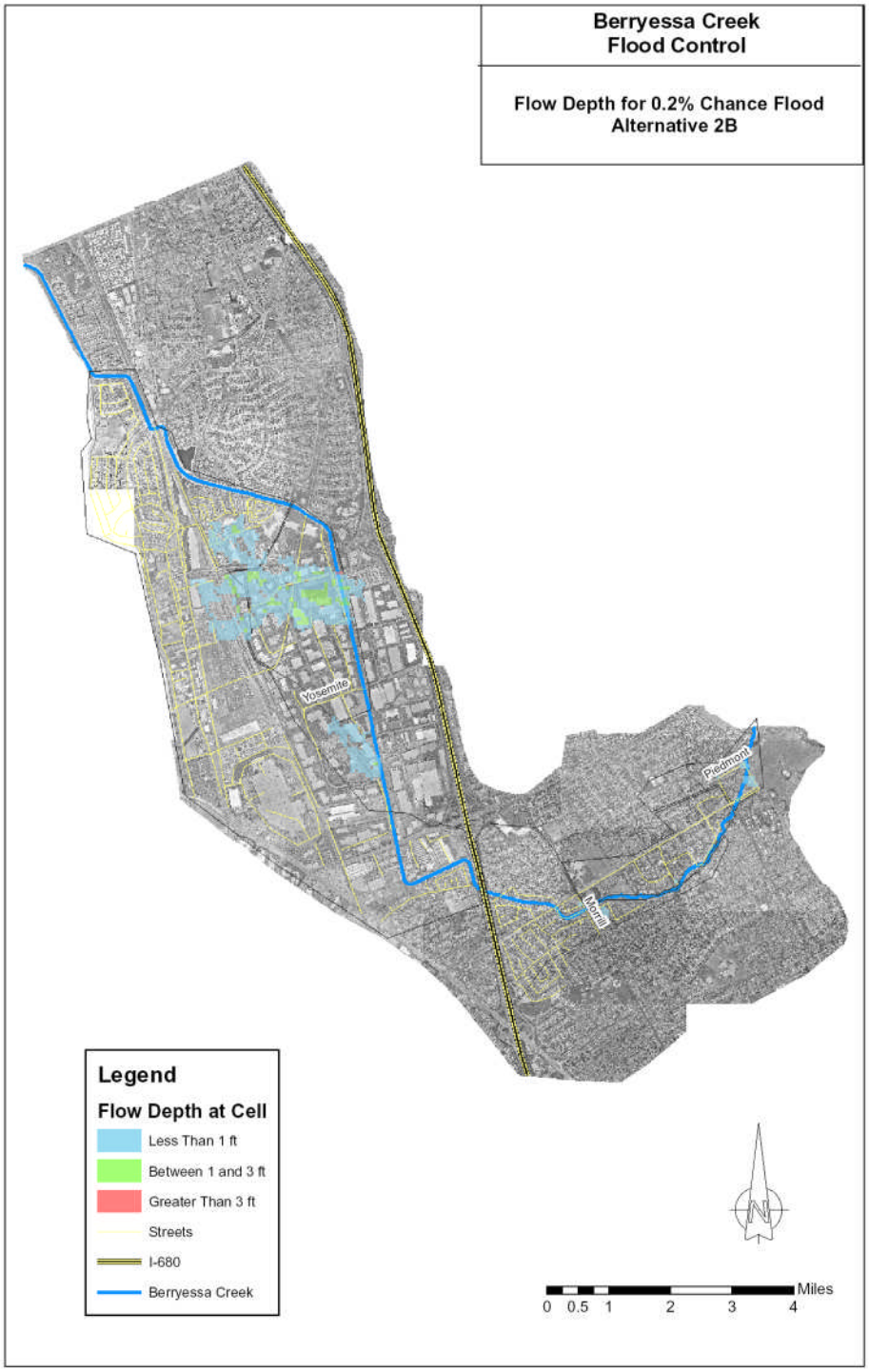

Figure 5-8 0.2% Chance Exceedance Event Floodplain for Alternative 2B

5.5 Alternative 3B –Terraced Trapezoidal Channel - FEMA-Certification Protection

Alternative 3B consists of a FEMA certifiable level of protection upstream and downstream of the I-680 culvert. Alternative 3B is fundamentally the same as Alternative 2B, with the primary difference being that the channel excavation/modifications downstream of the I-680 culvert was based on an earthen channel with terraces and levees. Alternative 3B would provide a more environmentally-sensitive project with a smaller inner channel. This allows for the construction of benches above the main channel that act as a floodplain which may be vegetated. Due to the reduced main channel size, Alternative 3B would require higher levees than Alternative 2B in order to confine the same design flow. The channel was modified by balancing the levee cut and fill along the tops of the banks. A 2:1 side slope was maintained throughout the lower reach with additional right of way required in locations.

Alternative 3B consists of the following project features:

- A 3-ft parapet wall and debris trap upstream of Old Piedmont Road
- Replace Old Piedmont Bridge with a 36-ft span bridge
- Construct riffle and pools with boulder weirs between Old Piedmont Road and Cropley Avenue
- Replace Piedmont-Cropley Culvert with 28-ft box
- Lower sediment basin bed by 4 feet.
- Excavate floodplain terrace and construct floodwall with maximum 2-ft height in the Greenbelt Reach.
- Replace Morrill Avenue with 32-ft span
- Removal of existing dragons teeth, channel invert smoothing, bridge replacement at Cropley Avenue Culvert with 24 ft span
- Construct up to 3-ft concrete parapet wall from Morrill Ave. to I-680.
- Excavate 10- bottom width with two 15-ft vegetated terrace channel and acquire up to 45 ft of additional right of way as needed from I-680 to Ames Ave.
- Replacement of the Montague Culvert with 60-foot span with 3-foot headwall
- Replacement of the UPRR Trestle with a triple 15ft x 12ft box culvert.
- Replacement of the UPRR Culvert with a triple 40-ft bridge
- Excavate 10- bottom width with two 15-ft vegetated terrace channel with earthen levees up to 3-ft and acquire up to 10 ft of additional right of way as needed from Ames Ave to Yosemite Drive.
- Excavate 10- bottom width with two 15-ft vegetated terrace channel with earthen levees up to 6-ft and acquire up to 15-ft of additional right of way as needed from Yosemite to downstream of Calaveras Blvd.
- Construct 100-ft bridge with 4-ft headwall at Los Coches Street
- Construct 100-ft raised deck bridge with 6-ft headwall at Calaveras Blvd.

An Alternative 3B HEC-RAS model was developed using the baseline HEC-RAS model and the Alternative 2B HEC-RAS model. The Alternative 2B geometry files were used for the portion of Berryessa Creek upstream of I-680 and the baseline HEC-RAS model geometry was modified to reflect the earthen trapezoid with terraces.

Table 5-10 lists the resulting channel and breakout flows for the Alternative 3B HEC-RAS model. The 0.2% chance exceedance floodplain was developed for Alternative 3B using the methods outlined in Chapter 1. Figure 5-9 shows the area of inundation for Alternative 3B.

Table 5-10 Original GRR Model Results for Alternative 3B Terraced Trapezoidal Channel – FEMA Certifiable Protection - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	2125		22
Sweigert Creek - Old Location	35029	2125		
Breakout at Cropley/Piedmont Culvert	34041	2125		0
Inflow at Sweigert Creek – Corrected Location	33136	2277	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	2276		1
Inflow at Crosley Creek	30478	2577	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2573		4
Inflow at Sierra Creek	28656	3113	1848	
Breakout at Morrill Avenue Culvert	28447	3113		0
Downstream Cropley Avenue	25744	3113		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	3134		6
Inflow at Montague Avenue	21821	4194	1230	
Lateral Weir Breakout Downstream of UPPR Trestle	20838-19390	4178		16
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	4178		0
Inflow at Yosemite Avenue	17465	4268	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	4268		0
Inflow from Piedmont Creek	16437	5608	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	5434		481 [2]
Inflow from Los Coches Creek	14422	6648 [2]	1848	
Calaveras Boulevard	13887	6648 [2]		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Includes losses from lateral weir flow downstream of Los Coches Creek Inflow, so discharge do not add up correctly

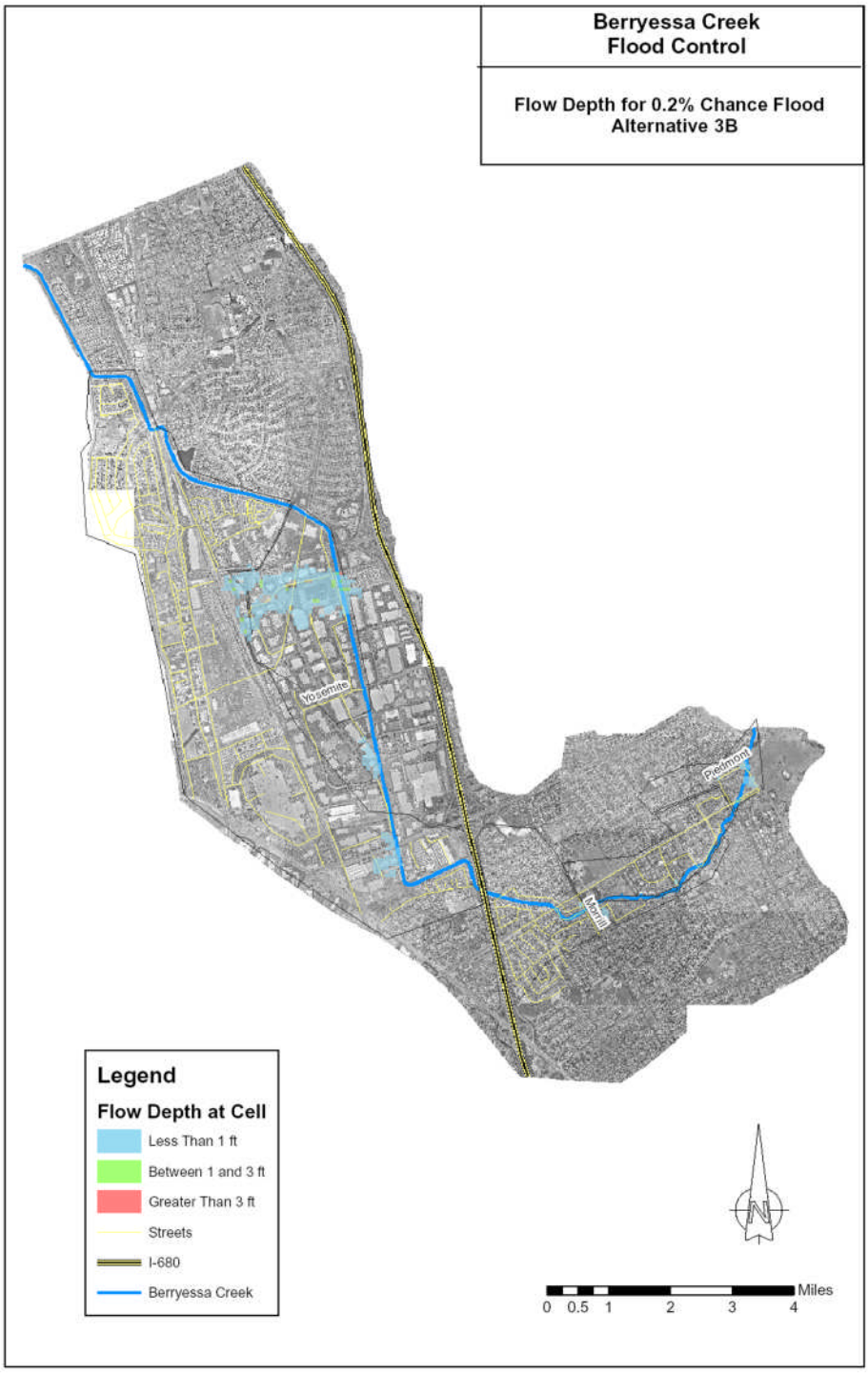

Figure 5-9 0.2% Chance Exceedance Event Floodplain for Alternative 3B

5.6 Alternative 3B –Walled Trapezoidal Channel - FEMA-Certification Protection

Alternative 4B consists of a FEMA certifiable level of protection upstream and downstream of the I-680 culvert. Alternative 4B is fundamentally the same as Alternatives 2A and 3A, with the major project features being the same. The primary difference is that the channel excavation/modifications downstream of the I-680 culvert were based on a terraced earthen bottom channel with concrete floodwalls on the terraces. This would allow Alternative 4B to be constructed within the existing right-of-way. In some locations, the right-of-way restrictions require adaptation of the typical section to accommodate the access road within the available right-of-way. In areas with limited right-of-way (e.g. in the vicinity of Montague Expressway), the access road would need to be located on the channel side of the floodwall to allow for additional conveyance area.

Alternative 4B consists of the following project features:

- A 3-ft parapet wall and debris trap upstream of Old Piedmont Road
- Replace Old Piedmont Bridge with a 36-ft span bridge
- Construct riffle and pools with boulder weirs between Old Piedmont Road and Cropley Avenue
- Replace Piedmont-Cropley Culvert with 28-ft box
- Lower sediment basin bed by 4 feet.
- Excavate floodplain terrace and construct floodwall with maximum 2-ft height in the Greenbelt Reach.
- Replace Morrill Avenue with 32-ft span
- Removal of existing dragons teeth, channel invert smoothing, bridge replacement at Cropley Avenue Culvert with 24 ft span
- Construct up to 3-ft concrete parapet wall from Morrill Ave. to I-680.
- Excavate 10- bottom width earthen channel with a 10-ft and 32-ft vegetated terrace channel with a concrete floodwalls up to 2-ft above original ground elevation from I-680 to Ames Ave.
- Replacement of the Montague Culvert with 60-foot span with 3-foot headwall
- Replacement of the UPRR Trestle with a triple 15ft x 12ft box culvert.
- Replacement of the UPRR Culvert with a triple 40-ft bridge
- Excavate 10- bottom width earthen channel with a 10-ft and 32-ft vegetated terrace channel with a concrete floodwalls up to 3-ft above original ground elevation from Ames Ave to Yosemite Drive.
- Excavate 10- bottom width earthen channel with a 10-ft and 32-ft vegetated terrace channel with a concrete floodwalls up to 6-ft above original ground elevation from Yosemite to downstream of Calaveras Blvd.
- Construct 100-ft bridge with 4-ft headwall at Los Coches Street
- Construct 100-ft raised deck bridge with 6-ft headwall at Calaveras Blvd.

Table 5-11 lists the resulting channel and breakout flows for the Alternative 4B HEC-RAS model. The 0.2% chance exceedance floodplain was developed for Alternative 4B using the methods outlined in Chapter 1. Figure 5-10 shows the area of inundation for Alternative 4B.

Table 5-11 Original GRR Model Results for Alternative 4B Walled Trapezoidal Channel – FEMA Certifiable Protection - 0.2% Chance Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	36242	2130		
Breakout at Old Piedmont Road Bridge	35249	2125		22
Sweigert Creek - Old Location	35029	2125		
Breakout at Cropley/Piedmont Culvert	34041	2125		0
Inflow at Sweigert Creek – Corrected Location	33136	2277	432	
Lateral Weir Breakout Upstream of Crosley Creek	31895-31026	2276		1
Inflow at Crosley Creek	30478	2577	535	
Lateral Weir Breakout Upstream Morrill Avenue	30468-29993	2573		4
Inflow at Sierra Creek	28656	3113	1848	
Breakout at Morrill Avenue Culvert	28447	3113		0
Downstream Cropley Avenue	25744	3113		
I-680 Culvert	25296	3140		
Lateral Weir Breakout Upstream of Montague	25295-21832	3138		2
Inflow at Montague Avenue	21821	4194	1230	
Lateral Weir Breakout Downstream of UPPR Trestle	20838-19390	4177		17
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	4177		0
Inflow at Yosemite Avenue	17465	4267	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	4267		0
Inflow from Piedmont Creek	16437	5607	1842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	5110		668
Inflow from Los Coches Creek	14422	6458	1848	
Calaveras Boulevard	13887	6458		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

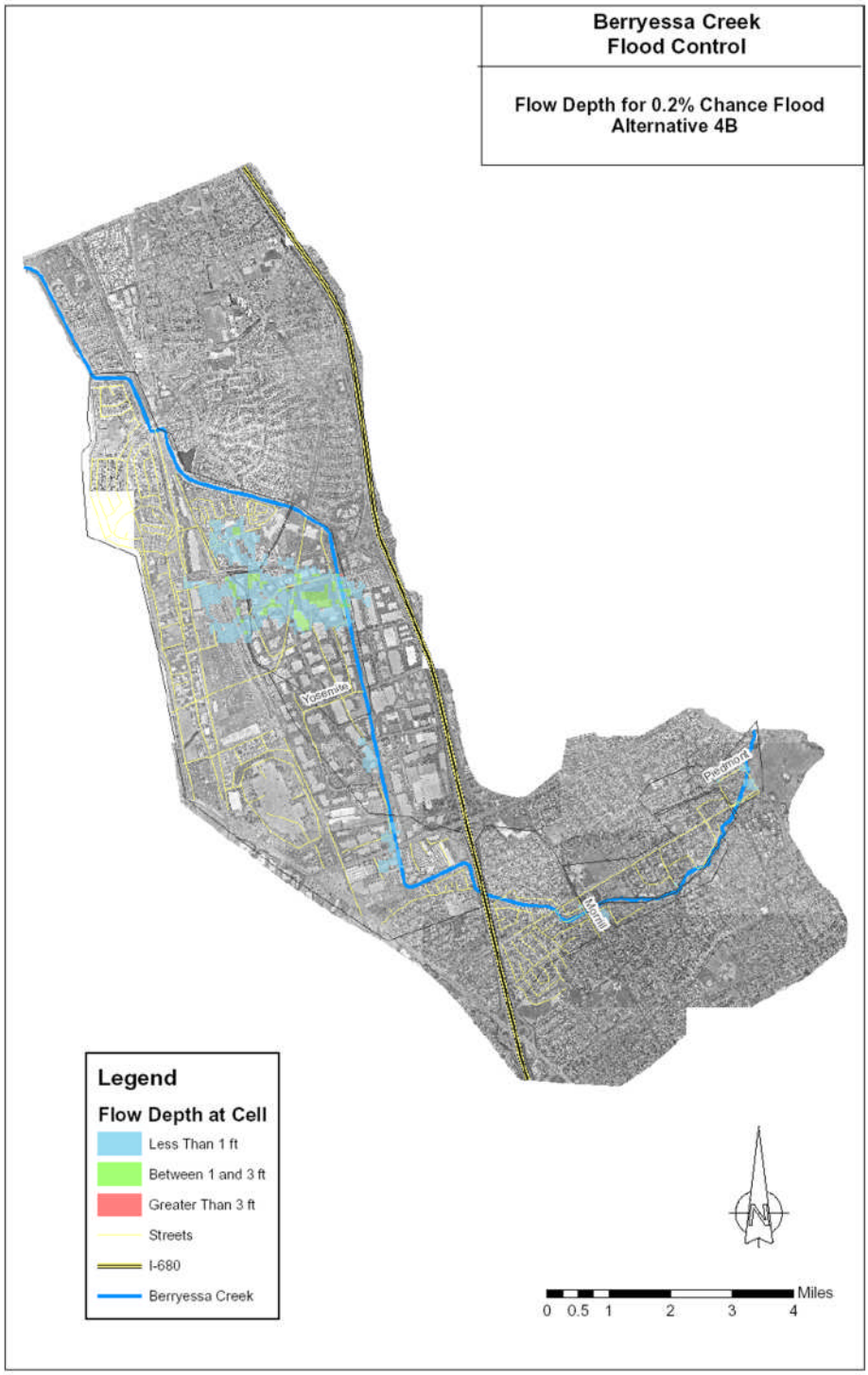

Figure 5-10 0.2% Chance Exceedance Event Floodplain for Alternative 4B

CHAPTER 6: FINAL ARRAY OF ALTERNATIVES

The final array of project alternatives were analyzed using the Lower Berryessa Creek FLO-2D model, described in Chapter 2. Four alternatives, Alternatives 2A/d, 2B/d, 4/d, and 5, were run using the revised GRR methodology models. Of the four alternatives, only Alternatives 2A/d and 5 have breakouts from the Berryessa Creek channel for the modeled events. Alternatives 2B/d and 4/d were developed to meet FEMA certification requirements using risk-based principles assuming SCVWD Bypass (see *Appendix B Part I: Hydraulic Modeling of Alternatives* for more details*)* is constructed upstream of I-680. The SCVWD Bypass design results in higher flow rates at I-680 resulting in Alternative 2B/d and 4/d having a larger conveyance capacity, which allows both alternatives to convey up to the 0.2% chance exceedance event. Therefore no floodplains were developed for Alternatives 2B/d and 4/d.

6.1 Alternative 2A/d – Incised Trapezoidal Channel - Moderate Protection

Alternative 2A/d consists of a 1% chance exceedance event level of protection upstream of the I-680 culvert. The formulation of Alternative 2A/d was based on the Alternative 2A from the preliminary array of alternatives with the upstream component eliminated between the preliminary and final arrays (see *Berryessa Creek GRR Study F5 Report* for details). A complete description of the changes in the Alternative 2A in the preliminary array of alternatives to Alterative 2A/d in the final array of alternatives can be found in *Appendix B Part I: Hydraulic Modeling of Alternatives*.

The inflow to the Lower Berryessa Creek FLO-2D model were developed using the Alternative 2A/d HEC-RAS model (see *Appendix B Part I: Hydraulic Modeling of Alternatives)*. The Alt 2A/d floodplain mapping for the upper Berryessa Creek is the same as the Without-Project Berryessa Creek FLO-2D model and the results are not repeated in the following tables (see Section 3.2 for the Upper Berryessa Without-Project results). . Table 6-1 and Table 6-2 list the resulting channel and breakout flows for the Alternative 2A/b HEC-RAS model. The 0.5 and 0.2 percent chance exceedance floodplains were developed for Alternative 2A/d using the methods outlined in Chapter 1. Figure 6-1 and Figure 6-2 show the area of inundation for Alternative 2A.

Table 6-1 Flows for Alternative 2A/d - 0.5% Chance Percent Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
I-680 Culvert	25296	1,611		
Lateral Weir Breakout Upstream of Montague	25295-21832	1,1476		55
Inflow at Montague Avenue	21821	2,439	1,077	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	2,438		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	2,399		0
Inflow at Yosemite Avenue	17465	2,587	354	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	2,542		32
Inflow from Piedmont Creek	16437	3,421	1,691	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	3,121		230
Inflow from Los Coches Creek	14422	4,347	1,583	
Calaveras Boulevard	13887	4,324		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

Table 6-2 Flows for Alternative 2A/d - 0.2% Chance Percent Exceedance Flood Event

LOCATION	RAS STATION	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
I-680 Culvert	25296	1,770		
Lateral Weir Breakout Upstream of Montague	25295-21832	1,362		234
Inflow at Montague Avenue	21821	2,511	1,230	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270	2,510		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602	2,505		0
Inflow at Yosemite Avenue	17465	2,861	401	
Lateral Weir Breakout Downstream of Yosemite Avenue	17460-16654	2,640		134
Inflow from Piedmont Creek	16437	3,910	1,842	
Lateral Weir Breakout Downstream Piedmont Creek	16654-14467	3,123		276
Inflow from Los Coches Creek	14422	4,378	1,848	
Calaveras Boulevard	13887	4,360		0

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.

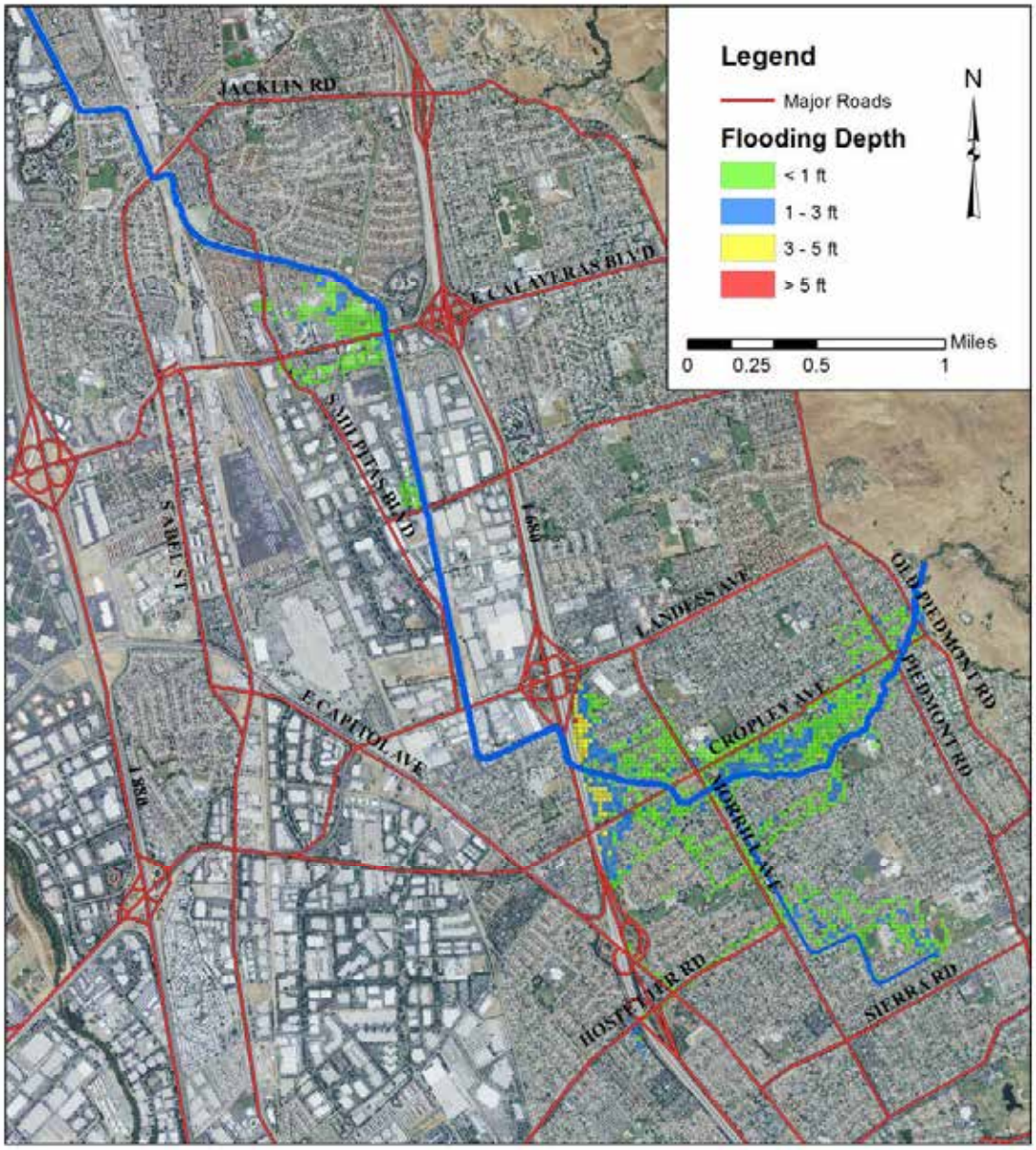

Figure 6-1 0.5% Exceedance Probability Event Floodplain for Alternative 2A

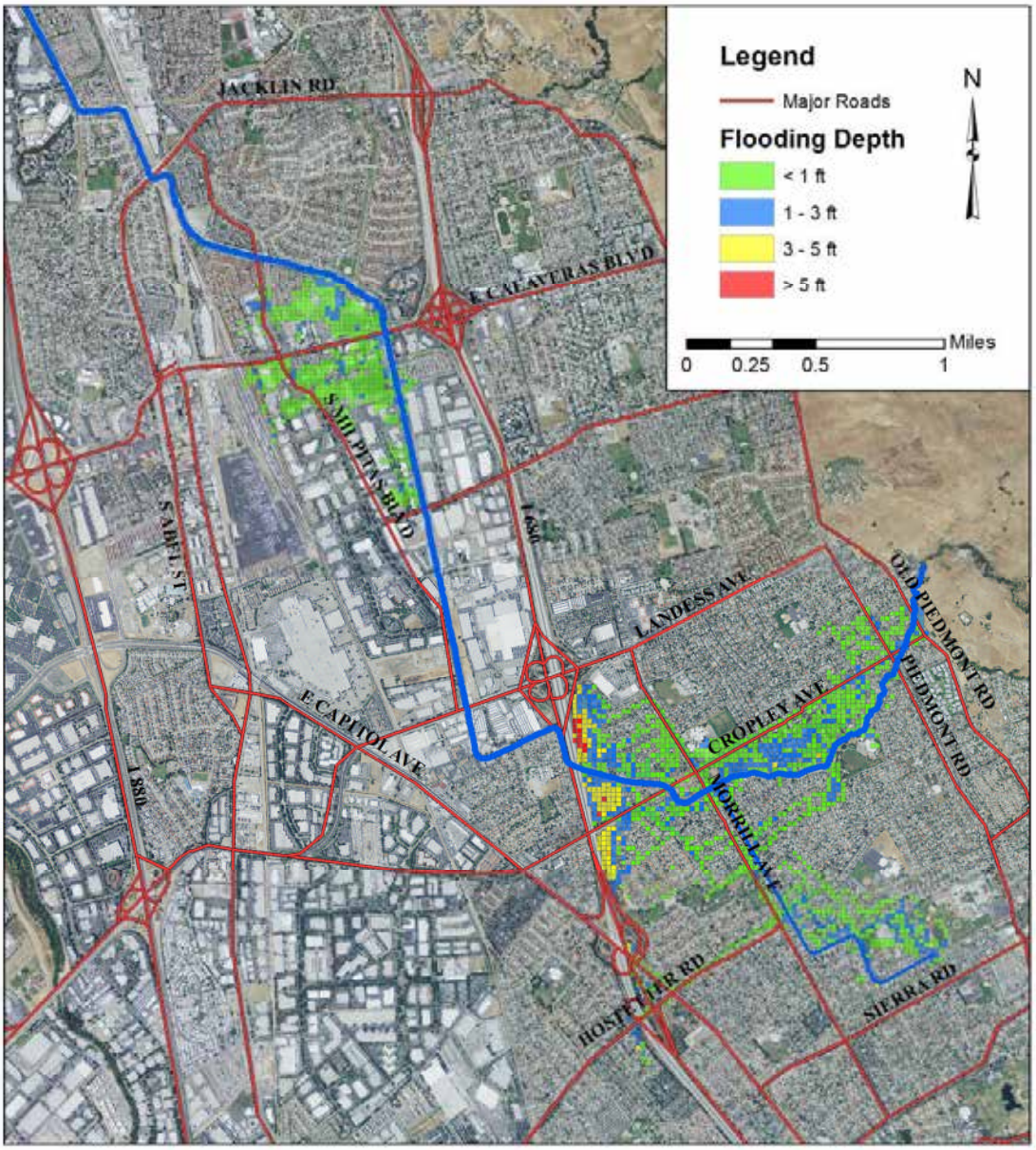

Figure 6-2 0.2% Exceedance Probability Event Floodplain for Alternative 2A

6.2 Alternative 5 – Authorized Project

Alternative 5 is the Authorized Project and is a single-purpose flood risk management project that includes mitigation of adverse effects as authorized by Congress in 1990. Alternative 5 begins 600 feet upstream of Old Piedmont Road Bridge and extends to 50 feet downstream of Calaveras Boulevard Bridge. A complete description of Alternative 5 can be found in *Appendix B Part I: Hydraulic Modeling of Alternatives*. *Appendix B Part I: Hydraulic Modeling of Alternatives*.

The Alternative 5 HEC-RAS model was used to develop the breakout flows into the lower Berryessa Floodplain (see *Appendix B Part I: Hydraulic Modeling of Alternatives)*. The breakout flows were then routed through the Lower Berryessa FLO-2D model to develop the lower Berryessa Creek floodplain mapping. The Alternative 5 Upper Berryessa Creek FLO-2D model (described in Section 2.3) was used to develop the Upper Berryessa Creek floodplains. Table 6-3 to Table 6-5 list the resulting channel and breakout flows for the Alternative 5 HEC-RAS model. The 1, 0.5, and 0.2 percent chance exceedance floodplains were developed for Alternative 5 using the methods outlined in Chapter 1. Figure 6-3 to Figure 6-5 show the area of inundation for Alternative 5.

As seen in the tables and figures, breakouts occur at Calaveras Boulevard and Los Coches Avenue for the 1% chance exceedance event. Alternative 5 was originally designed to convey the 1% chance exceedance event when authorized by Congress in 1990. Since then a number of changes have occurred in the watershed including improvement downstream of Calaveras Boulevard which changed the downstream boundary conditions from what were used to design Alternative 5. In addition, refinement of the Berryessa Creek hydrology also impacted the results.

Table 6-3 Flows for Alternative 5 - 1% Chance Percent Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	1,426		
Breakout at Old Piedmont Road Bridge	3106[2]	1,420		0
Sweigert Creek - Old Location	3072[2]	1,455		
Breakout at Cropley/Piedmont Culvert	3038[2]	1,427		0
Inflow at Sweigert Creek – Corrected Location	2850[2]	1,514	308	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	1,506		0
Inflow at Crosley Creek	2334[2]	1,553	329	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1,602		0
Inflow at Sierra Creek	1326[2]	2,003	1421	
Breakout at Morrill Avenue Culvert	1279[2]	2,002		0
Downstream Cropley Avenue	788[2]	1,997		
I-680 Culvert	25296[3]	1,998		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	1,995		4
Inflow at Montague Avenue	21821[3]	2,243	928	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	2,241		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	2,231		
Inflow at Yosemite Avenue	17448[3]	2,341	317	
Inflow from Piedmont Creek	16437[3]	3,179	858	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	3,161		0
Inflow from Los Coches Creek	14422[3]	4,222	928	
Calaveras Boulevard	13887[3]	4,118		161

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 6-4 Flows for Alternative 5 - 0.5% Chance Percent Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	1,828		
Breakout at Old Piedmont Road Bridge	3106[2]	1,846		0
Sweigert Creek - Old Location	3072[2]	1,890		
Breakout at Cropley/Piedmont Culvert	3038[2]	1,617		273
Inflow at Sweigert Creek – Corrected Location	2850[2]	1,748	379	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	1,635		113
Inflow at Crosley Creek	2334[2]	1,794	375	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1,874		0
Inflow at Sierra Creek	1326[2]	2,375	1493	
Breakout at Morrill Avenue Culvert	1279[2]	2,367		8
Downstream Cropley Avenue	788[2]	2,325		
I-680 Culvert	25296[3]	2,358		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	1,471		277
Inflow at Montague Avenue	21821[3]	2,604	1072	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	2,566		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	2,582		0
Inflow at Yosemite Avenue	17448[3]	2,826	361	
Inflow from Piedmont Creek	16437[3]	3,679	901	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	3,518		110
Inflow from Los Coches Creek	14422[3]	4,738	911	
Calaveras Boulevard	13887[3]	4,281		418

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

Table 6-5 Flows for Alternative 5 - 0.2% Chance Percent Exceedance Flood Event

LOCATION	RAS STATION/ FLO-2D GRID	CHANNEL FLOW (CFS)	PEAK TRIBUTARY INFLOW[1] (CFS)	BREAKOUT FLOW (CFS)
Upstream of Old Piedmont Road	3142[2]	2,134		
Breakout at Old Piedmont Road Bridge	3106[2]	2,053		81
Sweigert Creek - Old Location	3072[2]	2,036		
Breakout at Cropley/Piedmont Culvert	3038[2]	1,646		390
Inflow at Sweigert Creek – Corrected Location	2850[2]	1,782	438	
Lateral Weir Breakout Upstream of Crosley Creek	2379-2599[2]	1,664		118
Inflow at Crosley Creek	2334[2]	1,829	435	
Lateral Weir Breakout Upstream Morrill Avenue	1842-2114[2]	1,909		0
Inflow at Sierra Creek	1326[2]	2,455	1835	
Breakout at Morrill Avenue Culvert	1279[2]	2,419		36
Downstream Cropley Avenue	788[2]	2,368		
I-680 Culvert	25296[3]	2.358		
Lateral Weir Breakout Upstream of Montague	25295-21832[3]	1,446		566
Inflow at Montague Avenue	21821[3]	2,603	1227	
Lateral Weir Breakout Downstream of Montague Avenue	21666-21270[3]	2,566		0
Lateral Weir Breakout Upstream of Yosemite Avenue	18543-17602[3]	2,572		0
Inflow at Yosemite Avenue	17448[3]	2,826	401	
Inflow from Piedmont Creek	16437[3]	3,678	900	
Lateral Weir Breakout Downstream of Yosemite Avenue	14467-17460[3]	3,519		193
Inflow from Los Coches Creek	14422[3]	4,738	951	
Calaveras Boulevard	13887[3]	4,282		446

1. The tributary inflows are the peak discharge from the tributary and may not sum to the total channel flow due differences in the time to peak between the tributary and Berryessa Creek.
2. Upper FLO-2D Model Grid
3. Lower HEC-RAS Model Station

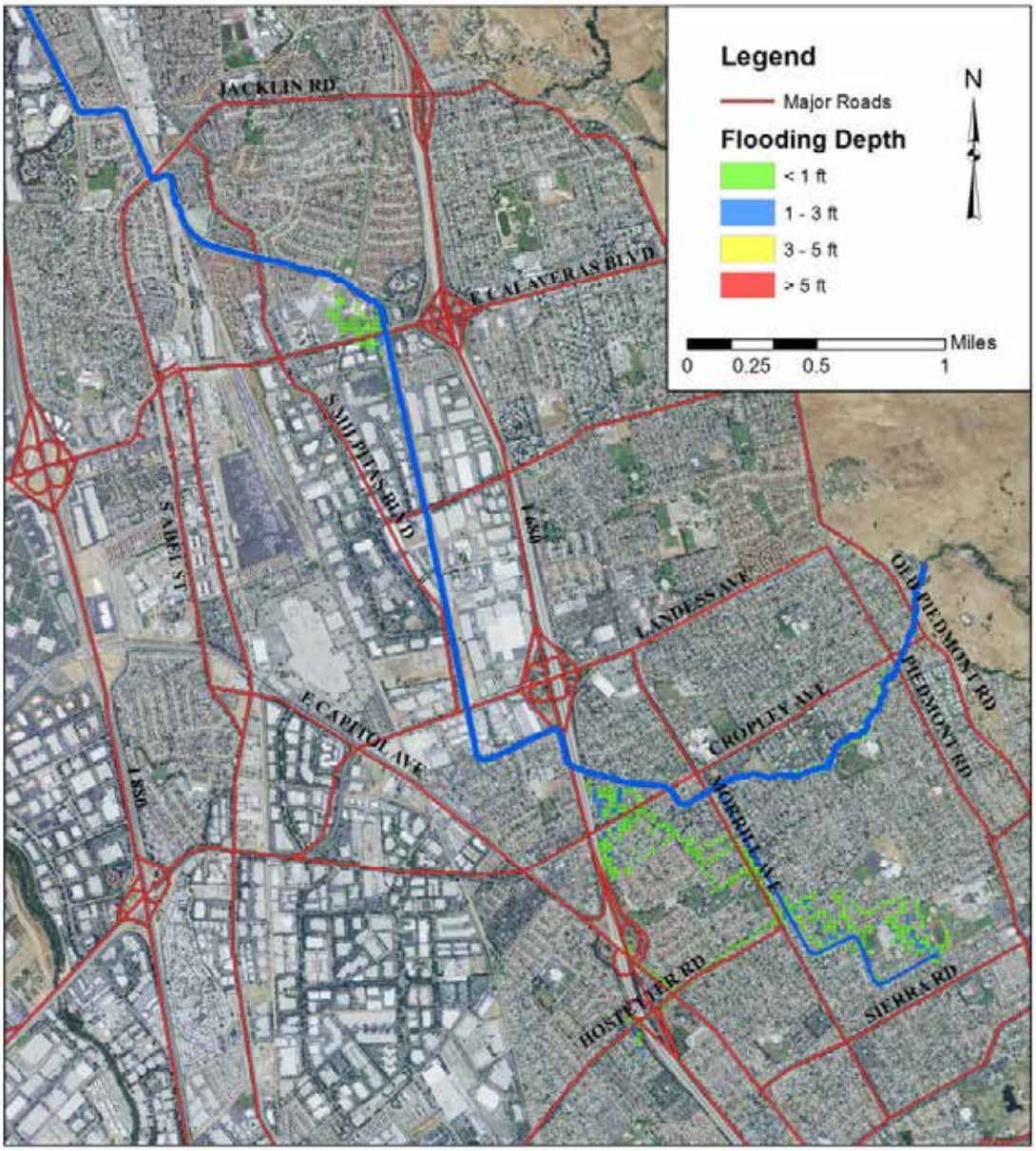

Figure 6-3 1% Exceedance Probability Event Floodplain for Alternative 5

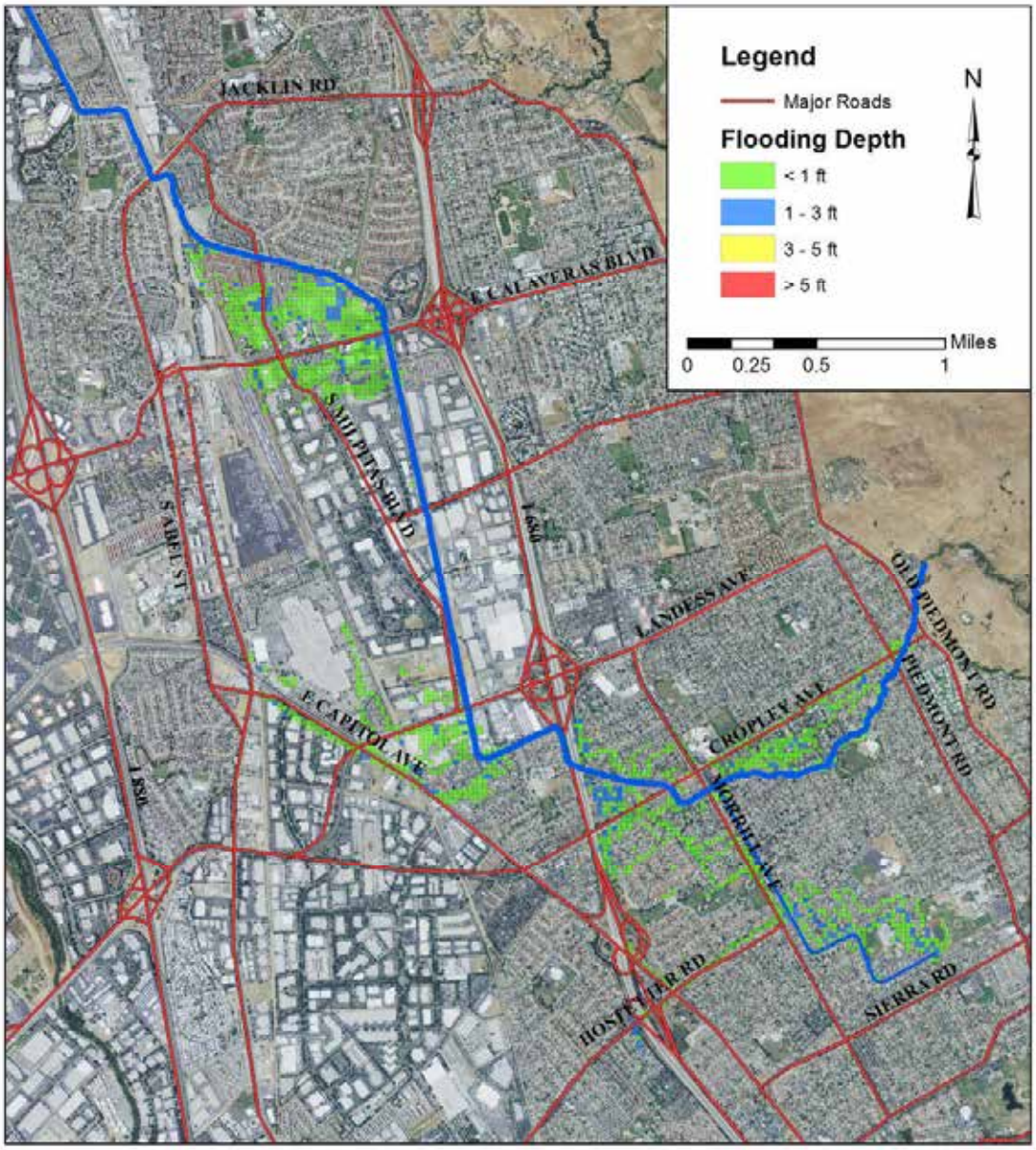

Figure 6-4 0.5% Exceedance Probability Event Floodplain for Alternative 5

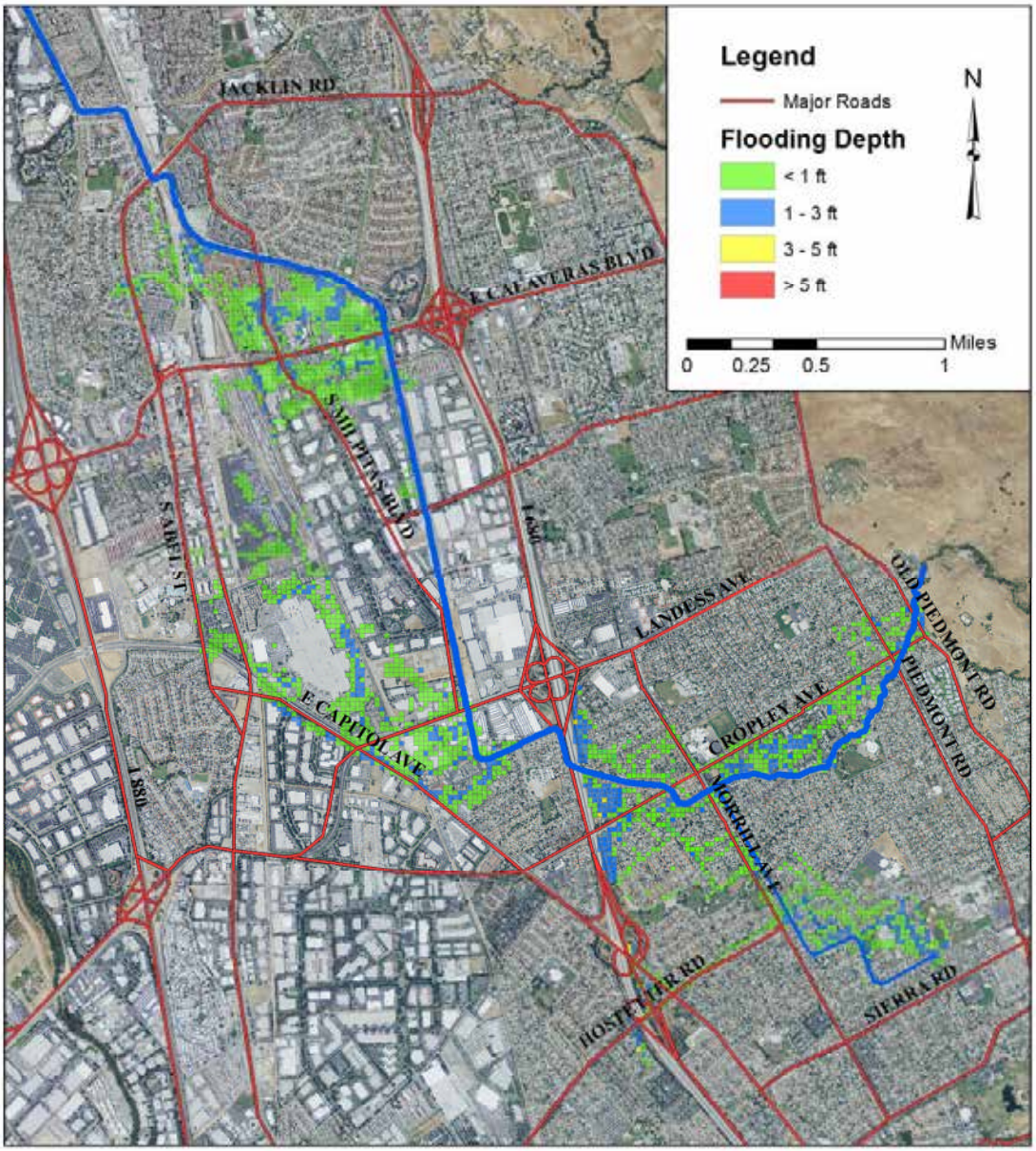

Figure 6-5 0.2% Exceedance Probability Event Floodplain for Alternative 5

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Berryessa Creek Project

Santa Clara County, California

Appendix B

Engineering and Design

Part III: Geomorphic and Sediment Transport Assessment

TETRA TECH

MAY 2012

BERRYESSA CREEK PROJECT

APPENDIX B, Part III: Geomorphic and Sediment Transport Assessment

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CHAPTER 1: INTRODUCTION

This appendix is Part III of the engineering appendices supporting the Berryessa Creek Flood Control Project Post-Authorization Study. The engineering appendices are as follows:

- Part I. Hydraulic Analysis of Alternatives
- Part II. Floodplain Development
- Part III. Geomorphic and Sediment Transport Assessment
- Part IV. Design and Cost of Alternatives

This appendix refers to figures, tables, and results in the accompanying appendices and in the main body of the report. This appendix provides supporting fluvial geomorphology and sediment transport analyses for the formulation and evaluation of the Berryessa Creek Project Alternatives. A summary and interpretation of previous work related to the geomorphology of the system is also included. In addition, insight from observations by the project team is provided, particularly in reference to supply of sediment from the upstream watershed.

Sediment transport analyses of the existing condition are summarized in light of available sediment removal records. The results of the hydraulic analysis of the alternatives is utilized to qualitatively address potential changes in sediment transport conditions under project scenarios compared to the without-project condition. This information is utilized to provide recommendations on design refinements to address fluvial geomorphic and sediment transport aspects of the project design as well as recommendations for additional analyses to support the design effort.

Figure 1-1 shows the delineations of watersheds draining to the project area, as presented in the NHC hydrology report (2003). Figure 1-2 shows the project footprint relative to the road crossings and other features within the project area.

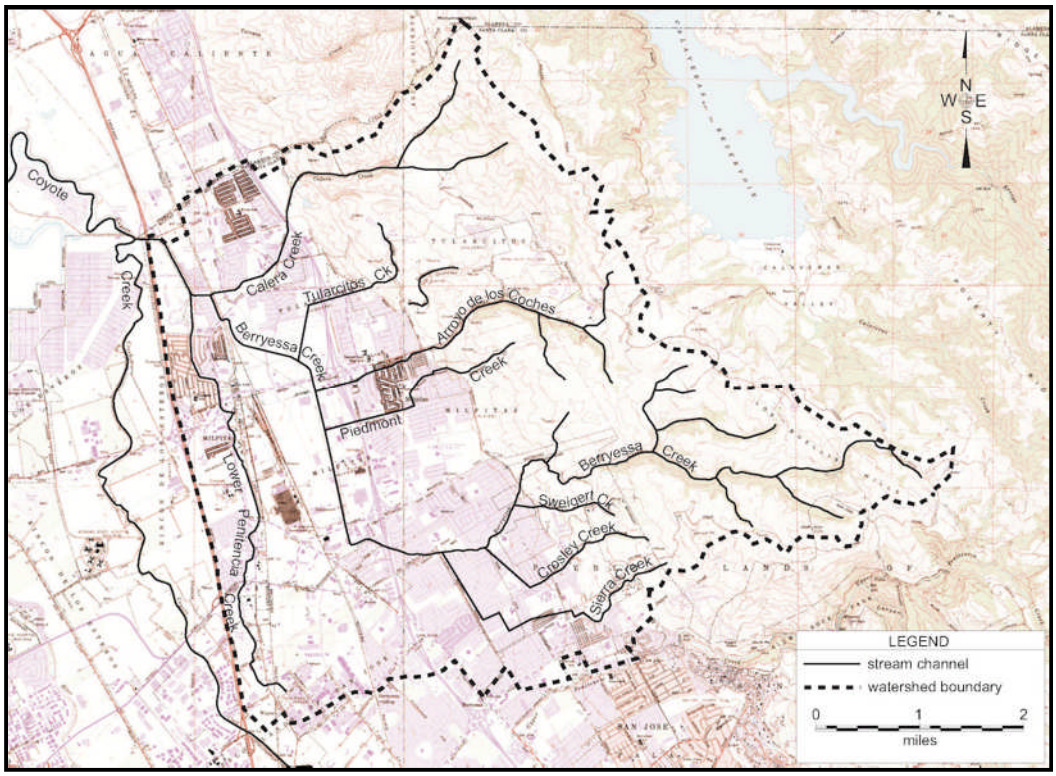

Figure 1-1 Watershed Map (Source: NHC 2003)

Figure 1-2 Project Footprint

A number of issues were identified as important for this analysis to address. An evaluation of the stability of the alternatives in terms of their sediment transport response is necessary. Because of the urbanized nature of the area and the limited area available for the project, it was determined early in the plan formulation process that the channel would be protected in most areas to prevent erosion. However, the channel bed will remain mobile so it is necessary to assess the potential for channel bed aggradation and degradation. The project alternatives should be designed to prevent excessive scour or deposition. The influence of the proposed alternatives on sediment removal requirements is another important issue. Historically, sediment removal in the project area (see Table 2-1) has averaged on the order of 1,046 cubic yards per year upstream and 616 cubic yards per year downstream of I-680 for the project reach with a total of 7,179 cubic yards per year from the entire Berryessa Creek channel. Also tied to sediment removal is the potential for changes to the existing sediment retention basin and construction of additional sediment management structures under consideration by others. The Corps GDM (USACE 1993) included a sediment basin above Old Piedmont Road. To address issues surrounding the reconfiguration of the sediment basin, the watershed was evaluated to determine if there were areas further upstream in which sediment management activities could be applied to reduce sediment delivery to the basin area.

Besides the sediment transport aspects of the design, fluvial geomorphology concepts were applied to evaluate the design and provide recommendations for potential refinements as necessary. Though the project is located in a highly urban environment with limited right of way and numerous constraints created by bridges, roads, utilities, and buildings; the concepts of fluvial geomorphology are still useful in developing an appropriate design. These concepts can help in evaluating the system response to the alternatives and provide input on ways of developing a more sustainable project in terms of maintenance and environmental quality. Application of fluvial geomorphology assisted in the evaluation of the sediment transport issues identified in the previous paragraph. In addition, recommendations for sizing the channel and evaluation of the response of the Greenbelt Reach, which will not be as constrained as the project area, are addressed.

The with-project alternatives evaluated in the current effort were carried forward from the conceptual alternatives presented in the F3 report (Tetra Tech 2004) and subsequently narrowed down to three alternatives by the Corps. Typical cross sections of each alternative are presented in *Appendix B, Part IV: Design and Cost of Alternatives* in this engineering appendix. An important purpose of these alternatives was to evaluate large-scale economic issues between general approaches to flood control. Alternative 1 is the without-project condition. Project alternatives under consideration by others include floodwall construction and excavation of a floodplain terrace within the Greenbelt Reach upstream of I-680 along with a high-flow bypass culvert running beneath Cropley Road. Downstream of I-680, Alternatives 2A/d and 2B/d were formulated to provide flood control utilizing channel excavation and bridge modifications to increase conveyance in a project footprint that could be constructed within the existing right of way. As a result, a large main channel is excavated that has the capacity to convey the 1% chance exceedance event. Alternative 2A/d is designed to pass the 1% chance exceedance event with a 50% conditional non-exceedance probability (CNP) using risk and uncertainty principles with Alternative 2B/d passing the 1%

chance exceedance event with 90% CNP (meeting the FEMA certification criteria). Levees or floodwalls are extended as needed to maintain a consistent capacity throughout the project with the appropriate certainty. Alternative 4/d incorporates vegetated floodplain benches along the low-flow channel, with concrete floodwalls extended vertically from the outer edges of the floodplain bench. This allows Alternative 4d/ to be constructed within the existing right of way.

Alternatives 2B/d and 4/d include the complete replacement of all bridge and culvert crossings with the exception of the Ames Avenue and Yosemite Drive crossings, which would require shoring/stabilization of existing abutments and construction of transition structures, and the I-680 crossing, which would not be affected. Modifications within channel reaches include excavation and levee/floodwall construction. Levees, floodwalls, and tops of bank are designed according to risk and uncertainty principles. Further details on the flow profiles and modeling methodology are described in *Appendix B, Part I: Hydraulic Analysis of Alternatives* in this engineering appendix. The analyses and recommendations presented in this appendix will be utilized to guide future sediment transport modeling efforts supporting more detailed designs that are carried forward.

CHAPTER 2: EXISTING CONDITIONS

2.1 Summary of Geomorphology

This report generally assesses the impacts of the sediment generated in the upper watershed on the proposed project alternatives in the lower watershed. Two primary documents provide information describing the geomorphology of Berryessa Creek within the project area and the upstream watershed: the Sacramento District's GDM (USACE 1993) and "Upper Berryessa Creek GRR Basin Geomorphology Technical Memorandum" (NHC 2001). "An Urban Geomorphic Assessment of the Berryessa and Upper Penitencia Creek Watersheds in San Jose, California," a Colorado State University dissertation by Jordan (2009), contains data and conclusions applicable to the site geomorphology and will likely be published in the near future. Preliminary results and analysis methods are summarized at the end of this report in Addendum 1. In addition, Tetra Tech has conducted several site visits to the project area and the upstream watershed to observe and document conditions related to fluvial geomorphology. The summary of existing geomorphic conditions is based on these three sources.

2.1.1 Geology and Soils

The Berryessa watershed consists of two distinct landforms. The watershed above the urbanized area is mountainous terrain consisting of the Los Buellis Hills, part of the Diablo Range. The highest point in the watershed is Monument Peak at an elevation 2,594 feet. Within the project area, Berryessa Creek flows across an alluvial fan created by Berryessa Creek and its tributaries. The minimum elevation in the watershed is 3 feet at the confluence with Penitencia Creek. At the downstream limits, Berryessa Creek is tidally influenced. Under existing conditions, the upland portion of the watershed is mostly undeveloped with a few residences scattered mostly along the basin divide. The primary land use in the upland portion of the watershed is grazing. Due to zoning practices, the future condition is not anticipated to change significantly in terms of land use. In contrast the alluvial fan portion of the watershed is almost entirely urbanized.

In the uplands, the geology consists mainly of Tertiary and Quaternary age sedimentary rocks composed primarily of sandstone, siltstone and shale. Minor tuff, claystone and partially to completely serpentinized ultramafic rock outcrop in the basin in smaller amounts (NHC 2001). As shown in Figure 2-1, two major faults cross the lower and upper extents of the watershed. The Hayward Fault zone trends across the base of the Los Buellis Hills and the Calaveras Fault passes along the upper watershed boundary. These two major faults and numerous minor faults cross the Berryessa Creek watershed in northwest to southeast direction.

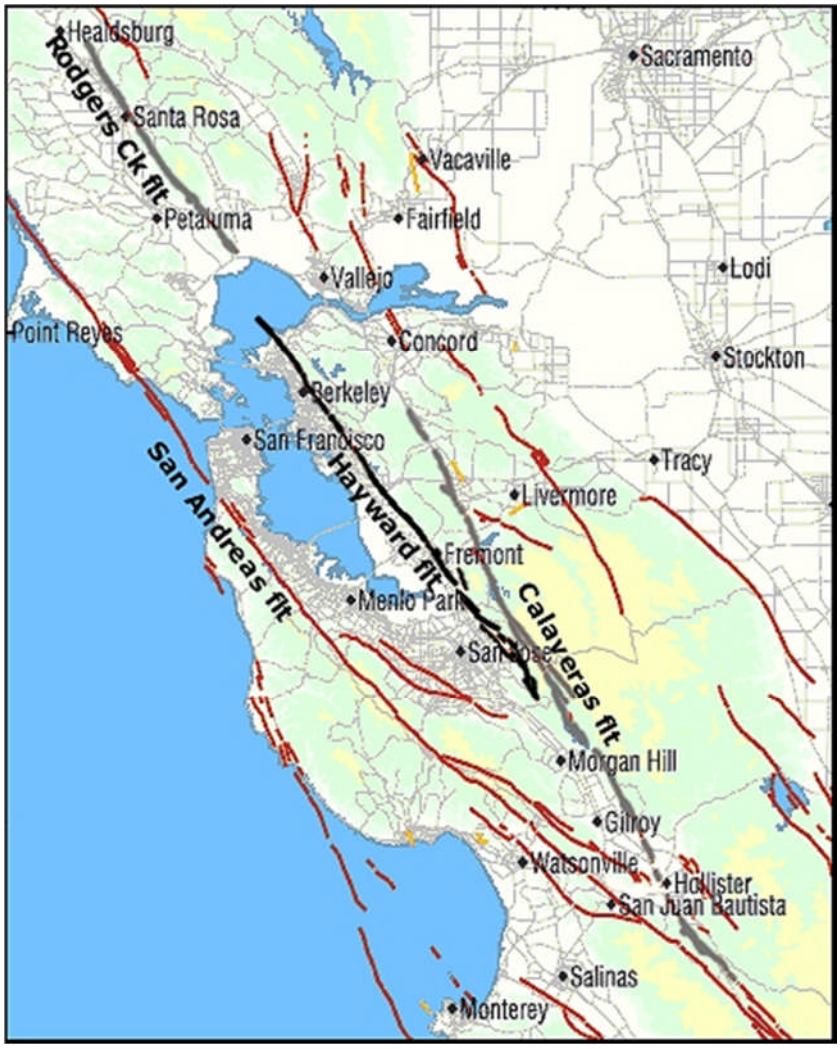

Figure 2-1 Bay Area Fault Zones (Source: USGS)

An important feature of the watershed occurs in the Hayward Fault zone, an area referred to in the previous reports as the "canyon" reach, extending from about 1,000 to 4,000 feet upstream of Old Piedmont Road. Underlying bedrock in this reach is composed of poorly consolidated, highly fractured Tertiary age rocks that contain swelling clays (NHC 2001). This is a high sediment production zone with erosive soils, large sediment supply from landslides, and a steep channel section capable of transporting large quantities of sediment. This is the only reach observed during the Tetra Tech watershed reconnaissance that had evidence of debris flows and transport of large boulders, several feet in diameter and larger. It also contained the only adjacent watershed area that was observed to have numerous active landslides scarps. The GDM (USACE 1993) supports this statement, indicating, "Upstream of the canyon zone, the ravines in Berryessa Creek and its larger tributaries are well treed and appear to be relatively stable."

Soils in the upland portion of Berryessa Creek are said to be of two types: clay loams on the relatively gentle slopes, and coarse rocky or gravelly soils on steeper slopes. Both types are derived from the underlying sedimentary rocks, the clay loams by weathering and vegetation, and the rocky soils by physical disintegration especially in the fault and shear zones (USACE 1993).

The geology of the alluvial fan in the Santa Clara Valley portion of the watershed is limited to Quaternary age, semi-consolidated alluvium near the base of the Los Buellis Hills with younger, unconsolidated alluvium further downslope. The alluvial sediments are largely fine grained, consisting primarily of moderate to poorly sorted fine sand, silt, and clay (NHC 2001). Borehole data from this lower portion of the creek, particularly downstream of I-680 show the creek to be underlain by large amounts of clayey soils.

In general, the Santa Clara Valley is underlain by some 1,000 to 1,500 feet of alternating estuarial and alluvial fan deposits of Quaternary age. The estuarial deposits were laid down under episodes of marine flooding and the alluvial fans during dryland episodes when the sea level was lowered during the major glaciations. The surficial materials in the valley are partly coarse alluvial fan deposits from stream channels, and partly fine materials derived from suspended load deposition during floods in areas between the stream channels (USACE 1993).

Within the project area, the streambanks are formed of fairly erosion-resistant material; the soils contain a large clay component primarily consisting of silty and sandy clay. Upstream of I-680, soils retain a significant clay component but exhibit more frequent clayey silt and clayey sand lenses with occasional gravels (NHC 2001). As a result, eroded sections of streambanks in this area are near vertical. Within the project area, bed material is somewhat variable due to the high level of channel alteration and the presence of numerous bridges and several other hydraulic structures. In general, the bed material is composed of sands and gravels. The average distribution for the entire urbanized reach upstream of Calaveras Boulevard, as presented in NHC (2003), is 28 percent sand, 69 percent gravel and 3 percent cobble with a median diameter of 5.5 mm (fine gravel).

The watershed upstream of Old Piedmont Ave. was broken into reaches with common characteristics based on field observations. Classification of these characteristics by reach allows for explanation of sediment transport-related trends and prediction of future erosion and deposition zones on a qualitative basis. The reach breakdown is shown in Figure 2.2 along with the locations of photographs presented below.

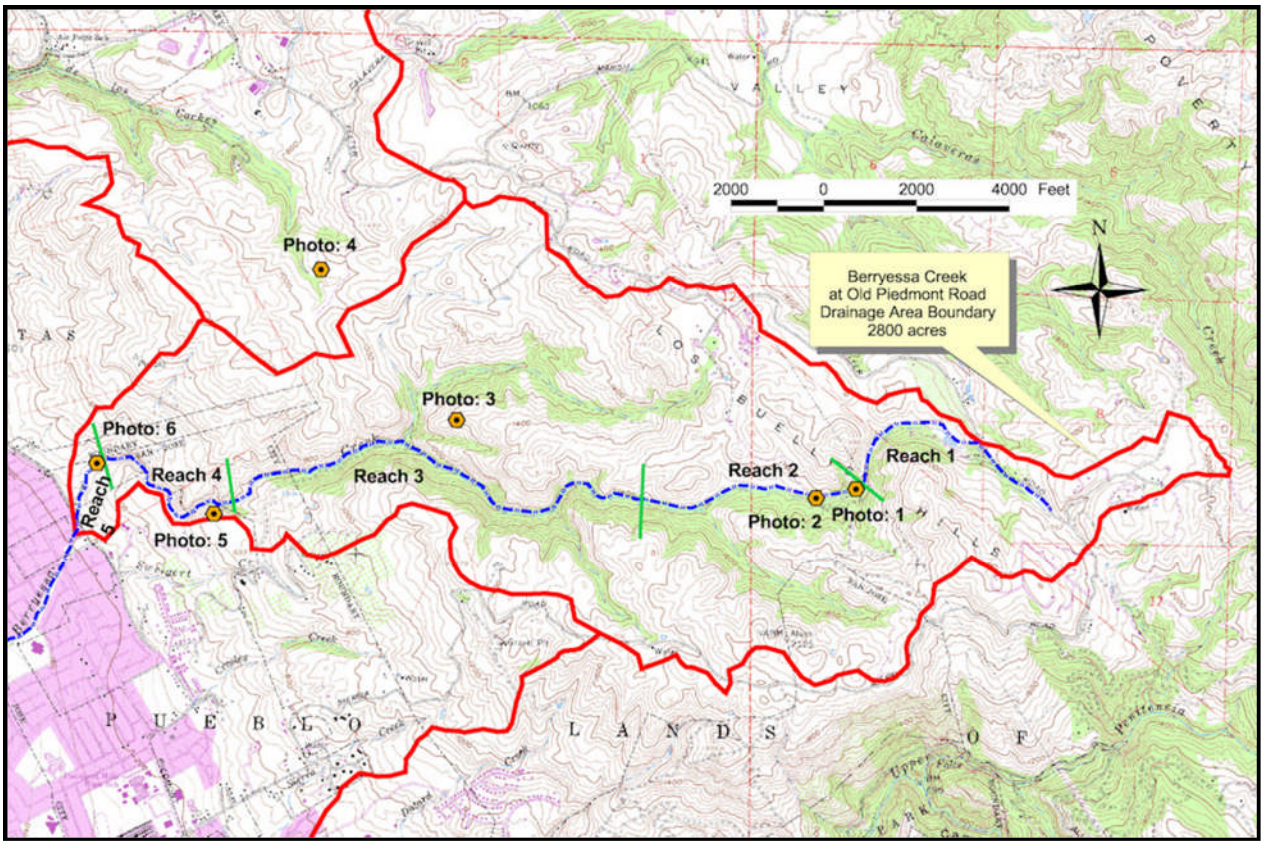

Figure 2-2 Upper Watershed Boundary, Reaches, and Photo Locations

2.1.2 Stream Profile

There is a distinct difference between the profile of Berryessa Creek in the uplands and on the alluvial fan within the Santa Clara Valley. Figure 2-3 shows the profile for the entire length from the estuary downstream from the confluence with Coyote Creek, upstream to the headwaters. Within the valley reach, which includes the project area, the channel gradient averages less than 1 percent. In contrast, the upland reach averages over 6 percent.

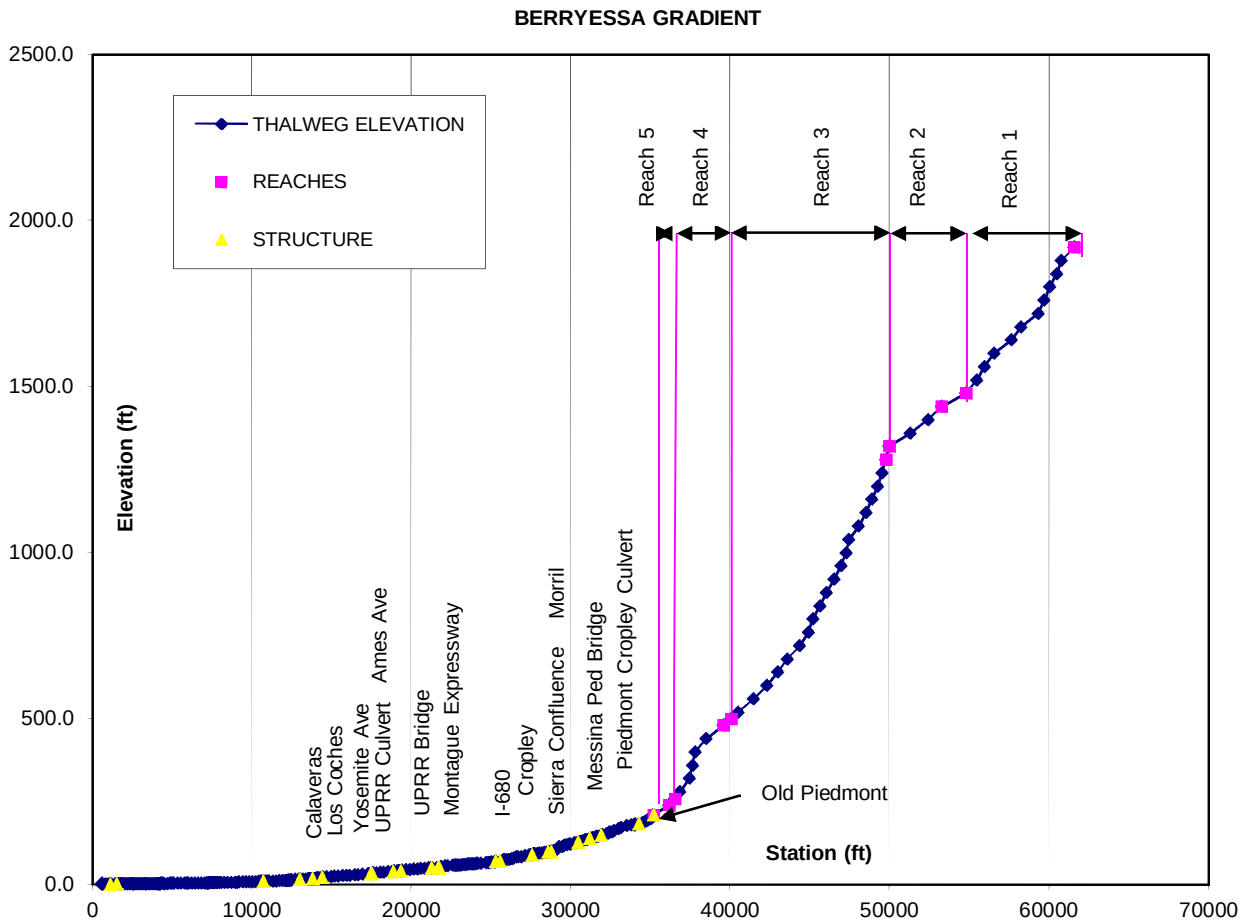

Figure 2-3 Berryessa Creek Profile from the Estuary to the Headwaters

Upstream of Calaveras Boulevard, the gradient follows the expected pattern of downstream reduction, with one exception. Starting at Old Piedmont Road, channel gradients are listed below:

Old Piedmont Road to Cropley Avenue	0.0271
Cropley Avenue to D/S of Piedmont Sediment Basin	0.0180
D/S of Sediment Basin to U/S of Sierra Cr. Drop	0.0156
Drop Structure to Cropley Avenue	0.0135
Cropley Avenue to I-680	0.0106
I-680 to Montague Expressway	0.0035
Montague Expressway to Calaveras Boulevard	0.0049

The channel leaves the uplands at a gradient of about 3 percent and gradually reduces to a slope on the order of 1 percent at I-680. However, below I-680, the gradient abruptly decreases by a factor of 3 to 0.35 percent between I-680 and Montague Expressway. Below Montague, the slope increases to approximately 0.5 percent.

There are numerous bed controls throughout the project area. These are formed by bridges or box culverts with concrete bottoms, drop structures, and segments of channels lined with concrete. Figure 2-4 identifies locations along the profile that act as grade controls.

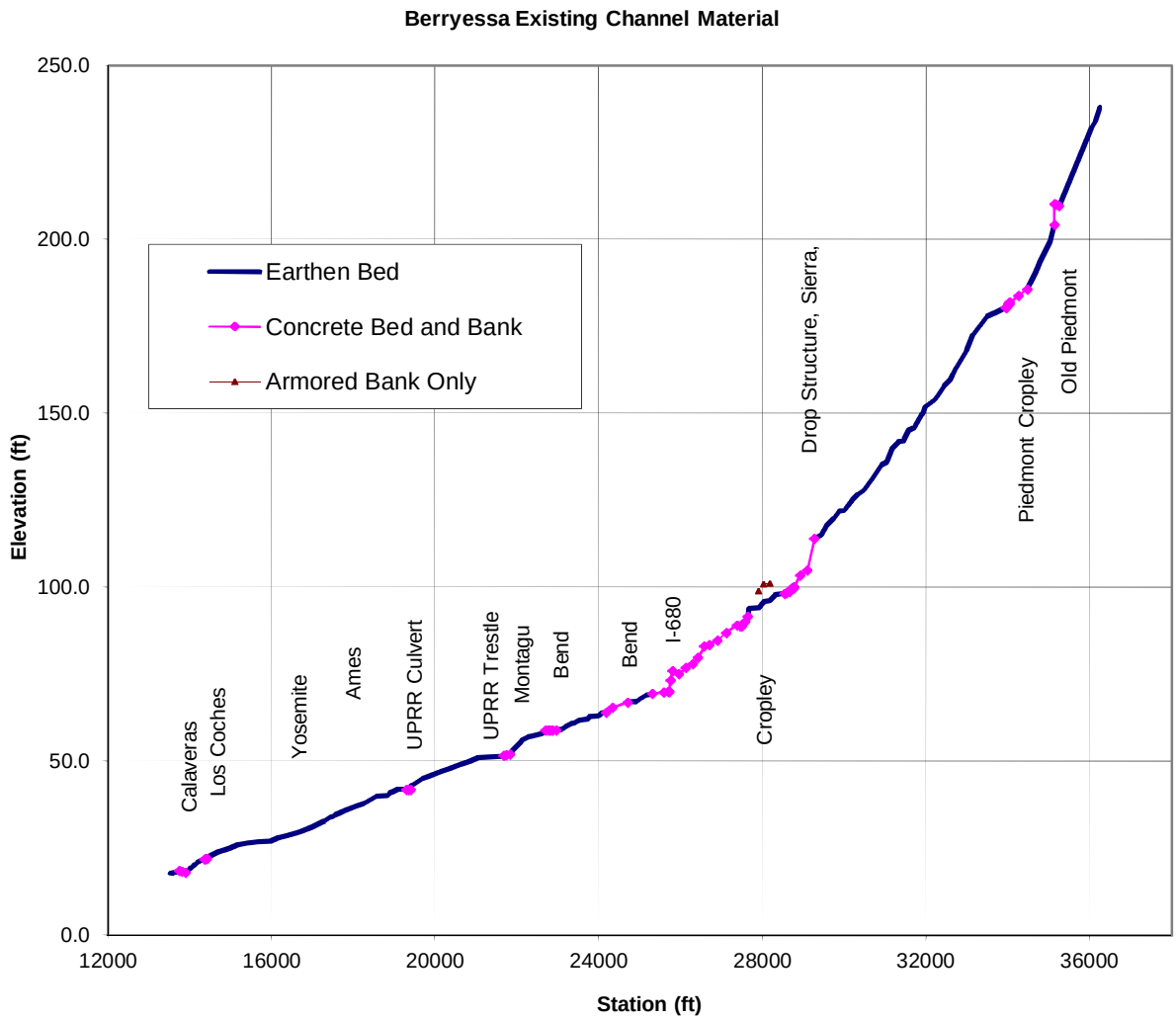

Figure 2-4 Location of Current Bed Controls along Berryessa Creek

The stream through the upper watershed was divided into five segments. Figure 2-5 provides a profile of the upland portion of Berryessa Creek. For the upper 1.3 miles, the gradient averages 6.5 percent. For about a mile, the gradient flattens to 3 percent. The gradient increases for the next two miles, averaging 8 percent with a gradual decrease in the downstream direction. The gradient then picks up as the stream crosses the Hayward Fault zone and passes through the "canyon" reach (Reach 4). The average gradient thought this segment is 8 percent with a portion of the stream near the center of the reach with a gradient of 15 percent. In the downstream 1,500 feet above Old Piedmont Road, Berryessa Creek transitions from the uplands to the alluvial fan with an average gradient of 4 percent.

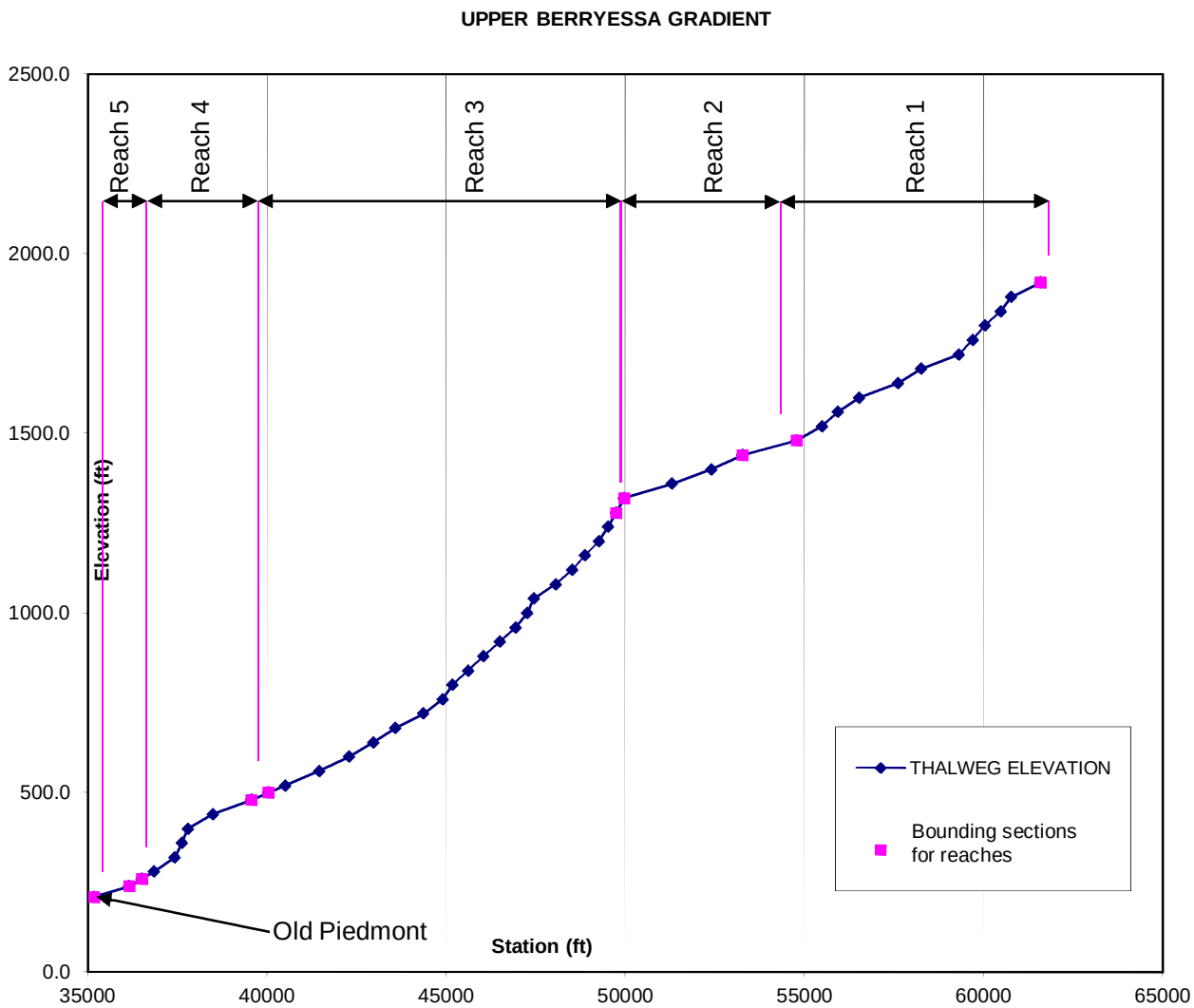

Figure 2-5 Berryessa Creek Profile from Old Piedmont Road to Headwaters

2.1.3 Channel Geometry

Within the project area, Berryessa Creek occupies a constructed channel that is heavily constrained by bridges, bank protection, channel lining and other constructed features. Thus channel dimensions are more a result of these influences as opposed to natural geomorphic processes. For description of the channel geometry, the project area was divided into eight reaches. During the analysis of the preliminary array of alternatives it was found that the portion of the project between Old Piedmont Road and I-680 was not justified and those portions of the project were removed from the final alternatives. Nevertheless, the six reaches between Old Piedmont Road and I-680 are described here to ensure continuity with the preliminary analysis completed prior to 2009. Descriptions of each reach are provided below. Additional details on channel cross sections can be found in the *Part I: Hydraulic Analysis of Alternatives* and *Part IV: Design and Cost of Alternatives* in this engineering appendix.

Calaveras Boulevard to Montague Expressway (Sta 138+03 to 217+38) – This reach is a straight, excavated earthen channel. It appears to have originally been excavated as a trapezoidal channel, but in some areas erosion and incision have resulted in the formation of steep, near vertical banks. The channel averages on the order of 10 to 12 feet in depth. The top width varies from a narrow 35 feet near the railroad trestle to on the order of 50 feet in other locations. The channel conveyance capacity ranges from 1,300 to 2,500 cfs.

Montague Expressway to I-680 (Sta 217+38 to 255+75) – This is another section of constructed trapezoidal earthen channel; with the exception that the channel bed and banks have been lined with concrete through the three 90 degree bends in this reach. The channel is approximately 40 feet wide with a depth of 7 to 8 feet. The conveyance capacity ranges from 800 to 1,500 cfs.

Upstream of the project area, the channel configuration and constraints vary significantly:

I-680 to Cropley Avenue (Sta 255+75 to 275+69) – This reach of Berryessa Creek is contained in a trapezoidal concrete channel with a top width on the order of 40 feet and a depth of 10 feet. These dimensions include the upper one to two feet of earthen material that continues to form channel sideslopes above the concrete. This segment of Berryessa Creek can contains approximately 2,800 cfs.

Cropley Avenue to Morrill Avenue (Sta 275+69 to 285+93) – This reach is a constructed trapezoidal, earthen channel with 2:1 sideslopes. The beds have been protected with concrete. The top width is on the order of 45 to 50 feet and the depth is typically 8 feet. The channel can contain flows up to approximately 1,500 cfs. The Cropley Avenue Bridge is a major constriction that creates a backwater upstream through much of the reach.

Morrill Avenue to Sierra Creek (Sta 285+93 to 292+00) – This reach is a combination of constructed channels. The downstream portion is a rectangular concrete channel with a 20 foot top width. The middle section is a trapezoidal channel with a gravel bed and banks protected by sacks filled with concrete. The top width is approximately 40 feet. The most upstream section is a drop structure that continues with banks protected by sacks filled with concrete, but has a concrete channel bottom. The top width of this segment is also approximately 40 feet. All three sections have depths on the order of 8 to 10 feet and contain flows up to approximately 1,500 cfs.

Sierra Creek to Piedmont Sediment Retention Basin (Sta 292+00 to 338+04) – This reach is referred to as the Greenbelt Reach. It contains the only section of channel that is not an excavated section constructed on an engineered alignment. The reach has only minor influences from bridges within its boundaries, with one pedestrian bridge crossing the channel without restricting it. The 20 to 30 foot wide channel varies from about 3 to 6 feet in depth. Portions of the channel have incised some, but banks remain stable due to vegetation and the silt and clay content which was reported to be roughly 50 percent (NHC 1990). Though the channel is free to meander within the 100 to 150 foot wide floodplain, the channel is fairly straight at a sinuosity of 1.06. The channel capacity is more representative of

a natural stream section in this reach than in other reaches with a bankfull capacity of approximately 500 cfs. The treed floodplain, which in some areas has berms and fill to help contain floods, can convey on the order of 1,300 cfs before flows breakout. Two tributaries, Crosley Creek and Sweigert Creek, enter in this portion of Berryessa Creek.

Piedmont Road Sediment Basin to Cropley Avenue (Sta 338+04 to 344+67) – This reach is comprised of two features. The downstream 250 feet is a sediment basin and the upstream 410 is a 12-ft by 7-ft concrete box culvert. To form the sediment retention basin, the channel has been widened and the banks protected to create an area to slow velocities and reduce shear stresses in order to collect upstream sediments. The sediment is then removed with construction equipment from the basin. The channel widens to 80 feet in the basin and has a depth that varies from 9 feet at the upstream end to about 6 feet as the basin transitions to the Greenbelt Reach. Santa Clara Valley Water District (SCVWD) records indicate that on the average nearly 527 cubic yards of sediment (see Table 2-1) are removed from the Piedmont Sediment Basin per year. The 410 foot long culvert that passes beneath the intersection of Piedmont Road and Cropley Avenue experiences deposition of coarse bed load from the build-up of material in the sediment retention basin. The basin will convey flows on the order of 1,500 cfs, but the culvert capacity is limited to passing approximately 900 cfs. The culvert capacity is often further restricted by sediment deposition within the culvert that can reduce the capacity to approximately 600 cfs or less.

Cropley Avenue to Old Piedmont Road (Sta 344+67 to 351+70) – This is an incised channel section with a width of approximately 40 feet and a depth of 10 feet. The channel banks in this reach have considerable gravel and small cobbles, though there is sufficient finer material for cementation to hold the banks near vertical. The channel capacity is approximately 1,500 cfs.

2.1.4 Current and Historical Channel Planform

The channel planform in the project area has undergone large changes since the middle of the 19th century. These are discussed in detail by NHC (2001) and summarized in this section. Of importance to understanding of the current conditions and the influences on the development of the flood control project is a comparison of the historic and current conditions. Before development, Berryessa Creek and its major tributaries flowed onto the alluvial fan for several thousand feet before spreading into distributary channels or infiltrating to the point that they were no longer shown on maps. As development increased, the streams were channelized to provide flood control and to supply irrigation water. It is also indicated that subsidence in the Santa Clara Valley may have contributed to the down fan progression of the defined stream channels.

By 1943, maps indicate that Berryessa Creek joined Penitencia Creek about 2 miles upstream of their current confluence. Significant realignment occurred between 1953 and 1961 when the creek was realigned to flow northward. This realignment placed the channel within its general flow path from the current I-680 crossing to Penitencia Creek. As a result of this realignment, the channel gradient was reduced from close to1 percent to less than 0.5 percent. The prior west flowing alignment was directly down the fan gradient whereas the realignment flows across the fan. This is the reason for the abrupt reduction in gradient

previously discussed for the reach mentioned from I-680 to the Montague Expressway. In 1976 the downstream-most portions of Berryessa Creek was realigned by the SCVWD as part of a flood control program. The current alignment from the fan apex to I-680 is close to that identified for 1943. The uppermost section of Berryessa Creek, from the apex to the middle of the Greenbelt Reach, is currently in the same general location as identified in 1899 maps.

2.1.5 Upper Watershed Site Inspection

An inspection of the Berryessa Creek watershed upstream of Old Piedmont Road was performed in August 2004. Participants in the field trip included representatives of the Sacramento District and Tetra Tech. The purpose of the field trip was to observe watershed and stream conditions that influenced sediment production and yield in order to develop potential strategies to reduce downstream sediment loading. More specifically the inspection was conducted to identify sediment sources, watershed processes controlling erosion and sedimentation, potential locations for sediment control facilities and the potential for land management activities to control sediment supply.

There were five distinct areas or zones observed in the stream and adjacent watershed. In the upper most 1.3 miles (Reach 1, upstream of the 1,480 foot contour), the creek is of moderately steep gradient averaging 6.5 percent and has a bed comprised of a wide range of material from gravels and cobbles to fines. The channel may be incised in some areas by several feet. There did not appear to be a high transport rate of the larger bed material (gravel and cobble) as there were few depositional bed features and there was a significant amount of finer material in the bed and heavy vegetation on the banks (Photo 2.1). On the hillsides, some minor gullying was observed where flow had been concentrated by roads or trails, but in the small gullies there were only a scattering of coarser materials so that it does not appear that this process is a significant source for coarser sediments in the upper portion of the watershed.

Photo 2.1 Typical Channel in Reach 1, Heavy Vegetation on Banks

The second segment of the channel (Reach 2) is relatively low gradient, particularly considering its location high in the watershed. This flatter section extends for approximately one mile at an average gradient of 3 percent, from the 1,480 foot contour on downstream to the 1,320 foot contour. Though the gradient flattens, the channel still has an incised appearance in areas. A significant depositional area of coarse material was not observed in this reach. This implies that the sediment production, of coarser materials is not high in the upper reach, otherwise the material would deposit in the area of reduced slope. The bed was comprised of sands and silts in portions of this reach, with only a scattering of angular gravels and cobbles (Photo 2.2). These larger materials may have fallen into the channel from the adjacent banks. In some areas where the bank material was exposed, there was a fairly heterogeneous matrix of material ranging from fines to small cobbles.

Photo 2.2 Typical Channel in Reach 2, Low Gradient

The third segment (Reach 3) of the upper channel starts as the stream gradient steepens and the channel becomes confined by steep hillsides. The bed material becomes dominated by gravels, cobbles and boulders with some bed rock outcroppings (Photo 2.3). The gradient was estimated at 8 percent for this reach which extends for approximately 2 miles to the 500 foot contour. Passage down the creek became difficult, so the inspection team walked along the hillside on the north side of the channel. At the several locations where the team returned to the creek bed, it was evident that the channel was capable of transporting materials up to boulders of over a foot in diameter. At several locations, bedrock was exposed in the channel and small falls were created. Though the watershed is very steep in this reach, the only landslides were observed near the downstream boundary of this reach. The south side of the valley wall is heavily forested while the north side is dominated by shrubs and grasses, except for a strip along the very bottom of the valley near the channel.

Photo 2.3 Typical Channel Section in Reach 3, Gradient of 8 Percent

Reach 4 begins where the stream enters what was referred to in previous reports (USACE 1993 and NHC 2001) as the canyon reach. The reach extends for approximately 0.6 miles at an average gradient of 8 percent with a short steep section of over 15 percent in the center of the reach. The most striking feature in this reach are a number of larger landslides that start hundreds of feet up on the hillside and continue down to the creek (Photo 2.4). These features are the largest concentrated sediment sources observed. The creek bed in this area is dominated by coarse material ranging from gravels and cobbles up to boulders on the order of 4 feet in diameter and greater. There is evidence that at times, the channel has transported debris torrents or flows. The formation comprising the surficial geology in this portion of the watershed is more susceptible to erosion and mass wasting than further upstream (Photo 2.5). This condition is further influenced by the Hayward Fault zone. The reduction in vegetative cover as elevation and rainfall decreases may also be a factor.

Photo 2.4 Mass Wasting Directly into Creek near Upstream Limits of Reach 4

Photo 2.5 Landslide Scarp on North Valley Wall in Reach 4 (Canyon Reach)

Reach 5 is a transition zone from the steeper upper watershed to the much flatter alluvial fan. The average gradient through this 0.3 mile reach is 4 percent. The channel bed in this reach is still comprised of material ranging from gravels to large boulders (Photo 2.6). Most or all of the larger boulders generated upstream appear to be deposited in this reach and do not cross Old Piedmont Road.

Photo 2.6 Typical Reach 5 Channel in Transition from Uplands to the Alluvial Fan

2.1.5.1 Implications of Watershed Inspection

Based on the observations during the site visit, control of sediments from the upper two segments (Reaches 1 and 2) of the watershed would have minor influence on delivery of coarse sediments (gravel and cobbles) to the reaches below Old Piedmont Road since it appears very little of this size material would make it through the flatter gradient of Reach 2. Sands and finer sediments may be produced in these areas, but their relative contribution would appear to be smaller than the portions of the watershed further downstream.

Based on the coarse bed material and steep gradient in Reach 3, a significant amount of gravel and cobble can be transported through this reach. However, no large point sources were identified. The team did not walk this portion of the creek bed so it could not be observed if there were large areas of bank erosion or contributions of sediments from point sources along the creek. This statement is based mainly on the lack of gullies crossed in walking along the north side of the valley wall and no visual identification of larger landslides on either the north or south valley wall. Construction of a sediment retention facility in this reach would be difficult due to the limited access and the small amount of storage volume per foot of structure height because of the steep channel gradient and steep confining valley walls.

Reach 4, the 0.6 mile length of the creek and associated watershed above Old Piedmont Road, appears to be the most significant area of sediment production. This is the area that several large point sources of sediment were identified, in the form of landslides in which feed directly into the creek. If a sediment retention or trap facility were to be constructed, it would appear that the best location would be in Reach 5 as the gradient decreases and the area adjacent to the channel increases. This area would control the large contribution of sediment from Reach 4. Lastly, this area has the best access for construction and maintenance.

In terms of land management, much of the upper watershed is grazed. There are a few residences, mainly along the watershed divide. The primary road serving the watershed travels near the watershed divide and in the majority of locations is in the adjacent watershed. There did not appear to be significant erosion problems created by any of these watershed disturbances. For example, there were no gullies observed as the result of concentration of flows from roadside drainage or from residential development. Likewise, there was no evidence of significant rilling or gullying occurring on the grazing lands or of trampling of streambanks by livestock. However, the influence of grazing was quite apparent with numerous trails contouring the hillsides and some locations with hillsides covered with hoof imprints left from the rainy season. Any control measures adopted to limit grazing activities along the channel banks would primarily reduce the fine sediment yield.

2.2 Summary of Sediment Transport Conditions

This section presents information on the current sediment transport conditions for the project area and upstream reaches that were presented in previous studies. The sediment removal history is also reviewed. The results of the hydraulic analysis for the with-project alternatives are utilized to qualitatively determine changes in sediment transport and removal requirements that would be induced by the project.

2.2.1 Previous Studies - Sediment Budget and Modeling

Previous analyses of the sediment budget (HMC 1990), geomorphology (NHC 2001) and sediment transport (NHC 2003) for the without-project condition of Berryessa Creek indicated two potential problems. The first was potential areas of deposition and the second was potential areas of degradation.

2.2.1.1 1990 Sediment Budget Analysis

An overall estimate of the sediment yield for Berryessa Creek was developed by NHC (1990). The results of this analysis indicated the following sediment yields:

Berryessa Creek at Old Piedmont Road	=	9,900 tons/year
Sweigert, Crosley, and Sierra Creeks	=	1,900 tons/year
Piedmont Creek	=	700 tons/year
Arroyo de los Coches	=	3,200 tons/year

The values provided for the tributaries are at their confluence with Berryessa Creek. The total yield is 15,700 tons/year. If a dry unit weight of 100 lbs/ft^3 is assumed for sediments, this represents 11,600 cubic yards per year.
The sediment budget performed by NHC (1990) estimated the mean annual inflowing sediment load at Calaveras Boulevard to be 9,200 tons/year or 6,800 cubic yards per year. This budget was based on deposition of 6,700 tons/year of sediment between Piedmont Road and Calaveras Boulevard. The study utilized a value of 5,000 cubic yards per year of sediment removal upstream of Calaveras Boulevard.

It should be noted that the 1990 study used a value of 23,800 cubic yards of sediment removed in 1983 between Sierra Creek and Calaveras Boulevard.

2.2.1.2 2001 Geomorphology Study

In 2001 NHC updated the 1990 sediment budget analysis (NHC 2001). One major change aside from the additional sediment removal data available was that the large value of 23,800 cubic yards of sediment removed in 1983 between Sierra Creek and Calaveras Boulevard was not included. If this large volume of removal is not included, the average annual rate for the 10-year period referenced in the 1990 Sediment Budget Analysis (NHC 1990) would be 2,620 cubic yards per year or 3,200 tons/year (NHC assumed 90 lbs/ft^3 for deposited sediments). This change in assumptions and additional sediment removal data resulted in the

sediment budget resulting in 12,400 tons/year of sediment passing Calaveras Boulevard as opposed to the 9,200 tons/year as indicated in the 1990 study.

2.2.1.3 2003 Sediment Transport Modeling

In 2003 estimates of sediment yield and budget were developed by NHC based on an HEC-6T sediment transport analysis (NHC 2003). The sediment yield was computed by integrating the HEC-6T simulated bed material load yields for the single storm events to determine average annual yields utilizing the method described by Mussetter *et. al.* (1994). This resulted in an average annual bed material yield at Old Piedmont Road of 2,500 to 3,000 tons per year. The overall budget identified a total of 170 tons per year of net erosion from the reach, indicating this reach is currently slightly degradational. This minimal amount of degradation translates into an average of 0.05 inches per year if the total volume were to be spread out over the entire reach. The sediment budget presented in the 2003 report did not indicate it accounted for sediment removal that takes place at several locations throughout the reach. The budget also did not provide an indication of the simulated tributary inflows and how or if they were accounted for in the budget.

2.2.1.4 Analysis of Previous Studies

If the 9,900 tons per year average annual sediment yield at Old Piedmont Road computed in the 1990 Sediment Budget Analysis is assumed to be 35 percent bed material load (sand, gravel and cobble) and 65% wash load (silts and clays), the resulting average annual bed material supply at Old Piedmont Road is 3,500 tons. This is in fairly close agreement with the 2003 HEC-6T Sediment Transport Study which indicated an average annual upstream loading on the order of 2,500 tons per year. In terms of the sediment balance in the reach, the HEC-6T modeling by NHC indicated a slight degradational trend. However, the modeling did not appear to include the sediment removal in the analysis. Accounting for sediment removal increases the degradational trend by several thousand tons per year. An overall degradational trend is supported by comparisons of the 1968 and 1998 channel thalweg profiles in the 2001 Geomorphic Study (NHC 2001). Comparison of these profiles indicates that the 1998 profile is at or below the 1967 profile throughout the project area. Continued sediment removal prevents the areas of deposition from being revealed on the profile comparison.

Because of the highly manipulated nature of the Berryessa Creek channel within the project area, its ability to transport sediment varies widely. Though there are segments of considerable deposition that require sediment removal to maintain flood conveyance capacity, there are areas with higher sediment transport capacity that result in channel degradation. This is supported by the comparison of the 1967 and 1998 thalweg profiles presented by NHC in the 2001 Geomorphic Study. The 2003 HEC-6T sediment modeling results show similar behavior with a slight overall trend for degradation, but a mixture of aggradation and degradation scattered throughout the project area.

The 2003 HEC-6T model results indicated that the bed material load from a single 1% chance exceedance event would be on the order of 13,000 tons at Old Piedmont Road, which is on the order of four to five times the estimated average annual bed material loading. During a 1% chance exceedance event, the maximum predicted aggradation is over 4 feet at the Piedmont/Cropley culvert and over 2 feet just upstream of the Ames Avenue Railroad trestle. At all other locations the aggradation is on the order of one foot or less. The maximum predicted degradation is 2 feet in the Greenbelt Reach just downstream of the sediment basin and just over one foot about 500 to 1,000 feet upstream of Los Coches Street. Based on these results the modeling indicates a mixture of aggradation and degradational areas. Though the actual historic profiles indicate primarily equilibrium or degradational reaches, the model did not appear to account for the sediment removal in the aggradation areas. If all sediment deposits indicated by the model results are removed, the required sediment removal predicted by the HEC-6T model would be on the order of 3,700 cubic yards per year. A further discussion of actual sediment removal history is presented in the next section.

2.2.2 Sediment Removal History

The SCVWD performs removal of sediment on an as needed basis to maintain the conveyance capacity of Berryessa Creek throughout the project area and upstream reaches. The two concentrated areas of removal upstream of the project area are the sediment retention basin below Piedmont Road and the reach between the Sierra Creek confluence downstream to Cropley Avenue. Additionally, sediment is removed at various locations throughout the project area. Table 2-1 presents the reported maintenance records of sediment removal from five reaches within the Berryessa Creek channel. The sediment removal for the study area between Old Piedmont Road and I-680 is divided into two reaches, the sediment retention basin below Piedmont Road and the area from Sierra Creek to Cropley Avenue. The sediment removal for the study area downstream of I-680 is also subdivided into two areas; I-680 to Montague Expressway and Montague Expressway to Calaveras Boulevard. The final reporting reach downstream of Calaveras Blvd and is outside of the project area.

Based on 33-years of maintenance records from 1977 to 2011 the most concentrated area of sediment deposition in the study area is at the sediment retention basin below Piedmont Road. In this several hundred foot long reach, an estimated average annual removal of 527 cubic yards occurs. This is the highest removal at any location in the study area and also represents the shortest stream reach of all the removal areas. The next highest sediment removal area is Sierra Creek to Cropley Avenue. In this 1,600 foot long reach, the estimated average annual removal is 525 cubic yards. In the 3,600 foot long reach from I-680 to Montague Expressway, the level of sediment removal is slightly less than the two upstream sites at 430 cubic yards per year. The lowest annual sediment removal is found in the downstream-most reach in the study area, from Montague Expressway to Calaveras Boulevard, an annual average of 205 cubic yards is removed in its 7,700 foot length.

Table 2-1 Summary of SCVWD Sediment Removal Maintenance Records on Berryessa Creek (NHC 2001 and SCVWD)

Year	Removal in Deposition Areas (cu. yd.)					Total (cu. yd.)
	DS of Calaveras	Montague to Calaveras	I-680 to Montague	Cropley to Sierra Creek	Piedmont Sed. Basin	
1977	0	0	0	0	0	0
1978	0	0	0	0	0	0
1979	0	0	0	0	0	0
1980	0	0	0	0	0	0
1981	4,210	4,100	0	0	0	8,310
1982	23,510	0	2,890	0	0	26,400
1983	0	0	0	0	0	0
1984	19,500	0	0	0	0	19,500
1985	14,352	0	1,136	1,137	1,137	17,762
1986	460	1,320	0	3,260	900	5,940
1987	9,820	800	250	0	0	10,870
1988	0		0	10	2,724	2,734
1989	13,330	400	0	432	0	14,162
1990	10,520	0	0	0	0	10,520
1991	4,066	0	0	0	300	4,366
1992	0	0	0	0	0	0
1993	2,800	0	0	2,500	1,250	6,550
1994	0	0	0	0	0	0
1995	0	0	0	0	0	0
1996	0	0	0	0	5,600	5,600
1997	30,000	0	0	700	810	31,510
1998	0	0	0	3,850	1,000	4,850
1999	1,250	0	8,850	0	0	10,100
2000	0	0	0	0	1,300	1,300
2001	7,189	0	0	3,165	1,525	11,879
2002	0	0	0	0	0	0
2003	4,640	0	0	0	0	4,640
2004	7260	0	20	0	450	7,730
2005	0	0	0	0	0	0
2006	0	90	0	1,744	930	2,764
2007	6,320	67	500	0	0	6,887
2008	0	0	964	0	0	964
2009	0	0	0	0	0	0
2010	0	0	0	1,040	0	30,040
2011	34,000[1]	0	0	0	890	34890
Average Annual	5,521	199	417	509	537	7,179
Totals	193,227	6,777	14,610	17,838	18,816	251,268

Note: 1. Maintenance has been deferred for the reach downstream of Calaveras from 2008 to present pending reconstruction of the reach by SCVWD. The current estimate by the SCVWD Water Operation Staff of 34,000 cubic yards of sediment in this reach is used to account for this deferred maintenance. (SCVWD 2011a)

The sediment deposition basin below Piedmont Road was developed to collect sediment as the channel leaves the upstream watershed and flows onto the alluvial fan. At the Piedmont Road sedimentation basin, the channel gradient has been reduced and the width increased to form the basin. In the Sierra Creek to Cropley Avenue reach, a combination of drop structures, energy dissipaters and restrictive bridges, as well as the possibility of supply of additional sediments from the Greenbelt Reach and Sierra Creek, result in an area of concentrated deposition. Below I-680, the overall gradient dramatically decreases by a factor of 2 to 3 compared with the reach from Cropley Avenue to I-680. As a result of this gradient reduction, the reach is subject to aggradation in areas where the channel widens or flows are backwatered upstream of restrictive bridges.

The results of the 2003 Sediment Transport Modeling were compared to the maintenance records sediment removal results presented in Table 2-1. In order to compare the two analyses, the results for the SCVWD sediment removal reaches reported in Table 2-1 were developed from the 2003 HEC-6T modeling. Note that the reported HEC-6T model estimated volumes do not include some areas of lesser deposition not included in Table 2-1, resulting in the total estimated average annual deposition for the sediment removal reaches not equaling the 3,700 cubic yards per year reported for the study area in the previous section. The resulting average annual sediment removal volumes for the SCVWD sediment removal reaches predicted in the HEC-6T model are listed in Table 2-2.

Table 2-2 Comparison of SCVWD Sediment Removal Records and NHC 2003 HEC-6T Sediment Transport Modeling

Sediment Removal Reach	Average Annual Sediment Removal Estimates (Cubic Yards per Year)		
	SCVWD Maintenance Records	2003 NHC HEC-6T Modeling	Percent Difference from SCVWD Records
Piedmont Sediment Basin	527	890	69%
Sierra Cr. to Cropley Avenue	525	390	-26%
I-680 to Montague Expressway	430	720	67%
Montague Expressway to Calaveras Boulevard	205	860	319%
TOTAL	**1,687**	**2,860**	**69%**

The 2003 Sediment Transport Modeling results reported in Table 2-2 are approximately 70 percent higher than those reported by SCVWD maintenance records for the total study area and of the two removal reaches. The only reach underestimated by the 2003 HEC-6T modeling in comparison to maintenance records is from Sierra Creek to Cropley Avenue where the HEC-6T results indicate 390 cubic yards and the maintenance records identify 525 cubic yards per year. In contrast, the HEC-6T model overestimates the required sediment removal in the Montague Expressway to Calaveras Boulevard reach by over 319%.

It should be noted that significant sediment deposition requiring removal occurs in the 8,500 foot reach from Calaveras Boulevard downstream to the Penitencia Creek confluence. This reach is tidally influenced and therefore sediment deposition is expected. In the GDM (USACE 1993), based on removal records from 1981 to 1990, the removal in this reach was equal to the total removal for all upstream reaches averaging 5,000 cubic yards per year.

Correspondence from the SCVWD indicated sediment removal operations has been performed downstream of Calaveras Boulevard eight times since 1990 with removal volumes ranging from 1,250 cubic yards in 1999 to 30,000 yards in 1997. In addition, recently sediment maintenance activity has been deferred for this reach because of pending reconstruction activity by SCVWD. To account for the sediment deposition in the reach from 2008 to present, the SCVWD Water Operation Staff has estimated that the volume of sediment that would have been removed for routine sediment operations in the reach is 29,000 cubic yards (SCVWD 2011a). The addition of the sediment removal activity since 1990 results in an average annual sediment removal of 4,683 cubic yards per year for Berryessa Creek from the confluence of Penitencia Creek to Calaveras Boulevard.

In evaluating the influence of with-project alternatives, consideration must be given to the portion of Berryessa Creek downstream of the project limits. Two important aspects of the sediment balance need to be incorporated into the overall project evaluation. First, if additional sediment is generated from bank erosion or bed degradation in the project area, if it is not deposited in the project area, most of the sediment would be deposited in the reach below Calaveras Boulevard. Second, any reduction in maintenance requirements that results from increasing sediment transport capacity within the project area will pass sediment through the project area, but will result in increased deposition in the reach below Calaveras Boulevard.

CHAPTER 3: WITH-PROJECT CONDITIONS

This chapter applies the information from the existing conditions assessment of geomorphology and sediment transport investigations to identify design considerations and issues to be addressed in the with-project alternatives. Results of the hydraulic analysis of the without and with-project alternatives are compared to qualitatively identify potential channel responses. The information is applied to identify recommendations as to potential modifications or refinements of the with-project alternatives. Sediment management features between Old Piedmont Road and I-680 are not part of the current project but are under consideration by others. These features are included herein for discussion purposes as the sediment supply through the upstream reaches affects the configuration of sediment management features in Alternatives 2A/d, 2B/d and 4B/d downstream of I-680.

3.1 Design Issues and Considerations

The following section identifies the issues or considerations, and then provides recommendations as to how they may be addressed in the alternatives. The general categories of issues to address are:

- Management of coarse sediment
- Minimize aggradation and degradation
- Provide opportunities for environmental enhancement

3.1.1 Management of Coarse Sediment

The Berryessa Creek Project Area extends from I-680 to Calaveras Boulevard and lies within an alluvial fan. Alluvial fans are created by sediment deposition as streams carrying large sediment loads exit the steep confined channel of the uplands and meet the lower gradient unconfined valley. As a result, sediment deposition is an inevitable process on an alluvial fan and any channel improvements must recognize this behavior. On the Berryessa Creek fan, at some point, between the apex of the fan and the Bay, all but the finest sediments will be deposited. Since the gradient decreases in the downstream direction along the fan, and the ability to transport sediment decreases along with it, the larger sediments are deposited furthest upstream.

Deposition in the project area currently requires on the order of 1,046 cubic yards per year of sediment between Old Piedmont Road and I-680 and 616 cubic yards per year of sediment downstream of I-680 be removed. Additional sediment deposits are also removed downstream of the project area. Even if a concrete channel that confined all the flow and maximized velocities and shear stresses were installed, though the coarse sediments would be conveyed further, they would either deposit in the lower gradient project area downstream of I-680 or in the tidally influence reach further downstream. Therefore at some point along Berryessa or Penitencia Creek, the sediments become a maintenance issue because removal is required to maintain flood conveyance capacity and prevent the eventual plugging of the

channel. Coarse sediment management approaches to be considered include reducing the supply of sediment and promoting sediment deposition in areas that will not induce flood problems and are readily accessible to perform periodic sediment removal.

3.1.2 Reduction of Coarse Sediment Supply

Coarse sediment supply is generated primarily upstream of the project on the mainstem of Berryessa Creek and passes through the bridge at Old Piedmont Road. Additional quantities of sand and gravel are supplied by the larger tributaries and some sediment may be generated from channel degradation and bank erosion within the project area. Inspection of the upland watershed and information contained in past studies indicate that the majority of coarse sediment is generated in the lower steep canyon reaches (Reach 4) of Berryessa Creek as a result of mass wasting and erosion of the steep hillsides immediately adjacent to the creek. Because of the scale of these sources and the fact that they are a result of natural process and conditions, including the presence of active fault zones and unstable geologic formation, controlling the coarse sediment supply at its source is not practical.

Another option would be to create a sediment retention basin upstream of Old Piedmont Road in the transition zone from the steep canyon to the alluvial fan. This is the zone that the large boulders that may be transported in debris torrents and flows are deposited in. Additionally, smaller boulders and cobble are also deposited in this area. The 1989 Authorized Plan and 1993 GDM (USACE 1993) included a sediment basin at this location with a capacity of 17,000 cubic yards which exceeds the volume of sediments deposited in a 1% chance exceedance event (12,000 cubic yards) plus the average annual sediment deposition (3,000 cubic yards).

The difficulty with such a large basin is that it would trap nearly all of the sediments from sand size and larger. This would result in the “hungry water” released from the sediment basin picking up sediments further downstream which would result in bed and bank erosion. This would likely cause the channel through the Greenbelt Reach to become incised and less connected to its floodplain. In the case of the channel design presented in the 1993 GDM, a concrete channel would be installed downstream of Old Piedmont Road. The concrete channel would have prevented bed degradation and bank erosion. However, with the “natural” channel bottom being proposed in the current with-project alternatives, the bed would be subject to degradation. Thus installation of a large sediment basin above Old Piedmont Road does not appear to be compatible with the implementation of a project with an alluvial bed. Given the limitations of a sediment basin at this location, a debris trap is considered as a possible future refinement of the GDM design. For the purposes of this study, the sediment basin upstream of Old Piedmont Road was analyzed as designed in the 1993 GDM since this was a component of the Authorized Project which needs to be analyzed as designed.

3.1.3 Debris Torrents and Flows

Based on site observations and past reports (USACE 1993 and NHC 2001), the potential for transport of large boulders in the form of debris torrents and flows exists. It appears that this

material is transported almost as far as the Old Piedmont Road crossing and could cause problems with the culvert. To reduce the possibility of plugging the culvert, which could result in the flows breaking out of the channel, an installation of a debris fence or other permeable structure designed to strain debris flows will be investigated upstream of Old Piedmont Road during the next phase (design of the selected plan) of the GRR. Such a structure would catch the larger material but allow passage of the majority of cobble and finer material. The structure would have little influence on normal flows. By only catching the larger material and debris, the volume of storage behind the structure is much smaller than for a sediment basin. Additionally, since it passes the majority of the sediment load, it does not have the potential to induce channel degradation downstream. The structure will need access for removal of trapped material; however, removal will only need to be performed after large events that mobilize boulders. The inclusion of the debris fence would not affect plan selection.

3.1.4 Coarse Sediment Management within the Project

Currently, coarse sediment is managed in the project by periodic removal of deposits. In most cases, sediment is removed from locations within the project area on an as-needed basis. The sediment retention basin upstream of the project area at Piedmont Road has been designed to facilitate sediment removal. This basin collects bed material load by providing a wide area with reduced flow velocity and shear stress. The capacity of the basin is on the order of 1,000 to 1,500 cubic yards. A significant problem with the basin is that once sediments start depositing in the basin, they quickly create a backwater that causes sediment to deposit in the 410 foot long culvert immediately upstream. This reduces the flood conveyance capacity of the culvert, which can result in flows breaking out upstream of the culvert at much lower return periods and increasing the frequency of flooding. In addition, it is extremely difficult to remove deposits from the culvert due to the limited workspace and clearance.

Several modifications should be considered for the basin to improve its performance. Potential modifications include regrading the basin to have a steep slope immediately downstream of the culvert outlet. This would provide sediment storage below the culvert invert and reduce the tendency for deposits to build up in the culvert. Additionally, the culvert invert could be altered to have a V-bottom. This would help concentrate flows and increase the transport capacity during low flows. Another potential option is to move the basin a short distance downstream so that there is some distance between the basin and the culvert outlet. The area between the two features should have a steep slope to prevent backup of deposits into the culvert. It is noted that increasing the storage volume of the basin may not be a good option. A significant increase in the volume would increase the trap efficiency which could induce channel degradation and incision in the Greenbelt Reach.

Accommodating the steep chute below the culvert or the shifting of the basin further downstream would require lowering the basin and possibly alteration of some of the channel in the Greenbelt Reach. Changes to the channel in the Greenbelt Reach should be analyzed carefully and kept to a level that does not create problems with the stability of this reach. Potential problems that would have to be mitigated would be reduced stability after

disturbing the vegetation on the banks and increased flow confinement if the channel was lowered.

In addition to improvements to the Piedmont sediment retention basin, additional coarse sediment management might be provided by creation of locations that were designed to conduct sediment removal operations. This would involve providing access to the channel bottom and possibly altering channel hydraulics to encourage sediment deposition. Based on historical sediment removal, likely locations would be between the Sierra Creek confluence and Cropley Avenue crossing and between I-680 and Montague Expressway. Sediment transport modeling of these facilities would be necessary to ensure that they function properly and do not trap so much sediment that downstream degradation problems are created. Additionally, locations for the facilities should be determined after sediment transport modeling of the with-project condition since the channel alterations under the with-project condition may alter the locations most prone to sediment deposition.

A high-flow bypass culvert running beneath Cropley Avenue is being considered by the SCVWD to reduce flooding in the Greenbelt reach. Detail planning for the SCVWD bypass plan has not been completed at the time of this study. Approximate sediment management implications are presented in this report and will be added to future design reports. The bypass alternative was only considered for the design of Alternatives 2B/d and 4/d.

3.1.5 Minimize Channel Bed Aggradation and Degradation

Berryessa Creek has areas that experience aggradation and others that have experienced degradation. If not properly accounted for, alteration of the system for flood control has the potential to increase either or both of these processes at various locations within the project area.

3.1.5.1 Flow Confinement

Confinement of higher flows to a limited area by excavation of a larger channel or construction of levees increases shear stresses which can mobilize larger sediments and increase transport rates. As a result, the flows erode sediments from the bed to satisfy the increase in sediment transport capacity. These sediments may be deposited downstream when the flows reach a portion of the channel where the hydraulic conditions become less severe. Evaluation of the Berryessa Project alternatives needs to account for this potential since much of the project involves measures that increase the flow confined to a main channel.

Sediment transport analysis and modeling should be conducted to refine the design of the selected alternative to assess areas where this may be a problem. If such locations are identified, then the channel dimensions need to be modified to reduce the potential for degradation. If this cannot be done, while maintaining flood control objectives, then the inclusion of grade controls to limit future degradation should be considered.

3.1.5.2 Channel Widening

In some cases excavation of a wide channel to create sufficient cross-sectional area to pass the design flows can actually result in reducing sediment transport capacity for smaller events. Though very large floods pass a greater amount of sediment on a single event basis, smaller flows, owing to their greater frequency of occurrence, are typically responsible for the greatest portion of sediment transport over the long term. The flood responsible for the greatest portion of sediment transport is referred to as the dominant or formative discharge and often ranges between the 20- to 75% chance exceedance events. Therefore, a reduction in sediment transport capacity at the lower return period floods, by spreading across the wider channel bed, may off-set the increase in sediment transport capacity created by confining the larger floods to the enlarged channel. Depending on the magnitude of the changes, the two factors may offset creating a condition of dynamic equilibrium or the change may be so large as to shift the channel into an aggrading mode. In some widened channels, alternate bars may form during low flows that become vegetated and cannot be removed at higher flows in some reaches. Though the channel might have the capacity to transport the sediment stored in the bars, the vegetation in some reaches prevents them from becoming scoured and they may need to be removed as part of a maintenance program. Since portions of the Berryessa Creek channel are widened, this behavior is also a possibility.

Sediment transport analysis and modeling for the selected alternative should identify any areas where channel widening is causing excessive degradation. If such locations are identified, the design should determine whether the channel can be narrowed while still meeting flood control objectives. This may require increasing levee or floodwall heights. In the former case, additional right of way may be needed to accommodate the wider levee footprint. Additionally, the evaluation should consider whether the problem could be remedied by slope alteration or modification to downstream structures that constrict the flow and cause backwater into the area of concern.

3.1.5.3 Gradient Alteration

The current channel gradient varies dramatically from near 3 percent at the upstream end to below 0.5 percent at the downstream end. Though there is a strong trend for decreasing gradient in the downstream direction, there are localized areas where the gradient changes abruptly. This is partially due to the wide range of channel configurations currently found in the project area. At the current level of design, the proposed channel sections have been superimposed on the existing channel gradient. In the next level of design, the profile needs to be refined considering minimizing changes in sediment transport capacity that result from local variations in the gradient. Additionally, this exercise will likely have benefits to the providing the most efficient flood control design.

3.1.5.4 Structures

Numerous structures are located throughout the project area and upstream reaches, including 13 stream crossings and several energy dissipators. Some of the bridges create constrictions that result in backwater and induce sediment deposition upstream. It is believed that the

modifications to these bridges to provide passage of floods should solve these problems, but sediment transport modeling should still be performed to substantiate this. Because of the channel alterations, the energy dissipation structures will be removed by others and will not be a factor under the with-project condition.

3.1.6 Provide Opportunities for Environmental Enhancement

Though the purpose of the project is flood control, environmental features have been identified as important aspects to local stakeholders. Therefore existing areas with higher environmental values should be preserved and in other areas it may be possible to increase the environmental values over current conditions. Channel morphology and sediment transport aspects of the channel design can play a role in preventing loss of existing high environmental value areas and to enchaining the environmental values in other areas. For example, the Greenbelt Reach upstream of the project area has environmental values that are not found in the project area. However, this is the reach that would likely be most susceptible to increase in changes in sediment supply. In other portions of the channel, creation of benches to provide at least limited floodplain can provide environmental enhancement. Also, the design of the channel influences the aquatic habitat. The most significant opportunities to provide environmental enhancement that relate to sediment transport, geomorphology and channel stability are listed below:

- Create a channel with an alluvial bed
- Utilize vegetation to the extent possible to provide bank stability
- Develop a main channel that conveys flows that are on the order of the 50% chance exceedance event
- Provide an area adjacent to the main channel that serves as a floodplain
- Promote growth of vegetation on the floodplain
- Avoid overly wide channels that spread flows very shallow

These opportunities have all been taken advantage of in alternatives 4B, with the extent of vegetation dependent on the further selection of vegetation types for the benches. Alternative 2B incorporates an alluvial channel and may incorporate some vegetation, but does not address the other environmental opportunities listed.

3.2 Qualitative Evaluation of Sediment Transport

This section presents a qualitative assessment of changes in sediment transport conditions and the potential changes in channel response based on comparisons of with- and without-project hydraulic conditions. The two hydraulic parameters chosen to perform the evaluation are velocity and shear stress. Sediment transport is sensitive to these parameters with sediment transport capacity typically increasing with velocity raised to a power of 3 to 5. Shear stress determines the sizes of bed material that can be mobilized. The qualitative evaluation of sediment transport is presented for the preliminary array of alternatives and for the final array of alternatives.

3.2.1 Preliminary Array of Alternatives

As described in Section 2.1 and Chapter 4 of *Part I: Hydraulic Analysis of Alternatives* of this engineering appendix, HEC-RAS models were developed to model the without-project condition and preliminary array of alternatives. To assess potential changes in sediment transport conditions within the project area, velocity and shear stress values from the original GRR methodology (see Section 2.1 of *Part I: Hydraulic Analysis of Alternatives* of this engineering appendix) HEC-RAS models were compared from reach to reach along the channel. The plots were reviewed for without-project baseline and the with-project alternatives. The velocity plots are presented in Figure 3-1 and Figure 3-2 for the 50% chance exceedance events and Figure 3-5 and Figure 3-6 for the 1% chance exceedance events. Similar shear stress versus project station plots are provided in Figure 3-3 and Figure 3-4 for the 50% chance exceedance events and Figure 3-8 for the 1% chance exceedance events. All figures have been separated into two plots (part 1 containing baseline, Alternatives 2A, 3A, and 3B and part 2 containing baseline, Alternative 4B and Alternative 5), plotted at the same scale, to facilitate easy comparison with baseline conditions. Results have been smoothed with running average values over two cross sections upstream and downstream of each station. Sections 2.1.2 and 4.3 of Part I: Hydraulic Analysis of Alternatives of this engineering appendix contains more comprehensive results for the original GRR methodology without-project and preliminary alternatives.

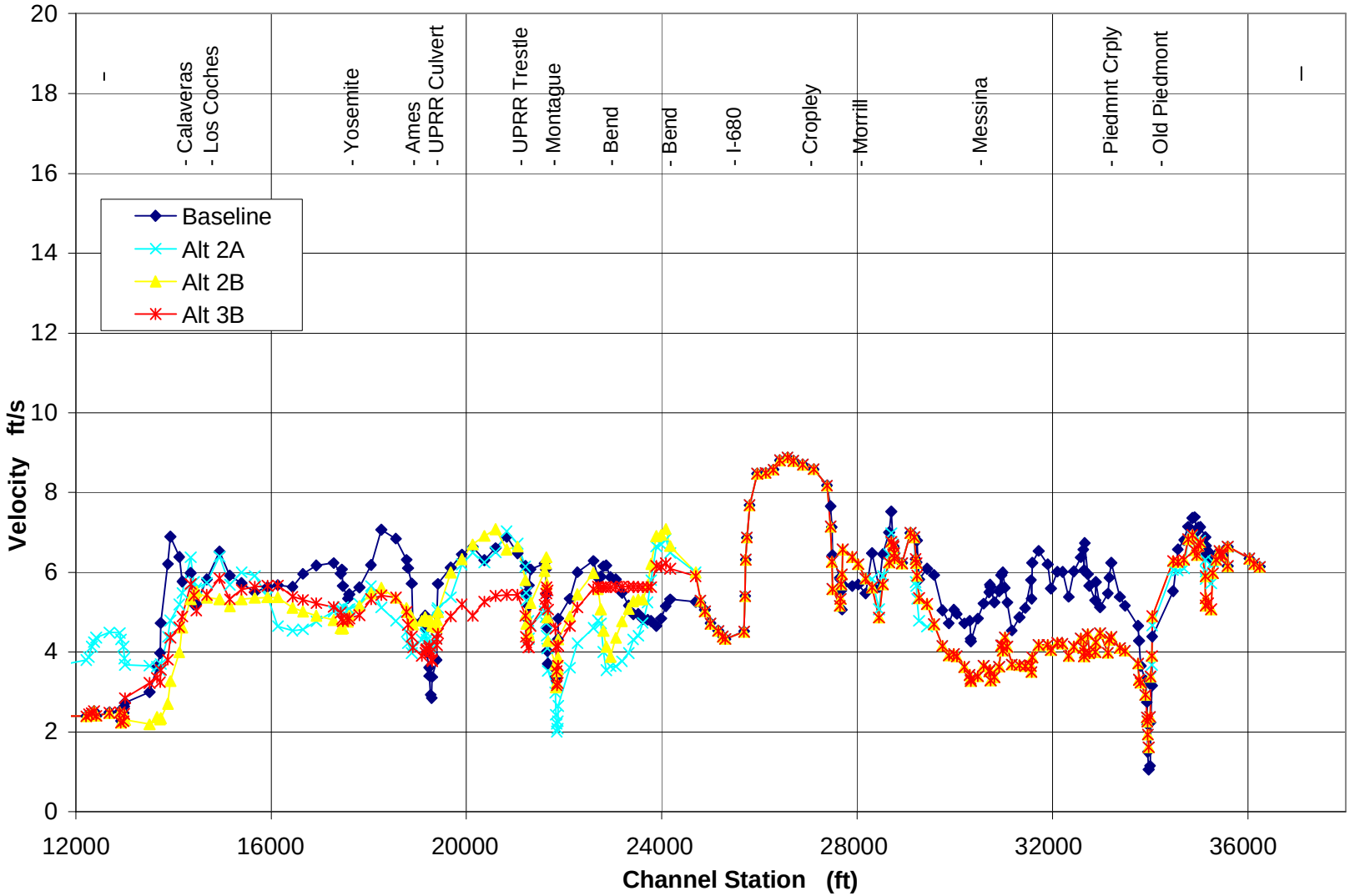

Figure 3-1 (Part 1 of 2) – Main Channel Velocity for Without- and With-Project Conditions, 50% Chance Exceedance Event

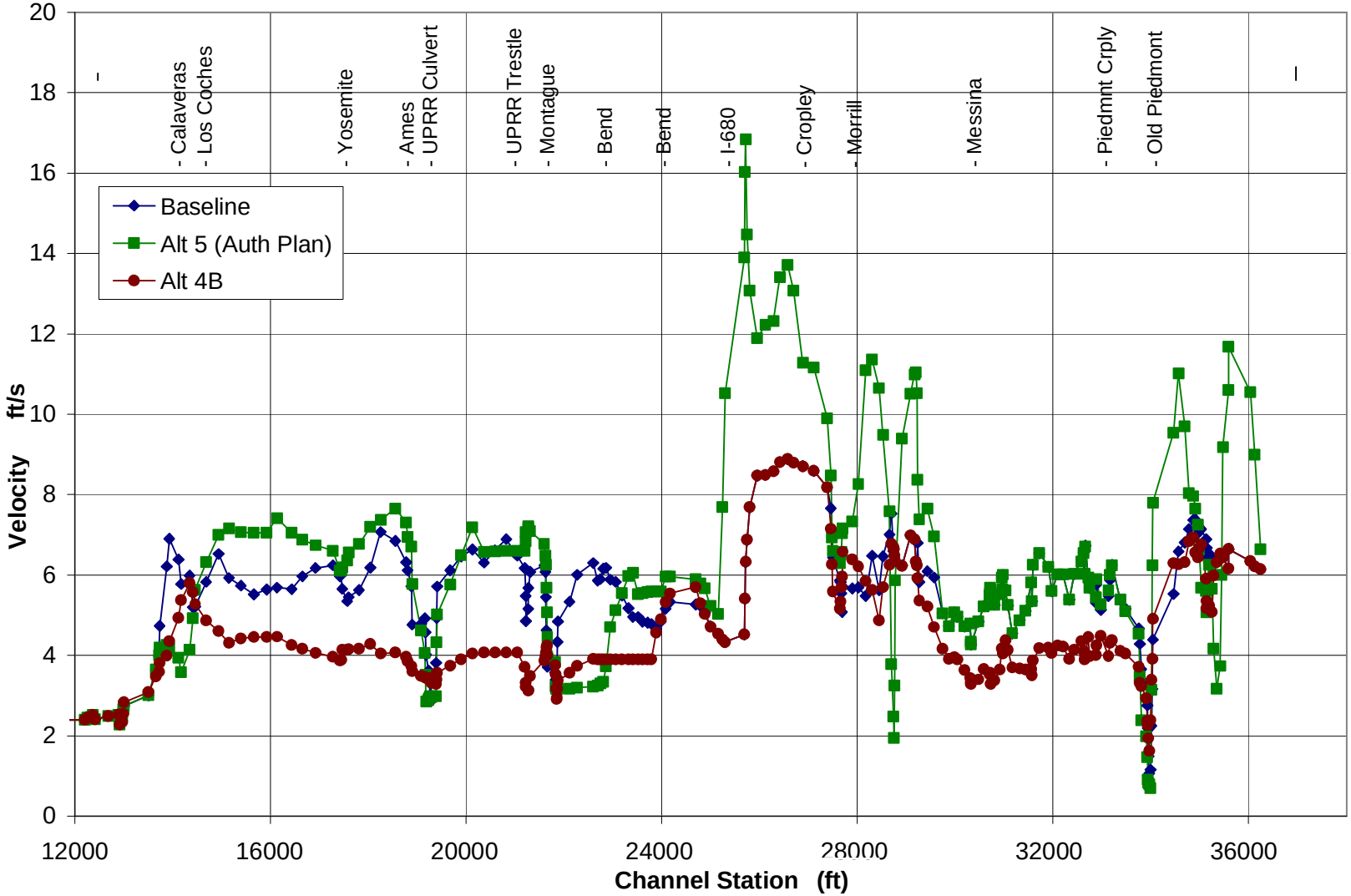

Figure 3-2 (Part 2 of 2) – Main Channel Velocity for Without- and With-Project Conditions, 50% Chance Exceedance Event

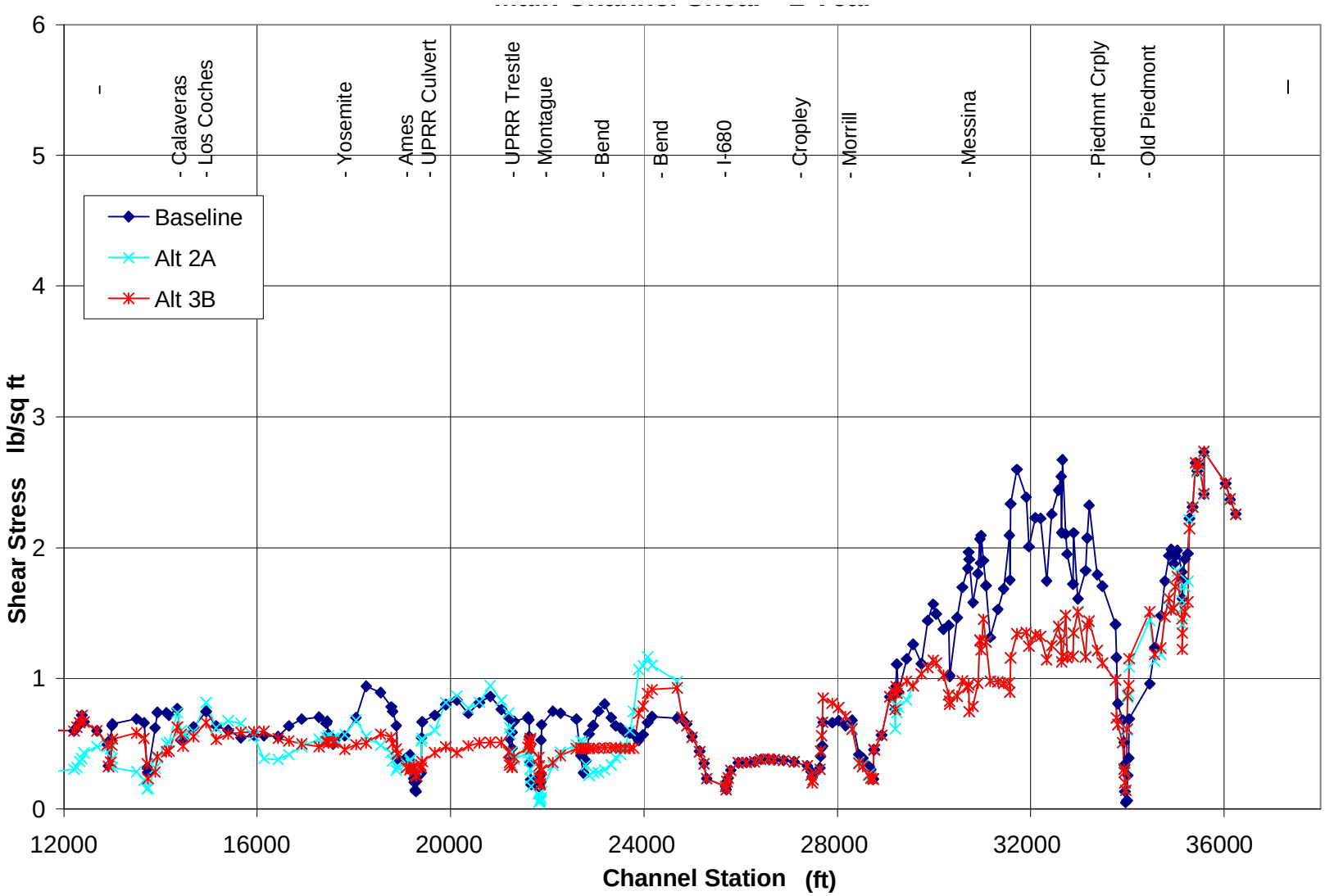

Figure 3-3 (Part 1 of 2) – Main Channel Shear Stress for Without- and With-Project Conditions, 50% Chance Exceedance Event

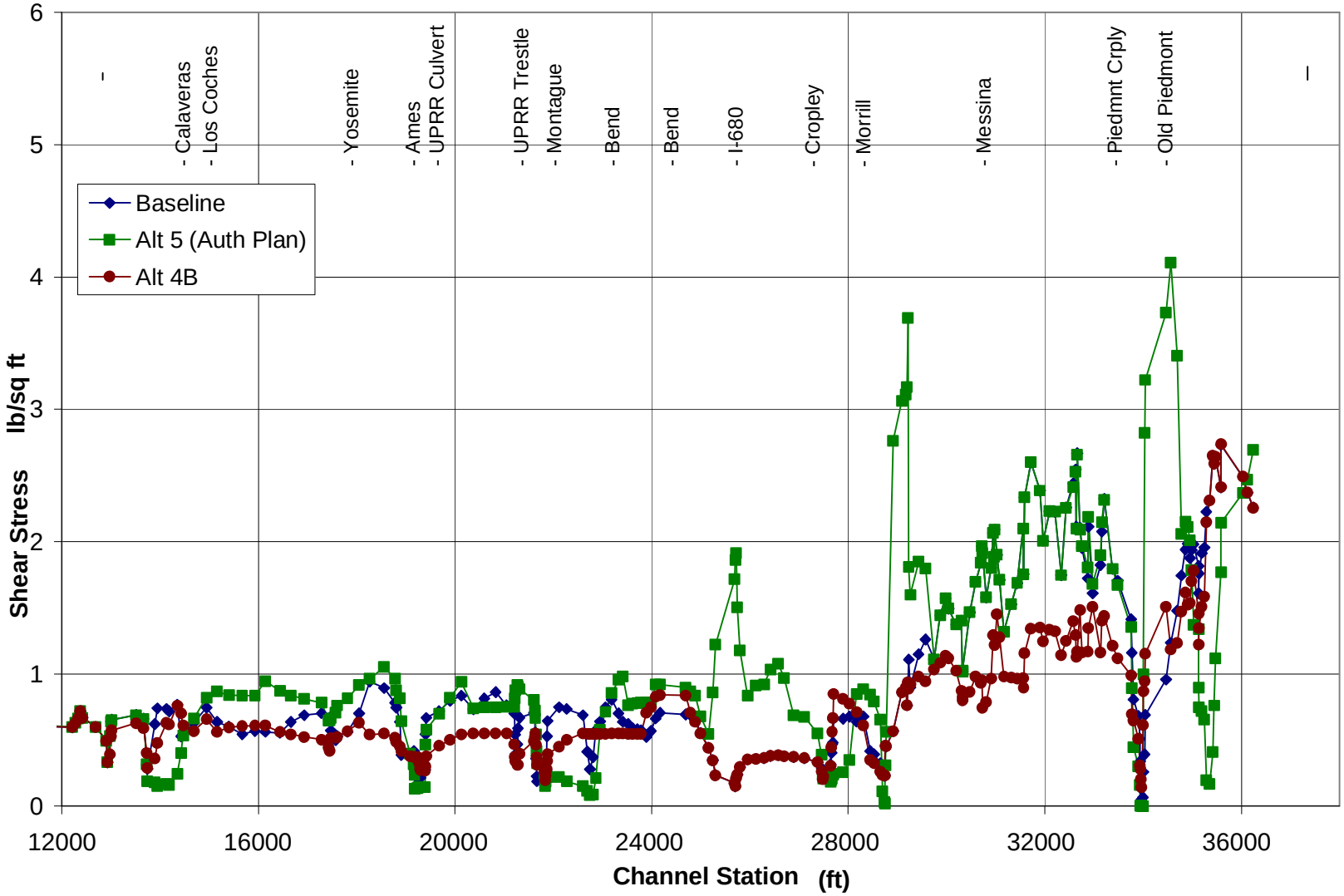

Figure 3-4 (Part 2 of 2) – Main Channel Shear Stress for Without- and With-Project Conditions, 50% Chance Exceedance Event

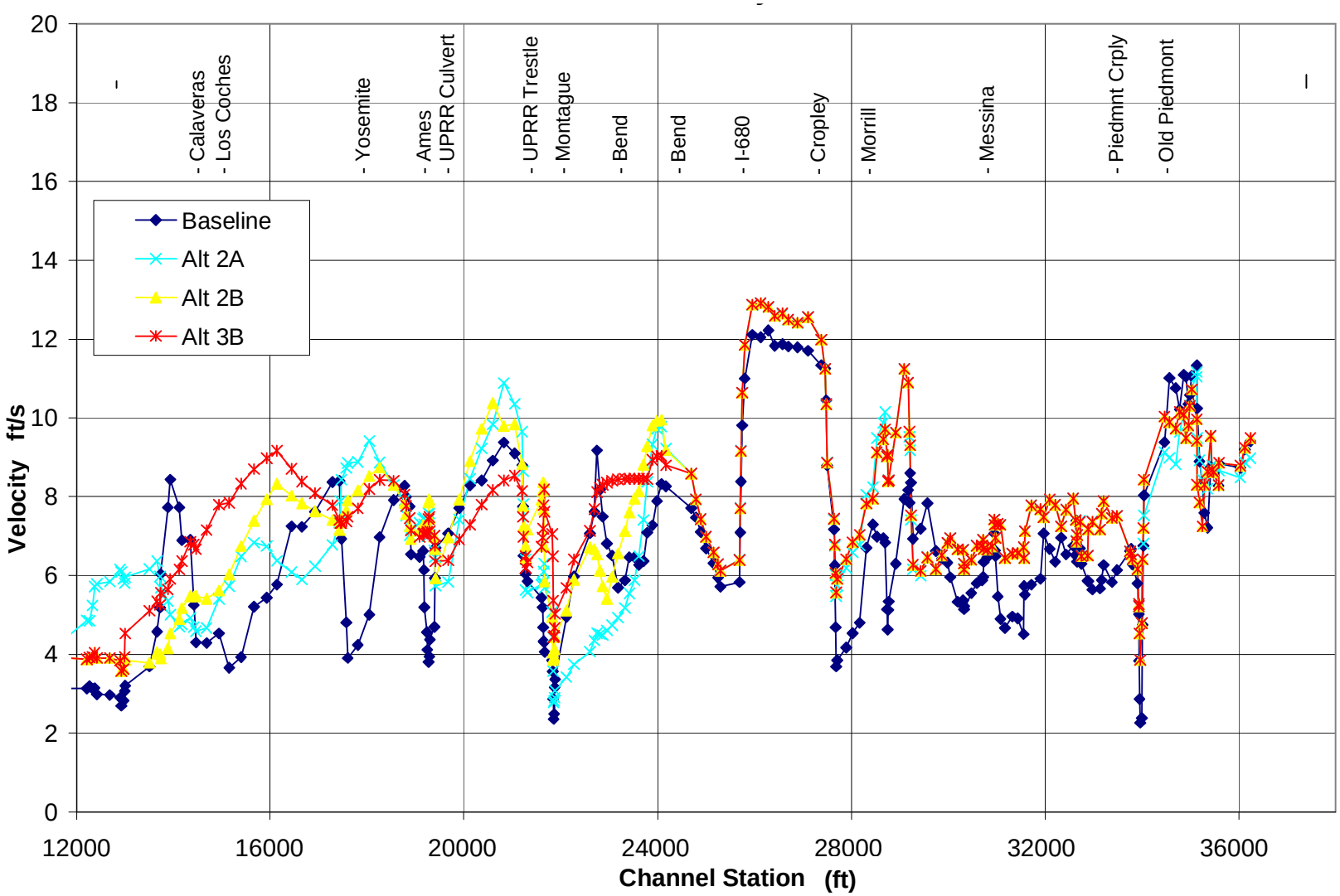

Figure 3-5 (Part 1 of 2) – Main Channel Velocity for Without- and With-Project Conditions, 1% Chance Exceedance Event

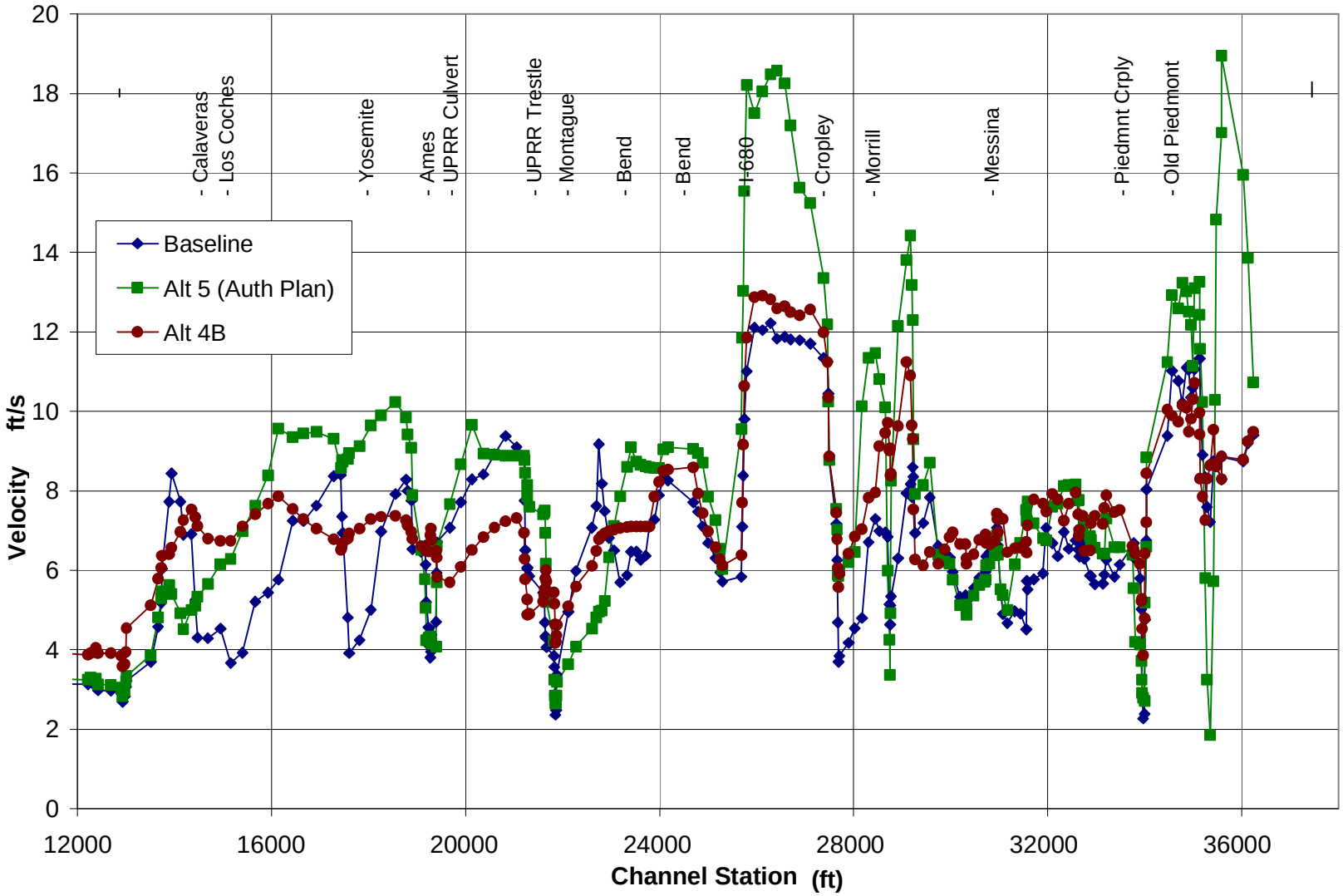

Figure 3-6 (Part 2 of 2) – Main Channel Velocity for Without- and With-Project Conditions, 1% Chance Exceedance Event

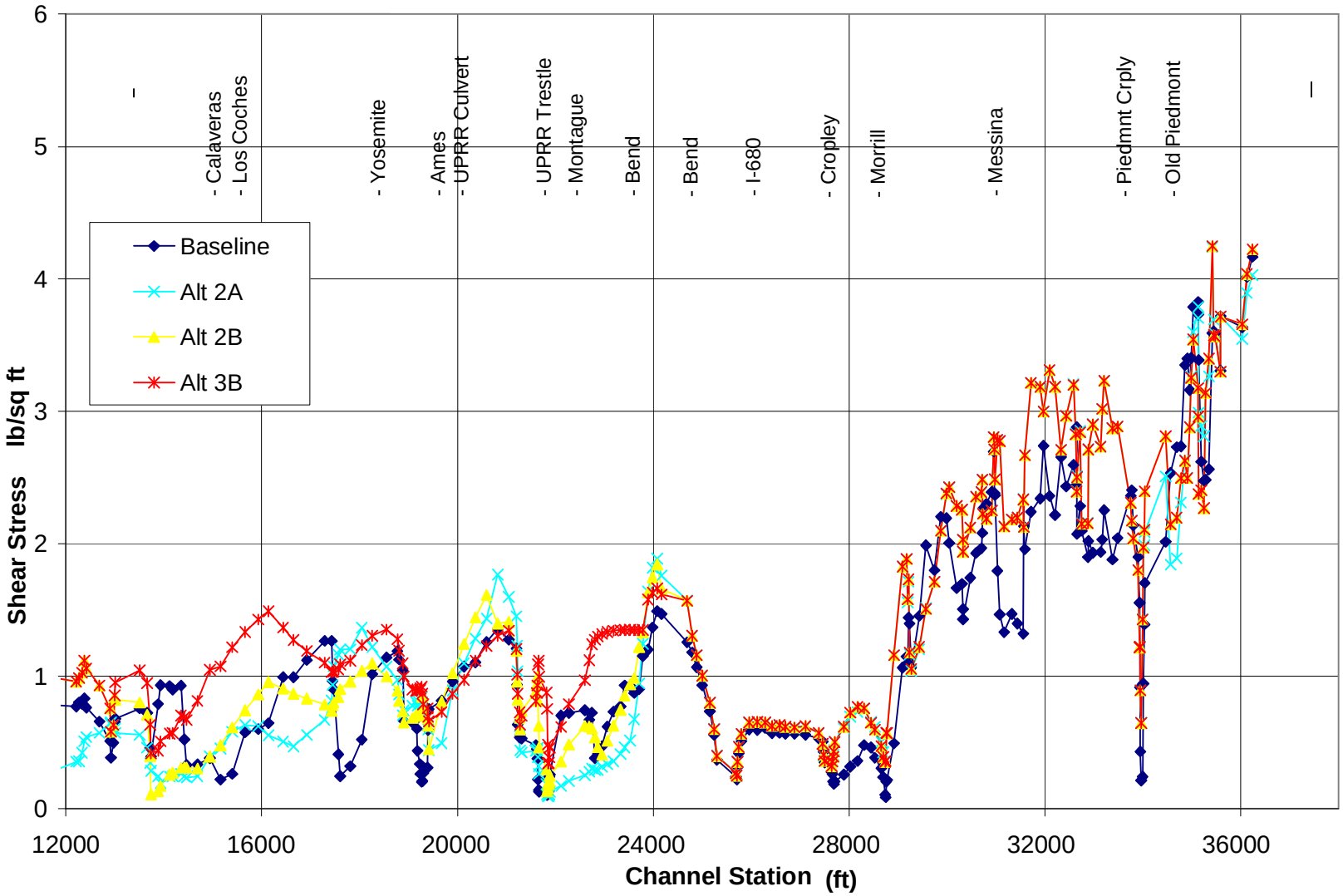

Figure 3-7 (Page 1 of 2) – Main Channel Shear Stress for Without- and With-Project Conditions, 1% Chance Exceedance Event

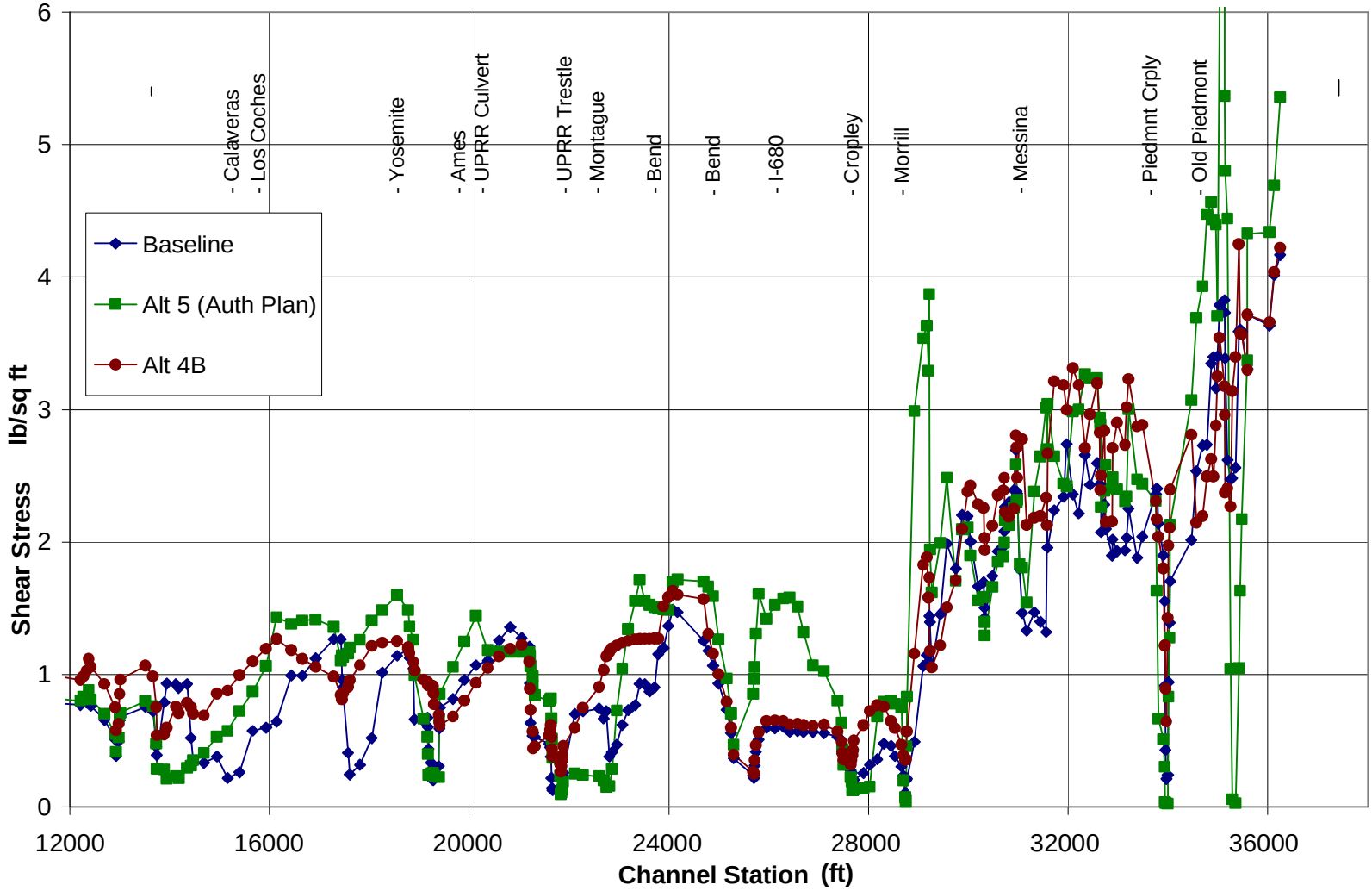

Figure 3-8 (Page 2 of 2) – Main Channel Shear Stress for Without- and With-Project Conditions, 1% Chance Exceedance Event

The values in both sets of plots are for the main channel since this is the portion of the flow that is responsible for nearly all the bed material load transport and it is the bed material load transport that determines the aggradation and degradation characteristics within the project area. Additionally, it is the sand and larger material that has been removed from the channel and sediment basin by past maintenance activities. The larger variation in shear stresses and velocities in the alternatives are related to the in-line detention basins, with backwater conditions behind and weir flow over the crest.

3.2.1.1 Comparison of 50% Chance Exceedance Event

The 50% chance exceedance event was used in the comparison because this event is considered to be approximately the channel forming flow, i.e. most representatives of typical conditions that determine the behavior of the channel over the long term.

<u>Velocity</u>

There is a general trend in reduction of the 50% chance exceedance event velocity for the with-project condition in the Calaveras Boulevard to Montague Expressway reach. Starting from the downstream end of the project, in the reach extending 500 feet upstream of Calaveras Boulevard, the velocities for all alternatives decrease by between 2 and 7 feet per second. The without-project velocity spikes at station 141+21 at 11 feet per second while the with-project velocities range from 3 to 7 feet per second. The largest decrease in this area is with Alternatives 2B and Alternative 5. For the rest of the distance up to Montague Expressway, the velocities for Alternatives 2A, 2B and 3B are similar to without-project condition, except where the velocity spikes (to almost 10 feet per second) downstream on the UPRR culvert; these higher values are eliminated for these with-project alternatives. A high velocity spike of nearly 9 feet per second is introduced in Alternative 2B immediately upstream of the UPRR culvert. The velocities for Alternative 4B are generally lower than the without-project condition in this reach, and the velocities for Alternative 5 are slightly higher than the without-project condition.

Upstream of I-680 to Morrill Avenue, the with-project conditions are extremely similar to the without for all alternatives except Alternative 5. Alternative 5 contains similar velocities to the without-project condition in some of this reach, but varies in particular in the vicinity of bridges due to differing conveyance capacity of the bridges and culverts in this alternative.

Upstream of Morrill Avenue to the upper extent of the Greenbelt area, the velocities of the without-project condition are generally higher than Alternative 2A, 2B, 3B and 4B, oscillating between roughly 3 and 8 feet per second. Many of the spikes are approximately 50 % higher than the values for these Alternatives (8 feet per second compared at 5 to 6 feet per second). Conversely, Alternative 5 has very similar velocities to the without-project condition in this reach, with the exception of two very high velocity spikes of 16 and 17 feet per second at stations 344+67 and 355+86 respectively.

Shear Stress

The comparison of shear stress for the 50% chance exceedance event show similar trends to the velocity comparison described previously. In the vicinity of Calaveras Boulevard, the shear stresses drop by 0.5 to 1 lbs/ft^2 for all with-project Alternatives. In the reach extending from Calaveras Boulevard up to I-680, shear stresses for all Alternatives are on average slightly lower than the without-project condition. Between I-680 and Morrill Avenue shear stresses of Alternatives 2A, 2B, 3B and 4B are identical to the with-project condition, typically 0.5 to 1 lbs/ft^2. From Morrill Avenue to the project upstream limit, shear stresses of the without-project condition oscillate considerably between 1 and 4 lbs/ft^2. Values for Alternatives 2A, 2B, 3B and 4B oscillate, generally between 1 and 2.5 lbs/ft^2. Alternative 5 differs significantly from the other with-project alternatives, due to the presence of in-line detention basins and the differing conveyance capacities of the bridges and culverts.

3.2.1.2 Comparison of 1% Chance Exceedance Event

The 1% chance exceedance event was used in the comparison because it is a large event that is typically utilized to represent the most severe conditions that the project is likely to experience during its design life. Though the 50% chance exceedance event indicates the general behavior of the project over a long period, the response during the 1% chance exceedance event can cause damages that can require significant maintenance or destroy project features.

Velocity

For the 1% chance exceedance event velocity, the velocity changes in the area of Calaveras Boulevard are more significant than for the 50% chance exceedance event. From 1,000 feet downstream to Calaveras Boulevard, they increase by about 1 foot per second for all with-project conditions, Alternative 2A showing a greater increase of up to 3 feet per second. At station 141+21, the without-project velocity spikes to 12 feet per second, whereas the velocities for the with-project alternatives are lower ranging from 5 and 8 feet per second. From upstream of Calaveras Boulevard to I-680, there is no clear trend between the with- and without-project conditions. Though the velocities are not the same, they all vary widely from about 4 feet per second to 12 feet per second, with similar averages through the reach but with significant differences at individual locations. Generally, velocities for the without-project condition spike and fall to a greater degree than for the with-project alternatives. Between the UPRR culvert and Trestle, Alternative 2A has two spikes over 12 feet per second, whereas Alternatives 2B, 3B, 4B and 5 are consistently between 8 to 10 feet per second. The baseline condition varies from 6 to 10 feet per second in this reach.

From Montague Expressway and upstream for 1,000 feet, the velocities drop by several feet per second for all alternatives, with Alternative 2A having the largest drop. The with-project conditions in this segment are the lowest in the entire project area, generally dropping to a maximum of 3 feet per second. Whereas the without-project condition has velocities of 3 to 4 feet per second only in the area of the Montague Expressway bridge, the with-project

conditions velocities remain in the 3 to 4 feet per second range for approximately 1,000 feet upstream. This is not desirable, since the area already experiences sediment deposition.

Further upstream between stations 260+00 and 300+00 the velocities for Alternatives 2A, 2B, 3B and 4B are extremely similar to the without-project condition. In the vicinity of the I-680 crossing, velocities under all project scenarios drop to 5 feet per second, but upstream of this the velocities in all cases increase to 12 to 13 feet per second. Alternative 5 shows much larger velocity spikes, over 20 feet per second, in this reach. Between Old Piedmont Road and I-680 to the upstream project limit, velocities oscillate to a greater degree for all Alternatives and the without-project condition, with values ranging between 5 and 10 feet per second. Again, Alternative 5 is the exception with spikes near to the project upstream limit of over 25 feet per second.

Shear Stress

The comparison of shear stress for the 1% chance exceedance event show similar trends to the velocity comparison. The with- and without-project conditions shear stresses overall for the 1% chance exceedance event indicate a drop of around 1 lbs/ft^2 for the with-project conditions. Overall the drop is least for Alt 3B and most substantial for Alt 2B. Alternative 2A has a high spike in shear stress at two locations between the UPRR culvert and trestle greater than 2 lbs/ft^2. Similar to velocity, there is a significant drop in shear stress in the vicinity and upstream of Montague Expressway. Values drop below 0.2 lbs/ft^2 for all alternatives. Between station 240+00 and 280+00 the shear stresses for all Alternatives except Alternative 5 are identical to the without-project condition. Between Old Piedmont Road and I-680, the with- and without-project shear stresses oscillate considerably between 1 and 6 lbs/ft^2. This is true mostly for Alternative 5, except for two large spikes of 11 and 17 lbs/ft^2.

3.2.2 Final Array of Alternatives

As described in Section 2.2 and Chapter 5 of *Part I: Hydraulic Analysis of Alternatives* of this engineering appendix, unsteady HEC-RAS models were developed as part of this study to model the without-project and final array of project alternatives. To assess potential changes in sediment transport conditions within the project area, velocity and shear stress values from the revised GRR methodology (see Section 2.2 of *Part I: Hydraulic Analysis of Alternatives* of this engineering appendix) HEC-RAS models were compared from reach to reach along the channel. During the analysis of the preliminary array of alternatives it was found that the portion of the project between Old Piedmont Road and I-680 was not justified and those portions of the project were removed from the final alternatives. Therefore, the following figures show only the downstream of I-680 results. The trends apparent in the plots were reviewed for without-project and with-project alternatives. The velocity plots are presented along the project station line in Figure 3-9 and Figure 3-11 for the 50% and 1% chance exceedance events, respectively. Similar plots are provided in Figure 3-10 and Figure 3-12 for shear stress. Results have been smoothed with running average values over two cross sections upstream and downstream of each station. Sections 2.2.2 and 5.4 of *Part I: Hydraulic Analysis of Alternatives* of this engineering appendix contains more comprehensive results for the revised GRR methodology without-project and final array of alternatives.

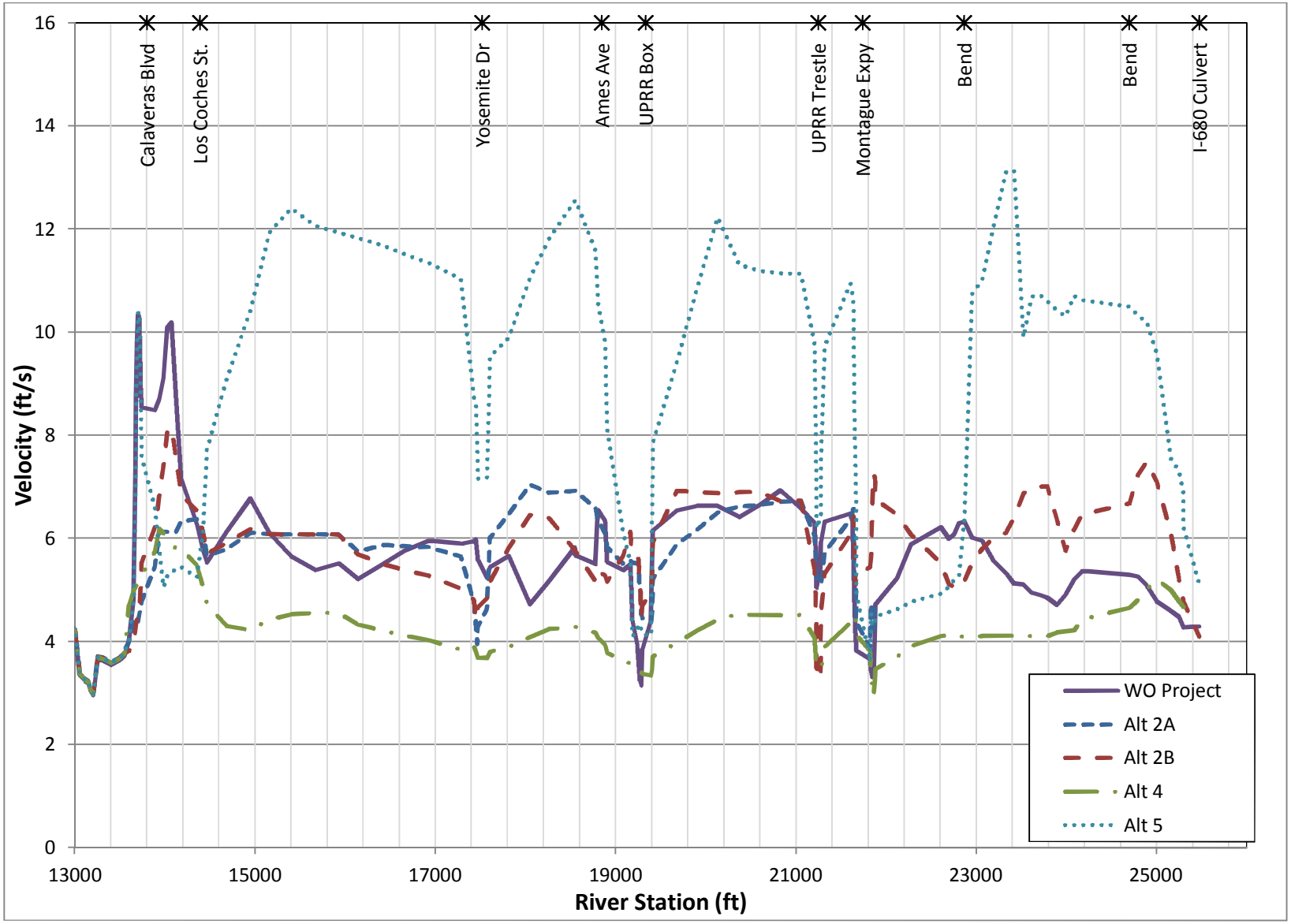

Figure 3-9 Main Channel Velocity Comparison of Without- and With-Project Conditions, 50% chance exceedance Event

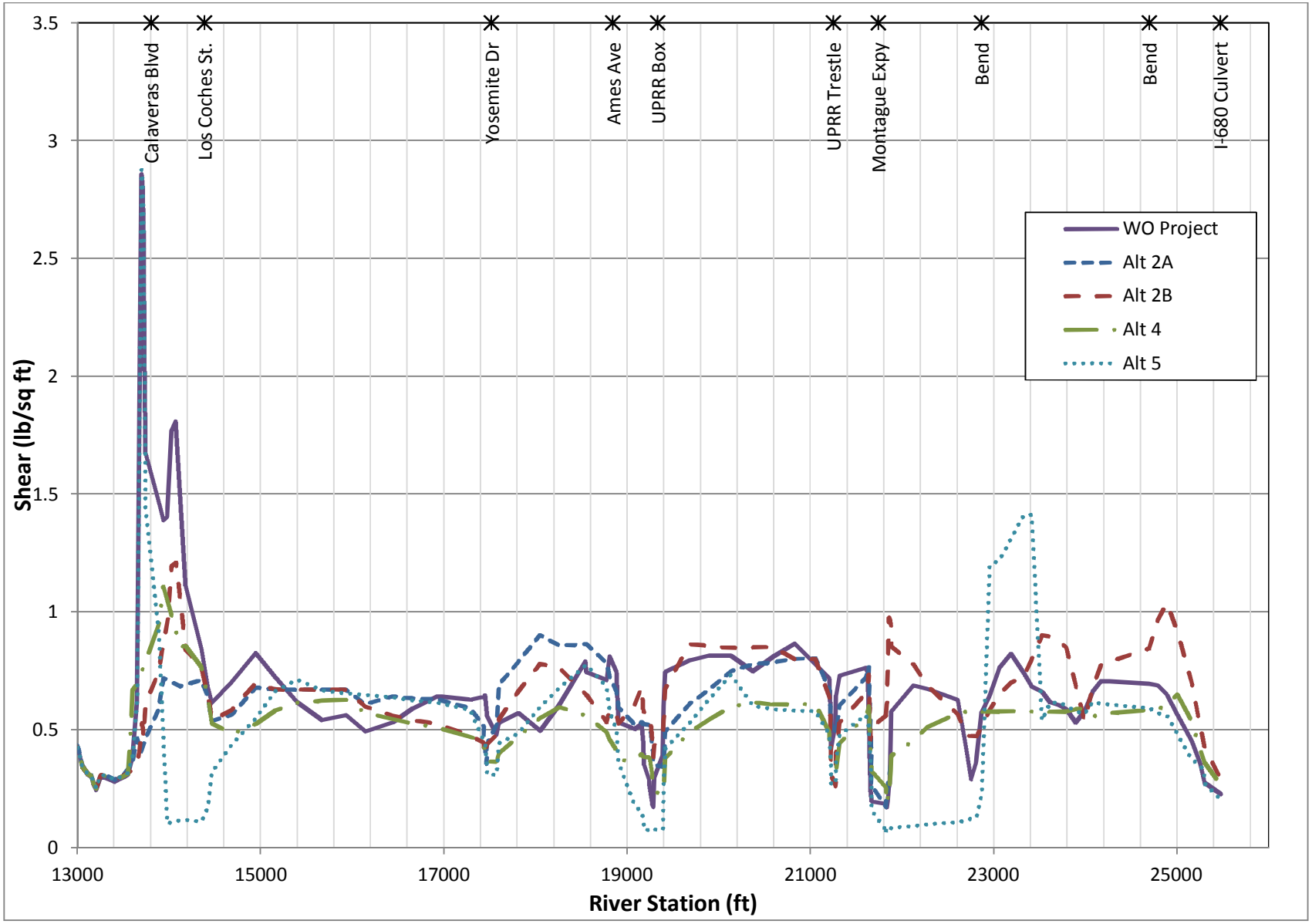

Figure 3-10 Main Channel Shear Stress Comparison of Without- and With-Project Conditions, 50% chance exceedance Event

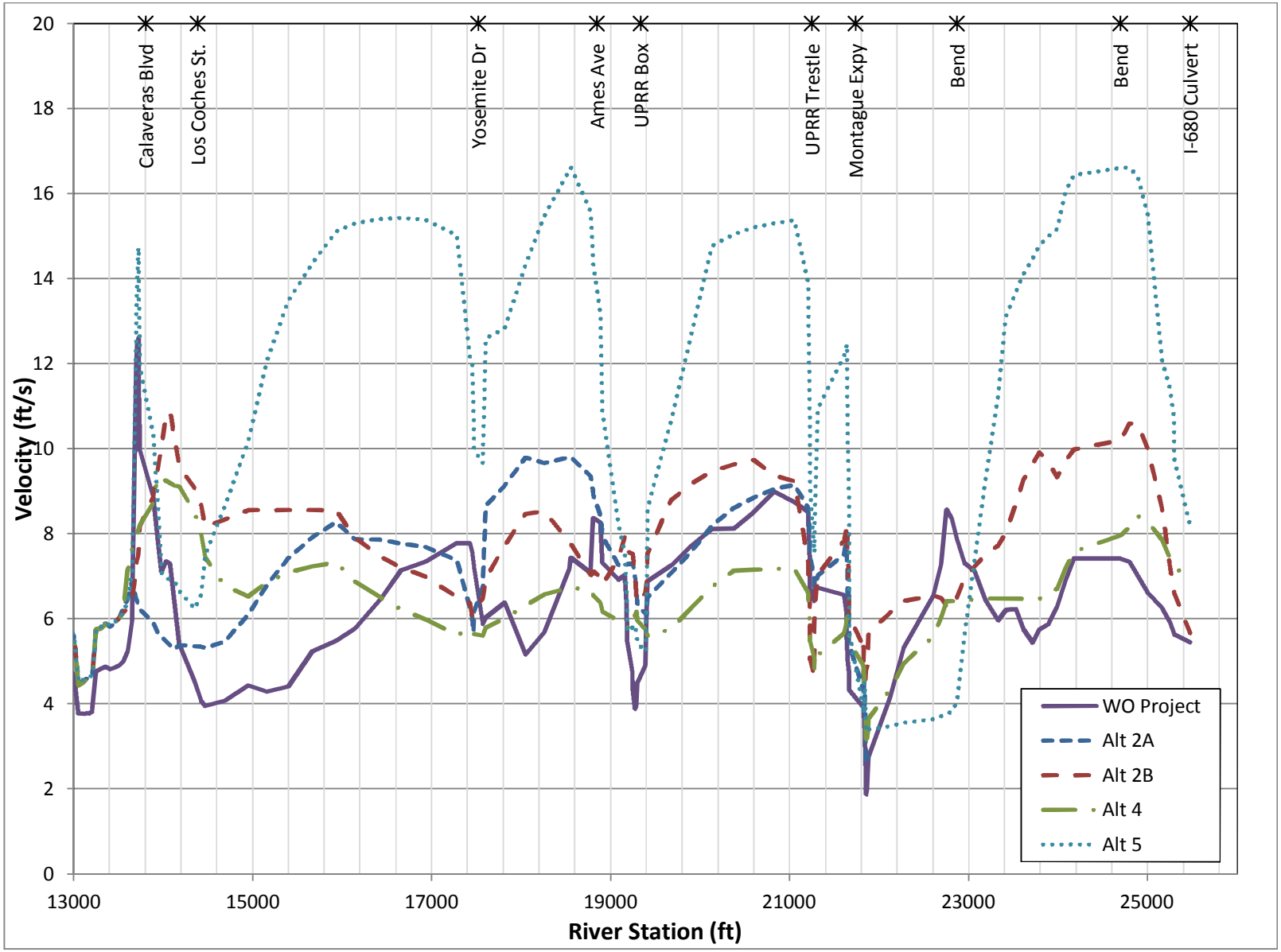

Figure 3-11 Main Channel Velocity Comparison of Without- and With-Project Conditions, 1% chance exceedance Event

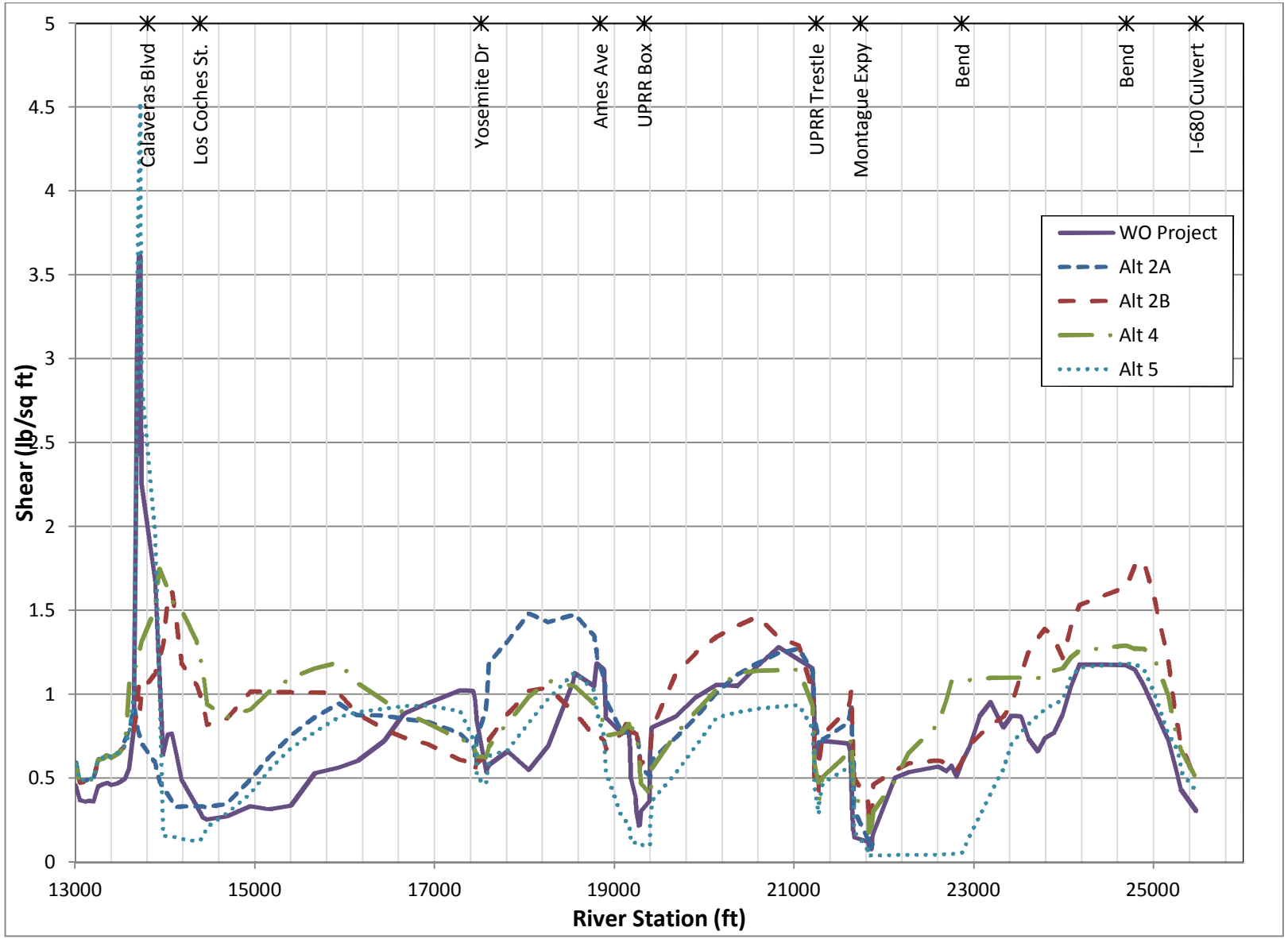

Figure 3-12 Main Channel Shear Stress Comparison of Without- and With-Project Conditions, 1% chance exceedance Event

The values in both sets of plots are for the main channel since this is the portion of the flow that is responsible for nearly all the bed material load transport and it is the bed material load transport that determines the aggradation and degradation characteristics within the Greenbelt and the project area. Additionally, it is the sand and larger material that has been removed from the channel and sediment basin by past maintenance activities.

3.2.2.1 Comparison of 50% Chance Exceedance Event

The 50% chance exceedance event was used in the comparison because this event is considered to be approximately the channel forming flow, i.e., the most representative of typical conditions that determine the behavior of the channel over the long-term.

The general trend in velocity is for Alternatives 2A/d and 2A/b is to approximately follow the without-project velocities with minor reductions in velocities upstream of Montague. Alterative 4/d shows a general reduction of the 50% chance exceedance velocity for the with-project condition relative to the without-project. The decrease is generally on the order of 0.5 up to 2.0 feet per second. In some isolated areas for Alternative 2A/d, 2B/d, and 4/d, particularly where the modification of bridges removed backwater effects, velocities show an increase. Alternative 5 shows a large increase in velocity over the without-project based on the concrete lined channel proposed. The highest running average velocity exhibited under with-project conditions is approximately 7.5 feet per second in Alternative 2B/d.

A comparison of shear stresses for the 50% chance exceedance event shows similar trends to the velocity, with shear stresses for Alternatives 2A/d, 2B/d, and 4/d on average equal to or slightly lower than the without-project condition. In a few areas, specifically above Montague Blvd and downstream of Yosemite Ave., the alternative shear stress is higher than the without project conditions. Shear stress for Alternative 5 is generally lower than the without-project conditions with the exception of two locations, one upstream of Montague Blvd. and one downstream of Yosemite Ave., that are higher than the without project condition.

3.2.2.2 Comparison of 1% Chance Exceedance Event

The 1% chance exceedance event was used in the comparison because it is a large event that is typically utilized to represent the most severe conditions that the project is likely to experience during its design life. Though the 50% chance exceedance event indicates the general behavior of the project over a long period, the response during the 1% chance exceedance event can cause damages that can require significant maintenance or destroy project features. Under existing conditions, the 1% chance exceedance discharge breaks out of the channel in several locations. The with-project alternatives contain a larger discharge and result in velocity and shear stress increases downstream of breakout locations. The increases in velocity are most pronounced in the reaches where the right-of-way is constrained. The maximum running average velocities exhibited under with-project conditions are approximately 16.5 feet per second in Alternative 5.

A comparison of shear stresses for the 1% chance exceedance event shows similar trends to the velocity comparison. The maximum running average shear stress under with-project conditions is approximately 1.8 lbs/sq ft for both Alternatives 2B/d and 4/d.

3.3 Quantitative Sediment Transport Analysis of the Final Array of Alternatives

A quantitative sediment transport analysis was conducted for the final array of alternatives. The purpose of the analysis was to develop an estimate of the potential O&M sediment removal quantities for the Final Array of Alternatives assuming existing conditions between Old Piedmont Road and I-680. In addition, an analysis was conducted assuming the SCVWD Bypass Alternative was in place between Old Piedmont Road and I-680 for Alternatives 2B/d and 4/d.

3.3.1 Methodology

This section presents the methodology used to conduct the sediment transport analysis. Due to differing levels of information being available between Old Piedmont Road and I-680 for the existing conditions and SCVWD Bypass alternatives, different methodologies were used for each analysis.

3.3.1.1 Existing Conditions between Old Piedmont Road and I-680 Methodology

A spreadsheet analysis of the sediment transport capacity through the study area was conducted to determine the potential O&M requirements for the final array of alternatives. The study area was divided into four reaches based on the reaches used to report sediment removal maintenance provided by SCVWD (as discussed in Section 3.1.4). Additionally, *Upstream of the Piedmont-Cropley Culvert* and the *Greenbelt between the Piedmont-Cropley Culvert and Morrill Avenue* were added as supply reaches, since these reaches are a source of sediment supply to the downstream reaches. The transport reaches used are listed in Table 3-1.

Table 3-1 Analysis Reaches

Reach	Reach Type
Upstream of the Piedmont-Cropley Culvert	Supply
Greenbelt between Piedmont-Cropley Culvert and Morrill Ave	Supply
Morrill Ave to I-680	Transport
I-680 to Montague Expressway	Transport
Montague Express to Calaveras Blvd	Transport
Downstream of Calaveras Blvd	Transport

The Yang sediment transport equation was used to estimate the sediment transport through each reach. The Yang sediment transport equation was chosen based on the research conducted by Brett Jordan on Berryessa Creek for his dissertation in 2009 (Jordan, 2009). Jordan concluded that the Yang equation best represented Berryessa Creek based on an analysis of potential sediment transport equations. The Yang equation has two variations based on whether the transport of sand and gravel is being estimated. The Yang equation estimates the sediment transport rate based on a representative diameter and reach-averaged hydraulics.

Sediment gradation curves were obtained from sediment sampling conducted for the Northwest Hydraulic Consultants' *Upper Berryessa Creek Existing Conditions Sediment Transport Assessment* (NHC, 2003). A number of samples were collected along each reach during different times of the year. For the purposes of this analysis samples taken during the winter season were used since the high flows in Berryessa Creek occur primarily during the winter rainy season. For the purpose of this analysis, the sediment gradation curves were divided into ten sediment size classes with a representative diameter assigned to each. The size fraction of each sediment size class was determined for each reach. Table 3-2 lists the minimum, maximum, and representative diameters for each of the sediment sizes classes used. Table 3-3 lists the fraction of the total for each sediment size class for each reach.

Table 3-2 Sediment Size Classes

Grain Size Interval	Min Diameter	Max Diameter	Representative Diameter
Fine/Very Fine Sand	0	0.25	0.125
Medium Sand	0.25	0.5	0.35
Course Sand	0.5	1	0.71
Very Coarse Sand	1	2	1.4
Very Fine Gravel	2	4	2.8
Fine Gravel	4	8	5.7
Medium Gravel	8	16	11.3
Course Gravel	16	32	22.6
Very Course Gravel	32	64	45.8
Small Cobble	64	128	91.6
Total			

Table 3-3 Sediment Class Size Distribution by Reach

Grain Size Interval	Sediment Class Size Distribution					
	Upstream of the Piedmont-Cropley Culvert	**Greenbelt from Piedmont-Cropley Culvert to Morrill Ave**	**Morrill Ave to I-680**	**I-680 to Montague Expressway**	**Montague Express to Calaveras Blvd**	**Downstream of Calaveras Blvd**
Fine/Very Fine Sand	6%	5%	6%	4%	3%	4%
Medium Sand	6%	6%	7%	7%	6%	10%
Course Sand	4%	5%	6%	7%	6%	10%
Very Coarse Sand	7%	7%	9%	14%	14%	13%
Very Fine Gravel	7%	12%	13%	18%	16%	15%
Fine Gravel	10%	17%	17%	16%	20%	18%
Medium Gravel	12%	20%	17%	19%	22%	18%
Course Gravel	21%	18%	16%	11%	11%	9%
Very Course Gravel	8%	6%	7%	4%	2%	3%
Small Cobble	19%	4%	2%	0%	0%	0%
Total	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

The average hydraulics for the 50% to 0.2% chance exceedance events were developed for each reach using the results of the FLO-2D and HEC-RAS modeling discussed in *Part I: Hydraulic Analysis of Alternatives* and *Part II: Floodplain Development of Alternatives*. Since the bulk of the average annual sediment transport is conveyed proportionally by smaller, more frequent events, a 67% chance exceedance event was developed. The 67% chance exceedance event was developed by plotting the inflows to the FLO-2D and HEC-RAS models and estimating the 67% chance exceedance event inflows. The ratio of the 67% to the 50% chance exceedance inflows was then computed and applied to the FLO-2D and HEC-RAS 50% chance exceedance inflows used to develop the hydraulics for the 67% chance exceedance event.

The reach-averaged hydraulics were used in conjunction with the sediment size class data to calculate the sediment transport for each sediment size class for each event. The total sediment transport rates for each event were developed by combining the calculated transport rates for each sediment class size based on based on the fraction of the total sediment gradation each class represented. Finally, the sediment transport rates for each event were probability-weighted to develop the average annual sediment transport rate for each reach.

The potential deposition in each reach was determined by subtracting the sediment transport through the reach from the transport rate of the reach upstream. A positive result indicated a reduction in the sediment transport capacity through the reach resulting in deposition. A negative result indicated an increase in sediment transport capacity through the reach resulting in pass-through conditions and potential erosion in unarmored section of channel.

Deposition in the sediment basin below the Piedmont-Cropley culvert was developed assuming that 100% of the gravels from the upstream reach were captured in the sediment basin. The amount of sand captured in the sediment basin was calculated based on the assumption that captured sediment matrix was composed of 75% gravel and 25% sand, with the sand filling voids in the gravel.

The initial without-project alternative results were compared to the average annual sediment removal based on maintenance records (see Section 3.1.4) to determine how well the spreadsheet analysis reflected observed deposition trends. As seen in Table 3-4, the initial results did not reflect the observed trend well. To better model the observed deposition calibration coefficients were applied to the sediment transport equations for each of the reaches to better match the observed deposition trends. As seen in Table 3-4 the application of calibration coefficients ranging from 0.98 to 5.31 produced results that matched the observed deposition. The remaining alternatives were analyzed by using the calibrated spreadsheet model and the alternative hydraulics.

Table 3-4 Model Calibration Results

Reach	Average Annual Sediment Deposition (cy)			Calibration Coefficient
	SCVWD Maintenance Records	Initial Results	Calibrated Results	
Upstream Old Piedmont to Piedmont-Cropley Sediment Basin[1]	537	2281	537	0.2355
Piedmont-Cropley Culvert to Morrill Ave (Greenbelt)	0	0	0	2.38
Morrill Ave to I-680	510	-1417	510	0.999
I-680 to Montague Expressway	418	2230	418	4.113
Montague Express to Calaveras Blvd	199	12	199	3.85
Downstream of Calaveras Blvd	5521	557	2180	1

[1]The average annual sediment deposition for this reach is based on the sediment captured in the sediment basin only with no deposition in the reach upstream of the sediment basin.

It should be noted that this methodology was developed based on the limited available hydraulic information. The use of average hydraulics and peaks flows to determine sediment concentrations through reaches represent one point on the sediment rating curve. This approach tends to overestimate the total sediment transport when applied to the entire flow volume from the storm event. A much more intensive modeling approach, beyond the scope of this study, would be required to truly develop the transport based on the sediment transport over the entire range of a storm event. Calibrating the equations to observed deposition trends largely accounts for this effect, thought the results will still be conservative. Therefore,

the methodology presented above satisfies the intent to estimate the change in the sediment deposition through the study area.

3.3.1.2 SCVWD Bypass Alternative between Old Piedmont Road and I-680 Methodology

The local sponsor (SCVWD) has proposed a future project between Old Piedmont Road and I-680 consisting of a bypass culvert diverting most of the flood flows around the Greenbelt reach to help alleviate flooding in the Greenbelt reach. The proposed bypass would divert most of the flood flow from Berryessa Creek just upstream of the Piedmont-Cropley culvert, convey the flow down a culvert under Cropley Avenue, and finally discharge the flow at a point near the Cropley Avenue Bridge. The SCVWD bypass alternative is discussed in more detail in Section 5.2.3 in *Part I: Hydraulic Analysis of Alternatives*. The impacts to the sediment maintenance requirements for alternatives 2B/d and Alt 4d were analyzed.

To evaluate the impacts of the SCVWD bypass, the *existing conditions between Old Piedmont Road and I-680* spreadsheet model required modification as detailed hydraulics were not available for the SCVWD bypass alternative. The bypass alters the potential amount of sediment supply from the Greenbelt as well as transporting sediment through the bypass culvert. The transport through the Greenbelt was approximated using the bypass diversion rating curve, the Berryessa Creek flows at the downstream of the Greenbelt, and the existing conditions between Old Piedmont Road and I-680 sediment rating curve for the Greenbelt reach. First the Berryessa Creek peak flows for the *existing conditions between Old Piedmont Road and I-680* at the downstream end of the Greenbelt were determined from the without-project HEC-HMS hydrologic modeling. Then the Berryessa Creek peak flow for the *SCVWD bypass alternatives between Old Piedmont Road and I-680* was developed using the SCVWD bypass HEC-HMS model. A sediment rating curve for the Greenbelt reach was developed using the *existing conditions between Old Piedmont Road and I-680* flows and the calculated sediment transport for each flow event. The sediment rating curve was then used to approximate the sediment transport rate through the greenbelt supply reach based on the Berryessa Creek *with SCVWD bypass alternatives between Old Piedmont Road and I-680* flows at the downstream end of the Greenbelt. .

In addition to altering the sediment transport rate in the greenbelt reach, the SCVWD bypass would also alter the deposition in the sediment basin below the Piedmont-Cropley culvert. To determine the deposition in the sediment basin, the sediment transport through the Piedmont-Cropley culvert was determined for the gravel fraction. A sediment rating curve based on the flow at the culvert for the existing conditions was developed for gravels. The flow through the culvert with the SCVWD bypass in place was then used to approximate the gravel transport through the culvert with the bypass. As for the *existing conditions between Old Piedmont Road and I-680* methodology, it was assumed that 100% of the gravel transported through the culvert would be captured in the basin and that the captured sediment matrix would consist of 75% gravel and 25% sands. Since the invert of the bypass culvert is one foot above the invert of the Piedmont–Cropley culvert, the gravel bed load is prevented from being conveyed through the bypass culvert. Therefore, the remaining portion of the gravel supply from upstream of the bypass will deposit in the reach. Since no detailed hydraulic results were available for the SCVWD bypass alternative, the location of deposition of this material cannot be determined. The remainder of the sand supply was assumed to be

conveyed through the bypass culvert and was added to the sediment supply estimate calculate for the Greenbelt reach.

The deposition estimates for the remaining reaches was then developed using the same procedures as the existing conditions *between Old Piedmont Road and* I-680 methodology. The average hydraulics for the study reaches were developed with the HEC-RAS models run with inflows reflecting the SCVWD bypass in place between Old Piedmont Road and I-680.

3.3.2 Results

The quantitative sediment analysis was conducted for the without-project, alternative 2A/d, 2B/d, and 4/d using hydraulic models developed for previous phases of this study for existing conditions between Old Piedmont Road and I-680. In addition, analyses were conducted for alternatives 2B/d and 4/d assuming the proposed SCVWD bypass alternative was in place between Old Piedmont Road and I-680. The potential deposition for each alternative was developed for each reach.

Table 3-5 lists the estimated average annual sediment transport rates and deposition for the without-project, Alternative 2A/d, 2B/d, and 4/d models using existing conditions between Old Piedmont Road and I-680. As seen in the table, for Alternatives 2A/d and 2B/d there is an increase in sediment transport through the I-680 to Montague and Montague to Calaveras. The increased transport results in a decrease in deposition in the I-680 to Montague reach for alternatives. With a larger amount of sediment being transported through the upstream reach, there in an increase in the amount of deposition in the Montague to Calaveras Boulevard reach for all alternatives over the without-project alternative. Overall, the total amount of sediment deposited in study area for Alternatives 2A/d and 2B/d is nearly equal to that under without-project conditions. For Alternative 4/d there is a marked increase in deposition in the study.

Table 3-5 Average Annual Sediment Transport and Deposition using Existing Conditions between Old Piedmont Road and I-680

Alternative	Reach						
	US of Old Piedmont Rd to Piedmont Cropley Culvert	Piedmont Cropley Sediment Basin	Piedmont-Cropley Culvert to Morrill Ave (Greenbelt)	Morrill Ave to I-680	I-680 to Montague Expressway	Montague Expressway to Calaveras Blvd	DS of Calaveras Blvd
Average Annual Sediment Transport Rate (cy)							
Without-Project	537	0	3318	2809	2391	2192	12
Alt 2A/d	537	0	3318	2809	3166	2161	10
Alt 2B/d	537	0	3318	2809	3836	2202	9
Alt 4/d	537	0	3318	2809	2208	1501	14
Average Annual Deposition (cy)							
Without-Project[1]	-na-	537	-na-	509	418	199	2180
Alt 2A/d	-na-	537	-na-	509	0	648	2151
Alt 2B/d	-na-	537	-na-	509	0	607	2192
Alt 4/d	-na-	537	-na-	509	601	707	1487

-na- not applicable as no deposition was modeled in these reaches since they act as supply reaches to the reaches below them and no deposition was reported in the SCVWD maintenance records.
[1]The without-project deposition values were calibrated to SCVWD sediment removal maintenance records.

Table 3-6 lists the average annual sediment transport rates and deposition results for Alternatives 2B/d and 4/d with the SCVWD Bypass between Old Piedmont Road and I-680. The without-project for existing conditions between Old Piedmont Road and I-680 alternative was included in the table for comparison purposes. As seen in the table there is a significant reduction in the deposition in the sediment basin below the Piedmont-Cropley culvert over existing conditions. This is due to a majority of flood flows being transported through the bypass culvert. The reduction in the flood flows to the Greenbelt reach results in a significant reduction in the sediment supply to the downstream reach. The sediment supply conveyed through the bypass culvert adds to the supply to the downstream reach, but accounts for only a small portion of the reduced Greenbelt sediment supply. As seen in the table, the sediment transport rate for the Morrill to I-680 reach is greater than the combined sediment supply for the Greenbelt and Bypass culvert. Since the sediment transport capacity through the reach is greater than the incoming supply, no deposition is seen in the reach. For both alternatives there is an increase in sediment transport through the I-680 to Montague and Montague to Calaveras reaches over the without-project alternative. The increased transport results in no deposition in the I-680 to Montague reach. Normally, a larger amount of sediment being transported through the upstream reach would result in an increase in the amount of deposition in the Montague to Calaveras Boulevard reach. But since the supply from the Greenbelt reach is limited, the transport capacity of Alternative 2B/d can transport the entire supply to the downstream reach with no deposition and Alternative 4/d showing a small amount of deposition.

Table 3-6 Average Annual Sediment Transport and Deposition for the SCVED Bypass between Old Piedmont Road and I-680

Alternative	Reach								
	US of Old Piedmont Rd to Piedmont Cropley Culvert	**Piedmont Cropley Sediment Basin**	**Bypass Culvert**	**Piedmont-Cropley Culvert to Morrill Ave (Greenbelt)**	**Total Sediment Supply entering the Morrill Ave to I-680 Reach[1]**	**Morrill Ave to I-680**	**I-680 to Montague Expressway**	**Montague Expressway to Calaveras Blvd**	**DS of Calaveras Blvd**
Average Annual Sediment Transport Rate (cy)									
Without-Project for existing conditions between Old Piedmont Road and I-680[2]	537	0	-	2219	2219	1709	1292	1092	38
Alt 2B/d with Bypass	537	0	88	1631	1718	2809	3774	2263	9
Alt 4/d with Bypass	537	0	88	1631	1718	2809	2283	1630	16
Average Annual Deposition (cy)									
Without-Project for existing conditions between Old Piedmont Road and I-680[2]	-na-	537	-	-na-	-na-	509	417	200	1057
Alt 2B/d with Bypass	-na-	450	-na-	-na-	-na-	0[3]	0[3]	0[3]	1709
Alt 4/d with Bypass	-na-	450	-na-	-na-	-na-	0[3]	0[3]	89	1702

1. The sediment supply to Morrill Avenue to I-680 reach is a combination of the transport from the Bypass Culvert and the Greenbelt reaches.
2. The without-project for existing conditions between Old Piedmont Road and I-680 alternative is included for comparison purposes.
3. Since the total supply from the Greenbelt to the reach is less than the transport through the reach zero deposition was recorded and potential erosion was not considered in this analysis.

-na- not applicable: no deposition was modeled in these reaches since they act as supply reaches to the reaches below them and no deposition was reported in the SCVWD maintenance records.

3.4 Conclusions

Several significant conclusions can be drawn from the comparisons of velocities and shear stress between the with- and without-project conditions in reference to the influence of the current alternatives on sediment transport conditions.

Throughout the project area, there are large variations in velocities and shear stresses that can cause localized sedimentation and scour problems. The project design needs to be further refined to reduce the level of these changes. Additionally, the measures used to provide passage of the design event through bridges should be reviewed. In cases in which walls were extended above the bridge deck to contain flows, there may be the creation of significant backwater conditions. The reduced velocity and shear stress may cause an additional potential for additional, localized deposition in an area that in some cases already experiences deposition.

Currently, the project area is a deposition zone and a reduction in velocity will further increase deposition and the need for maintenance. Constructed features should facilitate removal of deposited sediments.

Five sediment basin configurations have been previously evaluated upstream of the project area in order to reduce the downstream maintenance needs. The basin configurations are shown in Table 3-7. The schematic locations are shown in plan view and profile view in Figure 3-13 and Figure 3-14, respectively.

Table 3-7 Summary of Sediment Basin Location Alternatives

Alternative	Name	Description
A	F4A	F4A design concept. Existing basin bed lowered approximately 5 feet with 700-foot length excavated channel at basin outlet.
B	Reduced F4A	F4A design concept with reduced basin lowering (approximately 2.5 feet) and excavated channel length (approximately 350 feet).
C	Downstream Adjacent	Channelization of Berryessa Creek through the existing basin, with construction of a new basin located near the existing basin outlet.
D	Morrill	Channelization of Berryessa Creek through the existing basin, with construction of a new basin downstream of the Greenbelt Reach near Morrill Avenue.
E[1]	Authorized	Construction of a new sediment basin upstream of Old Piedmont Road and modification of existing basin with plunge pool, outlet weir, and 3-foot diameter culvert drain.

Notes: 1. Alternative E is the Proposed Sediment Basin per the 1993 GDM Authorized Project Design. (USACE 1993).

An evaluation of the advantages and disadvantages of each configuration concluded that a combination of the above alternatives would best balance maintenance needs against environmental impacts and hydraulic conveyance capacity. These alternatives are currently under consideration by others, and the design of features within the project reach should be coordinated with the design process of the upstream sediment basin in order to ensure consistent approaches. Recommendations and further details on the sediment basin evaluation are presented in a Technical Memorandum dated January 21, 2009 by Tetra Tech, Inc. (2009a).

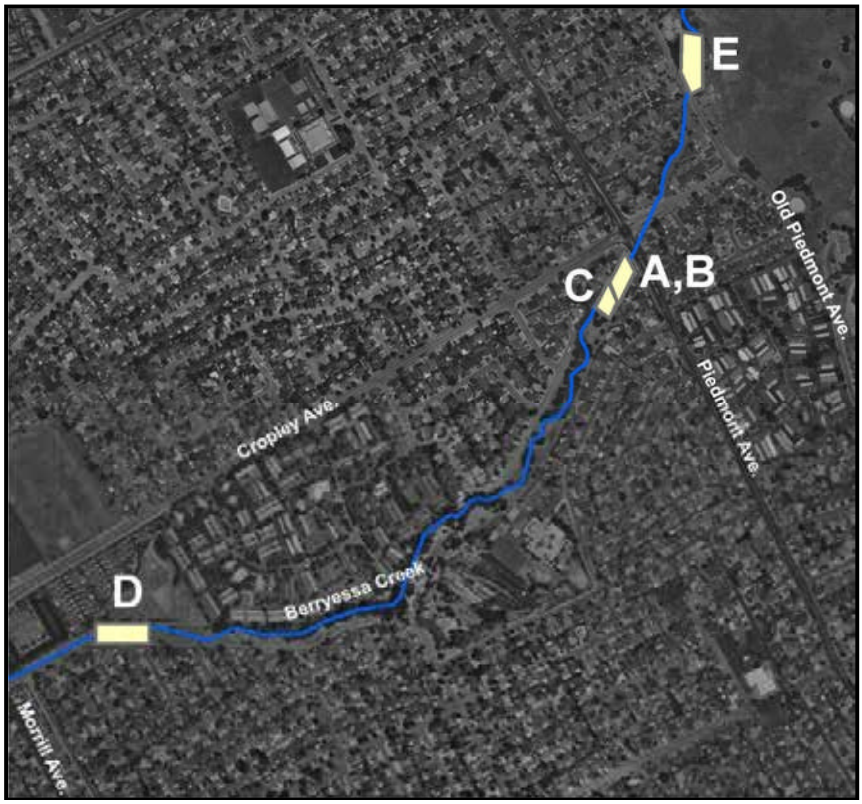

Figure 3-13 Plan View of Alternative Sediment Basin Configurations

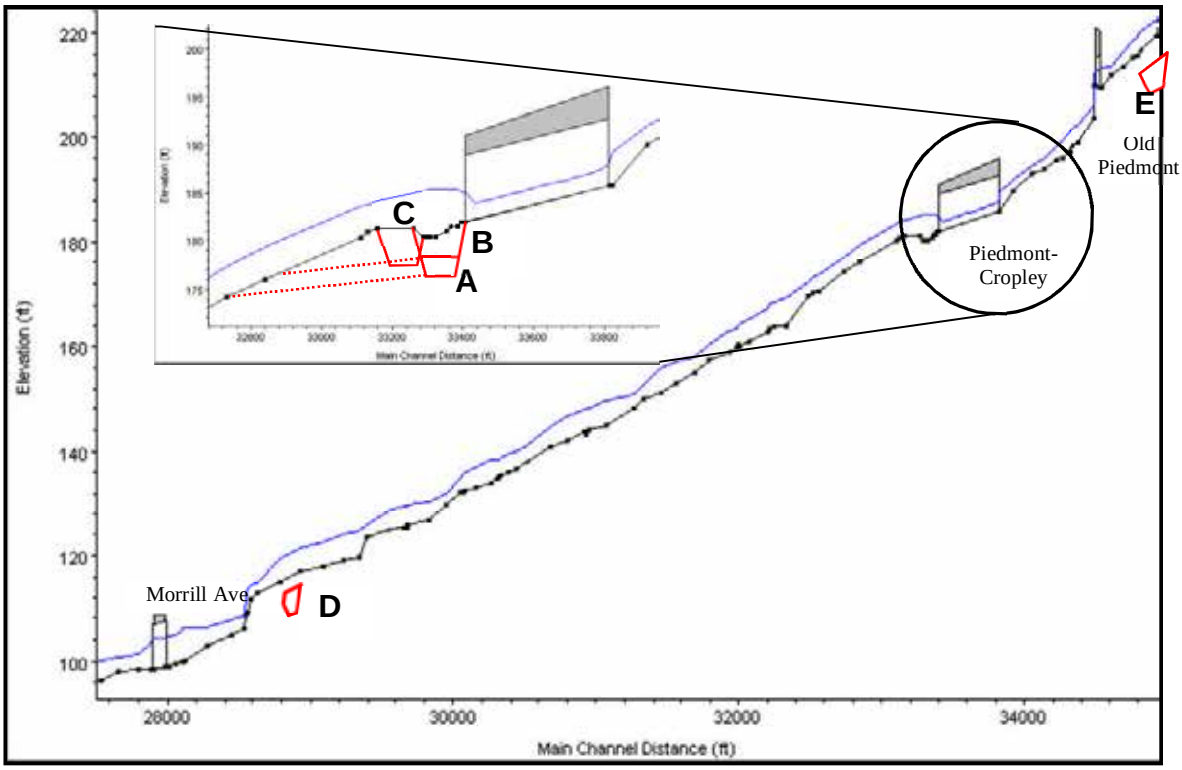

Figure 3-14 Profile View of Alternative Sediment Basin Configurations

CHAPTER 4: RECOMMENDATIONS FOR ADDITIONAL ANALYSES

To support the further development of the preferred alternative once selected, additional analyses and investigations related to the determination of sediment transport conditions within the project area should be performed. These analyses will assist in refining the design and providing a project that functions properly in relation to geomorphic and sediment transport conditions. The recommended investigations and analyses include the following:

- Perform inspections of the major tributaries entering the project to assess their sediment contribution and whether there are opportunities for sediment management on the tributaries. Past studies have focused on the main Berryessa Creek drainage since it is the largest sediment source; however, some opportunities may exist to improve sediment transport conditions within the project by addressing the supply of sediment from the tributaries.

- The HEC-6T model developed for the without-project condition should be applied to with-project condition. The results from the without-project condition showed that the model reasonably predicts the locations of sediment deposition and scour. The following are specific recommendations for the HEC-6T effort:

  - The model should be developed as an assessment and design tool for the preferred alternative rather than being applied in the alternative selection process. Application of the sediment transport and geomorphic assessment presented in this report should be adequate during the plan selection effort.

  - The current model uses only one sediment size distribution for the entire project area. This assumption should be reviewed and the possibility of utilizing several distributions as conditions change should be evaluated. This should be considered in terms of both the surface and subsurface distributions.

  - Based on the review of the NHC (2003) report, it did not appear the sediment removal was incorporated into the modeling effort. Consideration of running multiple events and incorporating sediment removal should be considered.

  - In applying the HEC-6T model some thinning of cross sections may be necessary from those used in the current HEC-RAS hydraulic model.

- Further refinement of the project design in terms of the channel sections should be undertaken to reduce the wide variations in velocities that occur within short distances. Many of these rapid variations may be due to the concentration of the initial design effort on determining the levee heights and bridge modifications to contain the design floods. The initial design modifications addressed the channel cross section size and levee heights primarily. In the next level of design, some adjustment of the channel gradient may be incorporated to provide a design with more consistent hydraulic conditions.

- Design modifications for the alternatives at several of the bridges downstream of I-680 result in increased flow areas that consequently cause existing deposition trends to be exacerbated. Specific problem areas identified are at Calaveras Boulevard, the UPRR trestle and Montague Expressway.

- Scour analyses need to be conducted to determine toedown depths for toe protection. General scour from the HEC-6T analysis should be added to bend and toe scour estimates. Because of the many modifications at bridges, the adequacy of the piers and abutments must also be evaluated in terms of scour, both local and general.

- Sizing of bank protection needs to be undertaken. Additionally, the ability of the upper bank protection and the vegetation on the floodplains to prevent erosion needs to be assessed based on shear stress and velocities.

- The n-values (roughness coefficients) assigned to the various channel components need to be adjusted if further refinements are made in terms of decisions on the types of vegetation that will be established in each area.

- Further analysis of potential changes in the configuration of the Piedmont sediment retention basin and other sediment retention facilities upstream of Old Piedmont Road need to be performed to quantify sediment removal.

- A more quantitative comparison should be made between these sediment modeling results and other modeling carried out by Jordan (2009) using SIAM and GSTARS-1D where possible, to reinforce confidence in model results.

CHAPTER 5: REFERENCES

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CHAPTER 6: ADDENDUM 1

6.1 Summary and Excerpts from Colorado State University Doctoral Dissertation

A detailed study comparing Berryessa Creek with Penitencia Creek was conducted as part of a PhD dissertation by Brett Jordan at Colorado State University. Full citation information and a summary of parts of the dissertation most pertinent to this study prepared by Tetra Tech, Inc. are presented in the following paragraphs.

Jordan, B. (2009). *An Urban Geomorphic Assessment of the Berryessa and Upper Penitencia Creek Watersheds in San Jose, California*. Colorado State University, Fort Collins, CO.

6.1.1 Summary of Abstract

- A quantitative urban geomorphic assessment was conducted for the Berryessa Creek watershed to investigate the effects of urban hydrologic change, valley subsidence and river infrastructure elements on channel stability.
- 47 monumented cross sections over a 3000-meter reach of Berryessa Creek were surveyed in 2004. Cross sections were surveyed yearly after high flow season (winter) for 3 years to document changes in river processes and form.
- Detailed geomorphic field data were used to conduct hydrologic and sediment transport modeling and investigate the relative effects of hydrologic alteration, valley subsidence and river infrastructure on water yield, sediment yield and channel stability.
- Results of this analysis indicate system instability in the urbanized valley portion of Berryessa Creek is caused primarily by drainage area capture by the urban storm sewer network and engineered river infrastructure elements.
- Hydrologic and sediment modeling indicates that these drainage system modifications have caused a water yield increase of 48 % and sediment yield increase of 9 % to 61 % based on historic conditions.
- Changes in the Berryessa Creek hydrological regime have transformed previously depositional reaches into incised reaches. Results of modeling indicate the maximum incision due to valley subsidence would be 0.27 m.
- Effects of base level lowering will be at a maximum approximately 500m upstream of the zone of maximum subsidence, which is minor increase in sediment yield of 0.3 % to 11 %. River infrastructure (an online sedimentation basin and 1.85 m grade control structure) has reduced the downstream sediment yield by 15 %.
- Subsidence effects from groundwater extraction are obscured by current channel instability caused by urban development which dominate system changes.

6.1.2 Summary of Introduction

- Methods of analysis: 1. time series aerial photos, topographic data, long profile analysis. 2. Field data collection. 3. Numerical hydrology and sediment transport modeling.

- The Berryessa watershed is an alluvial fan that has been anthropogenically manipulated along the valley floor to facilitate agriculture and urban development.
- Berryessa has been subject to channel realignment, engineering infrastructure, floodplain encroachment, drainage area expansion via storm sewers and has suffered severe erosion and sedimentation problems (e.g. in Summer 2004 approximately 7,100 m^3 sediment was dredged from two reaches of Berryessa; in comparison there was very little removal of sediment from fish ladder structures on the less modified Penitencia Creek).
- This dissertation contains a large literature review about effects of urbanization on watershed hydrology, sediment transport and ecology.
- Land subsidence of up to 3.5m was observed in parts of the Santa Clara Valley between 1934 and 67 due to groundwater pumping.

6.1.3 Summary of Methodology

- Page 29 contains useful table of all data collected.
- The study examined a time series of long profiles. Berryessa Creek has undergone 1.5m or more incision or mechanical sediment removal in reach where the steep upland transitions in valley flat, this reach would be expected to be depositional. The reason for this is channelization and floodplain encroachment.
- Page 36 presents the change in bed level over time. More scour than deposition is evident on Berryessa Creek.
- Historical aerial photography analysis showed in 1899 there was no defined channel on Berryessa Creek below mountain range, just the alluvial fan with multiple small paths. By 1939 the single thread channel had been formed by channelization to permit agriculture on the fan, development and flood control. Lengthening of the channel decreased the slope significantly. In 1899 it was 0.02, 1930s it was 0.01, 1950s it was 0.005. The natural stream response of reducing the gradient was to aggrade.
- Subsidence by reach on Berryessa: Reach 1: 1125-2000: 0.11m, Reach 2: 710-1125: 0.14m, Reach 3: 250-710: 0.23m. Normal base-level lowering causes increase in sinuosity. Conversely an increase in urbanization normally results in decrease in sinuosity due to lateral restraints and channelization.
- Reach 1: most upstream. Between 1939 and present a decrease in sinuosity due to channelization 1960-80 is observed. Reaches 2 and 3: no channelization has taken place, trend of increased sinuosity, likely due to increased discharge and reduced sediment load.
- Similar trends were observed in the meander belt width.
- Urbanization mainly occurred in the valley areas between 1960s and 1980s; little urbanization has taken place in the upper watershed.
- A drainage area expansion took place on Berryessa due to addition of two historic alluvial fan streams. In 1899 the drainage area was 13.0 sq km, in 2002 it was 15.5 sq km.
- The watershed is located on active Hayward fault. Large landslide activity delivers large sediment load to channel.
- Previously change in valley grade from steep uplands to flatter valley means sediment is deposited at interface. Berryessa sediment basin was constructed in 1962 has

reduced sediment deposition and can easily be excavated but sediment continuity downstream has been disrupted.

- Sediment has been dredged every 2 years between 1984 and 2004. The basin is effective at capturing large particles (>16 mm) transported as bedload. This has caused channel incision downstream.
- Summary: Upper Berryessa watershed is not urbanized, the lower watershed has become 85 % urbanized over last 100 years. Changes in hydrology magnify peaks and duration of flows capable of producing bedload transport in Berryessa Creek. A trend for downgrading and incision has been observed. (1.5m of incision between 1967 and 2004 downstream of the sedimentation basin). Berryessa has only subsided 0.23m (Penitencia 1.1m).
- Cross sections were resurveyed and the average bed change was calculated. Over 65% of Berryessa cross sections are degrading.
- Manning's n for Berryessa was considered to range between 0.037 and 0.064, with a mean of 0.047.
- Pebble counts conducted at each cross section. Page 89 contains a bed material size plot over the long profile.
- Bulk sampling was carried out. Berryessa shows fining (as would be expected) moving downstream. There is a sharp drop in size after the sediment basin as coarse particles are trapped in the sediment basin.
- Bank condition reconnaissance was carried out and the following sediment properties were recorded: depth of layer, sphericity (round, angular), texture, color, clast matrix supported structure, grain size, sorting.
- Bank height and angles were measured visually for stable and unstable bends. Bank height to depth ratio has been proposed as a measure of stability.
- Erosion pins (referred to as "bank rods") were installed for the winter 2004 season and monitored until 2006. Bank retreat ranged from 0 to 0.36m/yr.
- Bank material varies considerably between stratigraphic units.
- 15 min stage and discharge data was collected in 2005 and 2006. Bedload and suspended load were measured to develop a rating curve. Bedload sizes were measured at two locations on Berryessa.
- Rating curves for bedload and suspended were developed, although plots exhibit a considerable amount of scatter even with log-log axes. Comparing Berryessa to Penitencia, Berryessa has much large supply of sediment than Penitencia. Upland reaches of Berryessa have a considerable amount of landslide activity and colluvial sediment sources.

6.1.4 Hydrological Modeling

- Processes that have lead to flow regime changes on Berryessa Creek include increase in watershed impervious area and increased connectivity/changes in catchment area.
- A calibrated hydrological model was created in HEC-HMS. Three different simulations carried out.
- Upper watershed is characterized by steep slopes, clay/gravely loam soils with low infiltration rates. The valley has low relief, sandy soils and higher infiltration rates.

- Urbanization in the Berryessa watershed has caused a net increase of 14 % in urbanized land use for whole watershed. Diversions have created a 20 % increase in effective catchment area, causing higher peak flows and volumes.
- Hydrographs currently have higher peak discharges and more flashy time to concentration due to efficiency of the storm drains than historical conditions, resulting in multiple peaks for an event that would previously have a single peak.

6.1.5 Sediment Transport Modeling

- Two sediment transport models were used to evaluate urbanization and valley subsidence effects on channel stability: SIAM (snapshot in time) and GSTARS-1D (continuous simulation used to predict long term channel changes).
- Six versions of each model were produced for Berryessa Creek: two different geometries – historic (1939), current (2004) with urban infrastructure, current (2004) without urban infrastructure.
- As part of the dissertation efforts, a HEC-RAS model was developed by Colorado State University (CSU) independently from the Corps of Engineers model. The CSU HEC-RAS model was used to create the SIAM model. Ten SIAM reaches were used.
- A sediment transport function sensitivity analysis was carried out. Ten equations were tested. The synthesized results were compared with measured suspended load and bedload data, and observed morphology changes. Yang (1973) and Yang (1984) appeared to be most accurate and were selected for model use.
- 30-year simulations carried out with GSTARS-1D. The models do not include subsidence.
- Model results were compared to field observations. SIAM produced results closer to observed results than GSTARS-1D. Both models provide reasonably close predictions. SIAM showed a good agreement with amount of sediment deposited in the Berryessa basin on annual basis (compared against the dredging records).
- Models indicate that the watershed changes on Berryessa would induce significant channel change, especially in downstream reaches: change from deposition to incision, increase in sediment yield.
- Models indicate that instability problems may be introduced to the upstream reaches by removing the grade control structure on Berryessa Creek: degradation upstream, aggradation downstream.

6.1.6 Appendices

- Bankfull dimensions by cross section, superimposed surveyed cross sections from 2004/2005/2006 and bed material size data are presented.

Berryessa Creek Project

Santa Clara County, California

Appendix B

Engineering and Design

Part IV: Design and Cost of Alternatives

TETRA TECH

FEBRUARY 2013

BERRYESSA CREEK PROJECT

APPENDIX B, Part IV: Design and Cost of Alternatives

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CHAPTER 1: INTRODUCTION

This portion of the engineering appendix (*Appendix B, Part IV: Design and Cost of Alternatives*) describes the underlying assumptions behind project alternative designs, quantity takeoffs, and cost estimates for the Berryessa Creek project alternatives. Design considerations and corresponding costs are presented for individual project features along Berryessa Creek. The project features include modifications to channel reaches and bridge and culvert crossings located between I-680 at the upstream end of the project and Calaveras Boulevard at the downstream end. The project reach includes eight existing bridge and culvert crossings within the project area, as described in Table 1.1.

Table 1.1 Existing Bridge and Culvert Crossings within Berryessa Creek Project Area

Station	Description	Approximate Dimensions
248+00	I-680	60-ft top span x 10-ft height, trapezoidal channel
210+90	Montague Expy	Double 12-ft span x 9-ft height box culvert
206+05	UPRR Trestle	40-ft top span x 10-ft height, 4 sets of piers
186+80	UPRR Culvert	Triple 11-ft span x 12-ft height box culvert
182+10	Ames Avenue	75-ft top span x 10-ft height, trap. channel, single pier
168+80	Yosemite Drive	75-ft top span x 10-ft height, trap. channel, single pier
137+50	Los Coches Street	75-ft top span x 10-ft height, trap. channel, single pier
131+05	Calaveras Blvd	50-ft span x 7-ft height, 4 continuous piers

The following chapters discuss the proposed modifications to individual bridge and culvert crossings and the channel reaches bounded by each crossing. Project features are discussed in order from upstream to downstream. The hydraulic conveyance capacity of proposed channels and bridge and culvert crossings are based on the results presented in *Appendix B, Part I: Hydraulic Analysis of Alternatives*. Further discussion on damages, economic costs and benefits, and the selection of the level of performance is included in *Appendix C: Economics*.

All vertical elevation data referenced in this report, including cross sectional and profile plots, are presented relative to the NAVD88 vertical datum. Some cross section and profile views are shown with substantial vertical exaggeration. All cross sections are shown looking downstream, and references to right and left bank are likewise based on a downstream orientation. Stationing is based on the HEC-RAS cross section identifiers as described in *Appendix B, Part I: Hydraulic Analysis of Alternatives*. Figure 1.1 shows the relative location of the individual bridge and culvert crossings within the project footprint. A more detailed project footprint, including temporary construction easements, staging areas, and access routes, is presented in the overview exhibits of the accompanying set of 11”x17” plan/profile sheets (Sheets G-3, G-4, and G-5).

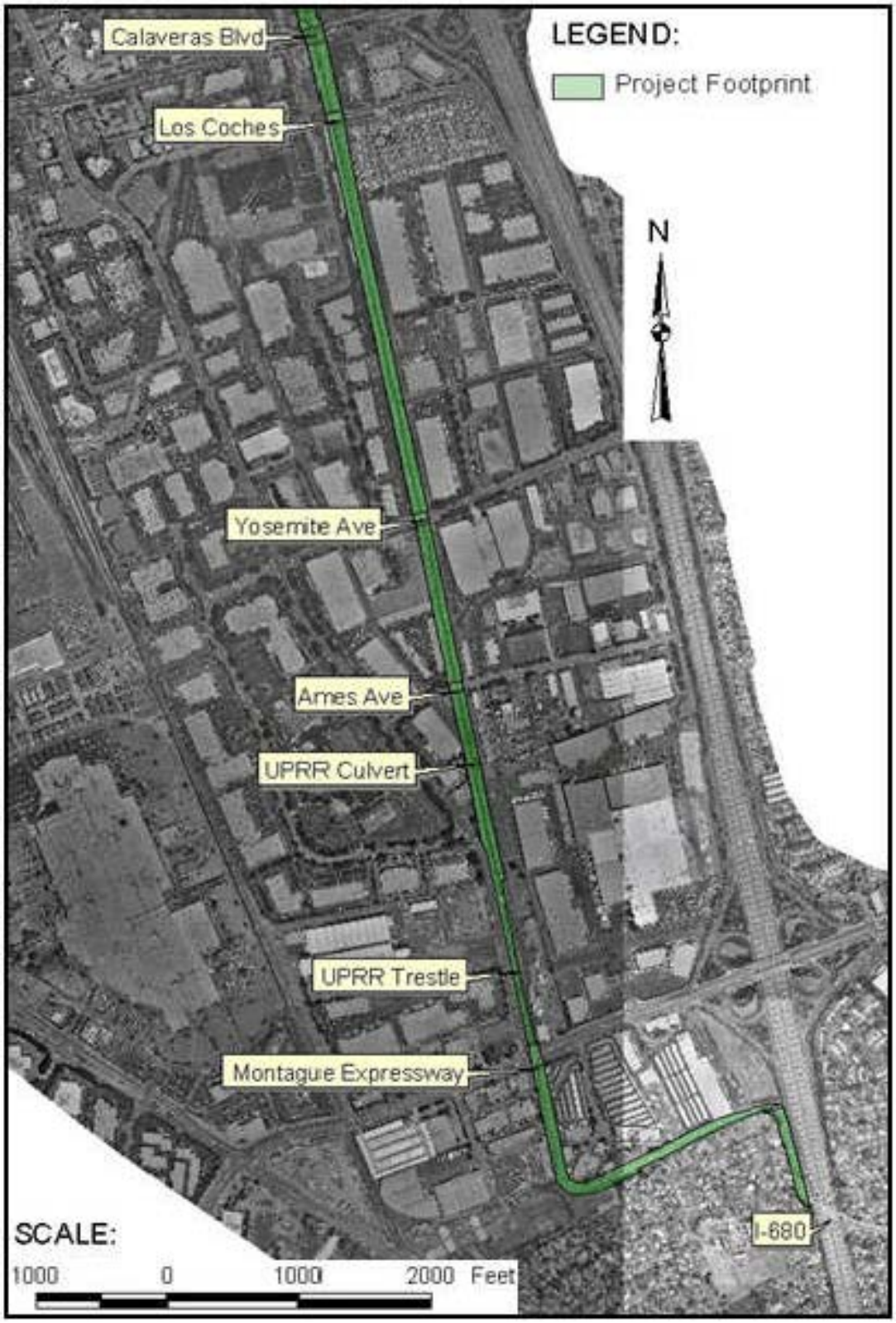


Figure 1.1 Berryessa Creek Project Footprint

CHAPTER 2: ALTERNATIVES

2.1 Preliminary Array of Alternatives

The preliminary array of alternatives included an incised trapezoidal channel, a terraced trapezoidal channel, a walled trapezoidal channel, and the Authorized Plan (a concrete trapezoidal channel). Further details on the evaluation criteria, screening process, and refinement of the alternatives array are included in *Appendix B, Part I: Hydraulic Analysis of Alternatives* and *Appendix C: Economics*.

The 1990 Authorized Plan was designed for 1% chance exceedance discharges that have since been modified under revised hydrologic analyses. Levees, floodwalls, and tops of bank in the current project alternatives are designed according to risk and uncertainty principles as described in *Appendix B, Part I: Hydraulic Analysis of Alternatives*.

2.2 Final Array of Alternatives

Three project alternatives are being evaluated under the final array of alternatives along with a no-action alternative.

- *Alternative 1 (No Action)*. Without-project condition, assuming routine maintenance.

- *Alternative 2A/d (Incised Trapezoidal Channel)*. Earthen trapezoidal channel section with varying bottom width and 2:1 side slopes. Free-standing concrete floodwalls as needed and in-channel access road where suitable. This alternative applies a moderate level of flood risk reduction, passing the 50% certainty 0.01 event without additional certainty. Under this alternative, all bridge and culvert crossings remain in their existing configuration, with the exception of the UPRR trestle, which is replaced with a triple-barrel concrete box culvert.

- *Alternative 2B/d (Incised Trapezoidal Channel)*. Earthen trapezoidal channel section with varying bottom width and 2:1 side slopes. Free-standing concrete floodwalls as needed and in-channel access road where suitable. This alternative applies a FEMA-certifiable level of flood risk reduction, passing the 0.01 event with 95% certainty. Under this alternative, all bridges and culverts are replaced with the exception of I-680, Ames Avenue and Yosemite Drive.

- *Alternative 4/d (Walled Trapezoidal Channel)*. 10-ft bottom width earthen low-flow channel with 3:1 side slopes, 3 ft deep. Two vegetated floodplain benches (32-ft bench width on the left bank, 10-ft width on the right bank) bounded by vertical concrete floodwalls. Access road location varies. Wall extensions as required to contain flows. This alternative applies a FEMA-certifiable level of flood risk reduction, passing the 0.01 event with 95% certainty. Under this alternative, all bridges and culverts are replaced with the exception of I-680, Ames Avenue and Yosemite Drive.

All project alternatives include a 15-foot obstruction-free zone outside of the project features along both banks. The obstruction-free zone also acts as an access route for flood-fighting and maintenance activities and as a vegetation-free zone to ensure compliance with current vegetation criteria for levees and floodwalls.

The project features comprising each alternative are summarized below:

2.2.1 Alternative 1

Alternative 1 is the no action alternative and represents without-project conditions, assuming routine maintenance. The performance of the existing creek and flood control system, including a description of the existing hydraulic conveyance capacities of channel reaches and bridge and culvert crossings, is described in *Appendix B, Part I: Hydraulic Analysis of Alternatives*. The no-action alternative assumes channel reaches and bridge and culvert crossings are fully maintained to remove accumulated debris and to repair flood damage. For areas with existing debris accumulation or erosion problems, the hydraulic performance of the without-project conditions model described in *Appendix B, Part I: Hydraulic Analysis of Alternatives* may therefore differ from the actual observed conditions. Estimated maintenance quantities are described in Chapter 3.

2.2.2 Alternative 2A/d

Schematic sections of Alternative 2A/d are shown in Figure 2.1. This alternative involves the following features:

- Channel excavation and earthen levee construction to the water surface level of the 50% certainty, 0.01 exceedance probability event discharge from I-680 to Calaveras Boulevard
- 2H:1V side slopes with cellular bank protection and buried riprap scour protection
- Free-standing concrete floodwalls in the immediate vicinity of Montague Expressway as well as between the Piedmont Creek confluence and Calaveras Blvd
- Access road located along the left bank channel slope downstream of Yosemite Drive
- Recreational trail within the obstruction-free zone where primary flood control use allows secondary recreational use
- Replacement of UPRR trestle with triple-barrel box culvert
- Transition structures designed to provide smooth transitions from the proposed channel to the existing bridge abutments to be constructed at Montague Expressway, UPRR Culvert, Los Coches Street, and Calaveras Blvd
- Shoring of bridge abutments and construction of transition structures at Ames Avenue and Yosemite Drive to accommodate widened channel
- Relocation of affected utilities, including storm drains entering the channel or running parallel to the channel that fall within the channel excavation areas

2.2.3 Alternative 2B/d

Schematic sections of Alternative 2B/d are shown in Figure 2.2. This alternative involves the following features:

- Channel excavation and earthen levee construction to the water surface level of the 95% certainty, 0.01 exceedance probability event discharge from I-680 to Calaveras Boulevard
- 2H:1V side slopes with cellular bank protection and buried rip rap scour protection
- Free-standing concrete floodwalls between I-680 and Montague Expressway and between Yosemite Drive and Calaveras Blvd
- Access road intermittently along one or both banks, within the channel (at an elevation between the 0.1 and 0.04 exceedance probability event), or both
- Replacement of Montague Expressway Culvert crossing with 60-ft span bridge
- Replacement of UPRR trestle with triple-barrel box culvert (15-ft span each barrel)
- Replacement of UPRR culvert with 60-ft span bridge
- Shoring of bridge abutments at Ames Avenue and Yosemite Drive to accommodate widened channel
- Replacement of Los Coches Street Bridge with 100-ft span bridge
- Replacement of Calaveras Boulevard Bridge with 100-ft span bridge
- Utility relocations as required

2.2.4 Alternative 4/d

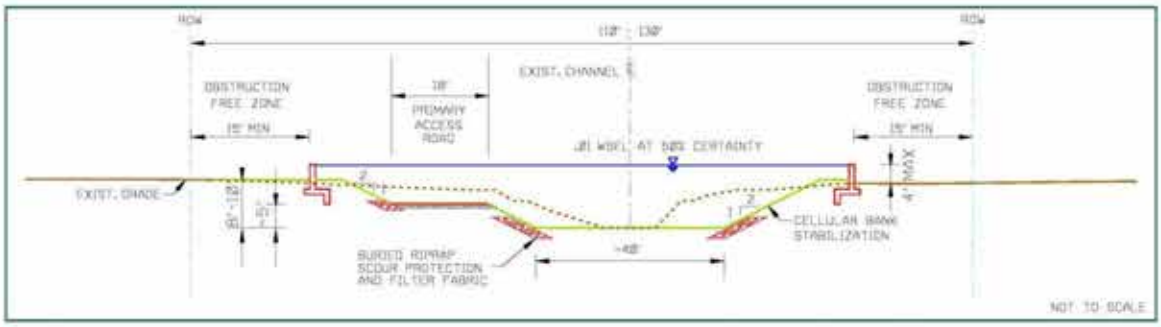
Schematic sections of Alternative 4/d are shown in Figure 2.3. This alternative involves the following features:

- Channel excavation and concrete wall construction to the water surface level of the 95% certainty, 0.01 exceedance probability event discharge from I-680 to Calaveras Boulevard
- Concrete retaining walls to the existing ground surface and above-ground floodwall extensions as required
- Replacement of Montague Expressway Culvert crossing with 60-ft span bridge
- Replacement of UPRR trestle with triple-barrel box culvert (15-ft span each barrel)
- Replacement of UPRR culvert with 60-ft span bridge
- Shoring of bridge abutments at Ames Avenue and Yosemite Drive to accommodate widened channel
- Replacement of Los Coches Street Bridge with 100-ft span bridge
- Replacement of Calaveras Boulevard Bridge with 100-ft span bridge
- Utility relocations as required

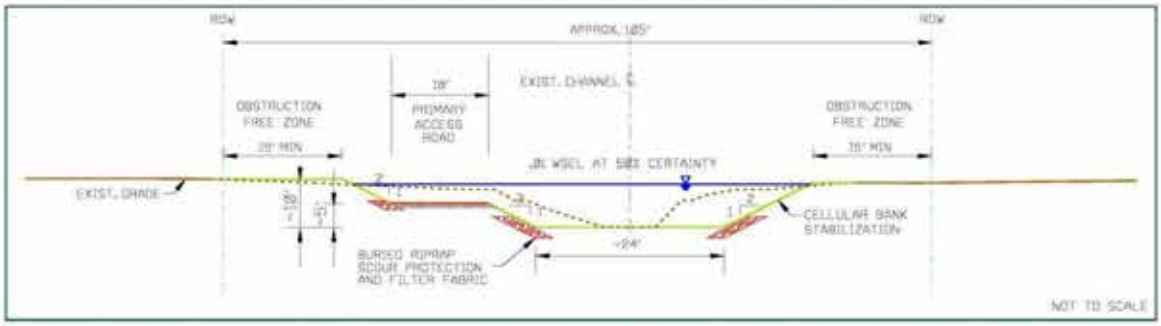
2.3 Description of Project Features in Final Array

Typical sections showing the overall configuration of each alternative are presented in Figure 2.1, Figure 2.2 and Figure 2.3 below. Additional details are shown in the accompanying 35-sheet set of 11”x17” plan/profile figures.

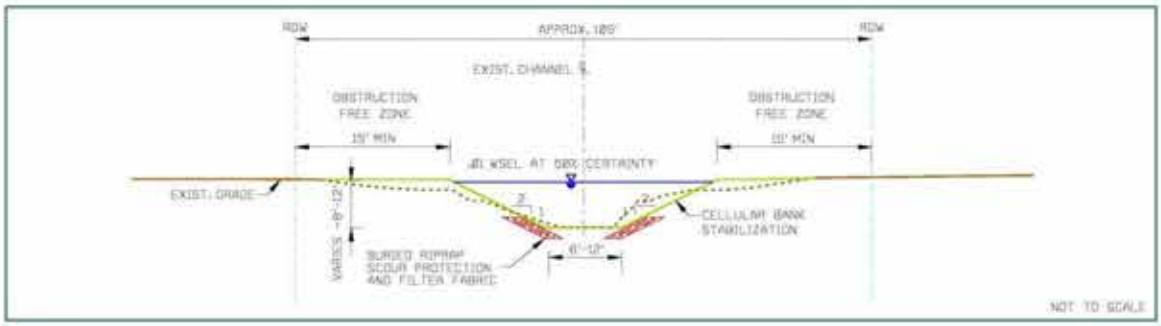
Table 2.1 tabulates the individual channel and bridge/culvert modifications that make up each of the three project alternatives. Utility modifications are required under all scenarios and are not called out individually in the summary table. The incorporation of optional recreational features along existing and proposed maintenance roads will be addressed further as the project develops.



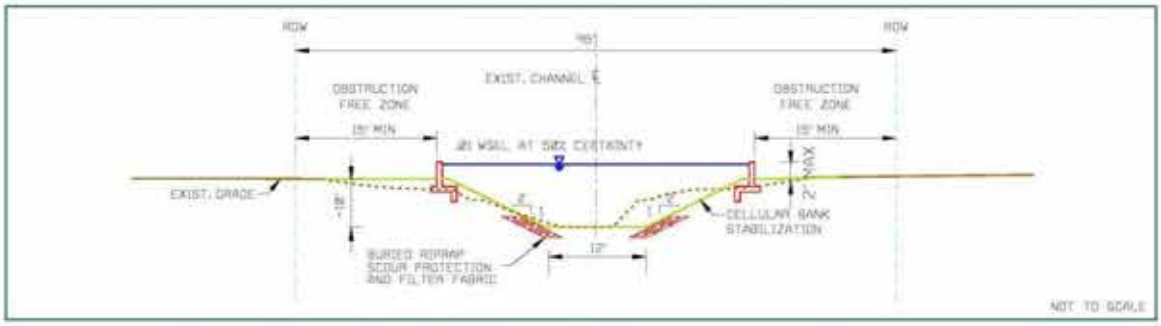
TYPICAL CROSS SECTION, CALAVERAS BLVD TO PIEDMONT CREEK (STA 130 TO 160)



TYPICAL CROSS SECTION, PIEDMONT CREEK TO YOSEMITE DR (STA 160 TO 170)

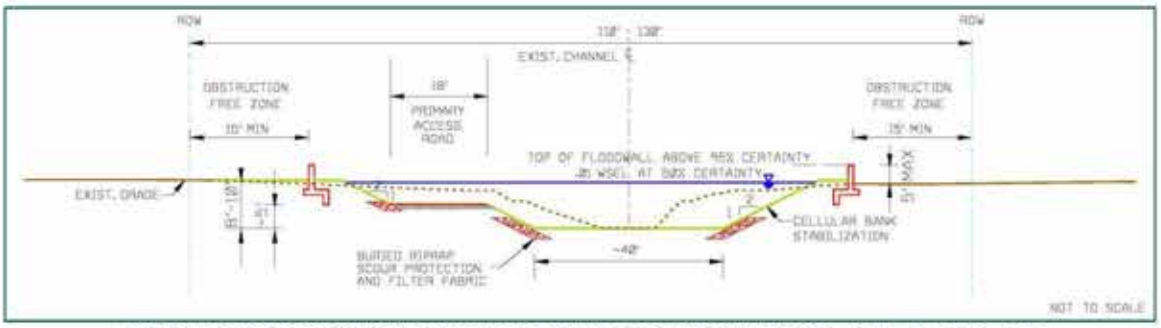


TYPICAL CROSS SECTION YOSEMITE DR TO I-680 (STA 170 TO 212 AND 214 TO 237)

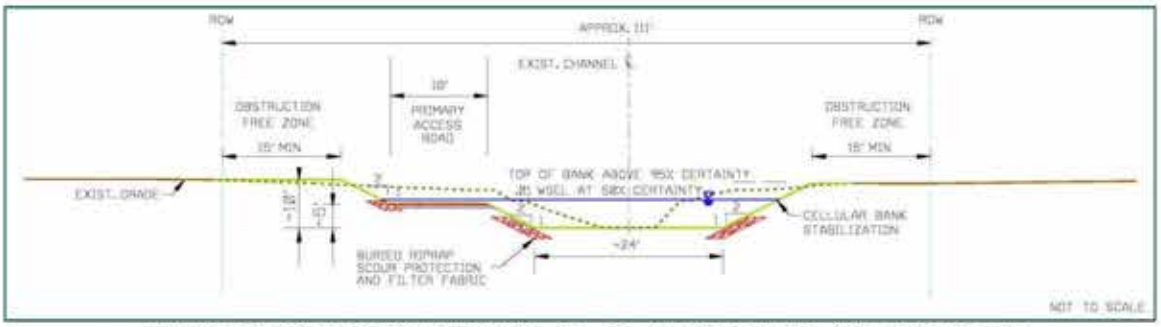


TYPICAL CROSS SECTION, MONTAGUE EXPY TO 200' UPSTREAM (STA 212 TO 214)

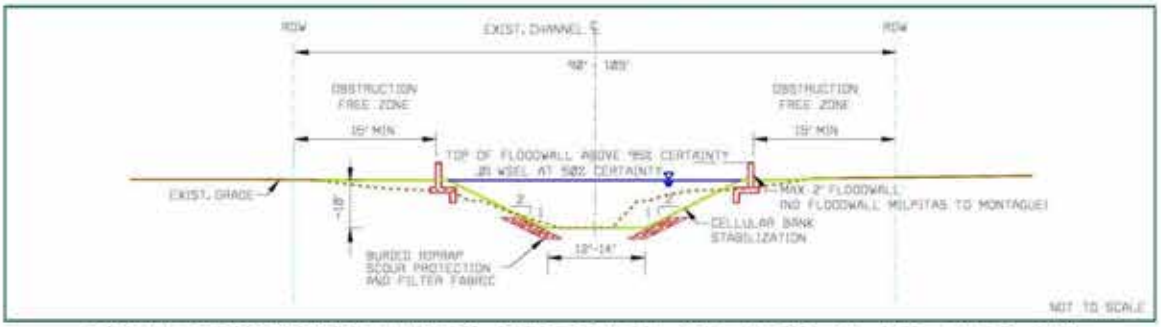
Figure 2.1 Alternative 2A/d Typical Sections



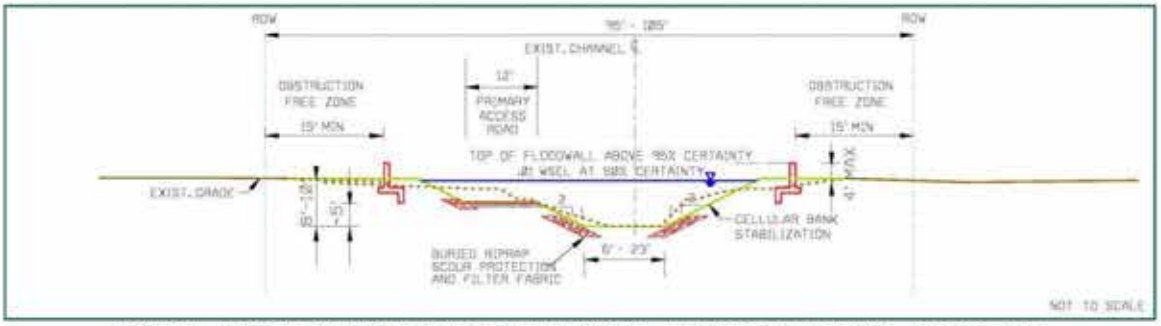
TYPICAL CROSS SECTION, CALAVERAS BLVD TO YOSEMITE DR (STA 130 TO 170)



TYPICAL CROSS SECTION, YOSEMITE DR TO MILPITAS BLVD (STA 170 TO 195)

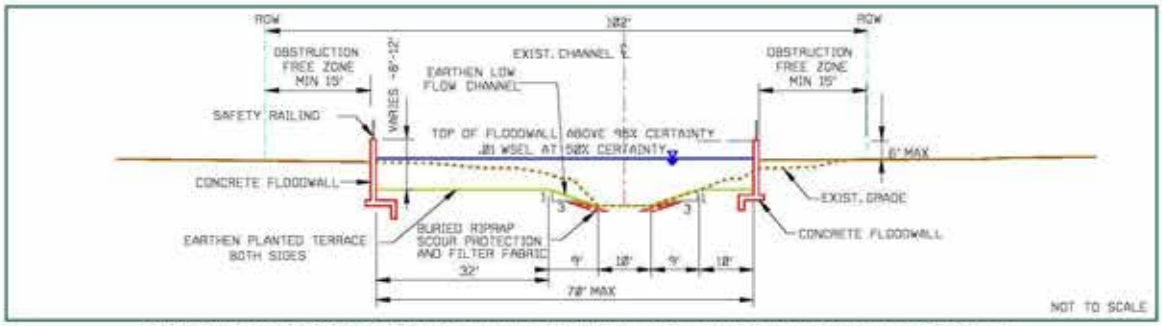


TYPICAL CROSS SECTION MILPITAS BLVD TO I-680 (STA 195 TO 212 AND 230 TO 248)

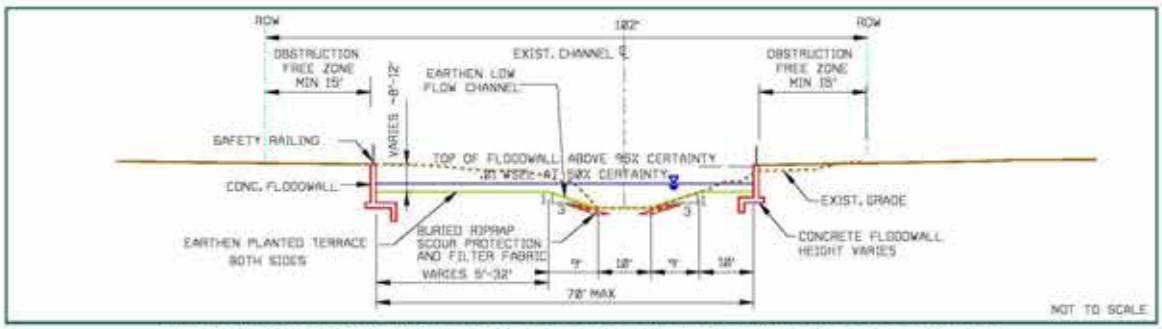


TYPICAL CROSS SECTION, MONTAGUE EXPY TO LAKEWOOD CT (STA 212 TO 230)

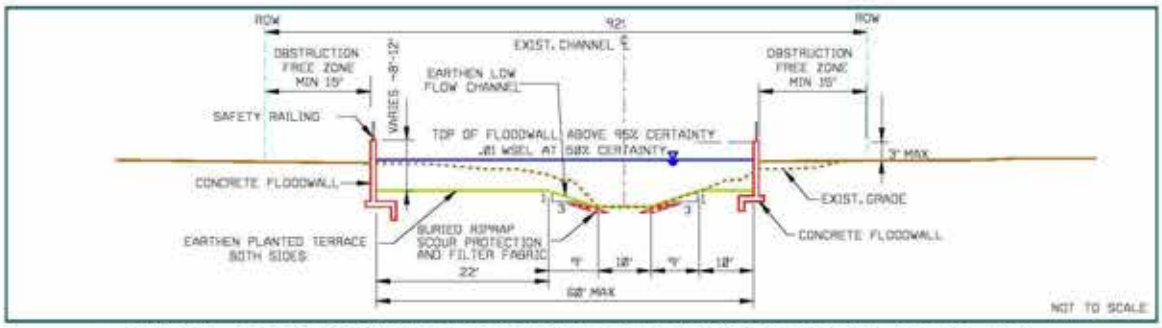
Figure 2.2 Alternative 2B/d Typical Sections



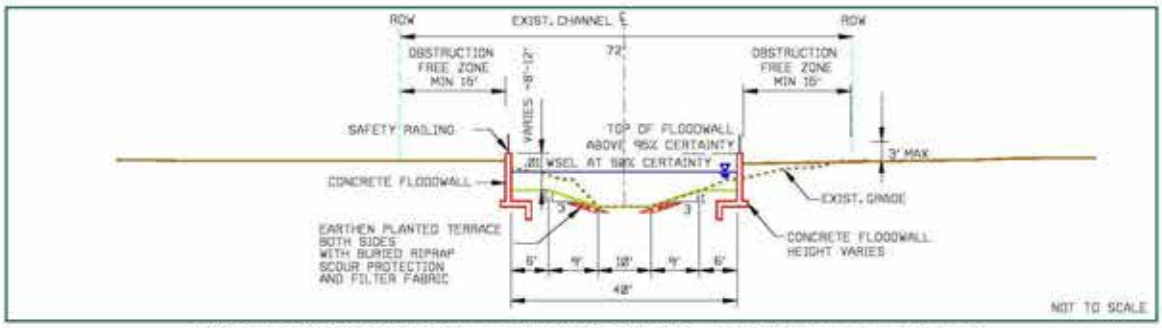
TYPICAL CROSS SECTION, CALAVERAS BLVD TO AMES AVE (STA 130 TO 182)



TYPICAL CROSS SECTION, AMES AVE TO MILPITAS BLVD (STA 182 TO 195)



TYPICAL CROSS SECTION, MILPITAS BLVD TO LAKEWOOD CT (STA 195 TO 230)



TYPICAL CROSS SECTION LAKEWOOD CT TO I-680 (STA 230 TO 248)

Figure 2.3 Alternative 4/d Typical Sections

Table 2.1 Summary of Project Alternative Features

Reach/Structure	Alternative Project Features		
	Alternative 2A/d Incised Trapezoidal Channel	**Alternative 2B/d** Incised Trapezoidal Channel	**Alternative 4/d** Walled Trapezoidal Channel
I-680 Bridge (Sta 248+00)	Remove accumulated sediment at downstream face	Remove accumulated sediment at downstream face	Remove accumulated sediment at downstream face
Channel Reach from I-680 to Montague Expressway (Sta 248+00 – 210+90)	Excavate 6- to 12-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope; Construct 200 lineal feet of free-standing concrete to maximum height of 2 feet	Excavate 6- to 22-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope and access road along left bank slope; Construct free-standing concrete floodwall to maximum height of 4 feet	Excavate 10-foot earthen channel with 10 and 22-foot vegetated terraces and vertical concrete walls extending a maximum of 3 feet above existing ground
Montague Expressway Culvert (Sta 210+90)	Tie floodwall into existing headwall at upstream face of structure; Construct transitions to existing wingwalls	Remove existing box culvert Construct raised 60-foot span bridge	Remove existing box culvert Construct raised 60-foot span bridge
Channel Reach from Montague Expressway to UPRR Trestle (Sta 213+90 – 206+05)	Excavate 12-foot bottom width earthen channel with cellular bank protection at 2H:1V sideslope	Excavate 14-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope; Construct free-standing concrete floodwall to maximum height of 2 feet	Excavate 10-foot earthen channel with 10 and 22-foot vegetated terraces and vertical concrete walls extending a maximum of 3 feet above existing ground

Reach/Structure	Alternative Project Features		
	Alternative 2A/d Incised Trapezoidal Channel	**Alternative 2B/d** Incised Trapezoidal Channel	**Alternative 4/d** Walled Trapezoidal Channel
UPRR Railroad Trestle Bridge (Sta 206+05)	Remove existing timber trestle Construct triple 15-foot span by 12-foot rise concrete box culvert with wingwalls	Remove existing timber trestle Construct triple 15-foot span by 12-foot rise concrete box culvert with wingwalls	Remove existing timber trestle Construct triple 15-foot span by 12-foot rise concrete box culvert with wingwalls
Channel Reach from UPRR Trestle to UPRR Culvert (Sta 206+05 - 186+80)	Excavate 12-foot bottom width earthen channel with cellular bank protection at 2H:1V sideslope	Excavate 10 to 12-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope and access road along left bank slope	Excavate 10-foot earthen channel with 10- and 32-foot vegetated terraces and vertical concrete walls extending to existing ground
UPRR Railroad Culvert (Sta 186+80)	Construct transition to existing wingwalls	Remove existing triple box culvert Construct 60-foot span 12-foot rise bridge	Remove existing triple box culvert Construct 60-foot span 12-foot rise bridge
Channel Reach from UPRR Culvert to Ames Avenue (Sta 186+80 – 182+10)	Excavate 12-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope	Excavate 17-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope and access road along left bank slope	Excavate 10-foot earthen channel with 10- and 32-foot vegetated terraces and vertical concrete walls extending to existing ground
Ames Avenue Bridge (Sta. 182+10)	Excavate 12-foot bottom width channel beneath bridge; Construct abutment and pier protection	Excavate 17-foot bottom width channel beneath bridge; Construct abutment and pier protection	Excavate channel and construct walls beneath bridge; Construct abutment and pier protection
Channel Reach from Ames Avenue to Yosemite Drive (Sta 182+10 – 168+80)	Excavate 15-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope	Excavate 24-foot bottom width earthen channel with cellular bank protection at 2H:1V sideslope and access road along left bank slope	Excavate 10-foot earthen channel with 10- and 32-foot vegetated terraces; Construct concrete floodwall to extend maximum of 6 feet above existing ground
Yosemite Drive Bridge (Sta 168+80)	Excavate 15-foot bottom width channel beneath bridge transitioning to 24-foot bottom width; Construct abutment and pier protection	Excavate 38-foot bottom width earthen channel beneath bridge; Construct abutment and pier protection	Excavate channel and construct walls beneath bridge; Construct abutment and pier protection
Channel Reach from Yosemite Drive to Los Coches Street (Sta 168+80 – 137+50)	Excavate 26-foot bottom width earthen channel with cellular bank protection at 2H:1V sideslope and access road along left bank slope	Excavate 38-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope and access road along left bank slope; Construct free-standing concrete floodwall to maximum height of 5 feet	Excavate 10-foot earthen channel with 10- and 32-foot vegetated terraces; Construct concrete floodwall to extend maximum of 6 feet above existing ground

Reach/Structure	Alternative Project Features		
	Alternative 2A/d Incised Trapezoidal Channel	**Alternative 2B/d** Incised Trapezoidal Channel	**Alternative 4/d** Walled Trapezoidal Channel
Los Coches Street Bridge (Sta 137+50)	Construct transition to existing structure	Remove existing bridge; Construct 100-foot span bridge with raised deck and 4-foot high solid bridge face	Remove existing bridge**;** Construct 100-foot span bridge with raised deck and 4-foot high solid bridge face
Channel Reach from Los Coches Street to Calaveras Boulevard (Sta 137+50-131+05)	Excavate 40-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope and access road along left bank slope; free-standing concrete floodwalls to maximum height of 4 feet	Excavate 38-foot bottom width earthen channel with cellular bank protection at 2H:1V side slope and access road along left bank slope; Construct free-standing concrete floodwall to maximum height of 5 feet	Excavate 10-foot earthen channel with 10- and 32-foot vegetated terraces; Construct concrete floodwall to extend maximum of 6 feet above existing ground
Calaveras Boulevard Bridge (Sta 131+05)	Construct transition to existing structure	Remove existing box culvert Construct 100-foot span bridge with raised deck	Remove existing box culvert Construct 100-foot span bridge with raised deck
Channel Reach Downstream of Calaveras Boulevard (Sta 131+05 – 129+80)	Construct transition to downstream project	Construct transition to downstream project	Construct transition to downstream project

2.3.1 Channel Modifications

Channel widening is proposed in combination with floodwalls under the project alternatives to meet the desired level of performance for the alternatives. The channel excavation templates are depicted in Figures 2.1, 2.2, and 2.3. The extent of proposed armoring, including toe-down depths and armor rock gradation, may vary from section to section as the design is refined. In narrow reaches, the toe protection may be continuous across the channel bottom to maintain the integrity of the channel. The channel profile may require grade control at bridge or utility crossing locations to prevent downcutting of the channel bed. Further geomorphic and sediment transport analyses may determine whether there is a need for additional grade control.

The typical sections for Alternatives 2A/d and 2B/d include an intermittent access road within the channel at the approximate level of the 0.1 to 0.04 exceedance probability event in order to increase the effective conveyance area within the available right-of-way for larger events and to allow maintenance equipment to have closer access to the channel. Alternative levels for the access road may be considered as the design of the selected alternative proceeds. The access road surface would need to be paved or graded and compacted to withstand flood flows, and a cross slope for drainage would be required. Although the access road location is generally shown on the left bank in the cross sections, it may alternatively be located on the right bank if deemed appropriate during the design phase, and a secondary access road may be located along the opposite bank. Several tributaries enter the channel from the right, and access to local streets is required along both sides of the tributaries. The final design should consider findings from additional utility investigations; the final access road configuration may vary from reach to reach.

Alternative 4/d includes vegetated floodplain terraces. Vegetation would need to be drought-tolerant and/or require irrigation for establishment. Selection of vegetation types should also account for the required root depth and the size of the inner channel. Further details on the vegetation types are included in Chapters 4 and 5 of the main report. While the overall project configuration has been designed to fall within the existing public rights of way, the acquisition of several small parcel areas is required to maintain continuous access along the channel. These areas are shown in further detail in the accompanying plan/profile views. Additionally, temporary construction easements, staging areas, and access routes are required for all three project alternatives. Discrepancies in the available real estate information are described in Tetra Tech, 2005b.

Figure 2.4 Schematic View of Channel Configuration of Alternatives 2A/d and 2B/d

Figure 2.5 Schematic View of Floodwalls and Channel Configuration of Alternative 4/d

2.3.2 I-680 Bridge

The I-680 Bridge marks the upstream extent of the project. Some debris is present at the downstream face of the bridge. This debris should be removed regularly to ensure that the conditions do not produce higher than anticipated water surface elevations along the channel banks downstream of the bridge. No with-project modification is proposed for the bridge structure itself except that any deferred maintenance will be performed by the local sponsor.

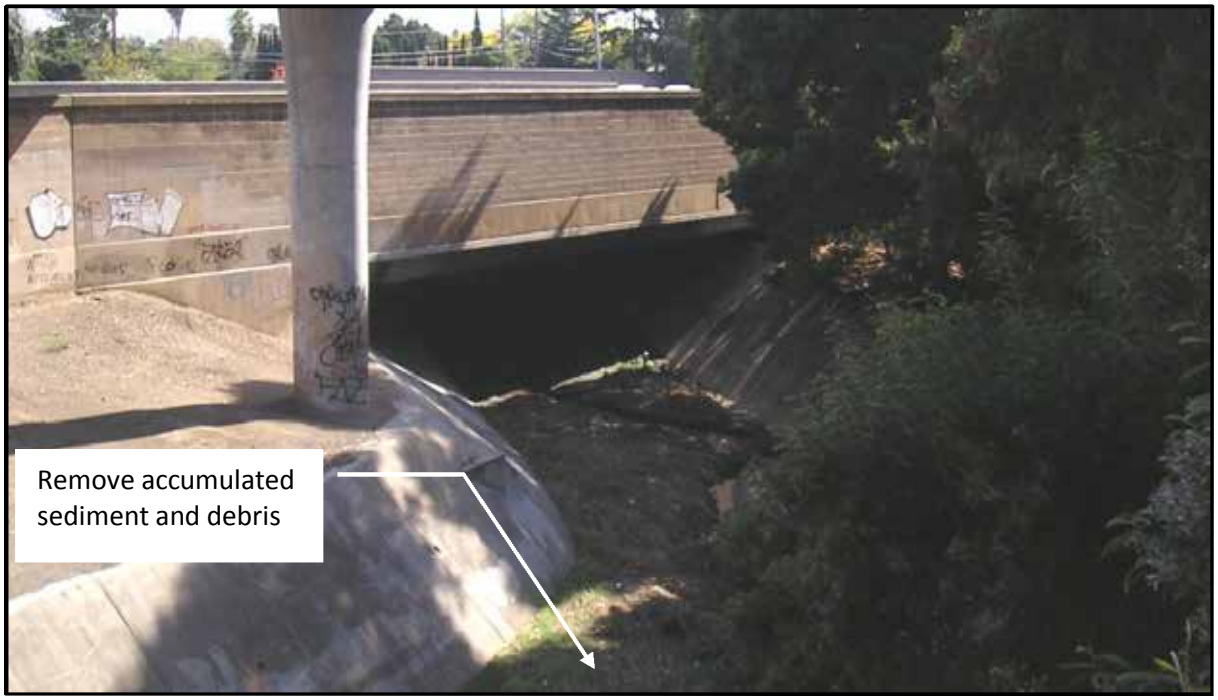


Figure 2.6 Photograph of I-680 Bridge (Looking Upstream)

2.3.3 Montague Expressway

Montague Expressway is a 6-lane arterial crossing over a double barrel 12-ft x 10-ft culvert. The existing bridge allows sufficient capacity for Alternative 2A/d, provided the channel walls tie into the existing structure. For Alternatives 2B/d and 4/d, a replacement span of 60 ft would be required in order to contain the flow in the channel and prevent breakouts. The deck would need to be raised approximately three feet, requiring extensive roadway work, and the headwall would need to tie into upstream and downstream floodwalls. The maintenance road (not shown) would need to transition out of the channel and over the levees or floodwalls.

Figure 2.7 Schematic View of Montague Channel Excavation for Alternative 2B/d

2.3.4 UPRR Trestle

The existing UPRR Trestle is a timber railroad crossing with four sets of piers. There is some discrepancy in the deck height that significantly affects the existing capacity of the trestle, as described in Tetra Tech, 2005a. Due to the condition of the existing structure, excavation around the bed or banks is assumed to be unacceptable, and complete replacement of the trestle is assumed under all project alternatives. A triple-barrel concrete box culvert is included in the project scenarios, with replacement configurations applied and modeled using the 1990 Authorized Plan and GDM designs. The cost estimates also assume that a temporary shoo-fly structure would be needed during construction.

Figure 2.8 Schematic View of UPRR Trestle Replacement for Alt 2B/d

2.3.5 UPRR Culvert

The channel transitions to a wider available right-of-way downstream of the point where Milpitas Boulevard veers away from the channel near the UPRR Culvert. The existing UPRR culvert is a triple 11-ft x 11-ft box culvert that crosses Berryessa Creek at a skew angle of almost 60 degrees. The existing structure has sufficient conveyance to meet the requirements of Alternative 2A/d, provided the channel banks are tied into the existing concrete wingwalls. Alternatives 2B/d and 4/d include the complete reconstruction of the culverts with a 60-foot wide span. The cost estimates assume that a temporary shoo-fly structure would be needed during construction.

Figure 2.9 Schematic View of UPRR Culvert Replacement for Alt 2B/d

2.3.6 Ames Avenue Bridge

The Ames Avenue Bridge is a two-lane bridge with a single continuous pier. The existing span is approximately 80 ft; however, the earthen channel banks block much of the cross section below the bridge deck. The existing bridge is retained under all project alternatives. The channel modifications proposed in this reach for Alternatives 2A/d and 2B/d include an access road on the overbank rather than within the channel. The bridge is shown in the photograph below along with a typical with-project scenario showing the maximum excavated footprint extending vertically down from the edge of the bridge deck and requiring some shoring to protect the bridge abutments.

In conjunction with the proposed channel excavation, the bridge passes the required channel flow with its existing deck and soffit heights. The depth and configuration of the existing foundation is unknown, and shoring or other stabilization of existing abutments is assumed to be required. Conservative estimates of the required materials have been included in the cost estimate.

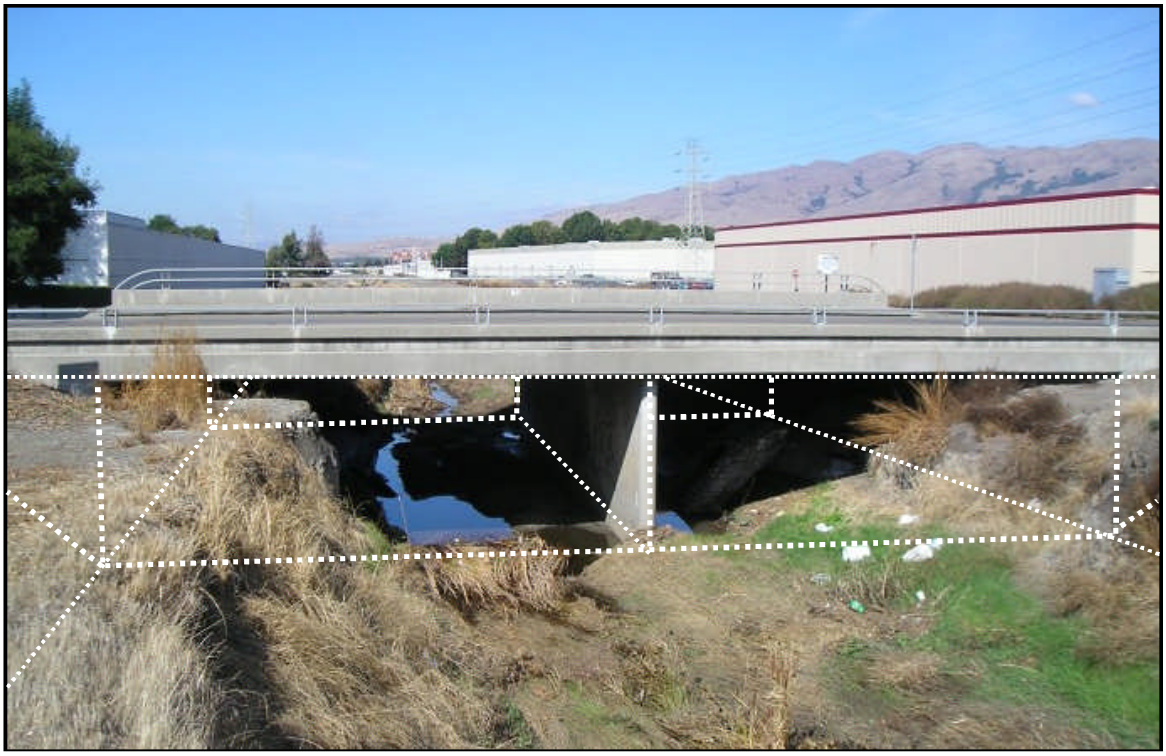


Figure 2.10 Schematic View of Ames Avenue Bridge Modifications

2.3.7 Yosemite Drive Bridge

Yosemite Drive carries a two-lane road over Berryessa Creek. Along the upstream face of the bridge, a major pipeline is supported by cantilevers, as shown in Figure 2.11. The span is approximately 80 ft with a single continuous pier; however, the existing channel banks block much of the cross section below the bridge deck. The existing bridge is retained under all project alternatives. The channel modifications proposed in this reach for Alternatives 2A/d and 2B/d include an access road on the overbank rather than within the channel. The bridge is shown in the photograph below along with a typical with-project scenario showing the maximum excavated footprint extending vertically down from the edge of the bridge deck and requiring some shoring to protect the bridge abutments.

In conjunction with the proposed channel excavation, the bridge passes the required channel flow with its existing deck and soffit heights. The depth and configuration of the existing foundation is unknown, and shoring or other stabilization of existing abutments is assumed to be required. Conservative estimates of the required materials have been included in the cost estimate.

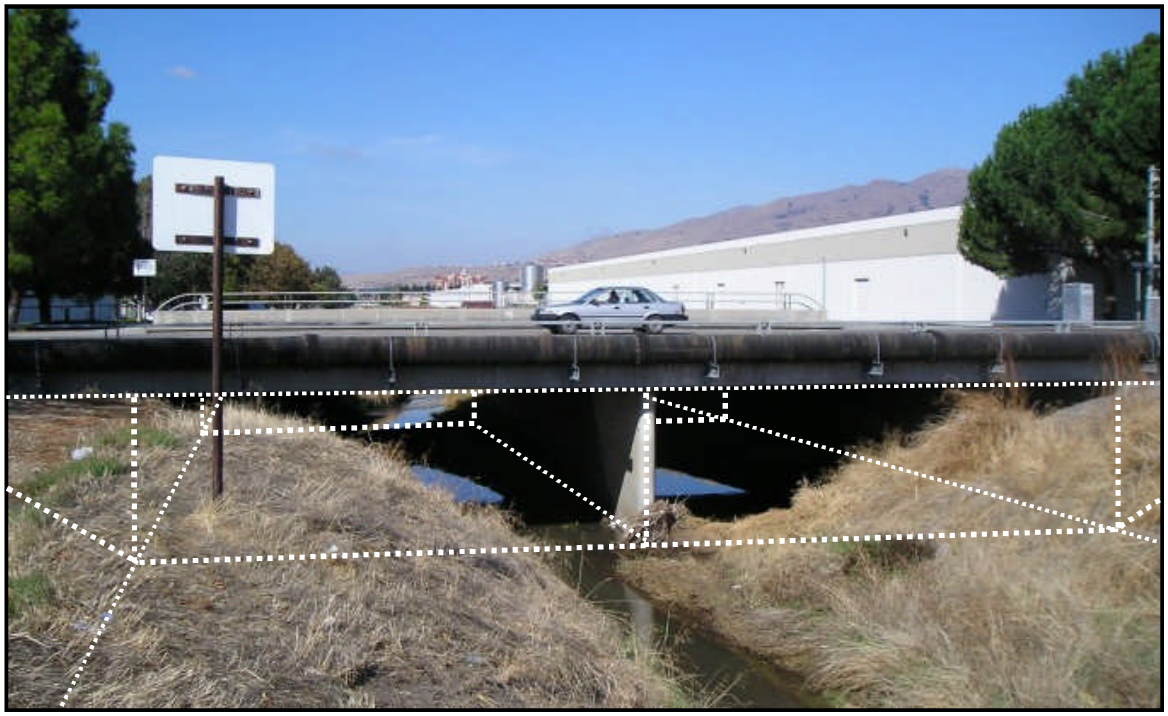


Figure 2.11 Schematic View of Yosemite Drive Bridge Modifications

2.3.8 Los Coches Street Bridge

The Los Coches Street Bridge carries two lanes of traffic over a trapezoidal cross section with a single continuous pier at the center. The left side of the channel is concrete, and the right side of the channel is earthen. The Arroyo de los Coches tributary enters at the upstream face on the right bank.

The existing structure allows sufficient conveyance to accommodate Alternative 2A/d, provided the channel walls are tied into the existing structure. For Alternatives 2B/d and 4/d, complete replacement of the Los Coches Street Bridge with a raised 100-foot open-span would be required to provide the required conveyance capacity. An arched bridge or other configuration with a similar effective conveyance area may also be acceptable. Any modifications in the upstream channel would also necessitate reconstructing the Arroyo de los Coches confluence area. In addition, the existing pedestrian bridge cantilevered on the upstream face would need to be reconstructed, and some rerouting of the bicycle path may be required. Raising the deck requires extensive roadway work.

Figure 2.12 Schematic View of Los Coches Street Bridge Replacement for Alt 2B/d

2.3.9 Calaveras Boulevard Bridge

The Calaveras Boulevard Bridge is an 8-lane, divided roadway. The crossing comprises four 8-ft high x 11-ft wide culvert barrels. Figure 2.13 shows the crossing along with a schematic view of the replacement scenario. The outer two barrels are partially filled with the earthen channel banks that project to the outside toe of the middle culvert barrels. Debris has accumulated to a depth of 1 to 2 ft within the inner two barrels. It is assumed that the apparent reverse grade through the culvert barrel is a result of deposition or survey error, and that the actual concrete invert is at a flat or downstream slope. The existing bridge provides sufficient conveyance to accommodate Alternative 2A/d, provided the sediment in the outer barrels is excavated and the channel walls are tied into the existing structure.

In order to provide the necessary conveyance capacity for Alternatives 2B/d and 4/d, the culvert barrels would need to be replaced by a raised 100-ft open-span bridge. The bridge soffit would need to be raised several feet. The side slopes would be 2H:1V to match the excavated channel footprint for Alternative 2B/d, and vertical abutments would be needed for Alternative 4/d. Proposed improvements downstream of the project area are assumed to be constructed prior to the initiation of any of the project alternatives under consideration. The downstream project extends to the existing Calaveras Boulevard Bridge but does not include modifications to the structure itself; as such, the project improvements under Alternatives 2B/d and 4/d include a transition to match the downstream project approximately 50 ft downstream of Calaveras Boulevard Bridge.

Figure 2.13 Schematic View of Calaveras Boulevard Bridge Replacement for Alt 2B/d

CHAPTER 3: COST ESTIMATES

3.1 Quantities

This chapter outlines the assumptions used in generating construction quantities for the project alternatives.

3.1.1 Bridges and Culverts

Concrete walls for replacement culverts are assumed to be 12" thick, and reinforcing steel is assumed at 200 lbs/cy. Standard wingwalls and headwalls are assumed for replacement bridges and culverts. Customized, cast-in-place wingwalls are assumed for modified bridges and culverts. All bridge and culvert resizing assumes that complete maintenance (sediment and debris removal) is performed periodically at the crossings to maintain the as-built, with-project condition bed elevations. Wingwall and headwall extensions at modified bridges and culverts assume partial demolition of bridge rails and preparation of the existing headwall for doweling into the surface. Transition structures (with variably sloping wingwalls) are assumed to extend for 50 to 75 ft upstream or downstream of the bridge face. Where applicable, the maintenance road transitions out of the channel and over floodwalls to meet existing grade at each roadway crossing.

All bridge replacement scenarios assume 2H:1V temporary side slopes for structural excavation and backfill. Pavement, curb and gutter demolition and reconstruction likewise assumes a footprint based on 2H:1V temporary side slopes. Traffic lanes are assumed to require replacement only to their existing level of service. Bridge construction includes foundations, abutments, and approach slabs. Design plans from the GDM study were used as the basis for resizing the upstream UPRR trestle (1993). Though the modeled inverts differ from the design plans, the general channel shape depicted in the plans was used in modeling the proposed replacement bridge.

3.1.2 Channels

All channel excavation and fill placement is assumed to be at 2H:1V or milder side slope. Channel excavation was modeled using the HEC-RAS channel modification function, as described in *Appendix B, Part I: Hydraulic Analysis of Alternatives*; excavation quantities in the cost estimate are based on end-area computations from HEC-RAS cross sections. Levee top widths (applied to fill placement along the channel banks) are assumed to be a minimum of 12 ft wide. Where the top of the levee serves as the primary access road, an 18-ft minimum width is assumed. Where the top of the levee serves as the secondary access road, a 12-ft minimum width is assumed. Vertical concrete floodwalls are required as described in Chapter 2. Concrete floodwalls include 42-inch safety railing for any wall heights above 2 feet. Traffic barriers are assumed for portions of Berryessa Creek running parallel to roadways. A minimum toedown of 3 ft is assumed for riprap toe protection and concrete footer walls. Buried riprap toe protection is assumed to proceed up to 3 ft vertically up the side slope. 12-inch D_{50} riprap is assumed, with a minimum thickness of 24 inches. A cellular confinement system or similar type of bank stabilization allowing the growth of grass on the

side slopes is assumed for channel excavation and for fill areas above the riprap toe protection.

Levee and floodwall heights are designed according to risk and uncertainty principles as described in *Appendix B, Part I: Hydraulic Analysis of Alternatives*. All channel fill above existing ground is based on the standards set forth in *EM 1110-2-1913 Design and Construction of Levees*. An obstruction-free zone is assumed adjacent to floodwalls or tops of earthen slopes. The obstruction-free zone is also designed to provide the required vegetation-free zones in accordance with the conditions of ETL 1110-2-571. Planting is assumed on sloped banks and terraces, but not along the channel bed or within the low flow channel banks. No tree planting is considered on levee slopes or channel slopes.

Gradation, compaction, and other parameters will be specified based on the results of geotechnical investigations. The suitability of reusing excavated material as fill will likewise be investigated further as the design process proceeds and as geotechnical investigations are completed. Pending further geotechnical analyses, stability of all side slopes will be verified according to *EM 1110-2-1902 Slope Stability*.

Concrete walls are assumed to be 12” thick. Free-standing floodwalls assume subsurface concrete accounts for 60% of the total concrete volume. Shoring or stabilization allowing temporary cut slopes of 1H:1V is assumed to allow placement of base slabs within the available right-of-way.

3.1.3 Operation, Maintenance, Rehabilitation, and Repair

Annual inspections of vegetation, bridges, culverts, and channel reaches are assumed throughout a 50-year project life. Vegetation control, partial vegetation replacement, sediment removal, and periodic structural maintenance are also assumed throughout the project life. Irrigation is assumed to be required during the establishment period of approximately 5 years for slope plantings and throughout the project life for floodplain benches. The initial establishment of vegetation is assumed to be included in the unit cost of original construction. Since 1977, an annual average of approximately 7,000 cubic yards of sediment and debris has been removed from Berryessa Creek upstream of Calaveras Blvd. Table 2-1 in the Geomorphic and Sediment Transport Appendix shows the estimated maintenance quantities for historical removal of existing debris and repair of local scour areas; results are presented for each year, and these approximate removal quantities are assumed to reflect the approximate requirements for with-project maintenance efforts.

3.1.4 Traffic Control

The assumed closure times associated with bridge and culvert modifications and replacements are presented in the accompanying traffic analysis (under separate cover).

3.1.5 Summary of Construction Quantities

Table 3.1 shows a summary of selected construction quantities.

Table 3.1 Summary of Construction Quantities

Material	Alternative		
	2A/d	2B/d	4/d
Demo & reconstruct pavement, curb & gutter (sf)	0	29,000	29,000
Concrete (cy)	1,300	12,000	32,000
Reinforcing steel (ton)	130	1,200	3,200
Excavate and Haul (cy)	46,000	61,000	86,000
Cellular confinement (sf)	170,000	134,000	0
Geotextile (sy)	33,000	49,000	27,000
Riprap (ton)	25,000	28,000	16,000
Planting - bank slopes (ac)	10	15	4
Planting - floodplain terraces (ac)	0	0	9

3.2 Unit Costs

Table 3.2 summarizes the unit costs and assumptions used in the cost estimate. Unit costs presented include labor and materials, with contractor overhead and profit included. Unit costs do not include contingency or other markups that are subsequently added to the construction subtotal. Contingencies apply to construction costs only and not to markups. Unit costs for operation and maintenance include all markups. Unit costs are assumed to be reflective of March 2012 and are escalated to the mid-point of construction in the total project cost summary sheets in Tables 3.3 to 3.6.

Table 3.2 Summary of Unit Costs

Item	Unit Cost	Comments / Assumptions
Demolition		
Demo, haul, and dispose concrete	$120/cy	Assumes 5 mile haul to Guadalupe disposal site (Newby Island Recycling) – demo and transport only, no material cost, assume market for purchase
Demo, haul, and dispose pavement curb & gutter	$7/sf	Assumes 5 mile haul to disposal/recycling site – demo and transport only, no material cost, assume market for purchase
Demo, haul, and dispose CMP pipe culvert	$25/lf	Assumes 5 mile haul to disposal/recycling site – demo and transport only, no material cost, market for purchase
Demo, haul, and dispose timber	$8/bf	Assume no creosote
Demo, haul, and dispose rails	$110/tf	Assume recycling, market for purchase
Demo and relocate rails	$300/tf	Assume shift onsite or raise on levee for add'l row alt only
Earthwork		
Earthwork - excavate and haul	$25/cy	Excess only, assume temporary stockpile and 5 mile haul to disposal site, no treatment for contamination, assume market for purchase
Earthwork - place and compact fill	$25/cy	Assumes all material available onsite from excess, temporary stockpile

Item	Unit Cost	Comments / Assumptions
Earthwork - excavate and regrade onsite	$15/cy	Includes channel shaping and compaction without stockpiling (no net import or disposal)
Earthwork - excavate, backfill and compact	$50/cy	Excavation, temporary shoring, and backfill for structural earthwork, including bedding material
Concrete/Steel		
Cast-in-place concrete for floodwalls	$600/cy	Cantilevers (floodwalls), assume temporary shoring included for floodwall excavation. 6' base slab, 2' cutoff wall 3' below adjacent EG
Cast-in-place concrete for bridges and culverts	$750/cy	Includes foundations, abutments, approach slabs, not wingwalls or headwalls, not applied to pedestrian bridge
Safety railing	$30/lf	42" high standard double steel tube rail
Concrete traffic barrier	$50/lf	Standard jersey barrier
Reinforcing steel	$2.00/lb	Assume ~100 lb/cy
Articulated revetment	$20/sf	8" thick with openings for vegetation, not including filter or earthwork/compaction
Standard wingwalls	$10,000 ea	10' high x 20' length, including foundation
Standard headwalls	$10,000 ea	2' high, max 40' length, sealed Jersey barrier type or precast, tied to wingwalls
Custom wingwalls/transition structures	$25,000 - $50,000 ea	50'-75' length, 10' high, transition from vertical to 2:1, 3' toedown, includes maintenance access transition
Headwall extension	$50,000 ea	18" headwall extension, assume ~50' length
Rail installation	$350/tf	Includes ties, rails, and bedding
Roadway subgrade	$40/cy	18" aggregate base course subgrade for access road
Access road surfacing	$8sf	Compacted aggregate, mixed grading
Repave roadway and replace curb and gutter	$12/sf	Replace to same level of service as existing; includes all agg base, resurfacing, formwork, striping, inductor loops, etc.
Sheet piling	$80/sf	Assume trapezoidal 1/4" interlocking Z-pile
Fabric, Rock, and Planting		
Geotextile	$6/sy	Assume 2' key-in either side, underlies riprap and articulated revetment
Cellular Confinement	$4/sf	Includes honeycomb material and installation with fill material, planting separate
Import and place riprap	$90/ton	12" D_{50}, angular, toe protection and local maintenance, 3' toedown, 2' thick layer, source within 12 miles
Planting – grasses and hydroseed	$12,000/ac	Includes prep work and 1st year warranty
Planting – floodplain terraces	$35,000/ac	Includes prep work and 1st year warranty. Type and density to be determined
Vegetation replacement	$500-2,500 / ac-yr	Higher during initial establishment period, lower during remaining project life
Clear & Grub	$10,000/ac	Prepare existing ground for levee fill placement, include construction footprint and staging areas
Rock for local O&M repair	$300/ton	Includes all markups – applies to emergency bank repairs
Sediment removal	$75/cy	Includes all markups – based on SCVWD records
Other Costs and Assumptions		

Item	Unit Cost	Comments / Assumptions
Periodic inspections	$10,000/yr	Includes vegetation, bridge/culvert, and channel inspections
Utilities	varies	See details by feature
Mob/Demob	5%	Approximate percentage based on construction subtotal. Assume staging areas available as shown in plans
Cultural Resources	1%	Approximate percentage based on construction subtotal
Dewater	$100,000 - $200,000	Dewatering/diversion during construction
Traffic Control	$800,000	Maintain traffic during construction at major arterials, 30-day closure assumed at secondary bridge replacements.
Contingency	varies 20%-60%	Varies by line item, based on high uncertainty
Design Phase/PED	22%	Assumes planning at ~50% complete, high complexity due to multiple project features
Construction Inspection, S&A	15-17%	Not including contractor cost
Federal Share	50%-65%	Not including maintenance
LERRD	Varies	Based on Corps real estate appraisal, acquisition only, breakdown of abutment, utility costs, etc. for distribution to LERRDS to be determined during cost-share apportionment.
Project Life	50 yrs	Assume periodic replacement/maintenance
Interest Rate	3.75%	Subject to change according to Federal direction

3.3 Total Project Cost

Table 3.3 lists the affected bridges and utilities by alternative along with the estimated relocation cost and LERRD allocation. The utility costs in Table 3.3 were incorporated into the total project cost summary sheets shown in Tables 3.4 to 3.7.

The alternative costs presented in Tables 3.4, 3.5, and 3.6 were developed at a spreadsheet level, combining derived quantities with assumed unit costs for each line item. For Alternative 2A/d (Table 3.6, recommended plan), costs were subsequently developed to a higher level of detail using the Micro-Computer Aided Cost Estimating System (MCACES) Second Generation (MII) software. The MII costs were developed by applying current construction cost databases, drawing from local labor rates and equipment databases in assembling construction crews and productivity rates. The MII estimate applies the same quantities as the spreadsheet estimate; however, because of the additional level of detail incorporated into the results, the total cost varies somewhat from the spreadsheet-level estimate. The MII costs for Alternative 2A/d are presented as the recommended plan.

Table 3.8 shows a comparison of construction cost of each feature for the alternatives. A detailed breakdown of individual line item costs can be found in the accompanying electronic spreadsheet.

Table 3.3 Affected Utilities

Stationing	Utility Type	Owner	Cost	Alt 2A/d	Alt 2B/d	Alt 4/d	LERRD or Project Cost
STA 128+20	Storm Drain Outlet	City of Milpitas	$ -	$ -	$ -	$ -	
STA 130+20	Telephone Conduit	AT&T	$ 10,000	$ -	$ 10,000	$ 10,000	LERRD
STA 130+40	Storm Drain Outlet	City of Milpitas	$ 25,000	$ -	$ 25,000	$ 25,000	LERRD
STA 130+40 to 131+65	Bridge	City of Milpitas	$ 4,674,750	$ -	$ 4,674,750	$ 4,674,750	LERRD
STA 131+20	Telephone Conduit	AT&T	$ 10,000	$ -	$ 10,000	$ 10,000	LERRD
STA 131+60	Electrical	PG&E	$ 60,000	$ -	$ 60,000	$ 60,000	LERRD
STA 131+60 to 182+40	Sanitary Sewer System	City of Milpitas	$ 15,000	$ 11,250	$ 11,250	$ 11,250	LERRD
STA 131+70	Storm Drain Outlet	City of Milpitas	$ 25,000	$ -	$ 25,000	$ 25,000	LERRD
STA 131+70	Storm Drain Outlet	City of Milpitas	$ 25,000	$ -	$ 25,000	$ 25,000	LERRD
STA 131+80	Sanitary Sewer System	City of Milpitas	$ 10,000	$ -	$ 10,000	$ 10,000	LERRD
STA 131+80 to133+40	Electrical	PG&E	$ 60,000	$ -	$ 60,000	$ 60,000	LERRD
STA 132+00 to 138+00	Electrical	PG&E	$ 78,000	$ 58,500	$ 58,500	$ 58,500	LERRD
STA 133+50	Storm Drain Outlet	City of Milpitas	$ 42,000	$ 42,000	$ 42,000	$ 42,000	LERRD
STA 134+80	Sanitary Sewer System	City of Milpitas	$ 10,000	$ 7,500	$ 7,500	$ 7,500	LERRD
STA 137+00	Cable	Comcast	$ 30,000	$ 22,500	$ 22,500	$ 22,500	LERRD
STA 137+00	Storm Drain Outlet	City of Milpitas	$ 30,000	$ 30,000	$ 30,000	$ 30,000	LERRD
STA 137+20	Sanitary Sewer System	City of Milpitas	$ 10,000	$ 7,500	$ 7,500	$ 7,500	LERRD
STA 137+20 to 137+80	Bridge	City of Milpitas	$ 2,147,625	$ -	$ 2,147,625	$ 2,147,625	LERRD
STA 137+20 to 138+20	Electrical	PG&E	$ 60,000	$ -	$ 60,000	$ 60,000	LERRD
STA 138+60 to 143+70	Electrical	PG&E	$ 53,000	$ 39,750	$ 39,750	$ 39,750	LERRD
STA 142+40	Sanitary Sewer System	City of Milpitas	$ 10,000	$ 7,500	$ 7,500	$ 7,500	LERRD
STA 149+20 to 151+00	Electrical	PG&E	$ 62,000	$ 46,500	$ 46,500	$ 46,500	LERRD
STA 151+00	Electrical	PG&E	$ 10,000	$ 7,500	$ 7,500	$ 7,500	LERRD
STA 153+80	Sanitary Sewer System	City of Milpitas	$ 10,000	$ 7,500	$ 7,500	$ 7,500	LERRD
STA 154+00	Storm Drain Outlet	City of Milpitas	$ 9,000	$ 9,000	$ 9,000	$ 9,000	LERRD
STA 159+00 to 160+00	Telephone Conduit	AT&T	$ 36,000	$ 27,000	$ 27,000	$ 27,000	LERRD
STA 181+20 to 181+80	Electrical	PG&E	$ 15,000	$ 11,250	$ 11,250	$ 11,250	LERRD

Stationing	Utility Type	Owner	Cost	Alt 2A/d	Alt 2B/d	Alt 4/d	LERRD or Project Cost
STA 183+00	Waterline	City of Milpitas	$ 17,000	$ 12,750	$ 12,750	$ 12,750	LERRD
STA 185+40 to 189+00	Bridge	City of Milpitas	$1,464,200	$ -	$ 1,464,200	$ 1,464,200	Project
STA 197+60	Electrical	PG&E	$ 6,000	$ 4,500	$ 4,500	$ 4,500	LERRD
STA 205+80	Electrical	PG&E	$ 7,000	$ 5,250	$ 5,250	$ 5,250	LERRD
STA 206+00	Bridge	Train Bridge	$1,052,200	$ 1,052,200	$ 1,052,200	$ 1,052,200	Project
STA 208+40	Electrical	PG&E	$ 5,000	$ 3,750	$ 3,750	$ 3,750	LERRD
STA 210+30 to 211+80	Bridge	City of Milpitas	$3,041,550	$ -	$ 3,041,550	$ 3,041,550	LERRD
STA 210+60	Electrical	PG&E	$ 60,000	$ -	$ 60,000	$ 60,000	LERRD
STA 210+60	Gas	PG&E	$ 50,000	$ -	$ 50,000	$ 50,000	LERRD
STA 210+80 to 214+60	Electrical	PG&E	$ 27,000	$ 20,250	$ 20,250	$ 20,250	LERRD
STA 222+00 to 222+60	Electrical	PG&E	$ 13,000	$ 9,750	$ 9,750	$ 9,750	LERRD
STA 226+00	Storm Drain System	City of San Jose	$ 15,000	$ 15,000	$ 15,000	$ 15,000	LERRD
STA 233+00	Electrical	PG&E	$ 7,000	$ 5,250	$ 5,250	$ 5,250	LERRD
STA 236+90	Storm Drain System	City of San Jose	$ 15,000	$ -	$ 15,000	$ 15,000	LERRD
STA 239+40	Waterline	San Jose Water	$ 25,000	$ -	$ 18,750	$ 18,750	LERRD
STA 239+60	Storm Drain System	City of San Jose	$ 25,000	$ -	$ 25,000	$ 25,000	LERRD
STA 242+00 to 246+00	Cable	Comcast	$ 30,000	$ -	$ 22,500	$ 22,500	LERRD
STA 245+40	Waterline	San Jose Water	$ 20,000	$ -	$ 15,000	$ 15,000	LERRD
STA 245+80	Electrical	PG&E	$ 25,000	$ -	$ 18,750	$ 18,750	LERRD

Table 3.4 Total Project Cost Summary for Alternative 2A/d

PROJECT: Berryessa Creek Flood Control - Alt 2A/d (Alt Comparison) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) Spent Thru: 8-Mar-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	$412	$177	43.08%	$589	1.2%	$417	$180	**$597**			$442	$191	$633
09	CHANNELS & CANALS	$8,856	$1,769	19.98%	$10,625	1.2%	$8,963	$1,791	**$10,754**			$9,505	$1,899	$11,404
				-		-								
	CONSTRUCTION ESTIMATE TOTALS:	$9,268	$1,947		**$11,215**	1.2%	$9,380	$1,970	**$11,351**			$9,947	$2,090	$12,037
01	LANDS AND DAMAGES	$8,522	$2,557	30.00%	$11,079	1.2%	$8,625	$2,588	**$11,213**			$8,918	$2,675	$11,593
30	PLANNING, ENGINEERING & DESIGN	$1,390	$308	22.18%	$1,698	2.2%	$1,420	$315	**$1,736**			$1,560	$346	$1,906
31	CONSTRUCTION MANAGEMENT	$927	$139	15.01%	$1,066	2.2%	$947	$142	**$1,090**			$1,088	$163	$1,252
	PROJECT COST TOTALS:	$20,107	$4,951	24.62%	**$25,058**	1.3%	$20,373	$5,015	**$25,389**			$21,514	$5,274	$26,788

CHIEF, COST ENGINEERING, xxx
PROJECT MANAGER, xxx
CHIEF, REAL ESTATE, xxx
CHIEF, PLANNING,xxx
CHIEF, ENGINEERING, xxx
CHIEF, OPERATIONS, xxx
CHIEF, CONSTRUCTION, xxx
CHIEF, CONTRACTING,xxx
CHIEF, PM-PB, xxxx
CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:
ESTIMATED NON-FEDERAL COST:
ESTIMATED TOTAL PROJECT COST: $26,788

****** CONTRACT COST SUMMARY ******

PROJECT: Berryessa Creek Flood Control - Alt 2A/d (Alt Comparison)
LOCATION: Milpitas, CA
This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

DISTRICT: Sacramento
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 11/20/2012

Estimate Prepared: 8-Mar-12
Effective Price Level: 8-Mar-12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

FULLY FUNDED PROJECT ESTIMATE

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS	$412	$177	43.08%	$589	1.2%	$417	$180	$597	2016Q3	6.0%	$442	$191	$633
09	CHANNELS & CANALS	$8,856	$1,769	19.98%	$10,625	1.2%	$8,963	$1,791	$10,754	2016Q3	6.0%	$9,505	$1,899	$11,404
	CONSTRUCTION ESTIMATE TOTALS:	$9,268	$1,947	21.01%	**$11,215**		$9,380	$1,970	$11,351			$9,947	$2,090	$12,037
01	LANDS AND DAMAGES	$8,522	$2,557	30.00%	$11,079	1.2%	$8,625	$2,588	$11,213	2015Q1	3.4%	$8,918	$2,675	$11,593
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$139	$31	22.18%	$170	2.2%	$142	$32	$174	2015Q1	8.3%	$154	$34	$188
1.5%	Planning & Environmental Compliance	$139	$31	22.18%	$170	2.2%	$142	$32	$174	2015Q1	8.3%	$154	$34	$188
4.5%	Engineering & Design	$417	$92	22.18%	$509	2.2%	$426	$95	$521	2015Q1	8.3%	$462	$102	$564
1.5%	Engineering Tech Review ITR & VE	$139	$31	22.18%	$170	2.2%	$142	$32	$174	2015Q1	8.3%	$154	$34	$188
1.0%	Contracting & Reprographics	$93	$21	22.18%	$114	2.2%	$95	$21	$116	2015Q1	8.3%	$103	$23	$126
2.0%	Engineering During Construction	$185	$41	22.18%	$226	2.2%	$189	$42	$231	2016Q3	14.9%	$217	$48	$265
1.5%	Planning During Construction	$139	$31	22.18%	$170	2.2%	$142	$32	$174	2016Q3	14.9%	$163	$36	$199
1.5%	Project Operations	$139	$31	22.18%	$170	2.2%	$142	$32	$174	2015Q1	8.3%	$154	$34	$188
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$649	$97	15.01%	$746	2.2%	$663	$100	$763	2016Q3	14.9%	$762	$114	$876
1.5%	Project Operation:	$139	$21	15%	$160	2.2%	$142	$21	$163	2016Q3	14.9%	$163	$24	$188
1.5%	Project Management	$139	$21	15%	$160	2.2%	$142	$21	$163	2016Q3	14.9%	$163	$24	$188
	CONTRACT COST TOTALS:	$20,107	$4,951		**$25,058**		$20,373	$5,015	$25,389			$21,514	$5,274	**$26,788**

Table 3.5 Total Project Cost Summary for Alternative 2B/d

PROJECT: Berryessa Creek Flood Control - Alt 2B/d (Alt Comparison) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) Spent Thru: 8-Mar-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	$10,786	$6,497	60.24%	$17,283	1.2%	$10,917	$6,576	**$17,493**			$11,577	$6,974	$18,550
09	CHANNELS & CANALS	$15,261	$3,681	24.12%	$18,942	1.2%	$15,446	$3,726	**$19,171**			$16,380	$3,951	$20,331
			-			-								
	CONSTRUCTION ESTIMATE TOTALS:	$26,047	$10,178		**$36,225**	1.2%	$26,362	$10,302	**$36,664**			$27,957	$10,925	$38,881
01	LANDS AND DAMAGES	$12,605	$3,782	30.00%	$16,387	1.2%	$12,758	$3,827	**$16,585**			$13,190	$3,957	$17,147
30	PLANNING, ENGINEERING & DESIGN	$3,908	$867	22.18%	$4,775	2.2%	$3,994	$886	**$4,880**			$4,387	$973	$5,360
31	CONSTRUCTION MANAGEMENT	$2,605	$441	16.93%	$3,046	2.2%	$2,662	$451	**$3,113**			$3,058	$518	$3,576
	PROJECT COST TOTALS:	$45,165	$15,268	33.80%	**$60,433**	1.3%	$45,776	$15,466	**$61,241**			$48,592	$16,372	$64,964

CHIEF, COST ENGINEERING, xxx
PROJECT MANAGER, xxx
CHIEF, REAL ESTATE, xxx
CHIEF, PLANNING,xxx
CHIEF, ENGINEERING, xxx
CHIEF, OPERATIONS, xxx
CHIEF, CONSTRUCTION, xxx
CHIEF, CONTRACTING,xxx
CHIEF, PM-PB, xxxx
CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:
ESTIMATED NON-FEDERAL COST:
ESTIMATED TOTAL PROJECT COST: $64,964

****** CONTRACT COST SUMMARY ******

PROJECT: Berryessa Creek Flood Control - Alt 2B/d (Alt Comparison) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx
This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Estimate Prepared: 8-Mar-12
Effective Price Level: 8-Mar-12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	RISK BASED COST ($K)	RISK BASED CNTG ($K)	RISK BASED CNTG (%)	RISK BASED TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS	$10,786	$6,497	60.24%	$17,283	1.2%	$10,917	$6,576	$17,493	2016Q3	6.0%	$11,577	$6,974	$18,550
09	CHANNELS & CANALS	$15,261	$3,681	24.12%	$18,942	1.2%	$15,446	$3,726	$19,171	2016Q3	6.0%	$16,380	$3,951	$20,331
	CONSTRUCTION ESTIMATE TOTALS:	$26,047	$10,178	39.08%	**$36,225**		$26,362	$10,302	$36,664			$27,957	$10,925	$38,881
01	LANDS AND DAMAGES	$12,605	$3,782	30.00%	$16,387	1.2%	$12,758	$3,827	$16,585	2015Q1	3.4%	$13,190	$3,957	$17,147
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$391	$87	22.18%	$478	2.2%	$400	$89	$488	2015Q1	8.3%	$433	$96	$529
1.5%	Planning & Environmental Compliance	$391	$87	22.18%	$478	2.2%	$400	$89	$488	2015Q1	8.3%	$433	$96	$529
4.5%	Engineering & Design	$1,172	$260	22.18%	$1,432	2.2%	$1,198	$266	$1,463	2015Q1	8.3%	$1,297	$288	$1,585
1.5%	Engineering Tech Review ITR & VE	$391	$87	22.18%	$478	2.2%	$400	$89	$488	2015Q1	8.3%	$433	$96	$529
1.0%	Contracting & Reprographics	$260	$58	22.18%	$318	2.2%	$266	$59	$325	2015Q1	8.3%	$288	$64	$352
2.0%	Engineering During Construction	$521	$116	22.18%	$637	2.2%	$532	$118	$651	2016Q3	14.9%	$612	$136	$747
1.5%	Planning During Construction	$391	$87	22.18%	$478	2.2%	$400	$89	$488	2016Q3	14.9%	$459	$102	$561
1.5%	Project Operations	$391	$87	22.18%	$478	2.2%	$400	$89	$488	2015Q1	8.3%	$433	$96	$529
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$1,823	$309	16.93%	$2,132	2.2%	$1,863	$315	$2,178	2016Q3	14.9%	$2,140	$362	$2,502
1.5%	Project Operation:	$391	$66	17%	$457	2.2%	$400	$68	$467	2016Q3	14.9%	$459	$78	$537
1.5%	Project Management	$391	$66	17%	$457	2.2%	$400	$68	$467	2016Q3	14.9%	$459	$78	$537
	CONTRACT COST TOTALS:	$45,165	$15,268		**$60,433**		$45,776	$15,466	$61,241			$48,592	$16,372	**$64,964**

Table 3.6 Total Project Cost Summary for Alternative 4/d

PROJECT: Berryessa Creek Flood Control - Alt 4/d (Alt Comparison) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) Spent Thru: 8-Mar-12 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
02	RELOCATIONS	$10,786	$6,497	60.24%	$17,283	1.2%	$10,917	$6,576	**$17,493**			$11,577	$6,974	$18,550
09	CHANNELS & CANALS	$34,947	$11,141	31.88%	$46,088	1.2%	$35,370	$11,276	**$46,646**			$37,509	$11,958	$49,467
			-			-								
	CONSTRUCTION ESTIMATE TOTALS:	$45,733	$17,639		**$63,372**	1.2%	$46,287	$17,852	**$64,139**			$49,086	$18,932	$68,017
01	LANDS AND DAMAGES	$12,450	$3,735	30.00%	$16,185	1.2%	$12,601	$3,780	**$16,381**			$13,028	$3,908	$16,936
30	PLANNING, ENGINEERING & DESIGN	$6,860	$1,522	22.18%	$8,382	2.2%	$7,010	$1,555	**$8,565**			$7,701	$1,708	$9,409
31	CONSTRUCTION MANAGEMENT	$4,573	$774	16.93%	$5,347	2.2%	$4,673	$791	**$5,464**			$5,369	$909	$6,277
	PROJECT COST TOTALS:	$69,616	$23,669	34.00%	**$93,285**	1.4%	$70,571	$23,979	**$94,550**			$75,183	$25,457	$100,640

CHIEF, COST ENGINEERING, xxx
PROJECT MANAGER, xxx
CHIEF, REAL ESTATE, xxx
CHIEF, PLANNING,xxx
CHIEF, ENGINEERING, xxx
CHIEF, OPERATIONS, xxx
CHIEF, CONSTRUCTION, xxx
CHIEF, CONTRACTING,xxx
CHIEF, PM-PB, xxxx
CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:
ESTIMATED NON-FEDERAL COST:
ESTIMATED TOTAL PROJECT COST: $100,640

****** CONTRACT COST SUMMARY ******

PROJECT: Berryessa Creek Flood Control - Alt 4/d (Alt Comparison) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx
This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Estimate Prepared: 8-Mar-12
Effective Price Level: 8-Mar-12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	RISK BASED COST ($K)	RISK BASED CNTG ($K)	RISK BASED CNTG (%)	RISK BASED TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	FULLY FUNDED PROJECT ESTIMATE Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS	$10,786	$6,497	60.24%	$17,283	1.2%	$10,917	$6,576	$17,493	2016Q3	6.0%	$11,577	$6,974	$18,550
09	CHANNELS & CANALS	$34,947	$11,141	31.88%	$46,088	1.2%	$35,370	$11,276	$46,646	2016Q3	6.0%	$37,509	$11,958	$49,467
	CONSTRUCTION ESTIMATE TOTALS:	$45,733	$17,639	38.57%	**$63,372**		$46,287	$17,852	$64,139			$49,086	$18,932	$68,017
01	LANDS & DAMAGES, SEVRNC, ADMIN	$12,450	$3,735	30.00%	$16,185	1.2%	$12,601	$3,780	$16,381	2015Q1	3.4%	$13,028	$3,908	$16,936
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$686	$152	22.18%	$838	2.2%	$701	$155	$857	2015Q1	8.3%	$759	$168	$928
1.5%	Planning & Environmental Compliance	$686	$152	22.18%	$838	2.2%	$701	$155	$857	2015Q1	8.3%	$759	$168	$928
4.5%	Engineering & Design	$2,058	$456	22.18%	$2,514	2.2%	$2,103	$466	$2,570	2015Q1	8.3%	$2,278	$505	$2,783
1.5%	Engineering Tech Review ITR & VE	$686	$152	22.18%	$838	2.2%	$701	$155	$857	2015Q1	8.3%	$759	$168	$928
1.0%	Contracting & Reprographics	$457	$101	22.18%	$558	2.2%	$467	$104	$571	2015Q1	8.3%	$506	$112	$618
2.0%	Engineering During Construction	$915	$203	22.18%	$1,118	2.2%	$935	$207	$1,142	2016Q3	14.9%	$1,074	$238	$1,312
1.5%	Planning During Construction	$686	$152	22.18%	$838	2.2%	$701	$155	$857	2016Q3	14.9%	$805	$179	$984
1.5%	Project Operations	$686	$152	22.18%	$838	2.2%	$701	$155	$857	2015Q1	8.3%	$759	$168	$928
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$3,201	$542	16.93%	$3,743	2.2%	$3,271	$554	$3,825	2016Q3	14.9%	$3,758	$636	$4,394
1.5%	Project Operation:	$686	$116	17%	$802	2.2%	$701	$119	$820	2016Q3	14.9%	$805	$136	$942
1.5%	Project Management	$686	$116	17%	$802	2.2%	$701	$119	$820	2016Q3	14.9%	$805	$136	$942
	CONTRACT COST TOTALS:	$69,616	$23,669		**$93,285**		$70,571	$23,979	$94,550			$75,183	$25,457	**$100,640**

Table 3.7 Total Project Cost Summary for Alternative 2A/d (Recommended Plan)

PROJECT: Berryessa Creek Flood Control - Alt 2A/d (Recommended Plan) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) Spent Thru: 8-Mar-12 ($K)	COST ($K)	CNTG ($K)	FULL ($K)
A	B	C	D	E	F	G	H	I	J	K	M	N	O
02	RELOCATIONS	$555	$228	41.08%	$783	1.2%	$562	$231	**$792**		$596	$245	$840
09	CHANNELS & CANALS	$8,596	$1,793	20.86%	$10,389	1.2%	$8,700	$1,815	**$10,515**		$9,226	$1,925	$11,151
			-			-							
	CONSTRUCTION ESTIMATE TOTALS:	$9,151	$2,021		**$11,172**	1.2%	$9,262	$2,046	**$11,307**		$9,822	$2,169	$11,991
01	LANDS AND DAMAGES	$8,522	$2,557	30.00%	$11,079	1.2%	$8,625	$2,588	**$11,213**		$8,918	$2,675	$11,593
30	PLANNING, ENGINEERING & DESIGN	$1,372	$277	20.18%	$1,649	2.2%	$1,402	$283	**$1,685**		$1,540	$311	$1,851
31	CONSTRUCTION MANAGEMENT	$915	$119	13.01%	$1,034	2.2%	$935	$122	**$1,057**		$1,074	$140	$1,214
	PROJECT COST TOTALS:	$19,960	$4,974	24.92%	**$24,934**	1.3%	$20,224	$5,095	**$25,262**		$21,354	$5,295	$26,649

CHIEF, COST ENGINEERING, xxx
PROJECT MANAGER, xxx
CHIEF, REAL ESTATE, xxx
CHIEF, PLANNING,xxx
CHIEF, ENGINEERING, xxx
CHIEF, OPERATIONS, xxx
CHIEF, CONSTRUCTION, xxx
CHIEF, CONTRACTING,xxx
CHIEF, PM-PB, xxxx
CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:
ESTIMATED NON-FEDERAL COST:
ESTIMATED TOTAL PROJECT COST: $26,649

****** CONTRACT COST SUMMARY ******

PROJECT: Berryessa Creek Flood Control - Alt 2A/d (Recommended Plan) DISTRICT: Sacramento PREPARED: 11/20/2012
LOCATION: Milpitas, CA POC: CHIEF, COST ENGINEERING, xxx
This Estimate reflects the scope and schedule in report; Berryessa Creek Project GRR

Estimate Prepared: 8-Mar-12
Effective Price Level: 8-Mar-12

Program Year (Budget EC): 2013
Effective Price Level Date: 1 OCT 12

WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
		RISK BASED								FULLY FUNDED PROJECT ESTIMATE				
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS	$555	$228	41.08%	$783	1.2%	$562	$231	$792	2016Q3	6.0%	$596	$245	$840
09	CHANNELS & CANALS	$8,596	$1,793	20.86%	$10,389	1.2%	$8,700	$1,815	$10,515	2016Q3	6.0%	$9,226	$1,925	$11,151
	CONSTRUCTION ESTIMATE TOTALS:	$9,151	$2,021	22.09%	**$11,172**		$9,262	$2,046	$11,307			$9,822	$2,169	$11,991
01	LANDS AND DAMAGES	$8,522	$2,557	30.00%	$11,079	1.2%	$8,625	$2,588	$11,213	2015Q1	3.4%	$8,918	$2,675	$11,593
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$137	$28	20.18%	$165	2.2%	$140	$28	$168	2015Q1	8.3%	$152	$31	$182
1.5%	Planning & Environmental Compliance	$137	$28	20.18%	$165	2.2%	$140	$28	$168	2015Q1	8.3%	$152	$31	$182
4.5%	Engineering & Design	$412	$83	20.18%	$495	2.2%	$421	$85	$506	2015Q1	8.3%	$456	$92	$548
1.5%	Engineering Tech Review ITR & VE	$137	$28	20.18%	$165	2.2%	$140	$28	$168	2015Q1	8.3%	$152	$31	$182
1.0%	Contracting & Reprographics	$92	$19	20.18%	$111	2.2%	$94	$19	$113	2015Q1	8.3%	$102	$21	$122
2.0%	Engineering During Construction	$183	$37	20.18%	$220	2.2%	$187	$38	$225	2016Q3	14.9%	$215	$43	$258
1.5%	Planning During Construction	$137	$28	20.18%	$165	2.2%	$140	$28	$168	2016Q3	14.9%	$161	$32	$193
1.5%	Project Operations	$137	$28	20.18%	$165	2.2%	$140	$28	$168	2015Q1	8.3%	$152	$31	$182
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$641	$83	13.01%	$724	2.2%	$655	$85	$740	2016Q3	14.9%	$753	$98	$850
1.5%	Project Operation:	$137	$18	13%	$155	2.2%	$140	$18	$158	2016Q3	14.9%	$161	$21	$182
1.5%	Project Management	$137	$18	13%	$155	2.2%	$140	$18	$158	2016Q3	14.9%	$161	$21	$182
	CONTRACT COST TOTALS:	$19,960	$4,974		**$24,934**		$20,224	$5,038	$25,262			$21,354	$5,295	**$26,649**

Table 3.8 Feature Cost Summary for Project Alternatives

Berryessa Creek Project Cost Summary

Reach/Structure	Type	Alternative 2A/d		Alternative 2B/d		Alternative 4/d		Alternative 5/d		Alternative 5	
		Line Item	Reach Total	Line Item	Reach Total	Line Item	Reach Total	Line Item	Reach Total	Line Item	Reach Total
Project features upstream of I-680										$ 8,114,360	
General Items		$1,254,000		$2,848,000		$3,885,000		$ 1,729,771		$ 1,729,771	
I-680	Bridge	$ 3,075		$ 3,075		$ 3,075		$ 1,490		$ 1,490	
I-680 to Montague	Channel	$1,248,620		$3,361,671		$9,027,685		$ 4,390,703		$ 4,390,703	
Montague Expressway	Bridge	$ 3,750		$3,041,550		$3,041,550		$ 1,040,751		$ 1,040,751	
Montague to UPRR Trestle	Channel	$ 232,630		$ 248,306		$1,144,325		$ 510,359		$ 510,359	
Railroad Trestle	Bridge	$1,052,200		$1,052,200		$1,052,200		$ 1,190,522		$ 1,190,522	
UPRR Trestle to Culvert	Channel	$ 741,935		$ 739,223		$4,867,625		$ 2,324,973		$ 2,324,973	
Railroad Culvert	Bridge	$ 1,500		$1,464,200		$1,464,200		$ 105,750		$ 105,750	
UPRR Culvert to Ames	Channel	$ 174,300	$ 9,267,645	$ 200,257	$ 26,066,195	$1,037,800	$ 45,752,885	$ 503,879	$ 17,775,316	$ 503,879	$ 25,889,676
Ames	Bridge	$ 210,500		$ 216,500		$ 216,500		$ 120,750		$ 120,750	
Ames to Yosemite	Channel	$ 469,130		$ 580,998		$3,012,850		$ 1,474,873		$ 1,474,873	
Yosemite	Bridge	$ 210,500		$ 216,500		$ 216,500		$ 120,750		$ 120,750	
Yosemite to Los Coches	Channel	$2,758,930		$3,992,742		$8,068,200		$ 3,086,919		$ 3,086,919	
Los Coches	Bridge	$ 1,875		$2,147,625		$2,147,625		$ 112,380		$ 112,380	
Los Coches to Calaveras	Channel	$ 827,215		$1,169,323		$1,713,275		$ 645,696		$ 645,696	
Calaveras Blvd	Bridge	$ 3,750		$4,674,750		$4,674,750		$ 110,750		$ 110,750	
Downstream of Calaveras	Channel	$ 73,735		$ 109,275		$ 179,725		$ 305,000		$ 305,000	
Channels and Canals (including contingencies)			$ 10,625,303		$ 18,941,357		$ 46,088,381		$ 18,780,663		$ 29,769,604
Relocations (including contingencies)			$ 589,132		$ 17,282,966		$ 17,282,966		$ 2,398,322		$ 5,110,967
Design/PED (including contingencies)			$ 1,698,481		$ 4,773,486		$ 8,381,466		$ 2,941,148		$ 4,745,282
CM/SI/SA (including contingencies)			$ 1,065,779		$ 3,045,582		$ 5,347,546		$ 1,875,724		$ 3,026,798
Real Estate (acquisitions, investigations, including contingencies)			$ 11,078,000		$ 16,386,900		$ 16,184,900		$ 39,560,000		$ 48,269,800
Total First Cost (including all markups)			$ 25,056,695		$ 60,430,291		$ 93,285,258		$ 65,555,858		$ 90,922,451
Fully Funded Total Project Cost (including escalation)			$ 26,786,609		$ 64,962,562		$100,639,868		$ 70,472,547		$ 97,741,635
Total Present Value (including O&M)			$ 28,200,843		$ 66,725,894		$102,640,904		$ 71,909,215		$100,614,971
Key:											
Channel Reach											
Bridge or Structure											

CHAPTER 4: INCIDENTAL RECREATION FEATURES

4.1 Features

While the Berryessa Creek project is a flood control project in terms of the project purpose and justification, the constructed features may also provide some opportunity to achieve incidental recreational benefits. The 15-foot wide obstruction-free zone provides access for maintenance, inspection, and flood-fighting purposes along both sides of the channel throughout the entire project reach. The obstruction-free zone must be kept free of vegetation and any other obstructions per Corps requirements for levees and floodwalls; however, some recreational use may be accommodated within the obstruction-free zone without hindering the primary purposes.

The quantities and cost estimates in Chapters 2 and 3 of this appendix assume the roadway in the obstruction-free zone is surfaced with compacted backfill, in-situ material, or coarse aggregate. A review of the City of Milpitas' Master Trail Plan (Sokale/Landry Collaborative 1997) was conducted to determine the feasibility of locating a multi-use recreation trail within the obstruction-free zone. The City of Milpitas was consulted in comparing the project features in the current design with the Master Plan criteria, and it was determined that additional paving would be required to allow the obstruction-free zone to serve as a recreational trail and meet American Disability Act (ADA) requirements and City of Milpitas design criteria.

While the Master Plan generally recommends that a trail easement should include a 25-foot buffer between the trail and adjoining parcels, the 15-foot wide obstruction-free zone in the current design is bounded intermittently along the project reach by buildings, roadways, and other infrastructure that would preclude the presence of a buffer zone. While not optimal, a City of Milpitas representative has stated that the current design widths will be adequate to meet the minimum standards of a recreational trail.

Only the routes on the upper channel banks are being considered for the multi-use recreational trail; the in-channel maintenance roads will not be utilized as the ramps would not necessarily provide ADA compliance; as such, undercrossings and stream access points are not being considered as incremental recreational features. It is anticipated that pedestrians users of the recreational trails would utilize existing at-grade street crossings; due to the proximity of the project alignment to the Milpitas Boulevard intersections, the installation of an additional pedestrian or bicycle crossing with signaling, striping, and other requirements, is not considered feasible, particularly for the high traffic-volume routes such at Montague and Calaveras. Because there is currently no undercrossing at the I-680 Bridge, the proposed recreational trail extends only between Calaveras Boulevard and the Montague Expressway. Future improvements by others may connect the obstruction-free zones to the existing pedestrian bridge at I-680, allowing this reach to include a recreational trail; however, these features are considered beyond the scope of the current project.

The Master Plan cites that identity signs, use signs, safety signs, private property signs, interpretive and protective signs, and regional signs should be used to mark trails; however, the 15-foot obstruction-free zone must be free of any structures, which includes signage that might encroach on the available width. While some safety signage may be required by the project regardless of recreational use (near floodwalls, bridge crossings, or hydraulic structures, for example), any additional signage would need to be implemented by the non-Federal agency and would need to be placed in locations outside of the obstruction free-zone. The current cost estimate for recreational features assumes signage is located at each access point where the trail meets one of the roadway crossings. Benches are also included at the access points and would likewise need to be located outside of the primary access route. Safety fencing is included in the project costs where vertical concrete walls are present; however, these costs are not considered part of the recreational features as they would be required with or without a multi-use trail. It is assumed that access along Berryessa Creek would remain open as at present; supplemental safety fencing is not provided along the top of the sloping earthen channel banks as part of the project or recreational features.

Due to the limitations of the project area's obstruction-free zone for providing permanent facilities to trail users, existing regional staging areas (e.g., parks and public recreation facilities) should be utilized to provide potable and non-potable water and sanitary facilities. The 2-mile project reach allows these facilities to be located beyond the extents of the project while still meeting the Master Plan requirement of a 5-mile maximum spacing.

Several features that are typically recommended in conjunction with recreational trails in the Master Plan are not considered incidental recreational benefits for the flood control project; non-incidental features are outside of the authorized project purpose. Adding this purpose to the Authorized Project would require additional authority from Congress, which would require a potentially lengthy approval process. These features could, however, be added to the project as non-Federally funded betterments without additional Congressional authority.

The plan view in Sheet R-1 following this appendix depicts the location of proposed incidental recreational features relative to the project area.

4.2 Quantities

As shown in the attached plan view, the incidental recreational features include twenty access points, each with two benches and two signs. In addition, the obstruction-free zone includes 244,000 square feet of surface area that would need to be paved in order to meet the requirements listed above. Since the multi-use trail would also be used by equipment for sediment removal and other maintenance purposes, the pavement would need to meet strength and durability requirements for heavy equipment access, including cranes, dump trucks, and excavators. An additional base course of 4 inches is assumed, along with a 4-inch thick asphalt section.

4.3 Costs

The total incremental cost of the recreation items is $1,626,000. This cost includes contingency but does not include costs for the PED phase or construction management.

4.4 Justification

Berryessa Creek runs through the cities of Milpitas and San Jose in Santa Clara County, California. The population of Milpitas and San Jose is 67,476 and 958,789, respectively (source: California Department of Finance, E-1 May 2011.) According to the 2000 Census data, there are over 60,000 residents within one mile of the trail. Expected recreational usage would likely be similar to the current recreational use of the project downstream of Calaveras Boulevard. The study area is located in an urbanized alluvial plain that includes primarily commercial and industrial land uses with a small residential development located adjacent to Los Coches Street; the heaviest usage of the trail would be expected in the vicinity of this residential development.

Construction of recreation features as part of the Corps project will be dependent upon completion of a third-party agreement between SCVWD and the City of Milpitas regarding funding and maintenance of the recreation features.

CHAPTER 5: CONCLUSIONS

This part of the engineering appendix (*Appendix B, Part IV: Design and Cost of Alternatives*) presents the basis of civil design and cost parameters for the Upper Berryessa Creek Project. Assumptions underlying the cost estimate are presented, including estimated construction quantities and unit costs.

- *Quantities*. Construction quantities are based on the required measures for conveying the given flow profiles within cross sectional templates that vary by alternative.

- *Unit Costs*. Unit costs for the MII estimate are based on the MCACES 2010 English Unit Cost Library, 2013 Santa Clara County Labor Library, the 2011 Equipment Library (Region VII), and individual vendor quotations.

Berryessa Creek Project

Santa Clara County, California

Appendix B

Engineering and Design

Part IV: Design and Cost of Alternatives - Geotechnical Evaluation

TETRA TECH

FEBRUARY 2013

BERRYESSA CREEK PROJECT
APPENDIX B, Part IV: Design and Cost of Alternative - Geotechnical Evaluation

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2.0 GEOLOGIC CONDITIONS 1
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4.0 SEISMIC CONDITIONS 2
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7.0 CHANNEL/BASIN SLOPES 3
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1.0 INTRODUCTION

Geologic and geotechnical conditions along the Berryessa Creek Project alignment between Calaveras Boulevard and Old Piedmont Road were summarized in the Geotechnical Office Report prepared by Parikh Consultants, Inc. (Parikh Consultants 2004). The report included data from several previous geotechnical and environmental studies performed along or adjacent to the creek alignment. A total of 70 boring logs were compiled in the Parikh report. Although many of the borings do not include data that would be necessary for final design of the project, the number and depth of the existing borings are considered adequate for feasibility-level design purposes. The preliminary geotechnical assessment did not encounter geotechnical or geologic factors that would preclude successful completion of this project, however, there are a number of issues that will need to be considered and addressed in the final design.

2.0 GEOLOGIC CONDITIONS

Several different soil units were identified along the creek alignment and included:

- Basin Deposits (Holocene) – Composed predominantly of clays and silty clays
- Young Alluvial Fan Deposits (Holocene) – Composed of gravelly sand and sandy and clayey gravel near the fan heads and upstream, grading to sandy and silty clay within downstream reaches.
- Older Alluvial Fan Deposits (Holocene) – Composed of gravelly sand and sandy and clayey gravel near the fan heads and upstream, grading to sandy and silty clay within downstream reaches.
- Alluvial Fan Deposits (Upper Pleistocene) – Composed of gravel and cobbles with clayey and sandy matrix.

The report by Parikh Consultants (2004) describes the Hayward Fault as being 1.2 miles from the project site, however the State of California maps active faulting closer to the eastern limits of the project (CDMG 1982). It should be noted that immediately east of the project alignment (east of Old Piedmont Road) is hilly terrain that has been impacted by both faulting and landslides. The Berryessa Formation (composed of mudstone, sandstone, and conglomerate) is mapped in this area; however, the geology has been significantly disturbed by northwest-southeast trending faulting associated with the Hayward Fault Zone. Numerous southwest trending landslides have developed in the terrain. The current project limits for Berryessa Creek do not extend into the faulting and landslide areas, however, any future project development east of Old Piedmont Road (e.g., upstream detention basins) needs to consider the impacts of both active faulting and landslides.

3.0 GROUNDWATER CONDITIONS

Groundwater was encountered in many of the borings within the most downstream section of the creek alignment (Calaveras Boulevard to Montague Expressway) at depths varying from approximately 8 to 12 feet below existing grade. In the vicinity of I-680 groundwater was encountered at a depth of greater than 30 feet below existing grade. Within the upper portion of the creek alignment (upstream of I-680) groundwater was not noted in any of the exploratory borings presented in the Parikh report except for one boring upstream of Old Piedmont Road where groundwater was encountered approximately 17 feet below existing grade. The Parikh report did note that groundwater levels could vary in the future due to seasonal groundwater fluctuations, water elevation in the creek, surface run-off, and other hydrologic conditions.

4.0 SEISMIC CONDITIONS

The Parikh report estimated a potential for high seismic activity for the project alignment (peak bedrock acceleration of 0.7). Design of floodwalls, channel walls, bridges and levees will need to incorporate the appropriate seismic factors to account for this high potential for seismic activity. Depending on the results of pseudo-static analysis of structures and levees, more extensive dynamic analysis may be needed to evaluate potential deformation.

The Parikh report did recognize that deposits of loose to medium dense sands and silty sands encountered within the creek alignment may be susceptible to liquefaction. These deposits were predominantly encountered in the upstream portion of the creek. The overall liquefaction potential was preliminarily judged by the Parikh report to be low because of the discontinuous nature of the liquefaction-susceptible soils and the lack of high groundwater in the areas that they were encountered. However, further investigation and groundwater monitoring was recommended during the final design phase of the project. If a higher degree of liquefaction is identified, then the effects of seismic settlement and lateral spread on structures and levees will need to be considered.

5.0 STRUCTURE FOUNDATIONS

Structures for this project may include floodwalls, vertical channel walls, culverts, and bridge crossings. Due to the significant variability of soil conditions along the creek alignment, it is anticipated that each structure will require site specific foundation design. Foundation support for bridge replacements will likely require deep pile foundations. Culverts and low to medium height wall structures can likely be supported on grade, although removal and re-compaction of existing subgrade soils may be necessary. Higher walls (>10 feet height) may require pile foundation support depending on their location along the alignment. Where significant retained soil heights are required (channel walls), importing of select granular backfill may be preferable over on-site clayey soils.

6.0 LEVEE EMBANKMENTS

New or raised levees should be designed and constructed in accordance with U.S. Army Corps of Engineers Manual EM 1110-2-1913 ([USACE] 2000).

Seepage analysis of the proposed levee should consider both seepage through the levee embankment and under-seepage through the foundation soils. The potential for high uplift pressures and high exit gradients near the landside toe of the levee must be evaluated, particularly where more granular foundation soils exist near the surface. If the potential for these detrimental factors exist then some form of mitigation (impermeable cutoffs, slurry trenches, relief drains) will need to be considered.
Stability analysis of levee embankments should consider the following conditions.

- End of Construction – Utilizing undrained shear strength for clayey soils
- Sudden Drawdown – Including unbalanced pore pressures within the riverside slope.
- Long-Term Seepage Conditions – Utilizing long-term or steady state seepage
- Earthquake – Utilizing pseudo-static stability analysis. If soil liquefaction is an issue, an analysis using post-liquefied strengths should also be performed. Where factors of safety are less than 1.2, a seismic deformation analysis may also be required.

Immediate and long-term settlement of new and raised levee should be performed and the impact on required freeboard be evaluated. Mitigation of settlement can be achieved by several methods including pre-loading, ground improvement, or over-building of embankments.

7.0 CHANNEL/BASIN SLOPES

Slope stability analysis should be performed on channel slopes for static, pseudo-static conditions and sudden drawdown conditions. Constructed slopes should be suitably protected against erosion from local runoff and stream flow.

8.0 FUTURE INVESTIGATION

Additional investigation and analysis will be necessary during the final design phase of the project. In some areas it is anticipated that information from existing borings will be utilized in the design, however, where specific field or laboratory test data required for analysis and design is lacking, supplemental field exploration will be necessary. A preliminary guideline for future investigation and analysis is presented in Table 1.

Table 1 Additional Investigation and Analysis

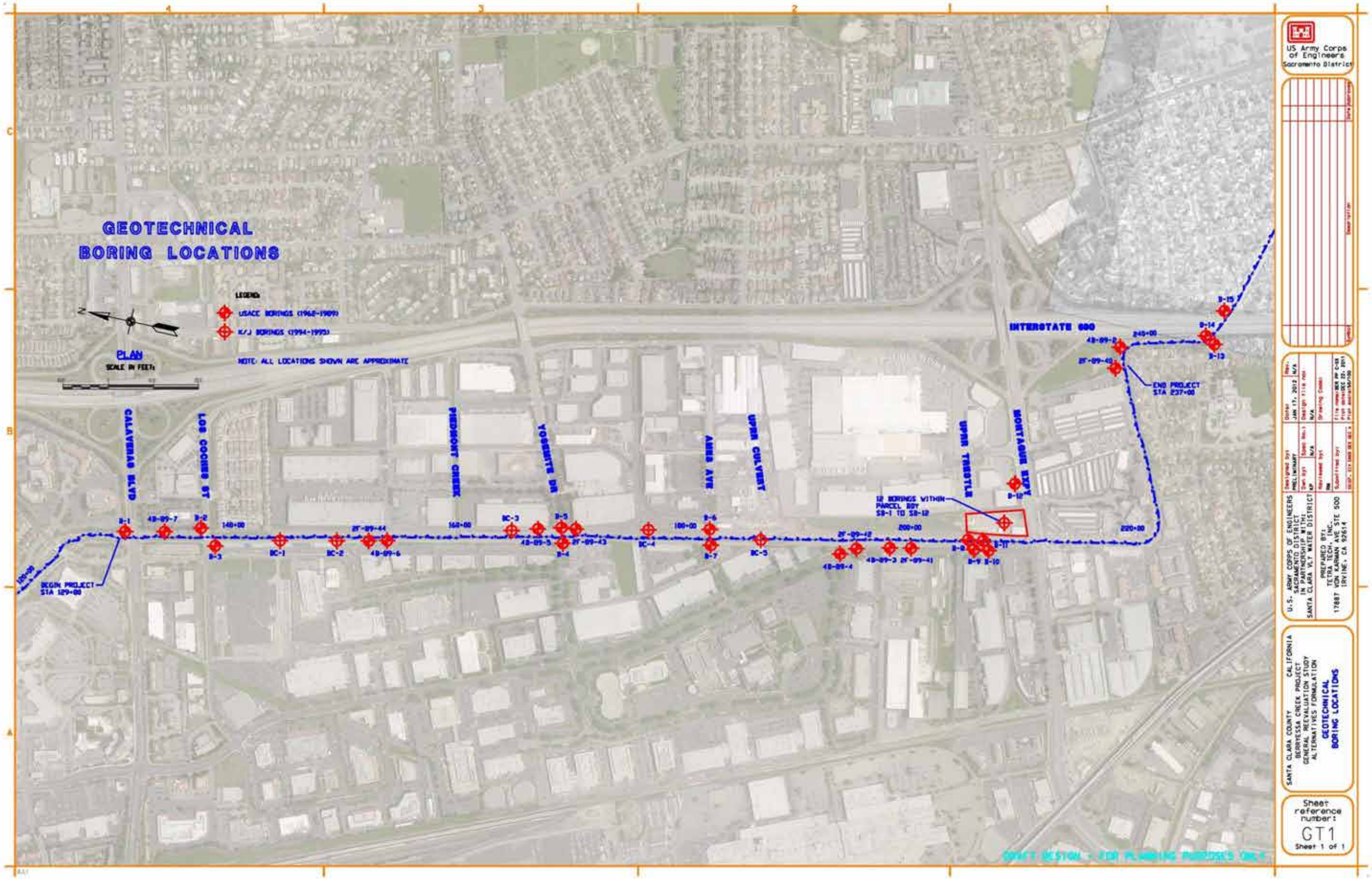
Project Components	Field Exploration	Laboratory Testing	Analyses
Levee Embankments/ Channel Slopes	Frequency: Minimum 1 boring / 500 ft. Depth: At least 3 x levee/slope height, and at least 5 feet below potentially liquefiable soils.	• Dry Density • Moisture Content • Shear Strength • Consolidation • Gradation • Permeability	• Seepage Analysis • (through seepage and under-seepage) • Slope Stability Analysis • Settlement Analysis • Scour Potential
Floodwalls/ Channel Walls	Frequency: Minimum 1 boring/500 ft. Depth: At least 3 x wall/culvert, and at least 5 feet below potentially liquefiable soils	• Dry Density • Moisture Content • Shear Strength • Consolidation • Gradation • Corrosion	• Earth Pressures • Vertical & Lateral Bearing Capacity • Settlement • Overturning/Sliding
Bridge Replacements	Frequency: 1 boring/support Depth: Typically 70 to 100 feet depending on loading conditions	• Dry Density • Moisture Content • Shear Strength • Consolidation • Gradation • Corrosion Potential	• Footing Bearing Capacity • Vertical and Lateral Pile Capacity • Earth Pressures • Seismic Design Parameters

9.0 REFERENCES

California Division of Mines and Geology (CDMG), 1982. State of California Special Studies Zone, Calaveras Reservoir. Effective January 1, 1882.

Parikh Consultants Inc., 2004. Geotechnical Office Report, Coyote and Berryless Creek, General Re-Evaluation Study for Proposed Project Modifications, Santa Clara County, California. April 2004).

United States Army Corps of Engineers (USACE), 2000. Engineers Manual EM 1110-2-1913 Design and Construction of Levees. April 30, 2000.


GEOTECHNICAL
BORING LOCATIONS
LEGEND
USACE BORINGS (1968-1989)
K/J BORINGS (1994-1995)
NOTE: ALL LOCATIONS SHOWN ARE APPROXIMATE
PLAN
SCALE IN FEET:
CALAVERAS BLVD
LOS COCHES ST
PIEDMONT CREEK
YOSEMITE DR
AVIS AVE
UPPER CULVERT
UPPER TRESTLE
MONTAGUE EXPY
INTERSTATE 880
BEGIN PROJECT
STA 129+00
END PROJECT
STA 237+00
12 BORINGS WITHIN
PARCEL BDY
SB-1 TO SB-12
B-1
49-89-7
B-2
140+00
B-3
BC-1
BC-2
25'-89-44
49-89-6
160+00
BC-3
B-5
49-89-5
25'-89-43
B-4
BC-4
100+00
B-6
B-7
BC-5
25'-89-42
49-89-4
49-89-3
25'-89-41
200+00
B-8
B-9
B-10
B-11
B-12
220+00
240+00
49-89-2
25'-89-40
B-13
B-14
B-15
DRAFT DESIGN - FOR PLANNING PURPOSES ONLY
US Army Corps of Engineers
Sacramento District
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT
PREPARED BY:
TETRA TECH, INC.
17885 VON KARMAN AVE STE 500
IRVINE, CA 92614
SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REVALUATION STUDY
ALTERNATIVES FORMULATION
GEOTECHNICAL
BORING LOCATIONS
Sheet reference number:
GT1
Sheet 1 of 1

Berryessa Creek Flood Control
Santa Clara County, CA

COST ENGINEERING REPORT
DRAFT SUBMITTAL

February 21, 2013

TETRA TECH

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Total Project Cost Summary (TPCS)……...…..……ii

Cost Estimate Narrative…….1

APPENDICES

A Site Plan
B Project Quantities and Detailed Quantity Take-Offs
C Tentative Construction Schedule
D Local Market Labor Rates
E Estimated Production Rates
F Phone Logs and Emails
G Abbreviated Cost and Schedule Risk Analysis
H MCACES Construction Cost Estimates

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Berryessa Creek Flood Control
LOCATION: Milpitas, CA

DISTRICT: Sacramento
POC: CHIEF, COST ENGINEERING, xxx

PREPARED: 2/21/2013

This Estimate reflects the scope and schedule in report; Beryessa Creek Project GRR

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
						Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: 29-Jan-13 ($K)		COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*K*	*L*	*M*	*N*	*O*
02	RELOCATIONS	$555	$125	22.51%	$680	1.3%	$562	$126	$688	$0		$587	$132	$719
09	CHANNELS & CANALS	$8,596	$1,935	22.51%	$10,531	1.3%	$8,704	$1,959	$10,663	$0		$9,095	$2,047	$11,142
14	RECREATION FACILITIES	$1,323	$298	22.51%	$1,621	1.3%	$1,339	$301	$1,641	$0		$1,400	$315	$1,715
18	CULTURAL RESOURCE PRESERVATION	$0	$0 -		$0	-	$0	$0	$0	$0		$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:	$10,474	$2,357		$12,831	1.3%	$10,605	$2,387	$12,992	$0		$11,082	$2,494	$13,576
01	LANDS AND DAMAGES	$11,078	$0	0.00%	$11,078	1.3%	$11,217	$0	$11,217	$0		$11,411	$0	$11,411
30	PLANNING, ENGINEERING & DESIGN	$1,570	$131	8.33%	$1,701	2.6%	$1,610	$134	$1,744	$0		$1,695	$141	$1,836
31	CONSTRUCTION MANAGEMENT	$1,047	$65	6.25%	$1,112	2.6%	$1,074	$67	$1,141	$0		$1,180	$74	$1,254
	PROJECT COST TOTALS:	$24,169	$2,554	11%	$26,722		$24,507	$2,588	**$27,095**	$0		$25,368	$2,709	$28,077

Mandatory by Regulation CHIEF, COST ENGINEERING, xxx

Mandatory by Regulation PROJECT MANAGER, xxx

Mandatory by Regulation CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:
ESTIMATED NON-FEDERAL COST:

ESTIMATED TOTAL PROJECT COST: **$28,077**

O&M OUTSIDE OF TOTAL PROJECT COST:

Filename: Berryess Creek_TPCS.xlsx
TPCS

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Berryessa Creek Flood Control
LOCATION: Milpitas, CA
This Estimate reflects the scope and schedule in report; Beryessa Creek Project GRR

DISTRICT: Sacramento
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 2/21/2013

Estimate Prepared: 29-Jan-13
Effective Price Level: 29-Jan-13

Program Year (Budget EC): 2014
Effective Price Level Date: 1 OCT 13

WBS Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
				RISK BASED										
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	INFLATED (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1 or CONTRACT 1													
02	RELOCATIONS	$555	$125	22.51%	$680	1.3%	$562	$126	$688	2016Q3	4.5%	$587	$132	$719
09	CHANNELS & CANALS	$8,596	$1,935	22.51%	$10,531	1.3%	$8,704	$1,959	$10,663	2016Q3	4.5%	$9,095	$2,047	$11,142
14	RECREATION FACILITIES	$1,323	$298	22.51%	$1,621	1.3%	$1,339	$301	$1,641	2016Q3	4.5%	$1,400	$315	$1,715
18	CULTURAL RESOURCE PRESERVATION	$0	$0	22.51%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
							$0							
	CONSTRUCTION ESTIMATE TOTALS:	$10,474	$2,357	22.51%	**$12,831**		$10,605	$2,387	$12,992			$11,082	$2,494	$13,576
01	LANDS AND DAMAGES	$11,078	$0	0.00%	$11,078	1.3%	$11,217	$0	$11,217	2015Q1	1.7%	$11,411	$0	$11,411
30	PLANNING, ENGINEERING & DESIGN													
1.5%	Project Management	$157	$13	8.33%	$170	2.6%	$161	$13	$174	2015Q1	3.8%	$167	$14	$181
1.5%	Planning & Environmental Compliance	$157	$13	8.33%	$170	2.6%	$161	$13	$174	2015Q1	3.8%	$167	$14	$181
4.5%	Engineering & Design	$471	$39	8.33%	$510	2.6%	$483	$40	$523	2015Q1	3.8%	$502	$42	$543
1.5%	Engineering Tech Review ITR & VE	$157	$13	8.33%	$170	2.6%	$161	$13	$174	2015Q1	3.8%	$167	$14	$181
1.0%	Contracting & Reprographics	$105	$9	8.33%	$114	2.6%	$108	$9	$117	2015Q1	3.8%	$112	$9	$121
2.0%	Engineering During Construction	$209	$17	8.33%	$226	2.6%	$214	$18	$232	2016Q3	9.9%	$236	$20	$255
1.5%	Planning During Construction	$157	$13	8.33%	$170	2.6%	$161	$13	$174	2016Q3	9.9%	$177	$15	$192
1.5%	Project Operations	$157	$13	8.33%	$170	2.6%	$161	$13	$174	2015Q1	3.8%	$167	$14	$181
31	CONSTRUCTION MANAGEMENT													
7.0%	Construction Management	$733	$46	6.25%	$779	2.6%	$752	$47	$799	2016Q3	9.9%	$826	$52	$878
1.5%	Project Operation:	$157	$10	6.25%	$167	2.6%	$161	$10	$171	2016Q3	9.9%	$177	$11	$188
1.5%	Project Management	$157	$10	6.25%	$167	2.6%	$161	$10	$171	2016Q3	9.9%	$177	$11	$188
	CONTRACT COST TOTALS:	$24,169	$2,554		**$26,722**		$24,507	$2,588	$27,095			$25,368	$2,709	**$28,077**

BERRYESSA CREEK FLOOD CONTROL

COST ESTIMATE NARRATIVE

1. Project Description

A. General: This work is in support of the conceptual design of flood control improvements along a section of Berryessa Creek that runs through San Jose and Milpitas, CA. The construction would consist of modifying the channel downstream of the I-680 Bridge to consist of an earthen trapezoidal shape. Earthen levees would also be constructed and the levees are designed to contain the 0.01 exceedance probability event discharges.

B. Purpose: The purpose of this work is to develop detailed cost estimates – consistent to the level of design – for the cost and quantities of the construction features using Micro-Computer Aided Cost Estimating System (MCACES).

C. Design Features: Construction features include earthwork; riprap; geotextile and cellular confinement systems; cast-in-place concrete, demolition and replacement of railroad; sheet piling; seeding; and roadway surfacing.

2. Basis of Estimate

a. Basis of Design: Available design documents of the project elements are listed below. The project site plan is presented in Appendix A.

- Berryessa Creek Project, Draft General Reevaluation Report and Environmental Impact Statement, Prepared by Tetra Tech, October, 2011
- Berryessa Creek Project General Reevaluation Study, Plan and Profile Drawings, Prepared by Tetra Tech

A. Basis of Quantities: The cost estimate is based on project quantity take-offs that have been calculated from the documents listed above. A quantity summary along with detailed quantity take-offs are presented in Appendix B. The detailed quantities include waste/loss factors for the project materials as listed below:

Soil Swell/Shrinkage Factor	15%
Riprap Overplace	15%
Geotextile Fabric Waste	5%
Concrete Overplace	10%
Asphalt Overplace	10%

3. Construction Schedule

It is estimated that overall construction would take approximately 23 months to construct. This duration has been used in the estimate to determine costs for the contractor to maintain field facilities and construction supervision. A simplified tentative construction

schedule of the overall project is presented in Appendix C. The overall schedule is based on the following reasoning and assumptions:

- Typical construction, crew (1 shift) working 8 hrs per day and 5 days per week.
- Construction progression would be from upstream to downstream by reach.
- It is assumed that construction could progress straight through the "wet months" because, at this level of design and analysis and based on the designer's opinion, it appears that there would not be a significant amount of water passing through the channel to require a stoppage of work for several months.

4. Acquisition Plan

The cost estimate is based on a single contract being awarded for all the construction components. The estimate also assumes that the Prime Contractor would hire subcontractors for the vegetative aspects, concrete placing, pile driving, asphalt and railroad aspects of the project. The prime contractor would be responsible for the preparatory work, channel excavation, and all other associated site work as well as overseeing the subcontractors' work on the landscaping, pile driving, concrete, asphalt and railroad work.

5. Project Construction

A. Staging and Site Access: Each reach would have its own staging and site access areas. They would be located in an appropriate area designated on the design drawings.

B. Borrow/Disposal Areas and Materials: The borrow materials for placement of riprap, aggregate base, and ballast rock are available nearby and would be trucked in from the quarry site.

The materials required for the cast-in-place concrete mixes including cement, coarse aggregate, fine aggregate, and various admixtures would be locally available.

All materials that need to be disposed of off-site are assumed to be loaded and hauled to the Newby Island Sanitary Landfill which is located in Milpitas, CA. This landfill is located approximately 5-miles from the project site. This landfill would be able to take in the excess excavated material as well as any demolished material that would be removed during construction.

C. Construction Methodology:

The construction would be performed by reach. There are a total of 16 reaches, with 8 of the reaches being the channel work, and 8 reaches being performed under or near overpass structures. The different construction components are as follows:

- Relocations – There are various utilities that run through the project site. The utilities would need to be relocated prior to the primary construction items being performed. However, clearing and grubbing would need to occur before the utility relocations can take place. The types of utilities in question include underground electric cables, piping, outlet structures and overhead lines. For the underground cables and pipes, the estimate assumes digging these items up and replacing them. The new materials would be placed at a greater depth in order to avoid the channel improvement work. The outlet

structures are assumed to be demolished, and replaced once construction is complete. It is assumed that no aspect of the relocations would occur outside of the right of way limits shown on the design plans, as well as no relocations would occur at the bridges.

- Dewatering – It has been estimated that there would be five dewatering phases that incorporate multiple reaches at a time. Earthen cofferdams would be constructed at the upstream and downstream section of the reaches under construction. The dams would consist of on-site excavated material, and would be covered with a water proof liner. Dewatering pumps and a diversion pipe would be placed to dewater the channel, and maintain dry conditions for the duration of construction. At the current level of design, it is assumed only surface water would be encountered during construction. The diversion pipe would be purchased to construct the first reaches, and then re-used on the later constructed reaches. Once the construction for the dewatered channel is complete, the upstream cofferdam would be removed and replaced downstream of the remaining cofferdam in order to dewater the next reaches to be constructed.
- Clearing and Grubbing – The entire channel area would require clearing and grubbing prior to construction. Clearing and grubbing would be performed with a crew using chainsaws and a dozer.
- Excavate and Haul – The construction of the channel requires material to be excavated and hauled off-site for disposal. The estimate assumes a hydraulic excavator would be used to remove and stockpile the material. A loader would then load the trucks, which are assumed to be 16-cy dump trucks. The trucks are assumed to travel 5-miles to the dump the materials.
- Place and Compact Fill – This item includes the filling and compacting of on-site material. The material would have come from previous excavation. The backfill would be performed with a front end loader. The compaction would be performed with a vibratory roller along with a water truck to prevent dust ups.
- Import and Place Riprap – Some of the channel banks would require riprap slope protection. The riprap is assumed to be trucked into the project site from a local quarry. The rock would then be placed with a hydraulic excavator.
- Geotextile Fabric – Geotextile fabric is required in various reaches throughout the project. The fabric would be placed using a crane and crew.
- Cellular Confinement System – Some reaches require a cellular confinement system for erosion protection. The confinement system would be placed using the same crane crew as the geotextile fabric.
- Cast-In-Place Concrete – An approximately 2-feet high retaining wall would be constructed in several reaches. This wall would include steel reinforcing and would be pumped and placed by a sub-contractor.

- Planting – All planting for this project is assumed to be seeding. The seed material would be installed by mechanical methods, and the work is assumed to be handled by a sub-contractor.
- Temporary Shoo-Fly Structure – A railroad line runs through the channel in Reach 5. A temporary shoo-fly structure would be constructed to allow for the replacement of the current wood trestle that supports the existing rails. An earthen berm would be constructed to support the temporary rails. New ballast rock, rails and ties would run over the berm and connect to the existing rails outside the channel. Once the new structure is constructed the temporary rails and berm would be removed.
- Demo, Haul, and Dispose Rails – The existing railroad line on top of the existing wood trestle would need to be removed. The rails, ballast and ties would be demolished, and then hauled off site for disposal.
- Demo, Haul, and Dispose Timber – The existing wood trestle would need to be removed. The entire timber structure would be demolished and hauled off site for disposal.
- Construct Replacement Culvert – After the removal of the existing railroad trestle, a triple box culvert would be installed. The culvert would have openings of approximately 10-ft x 11-ft. The concrete would be cast-in-place and would include steel reinforcing. The concrete is assumed to be pumped and placed by a sub-contractor.
- Reconstruct Rails and Ties – The railroad would need to be re-built on top of the new triple box culvert. New ballast rock would be brought in, along with new primary rails and wooden ties. The estimate assumes that the work would be performed by a sub-contractor.
- Sheet Piling – At a couple bridge locations sheet piling would be installed to protect some of the structures. The estimate assumes that the sheet piles would be PZ-27 type piles. They would be driven into place by a sub-contractor.
- Roadway Base – An aggregate base layer would be placed beneath an access road in several reaches. The aggregate base material is assumed to be trucked to the project site and then placed by a front end loader and grader.
- Access Road Surface – An asphalt access road would be constructed in several reaches. The road is assumed to be placed by a sub-contractor.
- Recreation – An asphalt concrete trail would be constructed along both banks of the channel. The trail would run approximately from Calaveras Blvd to Montague Expressway. This trail would be 15-feet wide and would require an aggregate base layer. Various access points would be required as well, and at these points benches and signs would be installed.

D. Unusual Conditions: (Soil, Water, Weather, Traffic). Flooding within the creek, seasonally variation in groundwater depths, varying bedrock elevations, poor soil conditions, and traffic may occur.

E. Unique Construction Techniques: Mostly in dry creek bed with possible shallow groundwater. Pile driving equipment would be necessary for the sheet pile placement.

F. Equipment/Labor Availability and Distance Traveled: All equipment and labor should be available in the greater Bay Area.

6. Environmental Concerns

Construction activities would likely increase turbidity in the creek. There is a potential for construction equipment to leak or spill contaminates into the creek and or damage existing plant and wildlife. However, costs to mitigate these issues would be included in the contractors spill prevention plan required for construction.

7. Effective Dates for Labor, Equipment and Material Pricing

The labor, equipment, and material pricing were developed using the MCACES 2010 English Unit Cost Library, 2013 Santa Clara County Labor Library, and the 2011 Equipment Library (Region VII) for the base cost estimates. The index pricing data has been prepared in January 2013 dollars.

The base cost estimates have been updated with current quoted fuel prices of $3.62/gal for off-road diesel, $4.29/gal for on-road diesel and $3.63/gal for gasoline in the Milpitas area.

8. Estimated Production Rates

Much of the construction cost estimate was developed utilizing user defined crews and production rates. See Appendix E for the Estimated Production Rates developed for this estimate.

9. Project Markups

A. Escalation: Escalation has been calculated within the Total Project Cost Summary. Price levels have been escalated from effective price levels of the construction cost estimate for January 2013 to the mid-point of construction. The appropriate escalation cost factors for each date for each feature account have been calculated within the TPCS.

B. Contingency: A 22.51% contingency has been included in the estimate for the Relocations, Channels & Canals, and Recreation accounts. Planning, Engineering and Design has an 8.33% contingency, and Construction Management has a 6.25% contingency. An abbreviated Cost and Schedule Risk Analysis (CSRA) has been performed to calculate the contingencies listed above. The abbreviated CSRA can be seen in Appendix G.

10. Functional Costs

Functional costs associated with this work were estimated as follows:

A. 01 Account – Lands and Damages: Costs for lands and damages were provided by the USACE, Sacramento District Real Estate Division. The costs came out of the Berryessa creek Flood Control Project, Real Estate Plan Report, which is dated Nov. 5th, 2012. The

lands and damages cost entered in the Total Project Cost Summary already includes contingency, and therefore no contingency is applied to the cost in the summary.

B. 02 Account – Relocations: Costs for this account have been estimated within the MII estimate. Costs include excavation, demolition and relocation to a greater depth of the existing utilities that are impacted by construction.

C. 18 Account – Cultural Resources: Costs for this account have not been determined, and will be included in subsequent submittals. This account covers the possibility of finding cultural significant items during construction.

D. 30 Account - Planning, Engineering, and Design: Costs for this account were estimated at 15.0% of the construction cost. This account covers the preparation of plans, and specifications.

E. 31 Account - Construction Management: Costs for this account were estimated to be 10.0% of the construction cost. This account covers construction management during construction.

11. MCACES Construction Cost Estimate

The construction cost estimate was developed using MCACES 2nd Generation (MII) estimating software in accordance with guidance contained in ER 1110-2-1302, Civil Works Cost Engineering. The MII cost estimate has only been developed to include the Relocations and Channels feature accounts. See Appendix G for the MII output report.

12. Total Project Cost Summary (TPCS)

The TPCS was prepared using the latest TPCS excel spreadsheet provided by the USACE, Walla Walla District. The TPCS incorporates the construction costs developed in the MII, the project markups, and the functional costs.

13. References

U.S. Army Corps of Engineers, 1993, *Engineering and Design Cost Engineering Policy and General Requirements, Engineering Regulation 1110-1-1300,* Department of the Army, Washington D.C., 26 March 1993.

U.S. Army Corps of Engineers, 1999, *Engineering and Design For Civil Works Projects, Engineering Regulation 1110-2-1150,* Department of the Army, Washington D.C., 31 August 1999.

U.S. Army Corps of Engineers, 2008a, *Civil Works Cost Engineering, Engineering Regulation 1110-2-1302,* Department of the Army, Washington D.C., 15 September 2008.

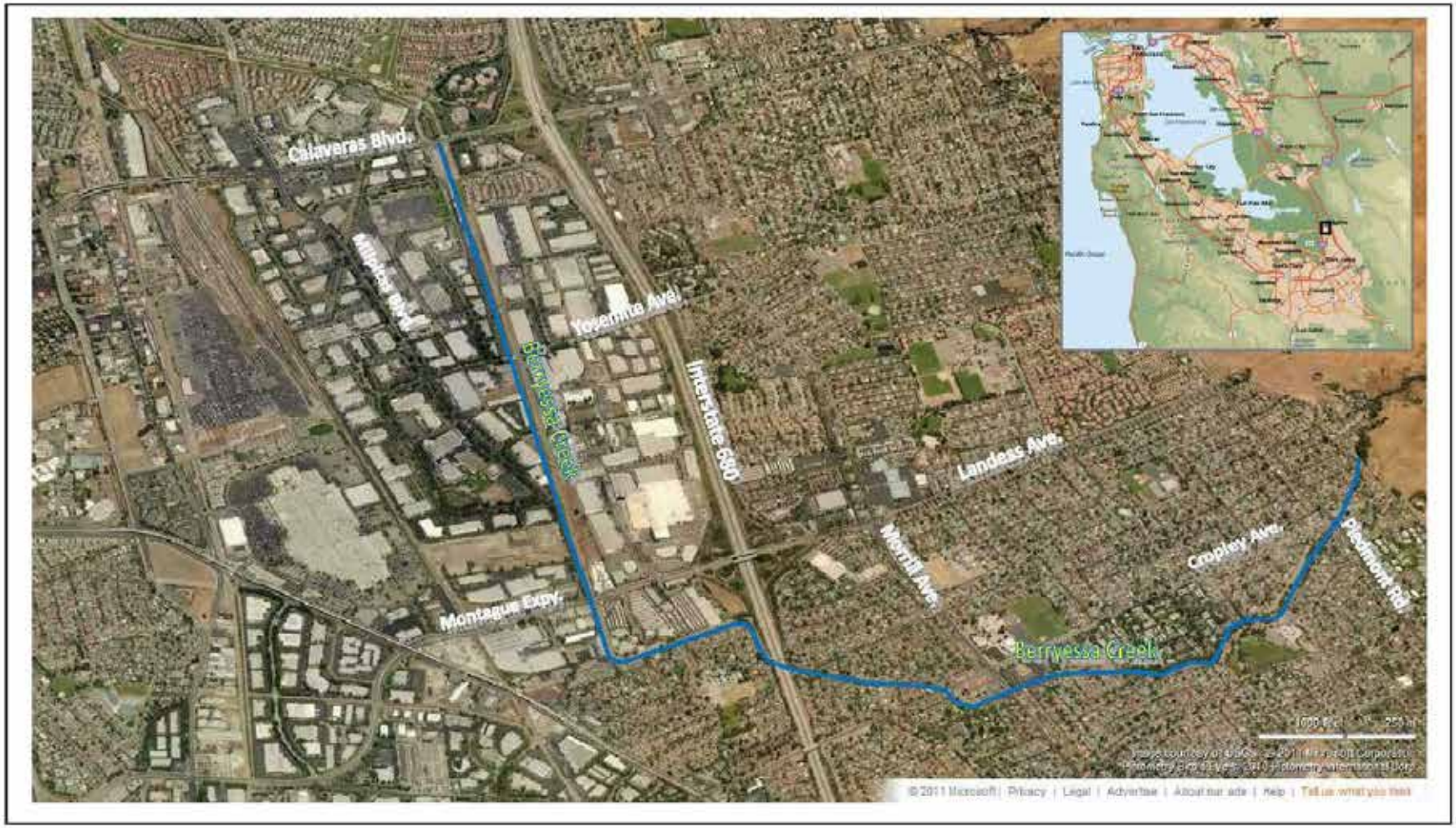
U.S. Army Corps of Engineers, 2008b, *Construction Cost Estimating Guide For Civil Works, Engineering Technical Letter 1110-2-573,* Department of the Army, Washington D.C., 30 September 2008.

U.S. Army Corps of Engineers, 2010, *Civil Works Construction Cost Index System, Engineering Manual 1110-2-1304,* Department of the Army, Washington D.C., 31 October 2011.

APPENDIX A

Site Plan

Site Plan


Calaveras Blvd.
Milpitas Blvd.
Yosemite Ave.
Berryessa Creek
Interstate 680
Landess Ave.
Morrill Ave.
Cropley Ave.
Piedmont Rd.
Montague Expy.
Berryessa Creek

APPENDIX B

Project Quantities and Detailed Quantity Take-Offs

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
[02]	**RELOCATIONS**	**-**	**LS**	**1**
[02 02]	**Reach 2**	**-**	**LS**	**1**
[02 02 01]	**12kv Underground Line - STA 233+00**	**-**	**LF**	**75**
[02 02 01 01]	**Demolition**	**-**	**LF**	**75**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	56
	Cable Demolition	-	LF	75
	Disconnect Both Ends of Cable	-	HR	8
[02 02 01 02]	**Relocation**	**-**	**LF**	**75**
	Structural Excavation	-	CY	93
	Trench Shoring	-	SF	1,050
	12kv Cable Installation	-	CLF	0.75
	Fill and Compact From Stockpile	-	CY	149
	Connect Both Ends of Cable	-	HR	8
[02 02 02]	**24" CMP Storm Drain - STA 226+00**	**-**	**LF**	**30**
[02 02 02 01]	**Demo Concrete Headwall and Pipe**	**-**	**LF**	**30**
	Demo Concrete Headwall	-	CF	36
	Structural Excavation	-	CY	22
	Demo 24" CMP	-	LF	30
	Backfill and Compact	-	CY	22
	Concrete Load and Haul	-	CY	16
	Tipping Fee, Reinforced Concrete	-	CY	2
[02 02 02 02]	**Replace Outlet Strcture**	**-**	**LF**	**30**
[02 02 02 02 01]	**RCP Placement**	**-**	**LF**	**30**
	Structural Excavation	-	CY	37
	Trench Shoring	-	SF	420
	Install 24" RCP	-	LF	30
	Install Flap Gate	-	EA	1
	Backfill and Compact	-	CY	37
[02 02 02 02 02]	**Concrete Headwall and Footing**	**-**	**CY**	**1.4**
	Concrete, Forms	-	SFC	85
	Concrete, Material	10%	CY	1.5
	Concrete, Placement	10%	CY	1.5
	Reinforcing Steel, Material	-	TON	210
	Reinforcing Steel, Placement	-	LBS	0.11
[09 02 02 02 03]	**Import and Place Riprap**	**-**	**TON**	**1.4**
	Rip Rap, Material	15%	TON	1.6
	Rip Rap, Placement	15%	TON	1.6
[02 02 03]	**350A Underground Line - STA 222+00**	**-**	**LF**	**140**
[02 02 03 01]	**Demolition**	**-**	**LF**	**140**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	104
	Cable Demolition	-	LF	140
	Disconnect Both Ends of Cable	-	HR	8
[02 02 03 02]	**Relocation**	**-**	**LF**	**140**
	Structural Excavation	-	CY	174
	350A Cable Installation	-	CLF	1.4
	Fill and Compact From Stockpile	-	CY	277
	Connect Both Ends of Cable	-	HR	8
[02 02 04]	**12kv Underground Line - STA 211+80**	**-**	**LF**	**280**
[02 02 04 01]	**Demolition**	**-**	**LF**	**280**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	207
	Cable Demolition	-	LF	280
	Disconnect Both Ends of Cable	-	HR	8
[02 02 04 02]	**Relocation**	**-**	**LF**	**280**
	Structural Excavation	-	CY	347

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	Trench Shoring	-	SF	3,920
	12kv Cable Installation	-	CLF	2.80
	Fill and Compact From Stockpile	-	CY	555
	Connect Both Ends of Cable	-	HR	8
[02 04]	**Reach 4**	**-**	**LS**	**1**
[02 04 01]	**12kv Underground Line - STA 208+40**	**-**	**LF**	**55**
[02 04 01 01]	**Demolition**	**-**	**LF**	**55**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	41
	Cable Demolition	-	LF	55
	Disconnect Both Ends of Cable	-	HR	8
[02 04 01 02]	**Relocation**	**-**	**LF**	**55**
	Structural Excavation	-	CY	68
	Trench Shoring	-	SF	770
	12kv Cable Installation	-	CLF	0.55
	Fill and Compact From Stockpile	-	CY	109
	Connect Both Ends of Cable	-	HR	8
[02 06]	**Reach 6**	**-**	**LS**	**1**
[02 06 01]	**12kv Underground Line - STA 205+80**	**-**	**LF**	**75**
[02 06 01 01]	**Demolition**	**-**	**LF**	**75**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	56
	Cable Demolition	-	LF	75
	Disconnect Both Ends of Cable	-	HR	8
[02 06 01 02]	**Relocation**	**-**	**LF**	**75**
	Structural Excavation	-	CY	93
	Trench Shoring	-	SF	1,050
	12kv Cable Installation	-	CLF	0.75
	Fill and Compact From Stockpile	-	CY	149
	Connect Both Ends of Cable	-	HR	8
[02 06 02]	**12kv Underground Line - STA 197+60**	**-**	**LF**	**60**
[02 06 02 01]	**Demolition**	**-**	**LF**	**60**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	44
	Cable Demolition	-	LF	60
	Disconnect Both Ends of Cable	-	HR	8
[02 06 02 02]	**Relocation**	**-**	**LF**	**60**
	Structural Excavation	-	CY	74
	Trench Shoring	-	SF	770
	12kv Cable Installation	-	CLF	0.60
	Fill and Compact From Stockpile	-	CY	119
	Connect Both Ends of Cable	-	HR	8
[02 08]	**Reach 8**	**-**	**LS**	**1**
[02 08 01]	**12" Waterlines**	**-**	**LF**	**75**
[02 08 01 01]	**Demolition**	**-**	**LF**	**75**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	201
	Pipe Demolition	-	LF	150
[02 08 01 02]	**Relocation**	**-**	**LF**	**75**
	Structural Excavation	-	CY	186
	Trench Shoring	-	SF	1,050
	12" RCP	-	LF	150
	Aggregate Base, Material	15%	TON	7.2
	Aggregate Base, Placement	15%	CY	4.8
	Pipe Test and Flush	-	HR	6
	Fill and Compact From Stockpile	-	CY	297
[02 08 02]	**30" RCP**	**-**	**LF**	**45**

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
[02 08 02 01]	**Demolition**	**-**	**LF**	**45**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	42
	Pipe Demolition	-	LF	45
[02 08 02 02]	**Relocation**	**-**	**LF**	**45**
	Structural Excavation	-	CY	56
	Trench Shoring	-	SF	630
	30" RCP	-	LF	45
	Aggregate Base, Material	15%	TON	12.9
	Aggregate Base, Placement	15%	CY	8.6
	Pipe Test and Flush	-	HR	6
	Fill and Compact From Stockpile	-	CY	98
[02 12]	**Reach 12**	**-**	**LS**	**1**
[02 12 01]	**Telephone Conduit - STA 160+00**	**-**	**LF**	**200**
[02 12 01 01]	**Demolition**	**-**	**LF**	**200**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	148
	Conduit Demolition	-	LF	200
[02 12 01 02]	**Relocation**	**-**	**LF**	**200**
	Structural Excavation	-	CY	184
	Trench Shoring	-	SF	2,800
	Conduit Installation	-	CLF	2.00
	Fill and Compact From Stockpile	-	CY	332
[02 12 02]	**27" CMP - STA 154+00**	**-**	**LF**	**35**
[02 12 02 01]	**Demolition**	**-**	**LF**	**35**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	32
	Pipe Demolition	-	LF	35
[02 12 02 02]	**Relocation**	**-**	**LF**	**35**
	Structural Excavation	-	CY	50
	Trench Shoring	-	SF	490
	27" RCP	-	LF	35
	Aggregate Base, Material	15%	TON	10.1
	Aggregate Base, Placement	15%	CY	6.7
	Pipe Test and Flush	-	HR	6
	Fill and Compact From Stockpile	-	CY	82
[02 12 03]	**3-1/0A XLCJ 21kv - STA 151+00**	**-**	**LF**	**70**
[02 12 03 01]	**Demolition**	**-**	**LF**	**70**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	52
	Cable Demolition	-	LF	210
	Disconnect Both Ends of Cable	-	HR	24
[02 12 03 02]	**Relocation**	**-**	**LF**	**70**
	Structural Excavation	-	CY	100
	Trench Shoring	-	SF	980
	12kv Cable Installation	-	CLF	2.10
	Fill and Compact From Stockpile	-	CY	152
	Connect Both Ends of Cable	-	HR	24
[02 12 04]	**3-700A and 1-350A Underground - STA 149+20**	**-**	**LF**	**160**
[02 12 04 01]	**Demolition**	**-**	**LF**	**160**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	119
	Cable Demolition	-	LF	640
	Disconnect Both Ends of Cable	-	HR	32
[02 12 04 02]	**Relocation**	**-**	**LF**	**160**
	Structural Excavation	-	CY	228
	Trench Shoring	-	SF	2,240

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	12kv Cable Installation	-	CLF	6.40
	Fill and Compact From Stockpile	-	CY	347
	Connect Both Ends of Cable	-	HR	32
[02 12 05]	**12kv Underground Line - STA 138+60**	**-**	**LF**	**550**
[02 12 05 01]	**Demolition**	**-**	**LF**	**550**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	407
	Cable Demolition	-	LF	550
	Disconnect Both Ends of Cable	-	HR	8
[02 12 05 02]	**Relocation**	**-**	**LF**	**550**
	Structural Excavation	-	CY	784
	Trench Shoring	-	SF	7,700
	12kv Cable Installation	-	CLF	5.50
	Fill and Compact From Stockpile	-	CY	1,192
	Connect Both Ends of Cable	-	HR	8
[02 14]	**Reach 14**	**-**	**LS**	**1**
[02 14 01]	**Underground Trench/Vault - STA 137+00**	**-**	**LF**	**110**
[02 14 01 01]	**Demolition**	**-**	**LF**	**110**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	81
	Duct Demolition	-	LF	110
[02 14 01 02]	**Relocation**	**-**	**LF**	**110**
	Structural Excavation	-	CY	157
	Electric Duct Installation	-	LF	110
	Aggregate Base, Material	15%	TON	7.0
	Aggregate Base, Placement	15%	CY	4.7
	Fill and Compact From Stockpile	-	CY	238
[02 14 02]	**24" CMP - STA 133+50**	**-**	**LF**	**45**
[02 14 02 01]	**Demolition**	**-**	**LF**	**45**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	33
	Pipe Demolition	-	LF	45
[02 14 02 02]	**Relocation**	**-**	**LF**	**45**
	Structural Excavation	-	CY	64
	27" RCP	-	LF	45
	Aggregate Base, Material	15%	TON	8.6
	Aggregate Base, Placement	15%	CY	5.8
	Fill and Compact From Stockpile	-	CY	98
[02 14 03]	**Underground 3-350A XLCJ 12kv**	**-**	**LF**	**550**
[02 14 03 01]	**Demolition**	**-**	**LF**	**550**
	Pot Holing	-	HR	4
	Structural Excavation	-	CY	407
	Cable Demolition	-	LF	550
	Disconnect Both Ends of Cable	-	HR	24
[02 14 03 02]	**Relocation**	**-**	**LF**	**550**
	Structural Excavation	-	CY	784
	12kv Cable Installation	-	CLF	16.50
	Fill and Compact From Stockpile	-	CY	1,192
	Connect Both Ends of Cable	-	HR	24
[09]	**CHANNELS**	**-**	**LS**	**1**
[09 AA]	**Mobilization / Demobilization**	**-**	**LS**	**1**
[09 BB]	**Dewatering**	**-**	**LS**	**1**
[09 BB 01]	**Dewatering Reaches 1-2**	**-**	**LS**	**1**
[09 BB 01 01]	**Coffer Dams**	**-**	**EA**	**2**
[09 BB 01 01 01]	**Cofferdam Installation**	**-**	**CY**	**534**
	Fill and Compact From Stockpile	15%	CY	614
	Embankment Liner	-	SF	2,700

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	Sandbags	-	EA	90
	Sand Material	15%	TON	10.8
	Sandbags Fill and Placement	-	EA	90
[09 BB 01 01 02]	**Cofferdam Removal**	**-**	**CY**	**267**
	Excavate, Load and Haul Downstream	-	CY	267
[09 BB 01 02]	**Dewater Pumping**	**-**	**LS**	**1**
	Dewatering Pump, Primary	-	DAY	94
	Dewatering Pump, Secondary	-	DAY	564
	24" HDPE Pipe	-	LF	3,500
[09 BB 02]	**Dewatering Reaches 3-8**	**-**	**LS**	**1**
[09 BB 02 01]	**Coffer Dams**	**-**	**EA**	**2**
[09 BB 02 01 01]	**Cofferdam Installation**	**-**	**CY**	**267**
	Fill and Compact From Stockpile	15%	CY	307
	Embankment Liner	-	SF	2,700
	Sandbags	-	EA	90
	Sand Material	15%	TON	10.8
	Sandbags Fill and Placement	-	EA	90
[09 BB 02 01 02]	**Cofferdam Removal**	**-**	**CY**	**267**
	Excavate, Load and Haul Downstream	-	CY	267
[09 BB 02 02]	**Dewater Pumping**	**-**	**LS**	**1**
	Dewatering Pump, Primary	-	DAY	167
	Dewatering Pump, Secondary	-	DAY	1,002
	24" HDPE Pipe	-	LF	3,300
[09 BB 03]	**Dewatering Reaches 9-10**	**-**	**LS**	**1**
[09 BB 03 01]	**Coffer Dams**	**-**	**EA**	**2**
[09 BB 03 01 01]	**Cofferdam Installation**	**-**	**CY**	**267**
	Fill and Compact From Stockpile	15%	CY	307
	Embankment Liner	-	SF	2,700
	Sandbags	-	EA	90
	Sand Material	15%	TON	10.8
	Sandbags Fill and Placement	-	EA	90
[09 BB 03 01 02]	**Cofferdam Removal**	**-**	**CY**	**267**
	Excavate, Load and Haul Downstream	-	CY	267
[09 BB 03 02]	**Dewater Pumping**	**-**	**LS**	**1**
	Dewatering Pump, Primary	-	DAY	68
	Dewatering Pump, Secondary	-	DAY	204
	24" HDPE Pipe	-	LF	1,200
[09 BB 04]	**Dewatering Reaches 11-12**	**-**	**LS**	**1**
[09 BB 04 01]	**Coffer Dams**	**-**	**EA**	**2**
[09 BB 04 01 01]	**Cofferdam Installation**	**-**	**CY**	**267**
	Fill and Compact From Stockpile	15%	CY	307
	Embankment Liner	-	SF	2,700
	Sandbags	-	EA	90
	Sand Material	15%	TON	10.8
	Sandbags Fill and Placement	-	EA	90
[09 BB 04 01 02]	**Cofferdam Removal**	**-**	**CY**	**267**
	Excavate, Load and Haul Downstream	-	CY	267
[09 BB 04 02]	**Dewater Pumping**	**-**	**LS**	**1**
	Dewatering Pump, Primary	-	DAY	139
	Dewatering Pump, Secondary	-	DAY	834
	24" HDPE Pipe	-	LF	3,500
[09 BB 05]	**Dewatering Reaches 13-16**	**-**	**LS**	**1**
[09 BB 05 01]	**Coffer Dams**	**-**	**EA**	**2**
[09 BB 05 01 01]	**Cofferdam Installation**	**-**	**CY**	**267**
	Fill and Compact From Stockpile	15%	CY	307
	Embankment Liner	-	SF	2,700
	Sandbags	-	EA	90

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	Sand Material	15%	TON	10.8
	Sandbags Fill and Placement	-	EA	90
[09 BB 05 01 02]	**Cofferdam Removal**	**-**	**CY**	**534**
	Excavate, Load and Haul	-	CY	534
[09 BB 05 02]	**Dewater Pumping**	**-**	**LS**	**1**
	Dewatering Pump, Primary	-	DAY	97
	Dewatering Pump, Secondary	-	DAY	291
	24" HDPE Pipe	-	LF	1,000
[09 CC]	**Clearing and Grubbing**	**-**	**ACRE**	**31**
[09 CC 01]	**Clear and Grub**	**-**	**ACRE**	**31**
	Clearing and Grubbing	-	ACRE	31
[09 CC 02]	**Load and Haul Debris**	**-**	**CY**	**12,400**
	Load and Haul Brush	-	CY	12,400
	Tipping Fee, Green Material	-	CY	3,100
[09 DD]	**Erosion Control**	**-**	**LS**	**1**
	Silt Fence	-	LF	21,440
	Straw Rolls	-	LF	42,880
	Construction Entrance	-	EA	10
[09 EE]	**Construction Access**	**-**	**LS**	**1**
[09 EE 01]	**Access Ramps**	**-**	**EA**	**10**
	Borrow Fill, Material	-	CY	135
	Aggregate Base, Material	-	TON	15
	Fill and Compact From Stockpile	-	CY	675
	Excavate Load and Haul Downstrema	15%	CY	621
	Excavate, Load and Haul to Disposal	-	CY	135
[09 EE 02]	**Temporary Access Roads**	**-**	**EA**	**10**
	Aggregate Base, Material	15%	TON	77
	Aggregate Base, Material	15%	CY	256
	Excavate Load and Haul Downstream	-	CY	1,022
	Excavate, Load and Haul to Disposal	-	CY	51
[09 01]	**Reach 1**	**-**	**LS**	**1**
[09 01 01]	**Excavate and Haul**	**-**	**CY**	**75**
	Excavate, Load and Haul	-	CY	75
[09 02]	**Reach 2**	**-**	**LS**	**1**
[09 02 01]	**Place and Compact Fill**	**-**	**CY**	**100**
	Fill and Compact From Stockpile	15%	CY	115
[09 02 02]	**Excavate and Haul**	**-**	**CY**	**4,074**
	Excavate, Load and Haul	-	CY	4,074
[09 02 03]	**Import and Place Riprap**	**-**	**TON**	**5,750**
	Rip Rap, Material	15%	TON	6,613
	Rip Rap, Placement	15%	TON	6,613
[09 02 04]	**Geotextile Fabric**	**-**	**SY**	**7,700**
	Geotextile Fabric, Material	5%	SY	8,085
	Geotextile Fabric, Staples	-	EA	7,700
	Geotextile Fabric, Placement	5%	SY	8,085
[09 02 05]	**Cellular Confinement System**	**-**	**SF**	**20,453**
	Cellular Confinement System, Material	5%	SF	21,476
	Cellular Confinement System, Placement	5%	SF	21,476
	Top Soil, Material	-	CY	379
	Top Soil, Placement	-	CY	379
[09 02 06]	**CIP Concrete**	**-**	**CY**	**90**
[09 02 06 01]	**Earthwork**	**-**	**CY**	**235**
	Excavate to Stockpile	-	CY	235
	Fill and Compact From Stockpile	-	CY	172
[09 02 06 02]	**Concrete**	**-**	**CY**	**90**
	Concrete, Forms	-	SFC	4,000
	Concrete, Material	10%	CY	99

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	Concrete, Placement	10%	CY	99
[09 02 07]	**Reinforcing Steel**	**-**	**LB**	**18,000**
	Reinforcing Steel, Material	-	TON	9.0
	Reinforcing Steel, Placement	-	LBS	18,000
[09 02 08]	**Planting - Grasses on Banks**	**-**	**ACRE**	**1.92**
	Hydroseeding	-	SY	9,289
[09 03]	**Reach 3**	**-**	**LS**	**1**
[09 03 01]	**Excavate and Haul**	**-**	**CY**	**150**
	Excavate, Load and Haul	-	CY	150
[09 04]	**Reach 4**	**-**	**LS**	**1**
[09 04 01]	**Excavate and Haul**	**-**	**CY**	**896**
	Excavate, Load and Haul	-	CY	896
[09 04 02]	**Import and Place Riprap**	**-**	**TON**	**1,000**
	Rip Rap, Material	15%	TON	1,150
	Rip Rap, Placement	15%	TON	1,150
[09 04 03]	**Geotextile Fabric**	**-**	**SY**	**1,400**
	Geotextile Fabric, Material	5%	SY	1,470
	Geotextile Fabric, Staples	-	EA	1,400
	Geotextile Fabric, Placement	5%	SY	1,470
[09 04 04]	**Cellular Confinement System**	**-**	**SF**	**8,156**
	Cellular Confinement System, Material	5%	SF	8,564
	Cellular Confinement System, Placement	5%	SF	8,564
	Top Soil, Material	-	CY	151
	Top Soil, Placement	-	CY	151
[09 04 05]	**Planting - Grasses on Banks**	**-**	**ACRE**	**0.41**
	Hydroseeding	-	SY	2,000
[09 05]	**Reach 5**	**-**	**LS**	**1**
[09 05 01]	**Excavate and Haul**	**-**	**CY**	**10**
	Excavate, Load and Haul	-	CY	10
[09 05 02]	**Temporary Shoo-Fly Structure**	**-**	**LS**	**1**
[09 05 02 01]	**Embankment**	**-**	**CY**	**306**
	Borrow Fill, Material	15%	CY	351
	Fill and Compact From Stockpile	15%	CY	351
[09 05 02 02]	**Railroad Track**	**-**	**LF**	**250**
	Ballast Stone	15%	TON	335
	Railroad Track	-	LF	500
	Railroad Ties	-	BF	8,077
	Railroad Switch	-	EA	2
[09 05 02 03]	**Demolition**	**-**	**LF**	**250**
	Remove Railroad Ties and Track	-	LF	250
	Remove Turnout	-	EA	2
	Rock Load and Haul	-	CY	194
	Excavate, Load and Haul	-	CY	306
	Tipping Fee	-	CY	32
[09 05 03]	**Demo, Haul, and Dispose Rails**	**-**	**LF**	**120**
	Remove Railroad Ties and Track	-	LF	120
	Load and Haul	-	CY	48
[09 05 04]	**Demo, Haul, and Dispose Timber**	**-**	**BF**	**10,000**
	Timber Demolition	-	MBF	10
	Load and Haul	-	CY	833
	Rock Load and Haul	-	CY	833
[09 05 05]	**Excavate, Backfill and Compact**	**-**	**CY**	**250**
	Excavate, Backfill and Compact	-	CY	250
[09 05 06]	**Construct Replacement Culvert (Triple Box)**	**-**	**CY**	**350**
	Concrete, Forms	-	SFC	8,750
	Concrete, Material	10%	CY	385
	Concrete, Placement	10%	CY	385

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
[09 05 07]	**Reinforcing Steel**	**-**	**LB**	**70,000**
	Reinforcing Steel, Shop Hanlding	-	TON	35.0
	Reinforcing Steel, Unload and Sort	-	TON	35.0
	Reinforcing Steel, Placement	-	LBS	70,000
[09 05 08]	**Construct Wingwalls & Headwalls w/ Rails**	**-**	**EA**	**6**
[09 05 08 01]	**Cast-in-Place Concrete**	**-**	**CY**	**53**
	Concrete, Forms	-	SFC	1,440
	Concrete, Material	10%	CY	59
	Concrete, Placement	10%	CY	59
[09 05 08 02]	**Reinforcing Steel**	**-**	**LB**	**10,600**
	Reinforcing Steel, Material	-	TON	5.3
	Reinforcing Steel, Placement	-	LBS	10,600
[09 05 08 03]	**Railing**	**-**	**LF**	**120**
	Railing	-	LF	120
[09 05 09]	**Reconstruct Rails and Ties**	**-**	**LF**	**120**
	Ballast Stone	15%	TON	57
	Railroad Track	-	LF	240
	Railroad Ties	-	BF	3,877
[09 05 10]	**Import and Place Riprap**	**-**	**TON**	**75**
	Rip Rap, Material	15%	TON	86
	Rip Rap, Placement	15%	TON	86
[09 05 11]	**Planting - Grasses on Banks**	**-**	**ACRE**	**0.10**
	Hydroseeding	-	SY	484
[09 06]	**Reach 6**	**-**	**LS**	**1**
[09 06 01]	**Excavate and Haul**	**-**	**CY**	**4,257**
	Excavate, Load and Haul	-	CY	4,257
[09 06 02]	**Import and Place Riprap**	**-**	**TON**	**4,750**
	Rip Rap, Material	15%	TON	5,463
	Rip Rap, Placement	15%	TON	5,463
[09 06 03]	**Geotextile Fabric**	**-**	**SY**	**6,650**
	Geotextile Fabric, Material	5%	SY	6,983
	Geotextile Fabric, Staples	-	EA	6,650
	Geotextile Fabric, Placement	5%	SY	6,983
[09 06 04]	**Cellular Confinement System**	**-**	**SF**	**20,351**
	Cellular Confinement System, Material	5%	SF	21,368
	Cellular Confinement System, Placement	5%	SF	21,368
	Top Soil, Material	-	CY	377
	Top Soil, Placement	-	CY	377
[09 06 05]	**Planting - Grasses on Banks**	**-**	**ACRE**	**2.05**
	Hydroseeding	-	SY	9,922
[09 07]	**Reach 7**	**-**	**LS**	**1**
[09 07 01]	**Excavate and Haul**	**-**	**CY**	**60**
	Excavate, Load and Haul	-	CY	60
[09 08]	**Reach 8**	**-**	**LS**	**1**
[09 08 01]	**Excavate and Haul**	**-**	**CY**	**1,222**
	Excavate, Load and Haul	-	CY	1,222
[09 08 02]	**Import and Place Riprap**	**-**	**TON**	**1,000**
	Rip Rap, Material	15%	TON	1,150
	Rip Rap, Placement	15%	TON	1,150
[09 08 03]	**Geotextile Fabric**	**-**	**SY**	**1,400**
	Geotextile Fabric, Material	5%	SY	1,470
	Geotextile Fabric, Staples	-	EA	1,400
	Geotextile Fabric, Placement	5%	SY	1,470
[09 08 04]	**Cellular Confinement System**	**-**	**SF**	**3,419**
	Cellular Confinement System, Material	5%	SF	3,590
	Cellular Confinement System, Placement	5%	SF	3,590
	Top Soil, Material	-	CY	63

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	Top Soil, Placement	-	CY	63
[09 08 05]	**Planting - Grasses on Banks**	**-**	**ACRE**	**0.37**
	Hydroseeding	-	SY	1,778
[09 09]	**Reach 9**	**-**	**LS**	**1**
[09 09 01]	**Excavate and Haul**	**-**	**CY**	**200**
	Excavate, Load and Haul	-	CY	200
[09 09 02]	**Excavate, Backfill and Compact**	**-**	**CY**	**100**
	Excavate, Backfill and Compact	-	CY	100
[09 09 03]	**Sheet Piling**	**-**	**SF**	**1,200**
	Sheet Pile Set Up and Removal	-	EA	1
	Sheet Pile, Material	-	SF	1,200
	Sheet Pile, Driven	-	VLF	800
[09 09 04]	**Import and Place Riprap**	**-**	**TON**	**50**
	Rip Rap, Material	15%	TON	58
	Rip Rap, Placement	15%	TON	58
[09 10]	**Reach 10**	**-**	**LS**	**1**
[09 10 01]	**Excavate and Haul**	**-**	**CY**	**2,600**
	Excavate, Load and Haul	-	CY	2,600
[09 10 02]	**Import and Place Riprap**	**-**	**TON**	**3,000**
	Rip Rap, Material	15%	TON	3,450
	Rip Rap, Placement	15%	TON	3,450
[09 10 03]	**Geotextile Fabric**	**-**	**SY**	**4,200**
	Geotextile Fabric, Material	5%	SY	4,410
	Geotextile Fabric, Staples	-	EA	4,200
	Geotextile Fabric, Placement	5%	SY	4,410
[09 10 04]	**Cellular Confinement System**	**-**	**SF**	**5,967**
	Cellular Confinement System, Material	5%	SF	6,265
	Cellular Confinement System, Placement	5%	SF	6,265
	Top Soil, Material	-	CY	110
	Top Soil, Placement	-	CY	110
[09 10 05]	**Planting - Grasses on Banks**	**-**	**ACRE**	**1.10**
	Hydroseeding	-	SY	5,333
[09 11]	**Reach 11**	**-**	**LS**	**1**
[09 11 01]	**Excavate and Haul**	**-**	**CY**	**200**
	Excavate, Load and Haul	-	CY	200
[09 11 02]	**Excavate, Backfill and Compact**	**-**	**CY**	**100**
	Excavate, Backfill and Compact	-	CY	100
[09 11 03]	**Sheet Piling**	**-**	**SF**	**1,200**
	Sheet Pile Set Up and Removal	-	EA	1
	Sheet Pile, Material	-	SF	1,200
	Sheet Pile, Driven	-	VLF	800
[09 11 04]	**Import and Place Riprap**	**-**	**TON**	**50**
	Rip Rap, Material	15%	TON	58
	Rip Rap, Placement	15%	TON	58
[09 12]	**Reach 12**	**-**	**LS**	**1**
[09 12 01]	**Place and Compact Fill**	**-**	**CY**	**75**
	Fill and Compact From Stockpile	15%	CY	86
[09 12 02]	**Excavate and Haul**	**-**	**CY**	**24,278**
	Excavate, Load and Haul	-	CY	24,278
[09 12 03]	**Excavate and Regrade Onsite**	**-**	**CY**	**25**
	Excavate, Load and Haul	-	CY	25
[09 12 04]	**Import and Place Riprap**	**-**	**TON**	**7,750**
	Rip Rap, Material	15%	TON	8,913
	Rip Rap, Placement	15%	TON	8,913
[09 12 05]	**Geotextile Fabric**	**-**	**SY**	**10,500**
	Geotextile Fabric, Material	5%	SY	11,025
	Geotextile Fabric, Staples	-	EA	10,500

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
	Geotextile Fabric, Placement	5%	SY	11,025
[09 12 06]	**Cellular Confinement System**	**-**	**SF**	**34,227**
	Cellular Confinement System, Material	5%	SF	35,938
	Cellular Confinement System, Placement	5%	SF	35,938
	Top Soil, Material	-	CY	634
	Top Soil, Placement	-	CY	634
[09 12 07]	**Roadway Base**	**-**	**CY**	**3,000**
	Aggregate Base, Material	15%	TON	5,175
	Aggregate Base, Placement	15%	CY	3,450
[09 12 08]	**Access Road Surface**	**-**	**SF**	**54,000**
	Asphalt, Binder Course	10%	SY	6,600
	Asphalt, Wearing Course	10%	SY	6,600
[09 12 09]	**CIP Concrete**	**-**	**CY**	**440**
[09 12 06 01]	**Earthwork**	**-**	**CY**	**1,203**
	Excavate to Stockpile	-	CY	1,203
	Fill and Compact From Stockpile	-	CY	883
[09 12 06 02]	**Concrete**	**-**	**CY**	**440**
	Concrete, Forms	-	SFC	19,556
	Concrete, Material	10%	CY	484
	Concrete, Placement	10%	CY	484
[09 12 10]	**Reinforcing Steel**	**-**	**LB**	**88,000**
	Reinforcing Steel, Material	-	TON	44.0
	Reinforcing Steel, Placement	-	LBS	88,000
[09 12 11]	**Planting - Grasses on Banks**	**-**	**ACRE**	**3.44**
	Hydroseeding	-	SY	16,667
[09 13]	**Reach 13**	**-**	**LS**	**1**
[09 13 01]	**Excavate and Haul**	**-**	**CY**	**75**
	Excavate, Load and Haul	-	CY	75
[09 14]	**Reach 14**	**-**	**LS**	**1**
[09 14 02]	**Excavate and Haul**	**-**	**CY**	**6,861**
	Excavate, Load and Haul	-	CY	6,861
[09 14 04]	**Import and Place Riprap**	**-**	**TON**	**1,250**
	Rip Rap, Material	15%	TON	1,438
	Rip Rap, Placement	15%	TON	1,438
[09 14 05]	**Geotextile Fabric**	**-**	**SY**	**1,750**
	Geotextile Fabric, Material	5%	SY	1,838
	Geotextile Fabric, Staples	-	EA	1,750
	Geotextile Fabric, Placement	5%	SY	1,838
[09 14 06]	**Cellular Confinement System**	**-**	**SF**	**8,803**
	Cellular Confinement System, Material	5%	SF	9,244
	Cellular Confinement System, Placement	5%	SF	9,244
	Top Soil, Material	-	CY	163
	Top Soil, Placement	-	CY	163
[09 14 07]	**Roadway Base**	**-**	**CY**	**500**
	Aggregate Base, Material	15%	TON	863
	Aggregate Base, Placement	15%	CY	575
[09 14 08]	**Access Road Surface**	**-**	**SF**	**9,000**
	Asphalt, Binder Course	10%	SY	1,100
	Asphalt, Wearing Course	10%	SY	1,100
[09 14 09]	**CIP Concrete**	**-**	**CY**	**220**
[09 14 06 01]	**Earthwork**	**-**	**CY**	**601**
	Excavate to Stockpile	-	CY	601
	Fill and Compact From Stockpile	-	CY	441
[09 14 06 02]	**Concrete**	**-**	**CY**	**220**
	Concrete, Forms	-	SFC	9,778
	Concrete, Material	10%	CY	242
	Concrete, Placement	10%	CY	242

Berryessa Creek Work Breakdown Structure Quantities

MCACES Source Tag	Item Description	Waste/Loss Factor (%)	Unit of Measure	Quantity
[09 14 10]	**Reinforcing Steel**	**-**	**LB**	**44,000**
	Reinforcing Steel, Material	-	TON	22.0
	Reinforcing Steel, Placement	-	LBS	44,000
[09 14 11]	**Planting - Grasses on Banks**	**-**	**ACRE**	**0.52**
	Hydroseeding	-	SY	2,500
[09 15]	**Reach 15**	**-**	**LS**	**1**
[09 15 01]	**Excavate and Haul**	**-**	**CY**	**150**
	Excavate, Load and Haul	-	CY	150
[09 16]	**Reach 16**	**-**	**LS**	**1**
[09 16 01]	**Excavate and Haul**	**-**	**CY**	**1,215**
	Excavate, Load and Haul	-	CY	1,215
[14]	**RECREATION**	**-**	**LS**	**1**
[14 01]	**Recreation Trails and Access Points**	**-**	**LS**	**1**
[14 01 01]	**Asphalt Concrete Trail**	**-**	**SF**	**244,000**
[14 01 01 01]	**Roadway Base**	**-**	**CY**	**3,012**
	Aggregate Base, Material	15%	TON	5,196
	Aggregate Base, Placement	15%	TON	3,464
[14 01 01 02]	**Trail Surface**	**-**	**SF**	**244,000**
	Asphalt, Binder Course	10%	SY	29,822
	Asphalt, Wearing Course	10%	SY	29,822
[14 01 02]	**Access Points**	**-**	**EA**	**20**
	Benches	-	EA	40
	Signs	-	EA	40

Berryessa Quantity Summary

Item No.	Item	UOM	Quantity
1	Clearing and Grubbing	ACRE	31
2	Place and Compact Fill	CY	175
3	Excavate and Haul	CY	46,324
4	Import and Place Rip Rap	TON	24,675
5	Geotextile	SY	33,600
6	Cellular Confinement System	SF	101,376
7	Cast-in-place Concrete	CY	950
8	Reinforcing Steel	TON	260,000
9	Planting - Grasses on Banks	ACRE	8.71
10	Temporary Shoo-Fly Structure	LS	1
11	Demo, Haul and Dispose Rails	TF	120
12	Demo, Haul and Dispose Timber	BF	10,000
13	Excavate, Backfill and Compact	CY	450
14	Construct Replacement Culvert	CY	350
15	Construct Wingwalls and Headwalls	EA	6
16	Reconstruct Rails and Ties	TF	120
17	Planting	ACRE	9.91
18	Sheet Piling	SF	2,400
19	Excavate and Regrade Onsite	CY	25
20	Roadway Base	CY	3,500
21	Access Road Surface	SF	63,000
22	Recreation - Ashpalt Trail	SF	244,000
23	Access Points	EA	20

Berryessa Creek Quantities by Reach

Reach No.	Reach Name	Item	UOM	Quantity
1	I-680 Bridge	Earthwork - excavate and haul	CY	75
2	I-680 to Montague - Channel	Relocate utilities	LS	1
		Earthwork - place and compact fill (bend scour area)	CY	100
		Earthwork - excavate and haul	CY	4,074
		Import and place rip rap	TON	5,750
		Geotextile	SY	7,700
		Cellular confinement system	SF	20,453
		Cast-in-place concrete (channel walls/bend)	CY	90
		Reinforcing steel	LB	18,000
		Planting - grasses on banks	ACRE	1.92
3	Montague	Earthwork - excavate and haul	CY	150
4	Montague to UPRR Trestle - Channel	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	896
		Import and place rip rap	TON	1,000
		Geotextile	SY	1,400
		Cellular confinement system	SF	8,156
		Planting - grasses on banks	ACRE	0.41
5	Railroad Trestle	Earthwork - excavate and haul	CY	10
		Temporary Shoo-Fly Structure	LS	1
		Demo, haul, and dispose rails	LF	120
		Demo, haul, and dispose timber	BF	10,000
		Relocate utilities	LS	1
		Earthwork - excavate, backfill, and compact	CY	250
		Construct replacement culvert (triple box)	CY	350
		Reinforcing steel	LB	70,000
		Construct wingwalls, headwalls w/ rails (cast-in-place sloping wingwalls))	EA	6
		Reconstruct rails and ties	LF	120
		Import and place rip rap	TON	75
		Planting	ACRE	0.1
6	UPRR Trestle to Culvert - Channel	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	4,257
		Import and place rip rap	TON	4,750
		Geotextile	SY	6,650
		Cellular confinement system	SF	20,351
		Planting - grasses on banks	ACRE	2.05
7	UPRR Culvert	Earthwork - excavate and haul	CY	60
8	UPRR Culvert to Ames - Channel	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	1,222
		Import and place rip rap	TON	1,000
		Geotextile	SY	1,400
		Cellular confinement system	SF	3,419
		Planting - grasses on banks	ACRE	0.37
9	Ames Bridge	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	200
		Earthwork - excavate, backfill and compact	CY	100
		Sheet piling	SF	1,200
		Cast-in-place concrete	CY	100
		Reinforcing steel	LB	20,000
		Import and place rip rap	TON	50
10	Ames to Yosemite - Channel	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	2,600
		Import and place rip rap	TON	3,000
		Geotextile	SY	4,200
		Cellular confinement system	SF	5,967
		Planting - grasses on banks	ACRE	1.10
11	Yosemite Bridge	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	200
		Earthwork - excavate, backfill and compact	CY	100
		Sheet piling	SF	1,200
		Cast-in-place concrete	CY	100
		Reinforcing steel	LB	20,000
		Import and place rip rap	TON	50
12	Yosemite to Los Coches - Channel	Relocate utilities	LS	1
		Earthwork - place and compact fill, Piedmont Crk Confl	CY	75
		Earthwork - excavate and haul	CY	24,278
		Earthwork - excavate and regrade onsite	CY	25
		Import and place rip rap	TON	7,750
		Geotextile	SY	10,500
		Cellular confinement system	SF	34,227
		Roadway base	CY	3,000
		Access road surface	SF	54,000
		Cast-in-place concrete (channel walls)	CY	440
		Reinforcing steel	LB	88,000
		Planting - grasses on banks	ACRE	3.44
13	Los Coches Bridge	Earthwork - excavate and haul	CY	75
14	Los Coches to Calaveras - Channel	Relocate utilities	LS	1
		Earthwork - excavate and haul	CY	6,861
		Import and place rip rap	TON	1,250
		Geotextile	SY	1,750
		Cellular confinement system	SF	8,803
		Roadway base	CY	500
		Access road surface	SF	9,000
		Cast-in-place concrete (channel walls)	CY	220
		Reinforcing steel	LB	44,000
		Planting - grasses on banks	ACRE	0.52
15	Calaveras Blvd	Earthwork - excavate and haul	CY	150
16	Downstream	Earthwork - excavate and haul	CY	1,215

Berryessa Creek Earthwork Volumes

Reach				Existing				Proposed						Difference		
From	To	Reach No.	Length	Bank Height	Bottom Width	Side Slope	Cross Section Area	Bank Height	Bottom Width	Side Slope	Access Road Height	Access Road Width	Cross Section Area	Cross Section	Excavation Volume	
			(ft)	(ft)	(ft)		(sf)	(ft)	(ft)		(ft)	(ft)	(sf)	(sf)	(cf)	(cy)
Calaveras	Los Coches	14	500	11	22	1.5	424	11	42	2	5	18	794	370.5	185,250	6,861
Los Coches	Yosemite	12	3,000	7	20	1.5	214	7	40	2	3	18	432	218.5	655,500	24,278
Yosemite	Ames	10	1,200	9	13	1.5	239	9	15	2	0	0	297	58.5	70,200	2,600
Ames	UPRR Culvert	8	400	11	12	1.5	314	11	14	2	0	0	396	82.5	33,000	1,222
UPRR Culvert	UPRR Trestle	6	1,900	11	12	1.5	314	11	12	2	0	0	374	60.5	114,950	4,257
UPRR Trestle	Montague	4	400	11	12	1.5	314	11	12	2	0	0	374	60.5	24,200	896
Montague	End of Project	2	2,200	10	12	1.5	270	10	12	2	0	0	320	50	110,000	4,074

Berryessa Creek Utility Relocations

Owner	Utility Type	Size	Stationing	Reach	Easement	Real Property Owner	Length
PG&E	Electrical	12kv Underground Lines	STA 233+00	2	Unknown	SCVWD	75
PG&E	Electrical	Overhead power lines	STA 231+20	2	Unknown	SCVWD	100
City of San Jose	Storm Drain System	24" with 36" Diameter Channel Flap Gate	STA 226+00	2	SCVWD	SCVWD	30
PG&E	Electrical	3-350A	STA 222+00 to 222+60	2	Unknown	SCVWD	140
PG&E	Electrical	12kv	STA 211+80 to 214+60	2	Unknown	SCVWD	280
PG&E	Electrical	12kv	STA 208+40	4	Unknown	Standard Realty and Development Co.	55
PG&E	Electrical	12kv	STA 205+80	6	Unknown	Standard Realty and Development Co.	75
PG&E	Electrical	12kv	STA 197+60	6	Unknown	Standard Realty and Development Co.	60
City of Milpitas	Waterline	12" ACWP	STA 183+00	8	Unknown	Standard Realty and Development Co.	75
City of Milpitas	Storm Drain Outlet	30" RCP	STA 182+80	8	Unknown	Standard Realty and Development Co.	45
AT&T	Telephone Conduit	NA	STA 160+00	12	Unknown	SCVWD	200
City of Milpitas	Storm Drain Outlet	27" CMP	STA 154+00	12	SCVWD	Unknown	35
PG&E	Electrical	3-1/0A XLCJ 21kv 4" underground/transformer	STA 151+00	12	Unknown	Unknown	70
PG&E	Electrical	3-700A and 1-350A 4" underground	STA 149+20 to 151+00	12	Unknown	Unknown	160
PG&E	Electrical	Underground 12kv	STA 138+60 to 143+70	12	Unknown	Unknown	550
Comcast	Cable	Underground Trench/Vault	STA 137+00	14	Unknown	SCVWD D.O.C 42534949	110
City of Milpitas	Storm Drain Outlet	24" CMP	STA 133+50	14	SCVWD	SCVWD D.O.C 42534949	45
PG&E	Electrical	Underground 3-350A XLCJ 12KV 6"	STA 132+00 to 138+00	14	Unknown	SCVWD D.O.C 42534949	550

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Dewatering
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[09 BB] DEWATERING

Quantities per 1 Cofferdam

Earthern Cofferdam

Height = 7.5 ft
Top Width = 8 ft
Bottom Width = 31 ft
Length of Dam = 50 lf

Dam Volume = **267 CY**

Impermeable Liner

Length = 50 lf
Width = 13.5 lf
# of Slopes = 2 ea

Liner Area = **1,350 SF**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Temporary Shoo-Fly Structure
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[09 05] REACH 5

[09 05 02] Temporary Shoo-Fly Structure

[09 05 02 01] Embankment

Earthen Berm

Height = 5 ft
Top Width = 9 ft
Bottom Width = 24 ft
Length = 100 lf

Berm Volume = **306 CY**

[09 05 02 02] Railroad Track

Ballast Stone

Depth = 2.33 ft
Width = 9 ft
Length of Track = 250 lf
Density = 1.5 ton/cy

Stone Weight = **292 TON**

Railroad Ties

Length = 250 lf
Spacing = 1.625 ft
Board Feet per Tie = 52.5 bf

Railroad Ties = **8,077 BF**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 02] REACH 2

[02 02 01] 12kv Underground Line

[02 02 01 01] Demolition

Line Demolition

Length = 75 lf

Line Demolition = **75 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 75 lf

Excavation Volume = **56 CY**

[02 02 01 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 75 lf

Excavation Volume = **56 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 75 lf
# of Sides = 2 ea

Excavation Volume = **38 CY**

Trench Box

Depth = 7 ft
Length = 75 lf
# of Sides = 2 ea

Excavation Volume = **1,050 SF**

Backfill

Demo Excavation = 56 cy
Extra Excavation = 93 cy

Backfill Volume = **149 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 02 02] 24" CMP with 36" Flap Gate
[02 02 02 01] Demolition

CMP Demolition
Length = 30 lf

Pipe Demolition **30 LF**

Concrete Demolition, Headwall
Length = 8.5 ft
Height = 3.67 ft
Thickness = .75 ft

Headwall Demolition = **.9 CY**
Headwall Demolition = **23 CF**

Concrete Demolition, Footing
Length = 8.5 ft
Height = .75 ft
Thickness = 2.0 ft

Footing Demolition = **.5 CY**
Footing Demolition = **13 CF**

Excavation
Depth = 5 ft
Width = 4 ft
Length = 30 lf

Excavation Volume = **22 CY**

[02 02 02 02] Replace Outlet Structure

Extra Excavation, Box Trench
Depth = 5 ft
Width = 4 ft
Length = 30 lf

Excavation Volume = **22 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 30 lf
# of Sides = 2 ea

Excavation Volume = **15 CY**

Trench Box

Depth = 7 ft
Length = 30 lf
# of Sides = 2 ea

Excavation Volume = **420 SF**

Riprap

Length = 5.0 ft
Width = 5.00 ft
Thickness = 1.00 ft

Riprap Volume = **.9 CY**
Riprap Weight = **1.4 TON**

[02 02 03] 350A Underground Line

[02 02 03 01] Demolition

Line Demolition

Length = 140 lf

Line Demolition = **140 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 140 lf

Excavation Volume = **104 CY**

[02 02 03 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 140 lf

Excavation Volume = **104 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 140 lf
# of Sides = 2 ea

Excavation Volume = **70 CY**

Trench Box

Depth = 7 ft
Length = 140 lf
# of Sides = 2 ea

Excavation Volume = **1,960 SF**

Backfill

Demo Excavation = 104 cy
Extra Excavation = 174 cy

Backfill Volume = **277 CY**

[02 02 04] 12kv Underground Line

[02 02 04 01] Demolition

Line Demolition

Length = 280 lf

Line Demolition = **280 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 280 lf

Excavation Volume = **207 CY**

[02 02 04 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 280 lf

Excavation Volume = **207 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 280 lf
# of Sides = 2 ea

Excavation Volume = **140 CY**

Trench Box

Depth = 7 ft
Length = 280 lf
# of Sides = 2 ea

Excavation Volume = **3,920 SF**

Backfill

Demo Excavation = 207 cy
Extra Excavation = 347 cy

Backfill Volume = **555 CY**

[02 04 01] 12kv Underground Line
[02 04 01 01] Demolition

Line Demolition

Length = 55 lf

Line Demolition = **55 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 55 lf

Excavation Volume = **41 CY**

[02 04 01 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 55 lf

Excavation Volume = **41 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 55 lf
# of Sides = 2 ea

Excavation Volume = **28 CY**

Trench Box

Depth = 7 ft
Length = 55 lf
# of Sides = 2 ea

Excavation Volume = **770 SF**

Backfill

Demo Excavation = 41 cy
Extra Excavation = 68 cy

Backfill Volume = **109 CY**

[02 06 01] 12kv Underground Line
[02 06 01 01] Demolition

Line Demolition

Length = 75 lf

Line Demolition = **75 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 75 lf

Excavation Volume = **56 CY**

[02 06 01 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 75 lf

Excavation Volume = **56 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 75 lf
# of Sides = 2 ea

Excavation Volume = **38 CY**

Trench Box

Depth = 7 ft
Length = 75 lf
# of Sides = 2 ea

Excavation Volume = **1,050 SF**

Backfill

Demo Excavation = 56 cy
Extra Excavation = 93 cy

Backfill Volume = **149 CY**

[02 06 02] 12kv Underground Line
[02 06 02 01] Demolition

Line Demolition

Length = 60 lf

Line Demolition = **60 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 60 lf

Excavation Volume = **44 CY**

[02 06 02 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 60 lf

Excavation Volume = **44 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 60 lf
# of Sides = 2 ea

Excavation Volume = **30 CY**

Trench Box

Depth = 7 ft
Length = 60 lf
# of Sides = 2 ea

Excavation Volume = **840 SF**

Backfill

Demo Excavation = 44 cy
Extra Excavation = 74 cy

Backfill Volume = **119 CY**

[02 08 01] 12" Waterline
[02 08 01 01] Demolition

Pipe Demolition

Length = 75 lf
No. of Pipes = 2 ea

Pipe Demolition = **150 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 150 lf

Excavation Volume = **111 CY**

[02 08 01 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 150 lf

Excavation Volume = **111 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 150 lf
# of Sides = 2 ea

Excavation Volume = **75 CY**

Trench Box

Depth = 7 ft
Length = 150 lf
# of Sides = 2 ea

Excavation Volume = **2,100 SF**

Backfill

Demo Excavation = 111 cy
Extra Excavation = 186 cy

Backfill Volume = **297 CY**

[02 08 02] 30" RCP
[02 08 02 01] Demolition

Pipe Demolition

Length = 45 lf

Pipe Demolition = **45 LF**

Excavation

Depth = 5 ft
Width = 5 ft
Length = 45 lf

Excavation Volume = **42 CY**

[02 08 02 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 45 lf

Excavation Volume = **33 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 45 lf
# of Sides = 2 ea

Excavation Volume = **23 CY**

Trench Box

Depth = 7 ft
Length = 45 lf
# of Sides = 2 ea

Excavation Volume = **630 SF**

Backfill

Demo Excavation = 42 cy
Extra Excavation = 56 cy

Backfill Volume = **98 CY**

Bedding Material

Depth = 1.5 ft
Length = 45 ft
Width = 3.0 ft

Bedding Volume = **7.5 CY**

[02 12 01] Telephone Conduit
[02 12 01 01] Demolition

Conduit Demolition

Length = 200 lf

Conduit Demolition = **200 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 200 lf

Excavation Volume = **148 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 12 01 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 4 ft
Length = 148 lf

Excavation Volume = **110 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 148 lf
# of Sides = 2 ea

Excavation Volume = **74 CY**

Trench Box

Depth = 7 ft
Length = 148 lf
# of Sides = 2 ea

Excavation Volume = **2,074 SF**

Backfill

Demo Excavation = 148 cy
Extra Excavation = 184 cy

Backfill Volume = **332 CY**

[02 12 02] 27" CMP
[02 12 02 01] Demolition

Pipe Demolition

Length = 35 lf

Pipe Demolition = **35 LF**

Excavation

Depth = 5 ft
Width = 5 ft
Length = 35 lf

Excavation Volume = **32 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 12 02 02] Relocation

Extra Excavation, Box Trench
Depth = 5 ft
Width = 5 ft
Length = 35 lf

Excavation Volume = **32 CY**

Extra Excavation, Top Edges (1.5:1)
Depth = 3 ft
Width = 4.5 ft
Length = 35 lf
# of Sides = 2 ea

Excavation Volume = **18 CY**

Trench Box
Depth = 7 ft
Length = 35 lf
# of Sides = 2 ea

Excavation Volume = **490 SF**

Backfill
Demo Excavation = 32 cy
Extra Excavation = 50 cy

Backfill Volume = **82 CY**

Bedding Material
Depth = 1.5 ft
Length = 35 ft
Width = 3.0 ft

Bedding Volume = **5.8 CY**

[02 12 03] 13-1/0A SLCJ 21kv
[02 12 03 01] Demolition

Cable Demolition
Length = 70 lf
No. of Cables = 3 ea

Cable Demolition = **210 LF**

Excavation

Depth = 5 ft
Width = 4 ft
Length = 70 lf

Excavation Volume = **52 CY**

[02 12 03 02] Relocation

Extra Excavation, Box Trench

Depth = 5 ft
Width = 5 ft
Length = 70 lf

Excavation Volume = **65 CY**

Extra Excavation, Top Edges (1.5:1)

Depth = 3 ft
Width = 4.5 ft
Length = 70 lf
# of Sides = 2 ea

Excavation Volume = **35 CY**

Trench Box

Depth = 7 ft
Length = 70 lf
# of Sides = 2 ea

Excavation Volume = **980 SF**

Backfill

Demo Excavation = 52 cy
Extra Excavation = 100 cy

Backfill Volume = **152 CY**

Bedding Material

Depth = 1.5 ft
Length = 210 ft
Width = 3.0 ft

Bedding Volume = **35.0 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 12 04] 3-700A and 1-350A Underground
[02 12 04 01] Demolition

Cable Demolition
Length = 160 lf
No. of Cables = 4 ea

Cable Demolition = **640 LF**

Excavation
Depth = 5 ft
Width = 4 ft
Length = 160 lf

Excavation Volume = **119 CY**

[02 12 04 02] Relocation

Extra Excavation, Box Trench
Depth = 5 ft
Width = 5 ft
Length = 160 lf

Excavation Volume = **148 CY**

Extra Excavation, Top Edges (1.5:1)
Depth = 3 ft
Width = 4.5 ft
Length = 160 lf
# of Sides = 2 ea

Excavation Volume = **80 CY**

Trench Box
Depth = 7 ft
Length = 160 lf
# of Sides = 2 ea

Excavation Volume = **2,240 SF**

Backfill
Demo Excavation = 119 cy
Extra Excavation = 228 cy

Backfill Volume = **347 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 12 05] 12kv Underground Line
[02 12 05 01] Demolition

Line Demolition
Length = 550 lf

Line Demolition = **550 LF**

Excavation
Depth = 5 ft
Width = 4 ft
Length = 550 lf

Excavation Volume = **407 CY**

[02 12 05 02] Relocation

Extra Excavation, Box Trench
Depth = 5 ft
Width = 5 ft
Length = 550 lf

Excavation Volume = **509 CY**

Extra Excavation, Top Edges (1.5:1)
Depth = 3 ft
Width = 4.5 ft
Length = 550 lf
# of Sides = 2 ea

Excavation Volume = **275 CY**

Trench Box
Depth = 7 ft
Length = 550 lf
# of Sides = 2 ea

Excavation Volume = **7,700 SF**

Backfill
Demo Excavation = 407 cy
Extra Excavation = 784 cy

Backfill Volume = **1,192 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

[02 14 01] Underground Trench/Vault - STA 137+00
[02 14 01 01] Demolition

Underground Duct Demolition
Length = 110 lf

Duct Demolition = **110 LF**

Excavation
Depth = 5 ft
Width = 4 ft
Length = 110 lf

Excavation Volume = **81 CY**

[02 14 01 02] Relocation

Extra Excavation, Box Trench
Depth = 5 ft
Width = 5 ft
Length = 110 lf

Excavation Volume = **102 CY**

Extra Excavation, Top Edges (1.5:1)
Depth = 3 ft
Width = 4.5 ft
Length = 110 lf
# of Sides = 2 ea

Excavation Volume = **55 CY**

Trench Box
Depth = 7 ft
Length = 110 lf
# of Sides = 2 ea

Excavation Volume = **1,540 SF**

Backfill
Demo Excavation = 81 cy
Extra Excavation = 157 cy

Backfill Volume = **238 CY**

Bedding Material
Depth = .5 ft
Length = 110 ft
Width = 2.0 ft

Bedding Volume = **4.1 CY**

[02 14 02] 24" CMP
[02 14 02 01] Demolition

Pipe Demolition
Length = 45 lf

Pipe Demolition = **45 LF**

Excavation
Depth = 5 ft
Width = 4 ft
Length = 45 lf

Excavation Volume = **33 CY**

[02 14 02 02] Relocation

Extra Excavation, Box Trench
Depth = 5 ft
Width = 5 ft
Length = 45 lf

Excavation Volume = **42 CY**

Extra Excavation, Top Edges (1.5:1)
Depth = 3 ft
Width = 4.5 ft
Length = 45 lf
# of Sides = 2 ea

Excavation Volume = **23 CY**

Trench Box
Depth = 7 ft
Length = 45 lf
# of Sides = 2 ea

Excavation Volume = **630 SF**

Backfill
Demo Excavation = 33 cy
Extra Excavation = 64 cy

Backfill Volume = **98 CY**

Bedding Material
Depth = 1.0 ft
Length = 45 ft
Width = 3.0 ft

Bedding Volume = **5.0 CY**

[02 14 03] Underground 3-350A XLCJ 12kv
[02 14 03 01] Demolition

Cable Demolition
Length = 550 lf
No. of Cables = 3 ea

Cable Demolition = **1,650 LF**

Excavation
Depth = 5 ft
Width = 4 ft
Length = 550 lf

Excavation Volume = **407 CY**

[02 14 03 02] Relocation

Extra Excavation, Box Trench
Depth = 5 ft
Width = 5 ft
Length = 550 lf

Excavation Volume = **509 CY**

Extra Excavation, Top Edges (1.5:1)
Depth = 3 ft
Width = 4.5 ft
Length = 550 lf
# of Sides = 2 ea

Excavation Volume = **275 CY**

TETRA TECH, INC.

PROJECT: Berryessa Creek Flood Control
DETAIL: Detailed Quantity Take-Offs for Utility Relocations
COMPUTED BY: SKV JOB NO.: T26465
CHECKED BY: DATE: 12/31/2011

Trench Box

Depth = 7 ft
Length = 550 lf
# of Sides = 2 ea

Excavation Volume = **7,700 SF**

Backfill

Demo Excavation = 407 cy
Extra Excavation = 784 cy

Backfill Volume = **1,192 CY**

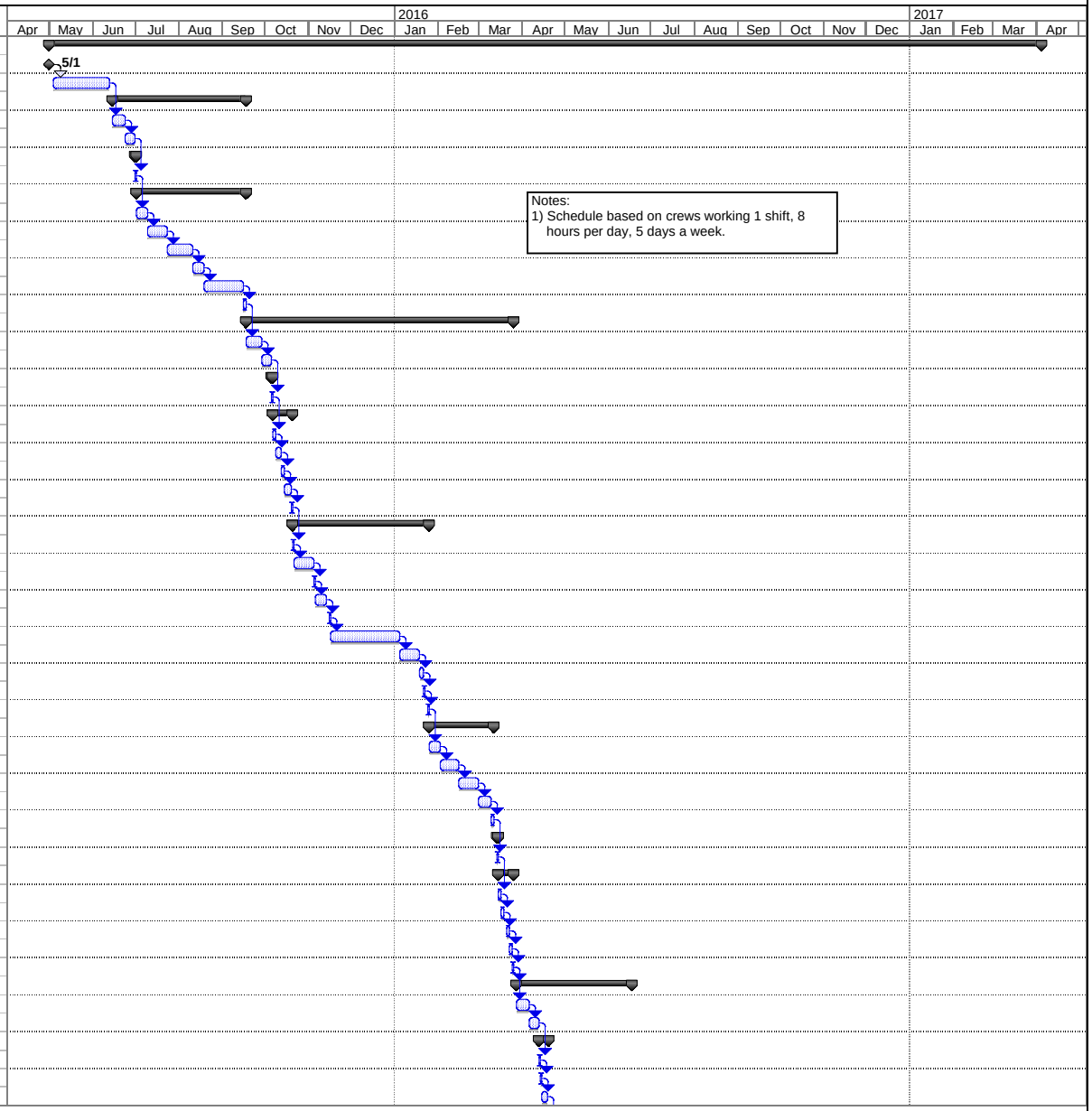
APPENDIX C

Tentative Construction Schedule

Berryessa Creek Flood Control
Tentative Construction Schedule

Tue 1/29/13

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Berryessa Creek Construction**	**503 days**	**Fri 5/1/15**	**Tue 4/4/17**	
2	Notice to Proceed	0 days	Fri 5/1/15	Fri 5/1/15	
3	Mobilization / Demobilization	30 days	Mon 5/4/15	Fri 6/12/15	2FS+1 day
4	**Construction Phase 1 - Reaches 1-2**	**69 days**	**Mon 6/15/15**	**Thu 9/17/15**	
5	Dewatering	7 days	Mon 6/15/15	Tue 6/23/15	3
6	Clearing and Grubing	5 days	Wed 6/24/15	Tue 6/30/15	5
7	**Reach 1**	**1 day**	**Wed 7/1/15**	**Wed 7/1/15**	
8	Excavate and Haul	1 day	Wed 7/1/15	Wed 7/1/15	6
9	**Reach 2**	**56 days**	**Thu 7/2/15**	**Thu 9/17/15**	
10	Excavate and Haul	6 days	Thu 7/2/15	Thu 7/9/15	8
11	Geotextile Fabric	10 days	Fri 7/10/15	Thu 7/23/15	10
12	Import and Place Riprap	12 days	Fri 7/24/15	Mon 8/10/15	11
13	Cellular Confinement System	6 days	Tue 8/11/15	Tue 8/18/15	12
14	CIP Concrete	20 days	Wed 8/19/15	Tue 9/15/15	13
15	Seeding	2 days	Wed 9/16/15	Thu 9/17/15	14
16	**Construction Phase 2 - Reaches 3-8**	**136 days**	**Fri 9/18/15**	**Fri 3/25/16**	
17	Dewatering	7 days	Fri 9/18/15	Mon 9/28/15	15
18	Clearing and Grubing	5 days	Tue 9/29/15	Mon 10/5/15	17
19	**Reach 3**	**1 day**	**Tue 10/6/15**	**Tue 10/6/15**	
20	Excavate and Haul	1 day	Tue 10/6/15	Tue 10/6/15	18
21	**Reach 4**	**10 days**	**Wed 10/7/15**	**Tue 10/20/15**	
22	Excavate and Haul	2 days	Wed 10/7/15	Thu 10/8/15	20
23	Geotextile Fabric	2 days	Fri 10/9/15	Mon 10/12/15	22
24	Import and Place Riprap	2 days	Tue 10/13/15	Wed 10/14/15	23
25	Cellular Confinement System	3 days	Thu 10/15/15	Mon 10/19/15	24
26	Seeding	1 day	Tue 10/20/15	Tue 10/20/15	25
27	**Reach 5**	**69 days**	**Wed 10/21/15**	**Mon 1/25/16**	
28	Excavate and Haul	1 day	Wed 10/21/15	Wed 10/21/15	26
29	Temporary Shoo Fly Structure	10 days	Thu 10/22/15	Wed 11/4/15	28
30	Demo, Haul and Dispose Rails	1 day	Thu 11/5/15	Thu 11/5/15	29
31	Demo, Haul and Dispose Timber	6 days	Fri 11/6/15	Fri 11/13/15	30
32	Excavate, Backfill and Compact	1 day	Mon 11/16/15	Mon 11/16/15	31
33	Construct Replacement Culvert	35 days	Tue 11/17/15	Mon 1/4/16	32
34	Construct Wingwalls & Headwalls	10 days	Tue 1/5/16	Mon 1/18/16	33
35	Reconstruct Rails and Ties	3 days	Tue 1/19/16	Thu 1/21/16	34
36	Import and place Riprap	1 day	Fri 1/22/16	Fri 1/22/16	35
37	Seeding	1 day	Mon 1/25/16	Mon 1/25/16	36
38	**Reach 6**	**34 days**	**Tue 1/26/16**	**Fri 3/11/16**	
39	Excavate and Haul	6 days	Tue 1/26/16	Tue 2/2/16	37
40	Geotextile Fabric	9 days	Wed 2/3/16	Mon 2/15/16	39
41	Import and Place Riprap	10 days	Tue 2/16/16	Mon 2/29/16	40
42	Cellular Confinement System	7 days	Tue 3/1/16	Wed 3/9/16	41
43	Seeding	2 days	Thu 3/10/16	Fri 3/11/16	42
44	**Reach 7**	**1 day**	**Mon 3/14/16**	**Mon 3/14/16**	
45	Excavate and Haul	1 day	Mon 3/14/16	Mon 3/14/16	43
46	**Reach 8**	**9 days**	**Tue 3/15/16**	**Fri 3/25/16**	
47	Excavate and Haul	2 days	Tue 3/15/16	Wed 3/16/16	45
48	Geotextile Fabric	2 days	Thu 3/17/16	Fri 3/18/16	47
49	Import and Place Riprap	2 days	Mon 3/21/16	Tue 3/22/16	48
50	Cellular Confinement System	2 days	Wed 3/23/16	Thu 3/24/16	49
51	Seeding	1 day	Fri 3/25/16	Fri 3/25/16	50
52	**Construction Phase 3 - Reaches 9-10**	**60 days**	**Mon 3/28/16**	**Fri 6/17/16**	**51**
53	Dewatering	7 days	Mon 3/28/16	Tue 4/5/16	51
54	Clearing and Grubbing	5 days	Wed 4/6/16	Tue 4/12/16	53
55	**Reach 9**	**5 days**	**Wed 4/13/16**	**Tue 4/19/16**	
56	Excavate and Haul	1 day	Wed 4/13/16	Wed 4/13/16	54
57	Excavate, Backfill and Compact	1 day	Thu 4/14/16	Thu 4/14/16	56
58	Sheet Piling	2 days	Fri 4/15/16	Mon 4/18/16	57

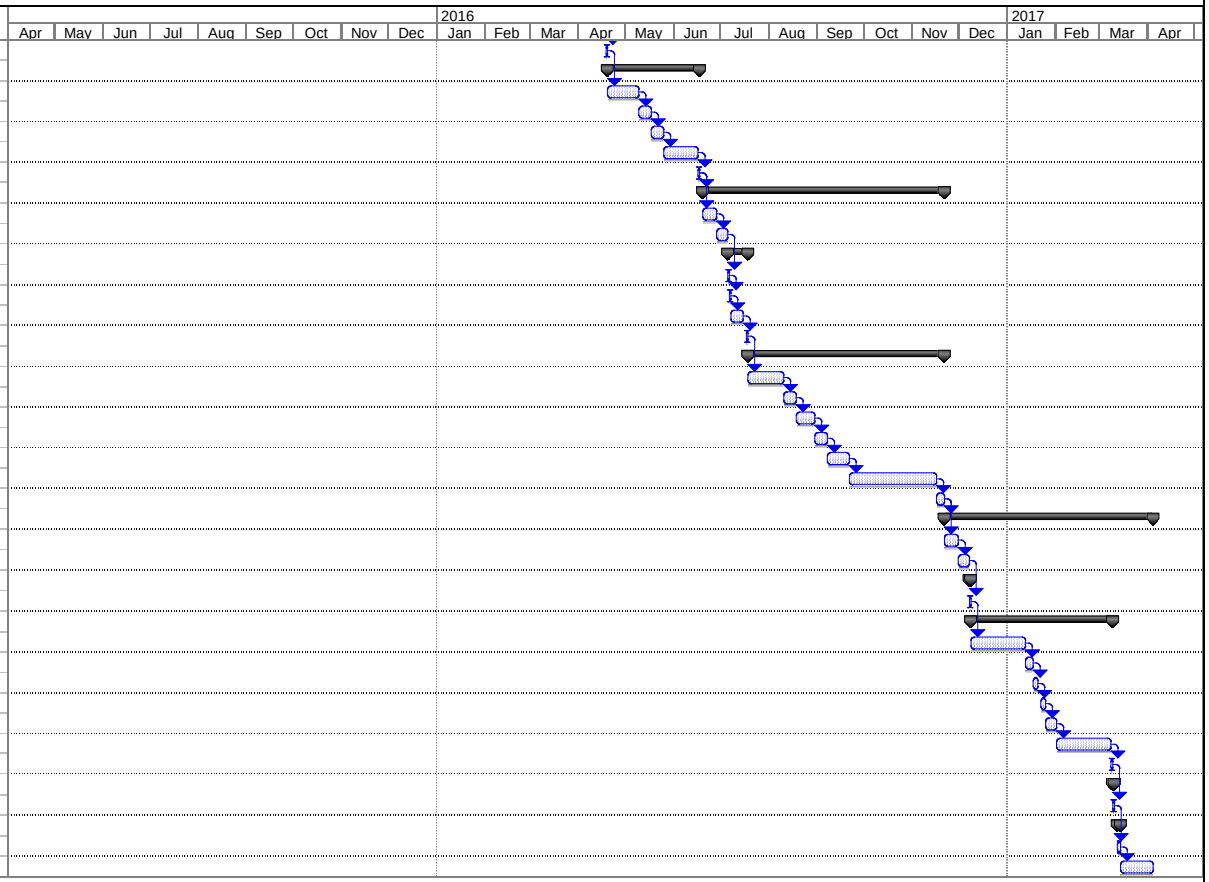


Task | Progress | Summary | External Tasks | Split
Split | Milestone | Project Summary | External MileTask

Berryessa Creek Flood Control
Tentative Construction Schedule

Tue 1/29/13

ID	Task Name	Duration	Start	Finish	Predecessors
59	Import and Place Riprap	1 day	Tue 4/19/16	Tue 4/19/16	58
60	**Reach 10**	**43 days**	**Wed 4/20/16**	**Fri 6/17/16**	
61	Excavate and Haul	14 days	Wed 4/20/16	Mon 5/9/16	59
62	Geotextile Fabric	6 days	Tue 5/10/16	Tue 5/17/16	61
63	Import and Place Riprap	6 days	Wed 5/18/16	Wed 5/25/16	62
64	Cellular Confinement System	16 days	Thu 5/26/16	Thu 6/16/16	63
65	Seeding	1 day	Fri 6/17/16	Fri 6/17/16	64
66	**Construction Phase 4 - Reaches 11-12**	**111 days**	**Mon 6/20/16**	**Mon 11/21/16**	**65**
67	Dewatering	7 days	Mon 6/20/16	Tue 6/28/16	65
68	Clearing and Grubbing	5 days	Wed 6/29/16	Tue 7/5/16	67
69	**Reach 11**	**9 days**	**Wed 7/6/16**	**Mon 7/18/16**	
70	Excavate and Haul	1 day	Wed 7/6/16	Wed 7/6/16	68
71	Excavate, Backfill and Compact	1 day	Thu 7/7/16	Thu 7/7/16	70
72	Sheet Piling	6 days	Fri 7/8/16	Fri 7/15/16	71
73	Import and Place Riprap	1 day	Mon 7/18/16	Mon 7/18/16	72
74	**Reach 12**	**90 days**	**Tue 7/19/16**	**Mon 11/21/16**	
75	Excavate and Haul	17 days	Tue 7/19/16	Wed 8/10/16	73
76	Geotextile Fabric	6 days	Thu 8/11/16	Thu 8/18/16	75
77	Import and Place Riprap	8 days	Fri 8/19/16	Tue 8/30/16	76
78	Cellular Confinement System	6 days	Wed 8/31/16	Wed 9/7/16	77
79	Access Road	10 days	Thu 9/8/16	Wed 9/21/16	78
80	CIP Concrete	40 days	Thu 9/22/16	Wed 11/16/16	79
81	Seeding	3 days	Thu 11/17/16	Mon 11/21/16	80
82	**Construction Phase 5 - Reaches 13-16**	**96 days**	**Tue 11/22/16**	**Tue 4/4/17**	**81**
83	Dewatering	7 days	Tue 11/22/16	Wed 11/30/16	81
84	Clearing and Grubbing	5 days	Thu 12/1/16	Wed 12/7/16	83
85	**Reach 13**	**1 day**	**Thu 12/8/16**	**Thu 12/8/16**	
86	Excavate and Haul	1 day	Thu 12/8/16	Thu 12/8/16	84
87	**Reach 14**	**65 days**	**Fri 12/9/16**	**Thu 3/9/17**	
88	Excavate and Haul	25 days	Fri 12/9/16	Thu 1/12/17	86
89	Geotextile Fabric	3 days	Fri 1/13/17	Tue 1/17/17	88
90	Import and Place Riprap	3 days	Wed 1/18/17	Fri 1/20/17	89
91	Cellular Confinement System	3 days	Mon 1/23/17	Wed 1/25/17	90
92	Access Road	5 days	Thu 1/26/17	Wed 2/1/17	91
93	CIP Concrete	25 days	Thu 2/2/17	Wed 3/8/17	92
94	Seeding	1 day	Thu 3/9/17	Thu 3/9/17	93
95	**Reach 15**	**1 day**	**Fri 3/10/17**	**Fri 3/10/17**	
96	Excavate and Haul	1 day	Fri 3/10/17	Fri 3/10/17	94
97	**Reach 16**	**2 days**	**Mon 3/13/17**	**Tue 3/14/17**	
98	Excavate and Haul	2 days	Mon 3/13/17	Tue 3/14/17	96
99	Demobilization	15 days	Wed 3/15/17	Tue 4/4/17	98



Task | Progress | Summary | External Tasks | Split
Split | Milestone | Project Summary | External MileTask

APPENDIX D

Local Market Labor Rates

General Decision Number: CA130029 01/18/2013 CA29

Superseded General Decision Number: CA20120029

State: California

Construction Types: Building, Heavy (Heavy and Dredging) and Highway

Counties: Alameda, Calaveras, Contra Costa, Fresno, Kings, Madera, Mariposa, Merced, Monterey, San Benito, San Francisco, San Joaquin, San Mateo, Santa Clara, Santa Cruz, Stanislaus and Tuolumne Counties in California.

BUILDING CONSTRUCTION PROJECTS; DREDGING PROJECTS (does not include hopper dredge work); HEAVY CONSTRUCTION PROJECTS (does not include water well drilling); HIGHWAY CONSTRUCTION PROJECTS

Modification Number	Publication Date
0	01/04/2013
1	01/18/2013

ASBE0016-001 04/01/2012

AREA 1: ALAMEDA, CONTRA COSTA, LAKE, MARIN, MENDOCINO, MONTEREY, NAPA, SAN BENITO, SAN FRANCISCO, SAN MATEO, SANTA CLARA, SANTA CRUZ, SOLANO, & SONOMA COUNTIES

AREA 2: ALPINE, AMADOR, BUTTE, CALAVERAS, COLUSA, DEL NORTE, EL DORADO, FRESNO, GLENN, HUMBOLDT, KINGS, LASSEN, MADERA, MARIPOSA, MERCED, MODOC, MONO, NEVADA, PLACER, PLUMAS, SACRAMENTO, SAN JOAQUIN, SHASTA, SIERRA, SISKIYOU, STANISLAU, SUTTER, TEHEMA, TRINITY, TULARE, TUOLUMNE, YOLO, & YUBA COUNTIES

	Rates	Fringes
Asbestos Workers/Insulator (Includes the application of all insulating materials, Protective Coverings, Coatings, and Finishes to all types of mechanical systems)		
Area 1	$ 52.20	18.47
Area 2	$ 40.55	18.47

ASBE0016-004 01/01/2012

	Rates	Fringes
Asbestos Removal worker/hazardous material handler (Includes preparation, wetting, stripping, removal, scrapping, vacuuming, bagging and disposing of all		

insulation materials from
mechanical systems, whether
they contain asbestos or not)....$ 30.53 6.75

BOIL0549-001 01/01/2009

AREA 1: ALAMEDA, CONTRA COSTA, SAN FRANCISCO, SAN MATEO & SANTA CLARA COUNTIES

AREA 2: REMAINING COUNTIES

	Rates	Fringes
BOILERMAKER		
Area 1	$ 40.17	22.32
Area 2	$ 37.01	22.25

BRCA0003-001 06/01/2011

	Rates	Fringes
MARBLE FINISHER	$ 28.02	12.22

BRCA0003-003 06/01/2011

	Rates	Fringes
MARBLE MASON	$ 39.22	18.68

BRCA0003-005 05/01/2011

	Rates	Fringes
BRICKLAYER		
(1) Fresno, Kings, Madera, Mariposa, Merced	$ 34.11	19.34
(7) San Francisco, San Mateo	$ 39.85	22.00
(8) Alameda, Contra Costa, San Benito, Santa Clara	$ 39.63	19.92
(9) Calaveras, San Joaquin, Stanislaus, Toulumne	$ 35.11	18.99
(16) Monterey, Santa Cruz	$ 35.91	22.42

BRCA0003-008 06/01/2011

	Rates	Fringes
TERRAZZO FINISHER	$ 30.30	13.77
TERRAZZO WORKER/SETTER	$ 39.30	21.20

BRCA0003-011 01/01/2011

AREA 1: Alameda, Contra Costa, Monterey, San Benito, San Francisco, San Mateo, Santa Clara, Santa Cruz

AREA 2: Calaveras, San Joaquin, Stanislaus, Tuolumne

AREA 3: Fresno, Kings, Madera, Mariposa, Merced

	Rates	Fringes
TILE FINISHER		
Area 1	$ 21.44	12.31
Area 2	$ 21.26	12.44
Area 3	$ 21.01	11.58
Tile Layer		
Area 1	$ 38.61	13.73
Area 2	$ 34.41	13.68
Area 3	$ 29.78	13.10

CARP0022-001 07/01/2012

San Francisco County

	Rates	Fringes
Carpenters		
Bridge Builder/Highway Carpenter	$ 38.50	25.68
Hardwood Floorlayer, Shingler, Power Saw Operator, Steel Scaffold & Steel Shoring Erector, Saw Filer	$ 38.65	25.68
Journeyman Carpenter	$ 38.50	25.68
Millwright	$ 38.60	27.27

CARP0034-001 07/01/2012

	Rates	Fringes
Diver		
Assistant Tender, ROV Tender/Technician	$ 37.75	28.88
Diver standby	$ 42.53	28.88
Diver Tender	$ 41.53	28.88
Diver wet	$ 85.06	28.88
Manifold Operator (mixed gas)	$ 46.53	28.88
Manifold Operator (Standby)	$ 41.53	28.88

DEPTH PAY (Surface Diving):
050 to 100 ft $2.00 per foot
101 to 150 ft $3.00 per foot
151 to 220 ft $4.00 per foot

SATURATION DIVING:
The standby rate shall apply until saturation starts. The saturation diving rate applies when divers are under pressure continuously until work task and decompression are complete. The diver rate shall be paid for all saturation hours.

DIVING IN ENCLOSURES:
Where it is necessary for Divers to enter pipes or tunnels,

or other enclosures where there is no vertical ascent, the following premium shall be paid: Distance traveled from entrance 26 feet to 300 feet: $1.00 per foot. When it is necessary for a diver to enter any pipe, tunnel or other enclosure less than 48" in height, the premium will be $1.00 per foot.

WORK IN COMBINATION OF CLASSIFICATIONS:
Employees working in any combination of classifications within the diving crew (except dive supervisor) in a shift are paid in the classification with the highest rate for that shift.

CARP0034-003 07/01/2012

	Rates	Fringes
Piledriver	$ 37.75	28.88

CARP0035-007 07/01/2012

AREA 1: Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara counties

AREA 2: Monterey, San Benito, Santa Cruz Counties

AREA 3: Calaveras, Fresno, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, Tuolumne Counties

	Rates	Fringes
Modular Furniture Installer		
Area 1		
Installer I	$ 22.61	16.71
Installer II	$ 19.18	16.71
Lead Installer	$ 26.06	17.21
Master Installer	$ 30.28	17.21
Area 2		
Installer I	$ 19.96	16.71
Installer II	$ 17.01	16.71
Lead Installer	$ 22.93	17.21
Master Installer	$ 26.56	17.21
Area 3		
Installer I	$ 19.01	16.71
Installer II	$ 16.24	16.71
Lead Installer	$ 21.81	17.21
Master Installer	$ 25.23	17.21

CARP0035-008 08/01/2012

AREA 1: Alameda, Contra Costa, San Francisco, San Mateo, Santa Clara counties

AREA 2: Monterey, San Benito, Santa Cruz Counties

AREA 3: San Joaquin

AREA 4: Calaveras, Fresno, Kings, Madera, Mariposa, Merced, Stanislaus, Tuolumne Counties

	Rates	Fringes
Drywall Installers/Lathers:		
Area 1	$ 38.50	26.12
Area 2	$ 32.62	26.12
Area 3	$ 33.12	26.12
Area 4	$ 31.77	26.12
Drywall Stocker/Scrapper		
Area 1	$ 19.25	15.03
Area 2	$ 16.31	15.03
Area 3	$ 16.56	15.03
Area 4	$ 15.88	15.03

CARP0152-001 07/01/2012

Contra Costa County

	Rates	Fringes
Carpenters		
Bridge Builder/Highway Carpenter	$ 38.50	25.68
Hardwood Floorlayer, Shingler, Power Saw Operator, Steel Scaffold & Steel Shoring Erector, Saw Filer	$ 38.65	25.68
Journeyman Carpenter	$ 38.50	25.68
Millwright	$ 38.60	27.27

CARP0152-002 07/01/2012

San Joaquin County

	Rates	Fringes
Carpenters		
Bridge Builder/Highway Carpenter	$ 38.50	25.68
Hardwood Floorlayer, Shingler, Power Saw Operator, Steel Scaffold & Steel Shoring Erector, Saw Filer	$ 32.77	25.68
Journeyman Carpenter	$ 32.62	25.68
Millwright	$ 35.12	27.27

CARP0152-004 07/01/2012

Calaveras, Mariposa, Merced, Stanislaus and Tuolumne Counties

	Rates	Fringes
Carpenters		
Bridge Builder/Highway Carpenter	$ 38.50	25.68
Hardwood Floorlayer, Shingler, Power Saw		

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     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer.......................$ 31.42            25.68
     Journeyman Carpenter........$ 31.27            25.68
     Millwright..................$ 33.77            27.27
-----------------------------------------------------------------
 CARP0217-001 07/01/2012

San Mateo County

                                   Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter...................$ 38.50            25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer.......................$ 38.65            25.68
     Journeyman Carpenter........$ 38.50            25.68
     Millwright..................$ 38.60            27.27
-----------------------------------------------------------------
 CARP0405-001 07/01/2012

Santa Clara County

                                   Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter...................$ 38.50            25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer.......................$ 38.65            25.68
     Journeyman Carpenter........$ 38.50            25.68
     Millwright..................$ 38.60            27.27
-----------------------------------------------------------------
 CARP0405-002 07/01/2012

San Benito County

                                   Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter...................$ 38.50            25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer.......................$ 32.77            25.68
     Journeyman Carpenter........$ 32.62            25.68
     Millwright..................$ 35.12            27.27
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 CARP0505-001 07/01/2012

Santa Cruz County
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                                  Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter..................$ 38.50           25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer......................$ 32.77           25.68
     Journeyman Carpenter........$ 32.62           25.68
     Millwright.................$ 35.12           27.27
----------------------------------------------------------------
 CARP0605-001 07/01/2012

Monterey County

                                  Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter..................$ 38.50           25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer......................$ 32.77           25.68
     Journeyman Carpenter........$ 32.62           25.68
     Millwright.................$ 35.12           27.27
----------------------------------------------------------------
 CARP0701-001 07/01/2012

Fresno and Madera Counties

                                  Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter..................$ 38.50           25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer......................$ 31.42           25.68
     Journeyman Carpenter........$ 31.27           25.68
     Millwright.................$ 33.77           27.27
----------------------------------------------------------------
 CARP0713-001 07/01/2012

Alameda County

                                  Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter..................$ 38.50           25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
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     Steel Shoring Erector, Saw
     Filer.......................$ 38.65            25.68
     Journeyman Carpenter........$ 38.50            25.68
     Millwright..................$ 38.60            27.27
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 CARP1109-001 07/01/2012

Kings County

                                  Rates          Fringes

Carpenters
     Bridge Builder/Highway
     Carpenter...................$ 38.50            25.68
     Hardwood Floorlayer,
     Shingler, Power Saw
     Operator, Steel Scaffold &
     Steel Shoring Erector, Saw
     Filer.......................$ 31.42            25.68
     Journeyman Carpenter........$ 31.27            25.68
     Millwright..................$ 33.77            27.27
-----------------------------------------------------------------
 ELEC0006-001 12/01/2011

ALAMEDA, CONTRA COSTA, MONTEREY, SAN BENITO, SAN MATEO, SANTA
CLARA, AND SANTA CRUZ COUNTIES


                                  Rates          Fringes

Sound & Communications
     Installer...................$ 30.12         3%+13.70
     Technician..................$ 34.29         3%+13.70

  SCOPE OF WORK:  Including any data system whose only function
  is to transmit or  receive information; excluding all other
  data systems or  multiple systems which include control
  function or power supply;  inclusion or exclusion of
  terminations and testings of  conductors determined by
  their function; excluding fire alarm  work when installed
  in raceways (including wire and cable  pulling) and when
  performed on new or major remodel building  projects or
  jobs for which the conductors for the fire alarm system are
  installed in conduit; excluding installation of raceway
  systems, line voltage work, industrial work, life-safety
  systems (all buildings having floors located more than 75'
  above the lowest floor level having building access);
  excluding energy management systems.

  FOOTNOTE:   Fire alarm work when installed in raceways
  (including wire and cable pulling), on projects which
  involve new or major remodel building construction, for
  which the conductors for the fire alarm system are
  installed in the conduit, shall be performed by the inside
  electrician.
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 ELEC0006-004 12/01/2011

SAN FRANCISCO COUNTY
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	Rates	Fringes
Sound & Communications		
Installer	$ 30.62	3%+14.20
Technician	$ 38.16	3%+14.20

SCOPE OF WORK: Including any data system whose only function is to transmit or receive information; excluding all other data systems or multiple systems which include control function or power supply; inclusion or exclusion of terminations and testings of conductors determined by their function; excluding fire alarm work when installed in raceways (including wire and cable pulling) and when performed on new or major remodel building projects or jobs for which the conductors for the fire alarm system are installed in conduit; excluding installation of raceway systems, line voltage work, industrial work, life-safety systems (all buildings having floors located more than 75' above the lowest floor level having building access); excluding energy management systems.

FOOTNOTE: Fire alarm work when installed in raceways (including wire and cable pulling), on projects which involve new or major remodel building construction, for which the conductors for the fire alarm system are installed in the conduit, shall be performed by the inside electrician.

ELEC0006-007 06/01/2012

SAN FRANCISCO COUNTY

	Rates	Fringes
ELECTRICIAN	$ 54.87	25.595

ELEC0006-008 12/01/2011

CALAVERAS, MARIPOSA, MERCED, SAN JOAQUIN, STANISLAUS AND TUOLUMNE COUNTIES

	Rates	Fringes
Communications System		
Installer	$ 30.12	3%+13.70
Technician	$ 34.29	3%+13.70

SCOPE OF WORK: Including any data system whose only function is to transmit or receive information; excluding all other data systems or multiple systems which include control function or power supply; inclusion or exclusion of terminations and testings of conductors determined by their function; excluding fire alarm work when installed in raceways (including wire and cable pulling) and when performed on new or major remodel building projects or jobs for which the conductors for the fire alarm system are installed in conduit; excluding installation of raceway systems, line voltage work, industrial work, life-safety systems (all buildings having floors located more than 75'

above the lowest floor level having building access); excluding energy management systems.

FOOTNOTE: Fire alarm work when installed in raceways (including wire and cable pulling), on projects which involve new or major remodel building construction, for which the conductors for the fire alarm system are installed in the conduit, shall be performed by the inside electrician.

ELEC0100-002 06/01/2012

FRESNO, KINGS, AND MADERA COUNTIES

	Rates	Fringes
ELECTRICIAN.....	$ 33.35	3%+18.33

ELEC0100-005 12/01/2011

FRESNO, KINGS, MADERA

	Rates	Fringes
Communications System		
Installer.....	$ 26.43	3%+13.70
Technician.....	$ 30.09	3%+13.70

SCOPE OF WORK

Includes the installation testing, service and maintenance, of the following systems which utilize the transmission and/or transference of voice, sound, vision and digital for commercial, education, security and entertainment purposes for the following: TV monitoring and surveillance, background-foreground music, intercom and telephone interconnect, inventory control systems, microwave transmission, multi-media, multiplex, nurse call system, radio page, school intercom and sound, burglar alarms, and low voltage master clock systems.

A. SOUND AND VOICE TRANSMISSION/TRANSFERENCE SYSTEMS Background foreground music, Intercom and telephone interconnect systems, Telephone systems Nurse call systems, Radio page systems, School intercom and sound systems, Burglar alarm systems, Low voltage, master clock systems, Multi-media/multiplex systems, Sound and musical entertainment systems, RF systems, Antennas and Wave Guide,

B. FIRE ALARM SYSTEMS Installation, wire pulling and testing

C. TELEVISION AND VIDEO SYSTEMS Television monitoring and surveillance systems Video security systems, Video entertainment systems, Video educational systems, Microwave transmission systems, CATV and CCTV

D. SECURITY SYSTEMS Perimeter security systems Vibration sensor systems Card access systems Access control systems, Sonar/infrared monitoring equipment

E. COMMUNICATIONS SYSTEMS THAT TRANSMIT OR RECEIVE

INFORMATION AND/OR CONTROL SYSTEMS THAT ARE INTRINSIC TO THE ABOVE LISTED SYSTEMS SCADA (Supervisory Control and Data Acquisition) PCM (Pulse Code Modulation) Inventory Control Systems, Digital Data Systems Broadband and Baseband and Carriers Point of Sale Systems, VSAT Data Systems Data Communication Systems RF and Remote Control Systems, Fiber Optic Data Systems

WORK EXCLUDED Raceway systems are not covered (excluding Ladder-Rack for the purpose of the above listed systems). Chases and/or nipples (not to exceed 10 feet) may be installed on open wiring systems. Energy management systems. SCADA (Supervisory Control and Data Acquisition) when not intrinsic to the above listed systems (in the scope). Fire alarm systems when installed in raceways (including wire and cable pulling) shall be performed at the electrician wage rate, when either of the following two (2) conditions apply:
1. The project involves new or major remodel building trades construction.
2. The conductors for the fire alarm system are installed in conduit.

ELEC0234-001 06/01/2012

MONTEREY, SAN BENITO AND SANTA CRUZ COUNTIES

	Rates	Fringes
ELECTRICIAN	$ 41.20	21.80

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* ELEC0302-001 07/02/2012

CONTRA COSTA COUNTY

	Rates	Fringes
CABLE SPLICER	$ 50.49	24.96
ELECTRICIAN	$ 44.21	24.78

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* ELEC0332-001 12/03/2012

SANTA CLARA COUNTY

	Rates	Fringes
CABLE SPLICER	$ 58.73	29.292
ELECTRICIAN	$ 51.07	29.062

FOOTNOTES: Work under compressed air or where gas masks are required, orwork on ladders, scaffolds, stacks, "Bosun's chairs," or other structures and where the workers are not protected by permanent guard rails at a distance of 40 to 60 ft. from the ground or supporting structures: to be paid one and one-half times the straight-time rate of pay.
Work on structures of 60 ft. or over (as described above): to be paid twice the straight-time rate of pay.

ELEC0595-001 06/01/2012

ALAMEDA COUNTY

	Rates	Fringes
CABLE SPLICER	$ 50.63	3%+27.93
ELECTRICIAN	$ 45.00	3%+27.93

ELEC0595-002 12/01/2011

CALAVERAS AND SAN JOAQUIN COUNTIES

	Rates	Fringes
CABLE SPLICER	$ 37.13	9.025%+21.74
ELECTRICIAN		
(1) Tunnel work	$ 34.65	9.025%+21.74
(2) All other work	$ 33.00	9.025%+21.74

ELEC0617-001 06/01/2011

SAN MATEO COUNTY

	Rates	Fringes
ELECTRICIAN	$ 50.00	3%+23.34

ELEC0684-001 01/01/2012

MARIPOSA, MERCED, STANISLAUS AND TUOLUMNE COUNTIES

	Rates	Fringes
ELECTRICIAN	$ 34.60	3%+17.15

CABLE SPLICER = 110% of Journeyman Electrician

ELEC1245-001 06/01/2012

	Rates	Fringes
LINE CONSTRUCTION		
(1) Lineman; Cable splicer	$ 48.95	14.05
(2) Equipment specialist (operates crawler tractors, commercial motor vehicles, backhoes, trenchers, cranes (50 tons and below), overhead & underground distribution line equipment)	$ 39.09	12.97
(3) Groundman	$ 29.91	12.70
(4) Powderman	$ 43.71	13.15

HOLIDAYS: New Year's Day, M.L. King Day, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving Day and day after Thanksgiving, Christmas Day

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ELEV0008-001 01/01/2012

	Rates	Fringes

ELEVATOR MECHANIC.....$ 57.29 23.535

FOOTNOTE:
PAID VACATION: Employer contributes 8% of regular hourly rate as vacation pay credit for employees with more than 5 years of service, and 6% for 6 months to 5 years of service.
PAID HOLIDAYS: New Years Day, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving Day, Friday after Thanksgiving, and Christmas Day.

ENGI0003-008 07/01/2012

	Rates	Fringes
Dredging: (DREDGING: CLAMSHELL & DIPPER DREDGING; HYDRAULIC SUCTION DREDGING:)		
AREA 1:		
(1) Leverman	$ 39.68	25.69
(2) Dredge Dozer; Heavy duty repairman	$ 34.72	25.69
(3) Booster Pump Operator; Deck Engineer; Deck mate; Dredge Tender; Winch Operator	$ 33.60	25.69
(4) Bargeman; Deckhand; Fireman; Leveehand; Oiler	$ 33.60	25.69
AREA 2:		
(1) Leverman	$ 41.68	25.69
(2) Dredge Dozer; Heavy duty repairman	$ 36.72	25.69
(3) Booster Pump Operator; Deck Engineer; Deck mate; Dredge Tender; Winch Operator	$ 35.60	25.69
(4) Bargeman; Deckhand; Fireman; Leveehand; Oiler	$ 32.30	25.69

AREA DESCRIPTIONS

AREA 1: ALAMEDA,BUTTE, CONTRA COSTA, KINGS, MARIN, MERCED, NAPA, SACRAMENTO, SAN BENITO, SAN FRANCISCO, SAN JOAQUIN, SAN MATEO, SANTA CLARA, SANTA CRUZ, SOLANO, STANISLAUS, SUTTER, YOLO, AND YUBA COUNTIES

AREA 2: MODOC COUNTY

THE REMAINGING COUNTIES ARE SPLIT BETWEEN AREA 1 AND AREA 2 AS NOTED BELOW:

ALPINE COUNTY:
Area 1: Northernmost part
Area 2: Remainder

CALAVERAS COUNTY:
Area 1: Remainder
Area 2: Eastern part

COLUSA COUNTY:
Area 1: Eastern part
Area 2: Remainder

ELDORADO COUNTY:
Area 1: North Central part
Area 2: Remainder

FRESNO COUNTY:
Area 1: Remainder
Area 2: Eastern part

GLENN COUNTY:
Area 1: Eastern part
Area 2: Remainder

LASSEN COUNTY:
Area 1: Western part along the Southern portion of border with Shasta County
Area 2: Remainder

MADERA COUNTY:
Area 1: Except Eastern part
Area 2: Eastern part

MARIPOSA COUNTY
Area 1: Except Eastern part
Area 2: Eastern part

MONTERREY COUNTY
Area 1: Except Southwestern part
Area 2: Southwestern part

NEVADA COUNTY:
Area 1: All but the Northern portion along the border of Sierra County
Area 2: Remainder

PLACER COUNTY:
Area 1: Al but the Central portion
Area 2: Remainder

PLUMAS COUNTY:
Area 1: Western portion
Area 2: Remainder

SHASTA COUNTY:
Area 1: All but the Northeastern corner
Area 2: Remainder

SIERRA COUNTY:
Area 1: Western part
Area 2: Remainder

SISKIYOU COUNTY:
Area 1: Central part
Area 2: Remainder

SONOMA COUNTY:

Area 1: All but the Northwestern corner
Area 2: Remainder

TEHAMA COUNTY:
Area 1: All but the Western border with Mendocino & Trinity Counties
Area 2: Remainder

TRINITY COUNTY:
Area 1: East Central part and the Northeastern border with Shasta County
Area 2: Remainder

TUOLUMNE COUNTY:
Area 1: Except Eastern part
Area 2: Eastern part

ENGI0003-018 06/25/2012

"AREA 1" WAGE RATES ARE LISTED BELOW

"AREA 2" RECEIVES AN ADDITIONAL $2.00 PER HOUR ABOVE AREA 1 RATES.

SEE AREA DEFINITIONS BELOW

	Rates	Fringes
OPERATOR: Power Equipment (AREA 1:)		
GROUP 1	$ 37.77	25.16
GROUP 2	$ 36.24	25.16
GROUP 3	$ 34.76	25.16
GROUP 4	$ 33.38	25.16
GROUP 5	$ 32.11	25.16
GROUP 6	$ 30.79	25.16
GROUP 7	$ 29.65	25.16
GROUP 8	$ 28.51	25.16
GROUP 8-A	$ 26.30	25.16
OPERATOR: Power Equipment (Cranes and Attachments - AREA 1:)		
GROUP 1		
Cranes	$ 38.65	25.16
Oiler	$ 29.39	25.16
Truck crane oiler	$ 31.68	25.16
GROUP 2		
Cranes	$ 36.89	25.16
Oiler	$ 29.18	25.16
Truck crane oiler	$ 31.42	25.16
GROUP 3		
Cranes	$ 35.14	25.16
Hydraulic	$ 30.79	25.16
Oiler	$ 28.90	25.16
Truck Crane Oiler	$ 31.18	25.16
OPERATOR: Power Equipment (Piledriving - AREA 1:)		
GROUP 1		
Lifting devices	$ 38.99	25.16

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      Oiler.....................$ 29.73            25.16
      Truck crane oiler.........$ 32.01            25.16
     GROUP 2
      Lifting devices...........$ 37.17            25.16
      Oiler.....................$ 29.46            25.16
      Truck Crane Oiler.........$ 31.76            25.16
     GROUP 3
      Lifting devices...........$ 35.49            25.16
      Oiler.....................$ 29.24            25.16
      Truck Crane Oiler.........$ 31.47            25.16
     GROUP 4
      Lifting devices...........$ 33.72            25.16
     GROUP 5
      Lifting devices...........$ 32.42            25.16
     GROUP 6
      Lifting devices...........$ 31.08            25.16
OPERATOR:  Power Equipment
(Steel Erection - AREA 1:)
     GROUP 1
      Cranes....................$ 39.62            25.16
      Oiler.....................$ 30.07            25.16
      Truck Crane Oiler.........$ 32.30            25.16
     GROUP 2
      Cranes....................$ 37.85            25.16
      Oiler.....................$ 29.80            25.16
      Truck Crane Oiler.........$ 32.08            25.16
     GROUP 3
      Cranes....................$ 36.37            25.16
      Hydraulic.................$ 31.42            25.16
      Oiler.....................$ 29.58            25.16
      Truck Crane Oiler.........$ 31.81            25.16
     GROUP 4
      Cranes....................$ 34.35            25.16
     GROUP 5
      Cranes....................$ 33.05            25.16
OPERATOR:  Power Equipment
(Tunnel and Underground Work
- AREA 1:)
     SHAFTS, STOPES, RAISES:
      GROUP 1...................$ 33.87            25.16
      GROUP 1-A.................$ 36.34            25.16
      GROUP 2...................$ 32.61            25.16
      GROUP 3...................$ 31.28            25.16
      GROUP 4...................$ 30.14            25.16
      GROUP 5...................$ 29.00            25.16
     UNDERGROUND:
      GROUP 1...................$ 33.77            25.16
      GROUP 1-A.................$ 36.24            25.16
      GROUP 2...................$ 32.51            25.16
      GROUP 3...................$ 31.18            25.16
      GROUP 4...................$ 30.04            25.16
      GROUP 5...................$ 28.90            25.16

  FOOTNOTE: Work suspended by ropes or cables, or work on a
  Yo-Yo Cat: $.60 per hour additional.


  POWER EQUIPMENT OPERATOR CLASSIFICATIONS

  GROUP 1: Operator of helicopter (when used in erection work);
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Hydraulic excavator, 7 cu. yds. and over; Power shovels, over 7 cu. yds.

GROUP 2: Highline cableway; Hydraulic excavator, 3-1/2 cu. yds. up to 7 cu. yds.; Licensed construction work boat operator, on site; Power blade operator (finish); Power shovels, over 1 cu. yd. up to and including 7 cu. yds. m.r.c.

GROUP 3: Asphalt milling machine; Cable backhoe; Combination backhoe and loader over 3/4 cu. yds.; Continuous flight tie back machine assistant to engineer or mechanic; Crane mounted continuous flight tie back machine, tonnage to apply; Crane mounted drill attachment, tonnage to apply; Dozer, slope brd; Gradall; Hydraulic excavator, up to 3 1/2 cu. yds.; Loader 4 cu. yds. and over; Long reach excavator; Multiple engine scraper (when used as push pull); Power shovels, up to and including 1 cu. yd.; Pre-stress wire wrapping machine; Side boom cat, 572 or larger; Track loader 4 cu. yds. and over; Wheel excavator (up to and including 750 cu. yds. per hour)

GROUP 4: Asphalt plant engineer/box person; Chicago boom; Combination backhoe and loader up to and including 3/4 cu. yd.; Concrete batch plant (wet or dry); Dozer and/or push cat; Pull- type elevating loader; Gradesetter, grade checker (GPS, mechanical or otherwise); Grooving and grinding machine; Heading shield operator; Heavy-duty drilling equipment, Hughes, LDH, Watson 3000 or similar; Heavy-duty repairperson and/or welder; Lime spreader; Loader under 4 cu. yds.; Lubrication and service engineer (mobile and grease rack); Mechanical finishers or spreader machine (asphalt, Barber-Greene and similar); Miller Formless M-9000 slope paver or similar; Portable crushing and screening plants; Power blade support; Roller operator, asphalt; Rubber-tired scraper, self-loading (paddle-wheels, etc.); Rubber- tired earthmoving equipment (scrapers); Slip form paver (concrete); Small tractor with drag; Soil stabilizer (P & H or equal); Spider plow and spider puller; Tubex pile rig; Unlicensed constuction work boat operator, on site; Timber skidder; Track loader up to 4 yds.; Tractor-drawn scraper; Tractor, compressor drill combination; Welder; Woods-Mixer (and other similar Pugmill equipment)

GROUP 5: Cast-in-place pipe laying machine; Combination slusher and motor operator; Concrete conveyor or concrete pump, truck or equipment mounted; Concrete conveyor, building site; Concrete pump or pumpcrete gun; Drilling equipment, Watson 2000, Texoma 700 or similar; Drilling and boring machinery, horizontal (not to apply to waterliners, wagon drills or jackhammers); Concrete mixer/all; Person and/or material hoist; Mechanical finishers (concrete) (Clary, Johnson, Bidwell Bridge Deck or similar types); Mechanical burm, curb and/or curb and gutter machine, concrete or asphalt); Mine or shaft hoist; Portable crusher; Power jumbo operator (setting slip-forms, etc., in tunnels); Screed (automatic or manual); Self-propelled compactor with dozer; Tractor with boom D6 or smaller; Trenching machine, maximum digging capacity over 5 ft.

depth; Vermeer T-600B rock cutter or similar

GROUP 6: Armor-Coater (or similar); Ballast jack tamper; Boom- type backfilling machine; Assistant plant engineer; Bridge and/or gantry crane; Chemical grouting machine, truck-mounted; Chip spreading machine operator; Concrete saw (self-propelled unit on streets, highways, airports and canals); Deck engineer; Drilling equipment Texoma 600, Hughes 200 Series or similar up to and including 30 ft. m.r.c.; Drill doctor; Helicopter radio operator; Hydro-hammer or similar; Line master; Skidsteer loader, Bobcat larger than 743 series or similar (with attachments); Locomotive; Lull hi-lift or similar; Oiler, truck mounted equipment; Pavement breaker, truck-mounted, with compressor combination; Paving fabric installation and/or laying machine; Pipe bending machine (pipelines only); Pipe wrapping machine (tractor propelled and supported); Screed (except asphaltic concrete paving); Self- propelled pipeline wrapping machine; Tractor; Self-loading chipper; Concrete barrier moving machine

GROUP 7: Ballast regulator; Boom truck or dual-purpose A-frame truck, non-rotating - under 15 tons; Truck-mounted rotating telescopic boom type lifting device, Manitex or similar (boom truck) - under 15 tons; Cary lift or similar; Combination slurry mixer and/or cleaner; Drilling equipment, 20 ft. and under m.r.c.; Firetender (hot plant); Grouting machine operator; Highline cableway signalperson; Stationary belt loader (Kolman or similar); Lift slab machine (Vagtborg and similar types); Maginnes internal full slab vibrator; Material hoist (1 drum); Mechanical trench shield; Pavement breaker with or without compressor combination); Pipe cleaning machine (tractor propelled and supported); Post driver; Roller (except asphalt); Chip Seal; Self-propelled automatically applied concrete curing mahcine (on streets, highways, airports and canals); Self-propelled compactor (without dozer); Signalperson; Slip-form pumps (lifting device for concrete forms); Tie spacer; Tower mobile; Trenching machine, maximum digging capacity up to and including 5 ft. depth; Truck- type loader

GROUP 8: Bit sharpener; Boiler tender; Box operator; Brakeperson; Combination mixer and compressor (shotcrete/gunite); Compressor operator; Deckhand; Fire tender; Forklift (under 20 ft.); Generator; Gunite/shotcrete equipment operator; Hydraulic monitor; Ken seal machine (or similar); Mixermobile; Oiler; Pump operator; Refrigeration plant; Reservoir-debris tug (self-propelled floating); Ross Carrier (construction site); Rotomist operator; Self-propelled tape machine; Shuttlecar; Self-propelled power sweeper operator (includes vacuum sweeper); Slusher operator; Surface heater; Switchperson; Tar pot firetender; Tugger hoist, single drum; Vacuum cooling plant; Welding machine (powered other than by electricity)

GROUP 8-A: Elevator operator; Skidsteer loader-Bobcat 743 series or smaller, and similar (without attachments); Mini excavator under 25 H.P. (backhoe-trencher); Tub grinder wood chipper

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ALL CRANES AND ATTACHMENTS

GROUP 1: Clamshell and dragline over 7 cu. yds.; Crane, over 100 tons; Derrick, over 100 tons; Derrick barge pedestal-mounted, over 100 tons; Self-propelled boom-type lifting device, over 100 tons

GROUP 2: Clamshell and dragline over 1 cu. yd. up to and including 7 cu. yds.; Crane, over 45 tons up to and including 100 tons; Derrick barge, 100 tons and under; Self-propelled boom-type lifting device, over 45 tons; Tower crane

GROUP 3: Clamshell and dragline up to and including 1 cu. yd.; Cranes 45 tons and under; Self-propelled boom-type lifting device 45 tons and under; Boom Truck or dual purpose A-frame truck, non-rotating over 15 tons; Truck-mounted rotating telescopic boom type lifting device, Manitex or similar (boom truck) over 15 tons;

PILEDRIVERS

GROUP 1: Derrick barge pedestal mounted over 100 tons; Clamshell over 7 cu. yds.; Self-propelled boom-type lifting device over 100 tons; Truck crane or crawler, land or barge mounted over 100 tons

GROUP 2: Derrick barge pedestal mounted 45 tons to and including 100 tons; Clamshell up to and including 7 cu. yds.; Self-propelled boom-type lifting device over 45 tons; Truck crane or crawler, land or barge mounted, over 45 tons up to and including 100 tons; Fundex F-12 hydraulic pile rig

GROUP 3: Derrick barge pedestal mounted under 45 tons; Self-propelled boom-type lifting device 45 tons and under; Skid/scow piledriver, any tonnage; Truck crane or crawler, land or barge mounted 45 tons and under

GROUP 4: Assistant operator in lieu of assistant to engineer; Forklift, 10 tons and over; Heavy-duty repairperson/welder

GROUP 5: Deck engineer

GROUP 6: Deckhand; Fire tender

STEEL ERECTORS

GROUP 1: Crane over 100 tons; Derrick over 100 tons; Self-propelled boom-type lifting device over 100 tons

GROUP 2: Crane over 45 tons to 100 tons; Derrick under 100 tons; Self-propelled boom-type lifting device over 45 tons to 100 tons; Tower crane

GROUP 3: Crane, 45 tons and under; Self-propelled boom-type lifting device, 45 tons and under

GROUP 4: Chicago boom; Forklift, 10 tons and over; Heavy-duty repair person/welder

GROUP 5: Boom cat

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TUNNEL AND UNDERGROUND WORK

GROUP 1-A: Tunnel bore machine operator, 20' diameter or more

GROUP 1: Heading shield operator; Heavy-duty repairperson; Mucking machine (rubber tired, rail or track type); Raised bore operator (tunnels); Tunnel mole bore operator

GROUP 2: Combination slusher and motor operator; Concrete pump or pumpcrete gun; Power jumbo operator

GROUP 3: Drill doctor; Mine or shaft hoist

GROUP 4: Combination slurry mixer cleaner; Grouting Machine operator; Motorman

GROUP 5: Bit Sharpener; Brakeman; Combination mixer and compressor (gunite); Compressor operator; Oiler; Pump operator; Slusher operator

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AREA DESCRIPTIONS:

POWER EQUIPMENT OPERATORS, CRANES AND ATTACHMENTS,TUNNEL AND UNDERGROUND [These areas do not apply to Piledrivers and Steel Erectors]

AREA 1: ALAMEDA, BUTTE, CONTRA COSTA, KINGS, MARIN, MERCED, NAPA, SACRAMENTO, SAN BENITO, SAN FRANCISCO, SAN JOAQUIN, SAN MATEO, SANTA CLARA, SANTA CRUZ, SOLANO, STANISLAUS, SUTTER, YOLO, AND YUBA COUNTIES

AREA 2 - MODOC COUNTY

THE REMAINING COUNTIES ARE SPLIT BETWEEN AREA 1 AND AREA 2 AS NOTED BELOW:

ALPINE COUNTY:
Area 1: Northernmost part
Area 2: Remainder

CALAVERAS COUNTY:
Area 1: Except Eastern part
Area 2: Eastern part

COLUSA COUNTY:
Area 1: Eastern part

Area 2: Remainder

DEL NORTE COUNTY:
Area 1: Extreme Southwestern corner
Area 2: Remainder

ELDORADO COUNTY:
Area 1: North Central part
Area 2: Remainder

FRESNO COUNTY
Area 1: Except Eastern part
Area 2: Eastern part

GLENN COUNTY:
Area 1: Eastern part
Area 2: Remainder

HUMBOLDT COUNTY:
Area 1: Except Eastern and Southwestern parts
Area 2: Remainder

LAKE COUNTY:
Area 1: Southern part
Area 2: Remainder

LASSEN COUNTY:
Area 1: Western part along the Southern portion of border with Shasta County
Area 2: Remainder

MADERA COUNTY
Area 1: Remainder
Area 2: Eastern part

MARIPOSA COUNTY
Area 1: Remainder
Area 2: Eastern part

MENDOCINO COUNTY:
Area 1: Central and Southeastern parts
Area 2: Remainder

MONTEREY COUNTY
Area 1: Remainder
Area 2: Southwestern part

NEVADA COUNTY:
Area 1: All but the Northern portion along the border of Sierra County
Area 2: Remainder

PLACER COUNTY:
Area 1: All but the Central portion
Area 2: Remainder

PLUMAS COUNTY:
Area 1: Western portion
Area 2: Remainder

SHASTA COUNTY:
Area 1: All but the Northeastern corner
Area 2: Remainder

SIERRA COUNTY:
Area 1: Western part
Area 2: Remainder

SISKIYOU COUNTY:
Area 1: Central part
Area 2: Remainder

SONOMA COUNTY:
Area 1: All but the Northwestern corner
Area 2: Reaminder

TEHAMA COUNTY:
Area 1: All but the Western border with mendocino & Trinity Counties
Area 2: Remainder

TRINITY COUNTY:
Area 1: East Central part and the Northeaster border with Shasta County
Area 2: Remainder

TULARE COUNTY;
Area 1: Remainder
Area 2: Eastern part

TUOLUMNE COUNTY:
Area 1: Remainder
Area 2: Eastern Part

ENGI0003-019 06/25/2012

SEE AREA DESCRIPTIONS BELOW

	Rates	Fringes
OPERATOR: Power Equipment (LANDSCAPE WORK ONLY)		
GROUP 1		
AREA 1	$ 28.64	23.75
AREA 2	$ 30.64	23.75
GROUP 2		
AREA 1	$ 25.04	23.75
AREA 2	$ 27.04	23.75
GROUP 3		
AREA 1	$ 20.43	23.75
AREA 2	$ 22.43	23.75

GROUP DESCRIPTIONS:

GROUP 1: Landscape Finish Grade Operator: All finish grade work regardless of equipment used, and all equipment with a rating more than 65 HP.

GROUP 2: Landscape Operator up to 65 HP: All equipment with a manufacturer's rating of 65 HP or less except equipment

covered by Group 1 or Group 3. The following equipment shall be included except when used for finish work as long as manufacturer's rating is 65 HP or less: A-Frame and Winch Truck, Backhoe, Forklift, Hydragraphic Seeder Machine, Roller, Rubber-Tired and Track Earthmoving Equipment, Skiploader, Straw Blowers, and Trencher 31 HP up to 65 HP.

GROUP 3: Landscae Utility Operator: Small Rubber-Tired Tractor, Trencher Under 31 HP.

AREA DESCRIPTIONS:

AREA 1: ALAMEDA, BUTTE, CONTRA COSTA, KINGS, MARIN, MERCED, NAPA, SACRAMENTO, SAN BENITO, SAN FRANCISCO, SAN JOAQUIN, SAN MATEO, SANTA CLARA, SANTA CRUZ, SOLANO, STANISLAUS, SUTTER, YOLO, AND YUBA COUNTIES

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Area 2: Eastern part

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Area 1: Eastern part
Area 2: Remainder

DEL NORTE COUNTY:
Area 1: Extreme Southwestern corner
Area 2: Remainder

ELDORADO COUNTY:
Area 1: North Central part
Area 2: Remainder

FRESNO COUNTY
Area 1: Except Eastern part
Area 2: Eastern part

GLENN COUNTY:
Area 1: Eastern part
Area 2: Remainder

HUMBOLDT COUNTY:
Area 1: Except Eastern and Southwestern parts
Area 2: Remainder

LAKE COUNTY:
Area 1: Southern part
Area 2: Remainder

LASSEN COUNTY:

Area 1: Western part along the Southern portion of border with Shasta County
Area 2: Remainder

MADERA COUNTY
Area 1: Remainder
Area 2: Eastern part

MARIPOSA COUNTY
Area 1: Remainder
Area 2: Eastern part

MENDOCINO COUNTY:
Area 1: Central and Southeastern parts
Area 2: Remainder

MONTEREY COUNTY
Area 1: Remainder
Area 2: Southwestern part

NEVADA COUNTY:
Area 1: All but the Northern portion along the border of Sierra County
Area 2: Remainder

PLACER COUNTY:
Area 1: All but the Central portion
Area 2: Remainder

PLUMAS COUNTY:
Area 1: Western portion
Area 2: Remainder

SHASTA COUNTY:
Area 1: All but the Northeastern corner
Area 2: Remainder

SIERRA COUNTY:
Area 1: Western part
Area 2: Remainder

SISKIYOU COUNTY:
Area 1: Central part
Area 2: Remainder

SONOMA COUNTY:
Area 1: All but the Northwestern corner
Area 2: Reaminder

TEHAMA COUNTY:
Area 1: All but the Western border with mendocino & Trinity Counties
Area 2: Remainder

TRINITY COUNTY:
Area 1: East Central part and the Northeaster border with Shasta County
Area 2: Remainder

TULARE COUNTY;

Area 1: Remainder
Area 2: Eastern part

TUOLUMNE COUNTY:
Area 1: Remainder
Area 2: Eastern Part

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* IRON0002-004 01/01/2013

	Rates	Fringes
Ironworkers:		
Fence Erector	$ 26.58	16.74
Ornamental, Reinforcing and Structural	$ 33.00	25.30

PREMIUM PAY:

$6.00 additional per hour at the following locations:

China Lake Naval Test Station, Chocolate Mountains Naval Reserve-Niland, Edwards AFB, Fort Irwin Military Station, Fort Irwin Training Center-Goldstone, San Clemente Island, San Nicholas Island, Susanville Federal Prison, 29 Palms - Marine Corps, U.S. Marine Base - Barstow, U.S. Naval Air Facility - Sealey, Vandenberg AFB

$4.00 additional per hour at the following locations:

Army Defense Language Institute - Monterey, Fallon Air Base, Naval Post Graduate School - Monterey, Yermo Marine Corps Logistics Center

$2.00 additional per hour at the following locations:

Port Hueneme, Port Mugu, U.S. Coast Guard Station - Two Rock

LABO0036-001 07/01/2007

SAN FRANCISCO AND SAN MATEO COUNTIES:

	Rates	Fringes
MASON TENDER, BRICK	$ 26.93	16.50

FOOTNOTES: Underground work such as sewers, manholes, catch basins, sewer pipes, telephone conduits, tunnels and cut trenches: $5.00 per day additional. Work in live sewage: $2.50 per day additional.

LABO0036-002 07/01/2007

SAN FRANCISCO AND SAN MATEO COUNTIES:

	Rates	Fringes
PLASTER TENDER	$ 26.48	16.23

FOOTNOTES: Work on a suspended scaffold: $5.00 per day

additional. Work operating a plaster mixer pump gun: $1.00 per hour additional.

LABO0067-002 12/01/2011

AREA "A" - ALAMEDA, CONTRA COSTA, MARIN, SAN FRANCISCO, SAN MATEO AND SANTA CLARA COUNTIES

AREA "B" - ALPINE, AMADOR, BUTTE, CALAVERAS, COLUSA, DEL NORTE, EL DORADO, FRESNO, GLENN, HUMBOLDT, KINGS, LAKE, LASSEN, MADERA, MARIPOSA, MENDOCINO, MERCED, MODOC, MONTEREY, NAPA, NEVADA, PLACER, PLUMAS, SACRAMENTO, SAN BENITO, SAN JOAQUIN, SANTA CRUZ, SHASTA, SIERRA, SISKIYOU, SOLANO, SONOMA, STANISLAUS, SUTTER, TEHAMA, TRINITY, TULARE, TUOLUMNE, YOLO AND YUBA COUNTIES

	Rates	Fringes
Asbestos Removal Laborer		
Areas A & B	$ 18.68	8.15
LABORER (Lead Removal)		
Area A	$ 36.25	7.79
Area B	$ 35.25	7.79

ASBESTOS REMOVAL-SCOPE OF WORK: Site mobilization; initial site clean-up; site preparation; removal of asbestos-containing materials from walls and ceilings; or from pipes, boilers and mechanical systems only if they are being scrapped; encapsulation, enclosure and disposal of asbestos-containing materials by hand or with equipment or machinery; scaffolding; fabrication of temporary wooden barriers; and assembly of decontamination stations.

LABO0067-003 07/01/2009

AREA A: ALAMEDA, CONTRA COSTA, MARIN, SAN FRANCISCO, SAN MATEO & SANTA CLARA

AREA B: ALPINE, AMADOR, BUTTE, CALAVERAS, COLUSA, DEL NORTE, EL DORADO, FRESNO, GLENN, HUMBOLDT, KINGS, LAKE, LASSEN, MADERA, MARIPOSA, MENOCINO, MERCED, MODOC, MONTEREY, NAPA, NEVADA, PLACER, PLUMAS, SANCRMENTO, SAN BENITO, SAN JOAQUIN, SANTA CRUZ, SIERRA, SHASTA, SISKIYOU, SOLANO, SONOMA, STANISLAUS,TEHAMA,TRINITY, TULARE, TUOLUMNE, YOLO & YUBA COUNTIES

	Rates	Fringes
LABORER (TRAFFIC CONTROL/LANE CLOSURE)		
Escort Driver, Flag Person		
Area A	$ 26.89	14.93
Area B	$ 25.89	14.93
Traffic Control Person I		
Area A	$ 27.19	14.93
Area B	$ 26.19	14.93
Traffic Control Person II		
Area A	$ 24.69	14.93

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      Area B.....................$ 23.69            14.93

  TRAFFIC CONTROL PERSON I: Layout of traffic control, crash
  cushions, construction area and roadside signage.

  TRAFFIC CONTROL PERSON II: Installation and removal of
  temporary/permanent signs, markers, delineators and crash
  cushions.
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 LABO0067-006 06/28/2010

AREA "A" - ALAMEDA, CONTRA COSTA, MARIN, SAN FRANCISCO, SAN
MATEO AND SANTA CLARA COUNTIES

AREA "B"  -  ALPINE, AMADOR, BUTTE, CALAVERAS, COLUSA, EL
DORADO, FRESNO, GLENN, KINGS, LASSEN, MADERA, MARIPOSA, MERCED,
MODOC, MONTEREY, NAPA, NEVADA, PLACER, PLUMAS, SACRAMENTO, SAN
BENITO, SAN JOAQUIN, SANTA CRUZ, SHASTA, SIERRA, SISKIYOU,
SOLANO, SONOMA, STANISLAUS, SUTTER, TEHAMA, TRINITY, TULARE,
TUOLUMNE, YOLO AND YUBA COUNTIES


                                  Rates          Fringes

Laborers: (CONSTRUCTION CRAFT
LABORERS - AREA A:)
     Construction Specialist
     Group......................$ 27.84            15.82
     GROUP 1....................$ 27.14            15.82
     GROUP 1-a..................$ 27.36            15.82
     GROUP 1-c..................$ 27.19            15.82
     GROUP 1-e..................$ 27.69            15.82
     GROUP 1-f..................$ 27.72            15.82
     GROUP 1-g (Contra Costa
     County)....................$ 27.34            15.82
     GROUP 2....................$ 26.99            15.82
     GROUP 3....................$ 26.89            15.82
     GROUP 4....................$ 20.58            15.82
  See groups 1-b and 1-d under laborer classifications.
Laborers: (CONSTRUCTION CRAFT
LABORERS - AREA B:)
     Construction Specialist
     Group......................$ 26.84            15.82
     GROUP 1....................$ 26.14            15.82
     GROUP 1-a..................$ 26.36            15.82
     GROUP 1-c..................$ 26.19            15.82
     GROUP 1-e..................$ 26.69            15.82
     GROUP 1-f..................$ 26.72            15.82
     GROUP 2....................$ 25.99            15.82
     GROUP 3....................$ 25.89            15.82
     GROUP 4....................$ 19.58            15.82
  See groups 1-b and 1-d under laborer classifications.
Laborers: (GUNITE - AREA A:)
     GROUP 1....................$ 28.10            15.82
     GROUP 2....................$ 27.60            15.82
     GROUP 3....................$ 27.60            15.82
     GROUP 4....................$ 27.60            15.82
Laborers: (GUNITE - AREA B:)
     GROUP 1....................$ 27.10            15.82
     GROUP 2....................$ 26.60            15.82
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     GROUP 3.....................$ 26.01            15.82
     GROUP 4.....................$ 25.89            15.82
Laborers: (WRECKING - AREA A:)
     GROUP 1.....................$ 27.14            15.82
     GROUP 2.....................$ 26.99            15.82
Laborers: (WRECKING - AREA B:)
     GROUP 1.....................$ 26.14            15.82
     GROUP 2.....................$ 25.99            15.82
Landscape Laborer (GARDENERS,
HORTICULTURAL & LANDSCAPE
LABORERS - AREA A:)
     (1) New Construction........$ 26.89            15.82
     (2) Establishment Warranty
     Period......................$ 20.58            15.82
Landscape Laborer (GARDENERS,
HORTICULURAL & LANDSCAPE
LABORERS - AREA B:)
     (1) New Construction........$ 25.89            15.82
     (2) Establishment Warranty
     Period......................$ 19.58            15.82
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FOOTNOTES:

Laborers working off or with or from bos'n chairs, swinging scaffolds, belts shall receive $0.25 per hour above the applicable wage rate. This shall not apply to workers entitled to receive the wage rate set forth in Group 1-a below.

LABORER CLASSIFICATIONS

CONSTRUCTION SPECIALIST GROUP: Asphalt ironer and raker; Chainsaw; Laser beam in connection with laborers' work; Cast-in- place manhole form setter; Pressure pipelayer; Davis trencher - 300 or similar type (and all small trenchers); Blaster; Diamond driller; Multiple unit drill; Hydraulic drill

GROUP 1: Asphalt spreader boxes (all types); Barko, Wacker and similar type tampers; Buggymobile; Caulker, bander, pipewrapper, conduit layer, plastic pipelayer; Certified hazardous waste worker including Leade Abatement; Compactors of all types; Concrete and magnesite mixer, 1/2 yd. and under; Concrete pan work; Concrete sander; Concrete saw; Cribber and/or shoring; Cut granite curb setter; Dri-pak-it machine; Faller, logloader and bucker; Form raiser, slip forms; Green cutter; Headerboard, Hubsetter, aligner, by any method; High pressure blow pipe (1-1/2" or over, 100 lbs. pressure/over); Hydro seeder and similar type; Jackhammer operator; Jacking of pipe over 12 inches; Jackson and similar type compactor; Kettle tender, pot and worker applying asphalt, lay-kold, creosote, lime, caustic and similar type materials (applying means applying, dipping or handling of such materials); Lagging, sheeting, whaling, bracing, trenchjacking, lagging hammer; Magnesite, epoxyresin, fiberglass, mastic worker (wet or dry); No joint pipe and stripping of same, including repair of voids; Pavement breaker and spader, including tool grinder;

Perma curb; Pipelayer (including grade checking in connection with pipelaying); Precast-manhole setter; Pressure pipe tester; Post hole digger, air, gas and electric; Power broom sweeper; Power tampers of all types (except as shown in Group 2); Ram set gun and stud gun; Riprap stonepaver and rock-slinger, including placing of sacked concrete and/or sand (wet or dry) and gabions and similar type; Rotary scarifier or multiple head concrete chipping scarifier; Roto and Ditch Witch; Rototiller; Sandblaster, pot, gun, nozzle operators; Signalling and rigging; Tank cleaner; Tree climber; Turbo blaster; Vibrascreed, bull float in connection with laborers' work; Vibrator; Hazardous waste worker (lead removal); Asbestos and mold removal worker

GROUP 1-a: Joy drill model TWM-2A; Gardner-Denver model DH143 and similar type drills; Track driller; Jack leg driller; Wagon driller; Mechanical drillers, all types regardless of type or method of power; Mechanical pipe layers, all types regardless of type or method of power; Blaster and powder; All work of loading, placing and blasting of all powder and explosives of whatever type regardless of method used for such loading and placing; High scalers (including drilling of same); Tree topper; Bit grinder

GROUP 1-b: Sewer cleaners shall receive $4.00 per day above Group 1 wage rates. "Sewer cleaner" means any worker who handles or comes in contact with raw sewage in small diameter sewers. Those who work inside recently active, large diameter sewers, and all recently active sewer manholes shal receive $5.00 per day above Group 1 wage rates.

GROUP 1-c: Burning and welding in connection with laborers' work; Synthetic thermoplastics and similar type welding

GROUP 1-d: Maintenance and repair track and road beds. All employees performing work covered herein shall receive $ .25 per hour above their regular rate for all work performed on underground structures not specifically covered herein. This paragraph shall not be construed to apply to work below ground level in open cut. It shall apply to cut and cover work of subway construction after the temporary cover has been placed.

GROUP 1-e: Work on and/or in bell hole footings and shafts thereof, and work on and in deep footings. (A deep footing is a hole 15 feet or more in depth.) In the event the depth of the footing is unknown at the commencement of excavation, and the final depth exceeds 15 feet, the deep footing wage rate would apply to all employees for each and every day worked on or in the excavation of the footing from the date of inception.

GROUP 1-f: Wire winding machine in connection with guniting or shot crete

GROUP 1-g, CONTRA COSTA COUNTY: Pipelayer (including grade checking in connection with pipelaying); Caulker; Bander; Pipewrapper; Conduit layer; Plastic pipe layer; Pressure

pipe tester; No joint pipe and stripping of same, including repair of voids; Precast manhole setters, cast in place manhole form setters

GROUP 2: Asphalt shoveler; Cement dumper and handling dry cement or gypsum; Choke-setter and rigger (clearing work); Concrete bucket dumper and chute; Concrete chipping and grinding; Concrete laborer (wet or dry); Driller tender, chuck tender, nipper; Guinea chaser (stake), grout crew; High pressure nozzle, adductor; Hydraulic monitor (over 100 lbs. pressure); Loading and unloading, carrying and hauling of all rods and materials for use in reinforcing concrete construction; Pittsburgh chipper and similar type brush shredders; Sloper; Single foot, hand-held, pneumatic tamper; All pneumatic, air, gas and electric tools not listed in Groups 1 through 1-f; Jacking of pipe - under 12 inches

GROUP 3: Construction laborers, including bridge and general laborer; Dump, load spotter; Flag person; Fire watcher; Fence erector; Guardrail erector; Gardener, horticultural and landscape laborer; Jetting; Limber, brush loader and piler; Pavement marker (button setter); Maintenance, repair track and road beds; Streetcar and railroad construction track laborer; Temporary air and water lines, Victaulic or similar; Tool room attendant (jobsite only)

GROUP 4: Final clean-up work of debris, grounds and building including but not limited to: street cleaner; cleaning and washing windows; brick cleaner (jobsite only); material cleaner (jobsite only). The classification "material cleaner" is to be utilized under the following conditions:
A: at demolition site for the salvage of the material.
B: at the conclusion of a job where the material is to be salvaged and stocked to be reused on another job.
C: for the cleaning of salvage material at the jobsite or temporary jobsite yard.

The material cleaner classification should not be used in the performance of "form stripping, cleaning and oiling and moving to the next point of erection".

GUNITE LABORER CLASSIFICATIONS

GROUP 1: Structural Nozzleman

GROUP 2: Nozzleman, Gunman, Potman, Groundman

GROUP 3: Reboundman

GROUP 4: Gunite laborer

WRECKING WORK LABORER CLASSIFICATIONS

GROUP 1: Skilled wrecker (removing and salvaging of sash, windows and materials)

GROUP 2: Semi-skilled wrecker (salvaging of other building materials)

LABO0067-010 07/01/2010

	Rates	Fringes
Tunnel and Shaft Laborers:		
GROUP 1	$ 33.35	16.08
GROUP 2	$ 33.12	16.08
GROUP 3	$ 32.87	16.08
GROUP 4	$ 32.42	16.08
GROUP 5	$ 31.88	16.08
Shotcrete Specialist	$ 33.87	16.08

TUNNEL AND SHAFT CLASSIFICATIONS

GROUP 1: Diamond driller; Groundmen; Gunite and shotcrete nozzlemen

GROUP 2: Rodmen; Shaft work & raise (below actual or excavated ground level)

GROUP 3: Bit grinder; Blaster, driller, powdermen, heading; Cherry pickermen - where car is lifted; Concrete finisher in tunnel; Concrete screedman; Grout pumpman and potman; Gunite & shotcrete gunman & potman; Headermen; High pressure nozzleman; Miner - tunnel, including top and bottom man on shaft and raise work; Nipper; Nozzleman on slick line; Sandblaster - potman, Robotic Shotcrete Placer, Segment Erector, Tunnel Muck Hauler, Steel Form raiser and setter; Timberman, retimberman (wood or steel or substitute materials therefore); Tugger (for tunnel laborer work); Cable tender; Chuck tender; Powderman - primer house

GROUP 4: Vibrator operator, pavement breaker; Bull gang - muckers, trackmen; Concrete crew - includes rodding and spreading, Dumpmen (any method)

GROUP 5: Grout crew; Reboundman; Swamper/ Brakeman

LABO0073-003 07/01/2011

CALAVERAS, MARIPOSA, MERCED, MONTEREY, SAN BENITO, SAN JOAQUIN, STANISLAUS AND TUOLUMNE COUNTIES:

	Rates	Fringes
LABORER		
Mason Tender-Brick	$ 30.62	14.43

LABO0073-005 07/01/2009

CALAVERAS, FRESNO, KINGS, MADERA, MARIPOSA, MERCED, SAN JOAQUIN, STANISLAUS & TUOLUMNE

	Rates	Fringes

Plasterer tender.....$ 28.37 14.14

LABO0166-001 07/01/2006

ALAMEDA AND CONTRA COSTA COUNTIES:

	Rates	Fringes
Brick Tender.....	$ 25.91	14.65

FOOTNOTES: Work on jobs where heat-protective clothing is required: $2.00 per hour additional. Work at grinders: $.25 per hour additional. Manhole work: $2.00 per day additional.

LABO0166-002 07/01/2006

ALAMEDA AND CONTRA COSTA COUNTIES:

	Rates	Fringes
Plasterer tender.....	$ 30.15	15.90

Gun Man $0.75 per hour additional

LABO0270-001 07/01/2008

SANTA CLARA & SANTA CRUZ COUNTIES

	Rates	Fringes
MASON TENDER, BRICK		
Santa Clara.....	$ 27.93	13.48
Santa Cruz.....	$ 26.93	13.48

FOOTNOTE: $2.00 per hour for refactory work where heat-protective clothing is required.

LABO0270-005 07/01/2007

SANTA CLARA AND SANTA CRUZ COUNTIES

	Rates	Fringes
PLASTER TENDER		
4 Stories and under.....	$ 27.62	13.73
5 Stories and above.....	$ 29.54	13.73

LABO0294-001 07/01/2011

FRESNO, KINGS AND MADERA COUNTIES

	Rates	Fringes
LABORER (Brick)		
Mason Tender-Brick.....	$ 30.62	14.43

LABO0297-001 08/01/2007

MONTEREY AND SAN BENITO COUNTIES

	Rates	Fringes
Plasterer tender	$ 23.70	11.50

FOOTNOTE: Mixer person: $4.00 per day additional.

PAIN0016-001 01/01/2012

ALAMEDA, CONTRA COSTA, MONTEREY, SAN BENITO, SAN MATEO, SANTA CLARA, AND SANTA CRUZ COUNTIES

	Rates	Fringes
Painters:	$ 33.09	19.83

PREMIUMS:

EXOTIC MATERIALS - $0.75 additional per hour.
SPRAY WORK: - $0.50 additional per hour.
INDUSTRIAL PAINTING - $0.25 additional per hour
[Work on industrial buildings used for the manufacture and processing of goods for sale or service; steel construction (bridges), stacks, towers, tanks, and similar structures]

HIGH WORK:
over 50 feet - $2.00 per hour additional
100 to 180 feet - $4.00 per hour additional
Over 180 feet - $6.00 per houir additional

PAIN0016-003 01/01/2012

AREA 1: ALAMEDA, CONTRA COSTA, SAN FRANCISCO, SAN MATEO & SANTA CLARA COUNTIES

AREA 2: CALAVERAS, MARIPOA, MERCED, MONTEREY, SAN BENITO, SAN JOAQUIN, SANTA CRUZ, STANISLAUS & TUOLUMNE COUNTIES

	Rates	Fringes
Drywall Finisher/Taper		
AREA 1	$ 40.37	19.64
AREA 2	$ 36.24	18.24

PAIN0016-012 01/01/2012

ALAMEDA, CONTRA COSTA, MARIPOSA, MERCED, MONTEREY, SAN BENITO, SAN FRANCISCO, SAN MATEO, SANTA CLARA AND SANTA CRUZ COUNTIES

	Rates	Fringes
SOFT FLOOR LAYER	$ 44.87	17.78

PAIN0016-015 01/01/2012

CALAVERAS, MARIPOSA, MERCED, SAN JOAQUIN, STANISLAUS & TUOLUMNE COUNTIES

	Rates	Fringes
PAINTER	$ 28.35	15.74
Brush	$ 28.35	15.74

FOOTNOTES:
SPRAY/SANDBLAST: $0.50 additional per hour.
EXOTIC MATERIALS: $1.00 additional per hour.
HIGH TIME: Over 50 ft above ground or water level $2.00 additional per hour. 100 to 180 ft above ground or water level $4.00 additional per hour. Over 180 ft above ground or water level $6.00 additional per hour.

PAIN0016-022 01/01/2012

SAN FRANCISCO COUNTY

	Rates	Fringes
PAINTER	$ 36.71	19.83

PAIN0169-001 07/01/2012

FRESNO, KINGS, MADERA, MARIPOSA AND MERCED COUNTIES:

	Rates	Fringes
GLAZIER	$ 32.48	17.60

PAIN0169-005 01/01/2012

ALAMEDA CONTRA COSTA, MONTEREY, SAN BENITO, SAN FRANCISCO, SAN MATEO, SANTA CLARA & SANTA CRUZ COUNTIES

	Rates	Fringes
GLAZIER	$ 41.88	20.39

PAIN0294-004 01/01/2012

FRESNO, KINGS AND MADERA COUNTIES

	Rates	Fringes
PAINTER		
Brush, Roller	$ 25.67	15.68
Drywall Finisher/Taper	$ 30.47	16.86

FOOTNOTE:
Spray Painters & Paperhangers recive $1.00 additional per hour. Painters doing Drywall Patching receive $1.25 additional per hour. Lead Abaters & Sandblasters receive $1.50 additional per hour. High Time - over 30 feet (does not include work from a lift) $0.75 per hour additional.

PAIN0294-005 01/01/2012

FRESNO, KINGS & MADERA

	Rates	Fringes
SOFT FLOOR LAYER.....	$ 27.83	15.46

PAIN0767-001 01/01/2012

CALAVERAS, SAN JOAQUIN, STANISLAUS AND TUOLUMNE COUNTIES:

	Rates	Fringes
GLAZIER.....	$ 32.24	18.59

PAID HOLIDAYS: New Year's Day, Martin Luther King, Jr. Day, President's Day, Memorial Day, Independence Day, Labor Day, Veteran's Day, Thanksgiving Day, and Christmas Day.

Employee rquired to wear a body harness shall receive $1.50 per hour above the basic hourly rate at any elevation.

PAIN1176-001 07/01/2011

HIGHWAY IMPR0VEMENT

	Rates	Fringes
Parking Lot Striping/Highway Marking:		
GROUP 1.....	$ 31.35	11.65
GROUP 2.....	$ 26.65	11.65
GROUP 3.....	$ 26.96	11.65

CLASSIFICATIONS

GROUP 1: Striper: Layout and application of painted traffic stripes and marking; hot thermo plastic; tape, traffic stripes and markings

GROUP 2: Gamecourt & Playground Installer

GROUP 3: Protective Coating, Pavement Sealing

PAIN1237-003 01/01/2012

CALAVERAS; SAN JOAQUIN COUNTIES; STANISLAUS AND TUOLUMNE COUNTIES:

	Rates	Fringes
SOFT FLOOR LAYER.....	$ 28.25	16.53

PLAS0066-002 08/01/2011

ALAMEDA, CONTRA COSTA, SAN MATEO AND SAN FRANCISCO COUNTIES:

	Rates	Fringes
PLASTERER.....	$ 33.13	24.64

PLAS0300-001 07/01/2009

	Rates	Fringes
PLASTERER		
AREA 188: Fresno	$ 29.72	14.21
AREA 224: San Benito, Santa Clara, Santa Cruz	$ 34.22	14.08
AREA 295: Calaveras & San Joaquin Couonties	$ 32.82	15.10
AREA 337: Monterey County	$ 31.01	13.93
AREA 429: Mariposa, Merced, Stanislaus, Tuolumne Counties	$ 32.82	15.30

PLAS0300-005 06/28/2010

	Rates	Fringes
CEMENT MASON/CONCRETE FINISHER	$ 28.65	18.56

PLUM0038-001 07/01/2012

SAN FRANCISCO COUNTY

	Rates	Fringes
PLUMBER (Plumber, Steamfitter, Refrigeration Fitter)	$ 60.00	39.94

PLUM0038-005 07/01/2012

SAN FRANCISCO COUNTY

	Rates	Fringes
Landscape/Irrigation Fitter (Underground/Utility Fitter)	$ 51.00	29.40

PLUM0062-001 10/01/2012

MONTEREY AND SANTA CRUZ COUNTIES

	Rates	Fringes
PLUMBER & STEAMFITTER	$ 40.55	23.69

PLUM0159-001 07/01/2012

CONTRA COSTA COUNTY

	Rates	Fringes
Plumber and steamfitter		
(1) Refrigeration	$ 49.33	29.24
(2) All other work	$ 50.22	29.34

PLUM0246-001 10/01/2012

FRESNO, KINGS & MADERA COUNTIES

	Rates	Fringes
PLUMBER & STEAMFITTER	$ 35.45	23.94

PLUM0246-004 01/01/2012

FRESNO, MERCED & SAN JOAQUIN COUNIES

	Rates	Fringes
PLUMBER (PIPE TRADESMAN)	$ 13.00	9.23

PIPE TRADESMAN SCOPE OF WORK:
Installation of corrugated metal piping for drainage, as well as installation of corrugated metal piping for culverts in connection with storm sewers and drains; Grouting, dry packing and diapering of joints, holes or chases including paving over joints, in piping; Temporary piping for dirt work for building site preparation; Operating jack hammers, pavement breakers, chipping guns, concrete saws and spades to cut holes, chases and channels for piping systems; Digging, grading, backfilling and ground preparation for all types of pipe to all points of the jobsite; Ground preparation including ground leveling, layout and planting of shrubbery, trees and ground cover, including watering, mowing, edging, pruning and fertilizing, the breaking of concrete, digging, backfilling and tamping for the preparation and completion of all work in connection with lawn sprinkler and landscaping; Loading, unloading and distributing materials at jobsite; Putting away materials in storage bins in jobsite secure storage area; Demolition of piping and fixtures for remodeling and additions; Setting up and tearing down work benches, ladders and job shacks; Clean-up and sweeping of jobsite; Pipe wrapping and waterproofing where tar or similar material is applied for protection of buried piping; Flagman

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PLUM0342-001 07/04/2012

ALAMEDA & CONTRA COSTA COUNTIES

	Rates	Fringes
PIPEFITTER		
CONTRA COSTA COUNTY	$ 52.46	32.54
PLUMBER, PIPEFITTER, STEAMFITTER		
ALAMEDA COUNTY	$ 52.46	32.54

PLUM0355-004 07/01/2012

ALAMEDA, CALAVERAS, CONTRA COSTA, FRESNO, KINGS, MADERA, MARIPOSA, MERCED, MONTEREY, SAN BENITO, SAN JOAQUIN, SAN MATEO, SANTA CLARA, SANTA CRUZ, STANISLAUS, AND TUOLUMNE COUNTIES:

	Rates	Fringes

Underground Utility Worker
/Landscape Fitter.....$ 28.35 8.00

PLUM0393-001 01/01/2012

SAN BENITO AND SANTA CLARA COUNTIES

	Rates	Fringes
PLUMBER/PIPEFITTER.....	$ 48.80	26.83

PLUM0442-001 10/01/2012

CALAVERAS, MARIPOSA, MERCED, SAN JOAQUIN, STANISLAUS & TUOLUMNE COUNTIES

	Rates	Fringes
PLUMBER & STEAMFITTER.....	$ 35.95	23.79

PLUM0467-001 07/01/2012

SAN MATEO COUNTY

	Rates	Fringes
Plumber/Pipefitter/Steamfitter...	$ 54.00	28.41

ROOF0027-002 09/01/2010

FRESNO, KINGS, AND MADERA COUNTIES

	Rates	Fringes
ROOFER.....	$ 27.65	8.07

FOOTNOTE: Work with pitch, pitch base of pitch impregnated products or any material containing coal tar pitch, on any building old or new, where both asphalt and pitchers are used in the application of a built-up roof or tear off: $2.00 per hour additional.

ROOF0040-002 08/01/2012

SAN FRANCISCO & SAN MATEO COUNTIES:

	Rates	Fringes
ROOFER.....	$ 33.61	12.37

ROOF0081-001 08/01/2011

ALAMEDA AND CONTRA COSTA COUNTIES:

	Rates	Fringes
Roofer.....	$ 33.16	10.90

ROOF0081-004 08/01/2012

CALAVERAS, MARIPOSA, MERCED, SAN JOAQUIN, STANISLAUS AND TUOLUMNE COUNTIES:

	Rates	Fringes
ROOFER	$ 29.99	11.82

ROOF0095-002 08/01/2011

MONTEREY, SAN BENITO, SANTA CLARA, AND SANTA CRUZ COUNTIES:

	Rates	Fringes
ROOFER		
Journeyman	$ 35.58	10.90
Kettle person (2 kettles); Bitumastic, Enameler, Coal Tar, Pitch and Mastic worker	$ 35.58	10.90
Kettleman (2 kettles), Bitumastic Enameler, Coal Tar, Pitch & Mastic	$ 33.73	9.89

SFCA0483-001 07/30/2012

ALAMEDA, CONTRA COSTA, SAN FRANCISCO, SAN MATEO AND SANTA CLARA COUNTIES:

	Rates	Fringes
SPRINKLER FITTER (FIRE)	$ 50.84	23.97

SFCA0669-011 04/01/2012

CALAVERAS, FRESNO, KINGS, MADERA, MARIPOSA, MERCED, MONTEREY, SAN BENITO, SAN JOAQUIN, SANTA CRUZ, STANISLAUS AND TUOLUMNE COUNTIES:

	Rates	Fringes
SPRINKLER FITTER	$ 32.33	19.20

SHEE0104-001 01/01/2012

AREA 1: ALAMEDA, CONTRA COSTA, SAN FRANCISCO, SAN MATEO, SANTA CLARA

AREA 2: MONTEREY & SAN BENITO

AREA 3: SANTA CRUZ

	Rates	Fringes
SHEET METAL WORKER		

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     AREA 1:
      Mechanical Contracts
      under $200,000.............$ 44.47            31.25
      All Other Work.............$ 48.85            31.55
     AREA 2......................$ 38.00            28.21
     AREA 3......................$ 40.15            26.06
-----------------------------------------------------------------
 SHEE0104-003 07/01/2012

CALAVERAS AND SAN JOAQUIN COUNTIES:

                                   Rates          Fringes

SHEET METAL WORKER...............$ 34.75            25.35
-----------------------------------------------------------------
* SHEE0104-005 01/01/2013

MARIPOSA, MERCED, STANISLAUS AND TUOLUMNE COUNTIES:

                                   Rates          Fringes

SHEET METAL WORKER (Excluding
metal deck and siding)...........$ 35.11            27.92
-----------------------------------------------------------------
 SHEE0104-007 07/01/2012

FRESNO, KINGS, AND MADERA COUNTIES:

                                   Rates          Fringes

SHEET METAL WORKER...............$ 33.68            28.49
-----------------------------------------------------------------
 SHEE0104-015 07/01/2012

ALAMEDA, CONTRA COSTA, MONTEREY, SAN BENITO, SAN FRANCISCO, SAN
MATEO, SANTA CLARA AND SANTA CRUZ COUNTIES:


                                   Rates          Fringes

SHEET METAL WORKER (Metal
Decking and Siding only).........$ 33.11            29.98
-----------------------------------------------------------------
* SHEE0104-018 01/01/2013

CALAVERAS, FRESNO, KINGS, MADERA, MARIPOSA, MERCED, SAN
JOAQUIN, STANISLAUS AND TUOLUMNE COUNTIES:


                                   Rates          Fringes

Sheet metal worker (Metal
decking and siding only).........$ 35.11            27.92
-----------------------------------------------------------------
 TEAM0094-001 07/01/2012

                                   Rates          Fringes

Truck drivers:
     GROUP 1.....................$ 27.13            22.49
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GROUP 2	$ 27.43	22.49
GROUP 3	$ 27.73	22.49
GROUP 4	$ 28.08	22.49
GROUP 5	$ 28.43	22.49

FOOTNOTES:

Articulated dump truck; Bulk cement spreader (with or without auger); Dumpcrete truck; Skid truck (debris box); Dry pre-batch concrete mix trucks; Dumpster or similar type; Slurry truck: Use dump truck yardage rate.

Heater planer; Asphalt burner; Scarifier burner; Industrial lift truck (mechanical tailgate); Utility and clean-up truck: Use appropriate rate for the power unit or the equipment utilized.

TRUCK DRIVER CLASSIFICATIONS

GROUP 1: Dump trucks, under 6 yds.; Single unit flat rack (2-axle unit); Nipper truck (when flat rack truck is used appropriate flat rack shall apply); Concrete pump truck (when flat rack truck is used appropriate flat rack shall apply); Concrete pump machine; Fork lift and lift jitneys; Fuel and/or grease truck driver or fuel person; Snow buggy; Steam cleaning; Bus or personhaul driver; Escort or pilot car driver; Pickup truck; Teamster oiler/greaser and/or serviceperson; Hook tender (including loading and unloading); Team driver; Tool room attendant (refineries)

GROUP 2: Dump trucks, 6 yds. and under 8 yds.; Transit mixers, through 10 yds.; Water trucks, under 7,000 gals.; Jetting trucks, under 7,000 gals.; Single-unit flat rack (3-axle unit); Highbed heavy duty transport; Scissor truck; Rubber-tired muck car (not self-loaded); Rubber-tired truck jumbo; Winch truck and "A" frame drivers; Combination winch truck with hoist; Road oil truck or bootperson; Buggymobile; Ross, Hyster and similar straddle carriers; Small rubber-tired tractor

GROUP 3: Dump trucks, 8 yds. and including 24 yds.; Transit mixers, over 10 yds.; Water trucks, 7,000 gals. and over; Jetting trucks, 7,000 gals. and over; Vacuum trucks under 7500 gals. Trucks towing tilt bed or flat bed pull trailers; Lowbed heavy duty transport; Heavy duty transport tiller person; Self- propelled street sweeper with self-contained refuse bin; Boom truck - hydro-lift or Swedish type extension or retracting crane; P.B. or similar type self-loading truck; Tire repairperson; Combination bootperson and road oiler; Dry distribution truck (A bootperson when employed on such equipment, shall receive the rate specified for the classification of road oil trucks or bootperson); Ammonia nitrate distributor, driver and mixer; Snow Go and/or plow

GROUP 4: Dump trucks, over 25 yds. and under 65 yds.; Water pulls - DW 10's, 20's, 21's and other similar equipment when pulling Aqua/pak or water tank trailers; Helicopter pilots (when transporting men and materials); Lowbedk Heavy Duty Transport up to including 7 axles; DW10's, 20's, 21's and other similar Cat type, Terra Cobra, LeTourneau Pulls,

Tournorocker, Euclid and similar type equipment when pulling fuel and/or grease tank trailers or other miscellaneous trailers; Vacuum Trucks 7500 gals and over and truck repairman

GROUP 5: Dump trucks, 65 yds. and over; Holland hauler; Low bed Heavy Duty Transport over 7 axles

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WELDERS - Receive rate prescribed for craft performing operation to which welding is incidental.

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Unlisted classifications needed for work not included within the scope of the classifications listed may be added after award only as provided in the labor standards contract clauses (29CFR 5.5 (a) (1) (ii)).

The body of each wage determination lists the classification and wage rates that have been found to be prevailing for the cited type(s) of construction in the area covered by the wage determination. The classifications are listed in alphabetical order of "identifiers" that indicate whether the particular rate is union or non-union.

Union Identifiers

An identifier enclosed in dotted lines beginning with characters other than "SU" denotes that the union classification and rate have found to be prevailing for that classification. Example: PLUM0198-005 07/01/2011. The first four letters , PLUM, indicate the international union and the four-digit number, 0198, that follows indicates the local union number or district council number where applicable , i.e., Plumbers Local 0198. The next number, 005 in the example, is an internal number used in processing the wage determination. The date, 07/01/2011, following these characters is the effective date of the most current negotiated rate/collective bargaining agreement which would be July 1, 2011 in the above example.

Union prevailing wage rates will be updated to reflect any changes in the collective bargaining agreements governing the rates.

0000/9999: weighted union wage rates will be published annually each January.

Non-Union Identifiers

Classifications listed under an "SU" identifier were derived

from survey data by computing average rates and are not union rates; however, the data used in computing these rates may include both union and non-union data. Example: SULA2004-007 5/13/2010. SU indicates the rates are not union majority rates, LA indicates the State of Louisiana; 2004 is the year of the survey; and 007 is an internal number used in producing the wage determination. A 1993 or later date, 5/13/2010, indicates the classifications and rates under that identifier were issued as a General Wage Determination on that date.

Survey wage rates will remain in effect and will not change until a new survey is conducted.

WAGE DETERMINATION APPEALS PROCESS

1.) Has there been an initial decision in the matter? This can be:

* an existing published wage determination
* a survey underlying a wage determination
* a Wage and Hour Division letter setting forth a position on a wage determination matter
* a conformance (additional classification and rate) ruling

On survey related matters, initial contact, including requests for summaries of surveys, should be with the Wage and Hour Regional Office for the area in which the survey was conducted because those Regional Offices have responsibility for the Davis-Bacon survey program. If the response from this initial contact is not satisfactory, then the process described in 2.) and 3.) should be followed.

With regard to any other matter not yet ripe for the formal process described here, initial contact should be with the Branch of Construction Wage Determinations. Write to:

Branch of Construction Wage Determinations
Wage and Hour Division
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

2.) If the answer to the question in 1.) is yes, then an interested party (those affected by the action) can request review and reconsideration from the Wage and Hour Administrator (See 29 CFR Part 1.8 and 29 CFR Part 7). Write to:

Wage and Hour Administrator
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

The request should be accompanied by a full statement of the interested party's position and by any information (wage payment data, project description, area practice material, etc.) that the requestor considers relevant to the issue.

3.) If the decision of the Administrator is not favorable, an interested party may appeal directly to the Administrative Review Board (formerly the Wage Appeals Board). Write to:

Administrative Review Board
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20210

4.) All decisions by the Administrative Review Board are final.

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END OF GENERAL DECISION

APPENDIX E

Estimated Production Rates

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Loading, Hauling and Disposal of Concrete		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

CONCRETE LOAD AND HAUL, SMALL QUANTITIES
16-cy Dump Truck, 5-mile Haul, 30-mph Avg.

CREW: *Load and Haul Concrete Crew* — 3 crew members

- 1 Equip. Oper. Heavy
- 1 Oiler
- 1 Truck Driver, Heavy
- 1 Front End Loader, 3-cy Bucket
- 1 16-cy Dump Truck

OVERALL PRODUCTION RATE → **10.5 cy/crew hr**

LOADING

SUB-CREW: Loading Crew — 2 crew members

- 1 Equip. Oper. Heavy
- 1 Oiler
- 1 Front End Loader, 3-cy Bucket

PRODUCTION

3	cy bucket
0.50	% fill
50	min/hr
0.75	cycle/min
56	cy/crew hr

→ 56 cy/crew hr

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Loading, Hauling and Disposal of Concrete		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

HAUL TO DISPOSAL SITE

SUB-CREW: Truck Haul Crew — 1 crew members

1 Truck Driver, Heavy
1 16-cy Dump Truck

PRODUCTION

16	cy truck
0.50	% fill
17.1	min. for loading
5	mi. to disposal location
30	mph haul speed
8.5	min. dump time

Quantity per Truck 8.0 cy/truck

Duration of Round Trip 0.76 hr

10.5 cy/hr

1.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Clearing and Grubbing		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

Sheet No. 1 of 1

CLEARING AND GRUBBING
Medium Brush Including Trees

CREW: Clear and Grub Crew — 3 crew members

1 Equip. Oper. Medium
2 Laborers
2 Chainsaws
1 Dozer

480 min/acre

OVERALL PRODUCTION RATE **0.125 acre/hr**

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Loading, Hauling and Disposal of Rock		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

ROCK LOAD AND HAUL
16-cy Dump Truck, 5-mile Haul, 30-mph Avg.

CREW: *Rock Load and Haul Crew* — 6 crew members

- 1 Equip. Oper. Heavy
- 1 Oiler
- 4 Truck Driver, Heavy
- 1 Front End Loader, 3-cy Bucket
- 4 16-cy Dump Truck

OVERALL PRODUCTION RATE → **74 cy/crew hr**

LOADING

SUB-CREW: Loading Crew — 2 crew members

- 1 Equip. Oper. Heavy
- 1 Oiler
- 1 Front End Loader, 3-cy Bucket

PRODUCTION

3	cy bucket
0.70	% fill
50	min/hr
0.70	cycle/min
74	cy/crew hr

→ 74 cy/crew hr

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Loading, Hauling and Disposal of Rock		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

HAUL TO DISPOSAL SITE

SUB-CREW: Truck Haul Crew — 1 crew members

1 Truck Driver, Heavy
1 16-cy Dump Truck

PRODUCTION

16	cy truck
0.80	% fill
13.1	min. for loading
5	mi. to disposal location
30	mph haul speed
6.5	min. dump time

Quantity per Truck 12.8 cy/truck

Duration of Round Trip 0.66 hr

19.4 cy/hr →

4.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Loading, Hauling and Disposal of Rock		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

ROCK LOAD AND HAUL
16-cy Dump Truck, 5-mile Haul, 30-mph Avg.

CREW: *Rock Load and Haul Crew* — 6 crew members

1 Equip. Oper. Heavy
1 Oiler
4 Truck Driver, Heavy
1 Front End Loader, 3-cy Bucket
4 16-cy Dump Truck

OVERALL PRODUCTION RATE → **90 cy/crew hr**

LOADING

SUB-CREW: Loading Crew — 2 crew members

1 Equip. Oper. Heavy
1 Oiler
1 Front End Loader, 3-cy Bucket

PRODUCTION

3	cy bucket
0.80	% fill
50	min/hr
0.75	cycle/min
90	cy/crew hr

→ 90 cy/crew hr

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Loading, Hauling and Disposal of Rock		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

HAUL TO DISPOSAL SITE

SUB-CREW: Truck Haul Crew — 1 crew members

1 Truck Driver, Heavy
1 16-cy Dump Truck

PRODUCTION

16	cy truck
0.50	% fill
10.7	min. for loading
5	mi. to disposal location
30	mph haul speed
5.3	min. dump time

Quantity per Truck 8.0 cy/truck

Duration of Round Trip 0.60 hr

13.3 cy/hr →

4.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Stone Placement		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

Sheet No. 1 of 1

RIPRAP

CREW:

Riprap Placement Crew — 5 crew members

- 2 Laborers
- 1 Labor Foreman
- 1 Oiler
- 1 Equip. Oper. Heavy
- 1 Hydraulic Excavator, 3-cy Bucket

PRODUCTION

3	cy bucket
0.75	% fill
50	min/hr
0.65	cycle/min

73 cy/crew hr

OVERALL PRODUCTION RATE — **73 cy/crew hr**

AGGREGATE BASE

CREW:

Aggregate Base Crew — 6 crew members

- 3 Equip. Oper. Medium
- 1 Labor Foreman
- 1 Laborers
- 1 Oiler
- 1 Vibratory Roller
- 1 Front End Loader, 3-cy Bucket
- 1 Grader

3	cy bucket
0.90	% fill
50	min/hr
0.80	cycle/min

OVERALL PRODUCTION RATE — **108 cy/hr**

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Fill and Compact From Stockpile		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

FILL AND COMPACT FROM STOCKPILE
300-ft Haul , 3-cy Bucket, Vibro Compacted, with 3,000-gal Water Truck

CREW NAME: *Fill and Compact from Stockpile Crew* 5.5 crew members

3	Eq. Oper. Med.
1.5	Laborers
1	Truck Driver, Heavy
1	Front End Loader 3-cy Bucket
1	Vibratory Roller, Double Drum
1	Dozer
1	Water Truck, 3000-gal

OVERALL PRODUCTION RATE **84 cy/crew hr**

FILL FROM STOCKPILE

SUB-CREW: Fill From Stockpile Crew 3 crew members

2	Eq. Oper. Med.
1	Laborer
1	Front End Loader, 3-cy Bucket
1	Dozer

PRODUCTION

3	cy bucket
0.80	% fill
50	min/hr
0.70	cycle/min

84 cy/crew hr

COMPACT FILL

SUB-CREW: Compaction Crew 1.5 crew members

0.5	Laborer
1	Equip. Oper. Medium
1	Vibratory Roller, Double Drum

PRODUCTION 0.24 min/cy 250 cy/hr

0.34 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Fill and Compact From Stockpile		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

WATER TRUCK

SUB-CREW: Water Truck Crew — 1 crew members

1 Truck Driver, Heavy
1 Water Truck, 3000-gal

PRODUCTION 0.25 min/cy — 240 cy/hr

0.35 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Top Soil Placement		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

FILL AND COMPACT FROM STOCKPILE
300-ft Haul , 3-cy Bucket, Vibro Compacted, with 3,000-gal Water Truck

CREW NAME: *Fill and Compact from Stockpile Crew* — 5 crew members

- 3 Eq. Oper. Med.
- 2 Laborers
- 1 Front End Loader 3-cy Bucket
- 1 Vibratory Roller, Double Drum
- 1 Dozer

OVERALL PRODUCTION RATE → **84 cy/crew hr**

FILL FROM STOCKPILE

SUB-CREW: Fill From Stockpile Crew — 3 crew members

- 2 Eq. Oper. Med.
- 1 Laborer
- 1 Front End Loader, 3-cy Bucket
- 1 Dozer

PRODUCTION

3	cy bucket
0.80	% fill
50	min/hr
0.70	cycle/min

→ 84 cy/crew hr

COMPACT FILL

SUB-CREW: Compaction Crew — 1.5 crew members

- 1 Laborer
- 1 Equip. Oper. Medium
- 1 Vibratory Roller, Double Drum

PRODUCTION 0.24 min/cy → 250 cy/hr

0.34 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavate, Load and Haul to Disposal Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

EXCAVATE, LOAD AND HAUL TO DISPOSAL
2-cy Excavator, 3-cy Loader, 16-cy Dump Truck, 20-mile Haul, 25-mph avg.

CREW NAME: *Excavate, Load and Haul Crew* 8 crew members

2 Eq. Oper. Heavy
1 Oilers
5 Truck Driver, Heavy
1 Hyd. Excavator, 2-cy Bucket
1 Front End Loader, 3-cy Bucket
5 16-cy Dump Trucks

OVERALL PRODUCTION RATE **92 cy/crew hr**

EXCAVATION

SUB-CREW: Excavation Crew 1.5 crew members

1 Equip. Oper. Heavy
0.5 Oiler
1 Hydraul. Excavator, 2-cy Bucket

PRODUCTION

2 cy bucket
0.80 % fill
50 min/hr
1.15 cycle/min

92 cy/crew hr

LOADING

SUB-CREW: Loading Crew 1.5 crew members

1 Equip. Oper. Heavy
0.5 Oiler
1 Front End Loader, 3-cy Bucket

PRODUCTION

3 cy bucket
0.90 % fill
50 min/hr
1.15 cycle/min
15% swell factor

135 cy/crew hr 135 cy/crew hr

0.68 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavate, Load and Haul to Disposal Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

HAUL TO DISPOSAL SITE

SUB-CREW: Truck Haul Crew — 1 crew members

1 Truck Driver, Heavy
1 16-cy Dump Truck

PRODUCTION

16	cy truck
0.90	% fill
7.1	min. for loading
5	mi. to disposal location
30	mph haul speed
3.6	min. dump time
50	min/hr
15%	swell factor

QUANTITY PER TRUCK 12.2 cy/truck

DURATION OF HAULING 0.61 hr

20.0 cy/hr →

5.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavate, Load and Haul to Disposal Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

EXCAVATE COFFERDAM, LOAD AND HAUL DOWNSTREAM
2-cy Excavator, 3-cy Loader, 16-cy Dump Truck, 6000-foot Haul, 10-mph avg.

CREW NAME: *Excavate Cofferdam, Load and Haul Crew* 6 crew members

2 Eq. Oper. Heavy
1 Oilers
3 Truck Driver, Heavy
1 Hyd. Excavator, 2-cy Bucket
1 Front End Loader, 3-cy Bucket
3 16-cy Dump Trucks

OVERALL PRODUCTION RATE **92 cy/crew hr**

EXCAVATION

SUB-CREW: Excavation Crew 1.5 crew members

1 Equip. Oper. Heavy
0.5 Oiler
1 Hydraul. Excavator, 2-cy Bucket

PRODUCTION

2 cy bucket
0.80 % fill
50 min/hr
1.15 cycle/min

92 cy/crew hr

LOADING

SUB-CREW: Loading Crew 1.5 crew members

1 Equip. Oper. Heavy
0.5 Oiler
1 Front End Loader, 3-cy Bucket

PRODUCTION

3 cy bucket
0.90 % fill
50 min/hr
1.15 cycle/min
15% swell factor

135 cy/crew hr 135 cy/crew hr

0.68 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavate, Load and Haul to Disposal Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

HAUL TO DISPOSAL SITE

SUB-CREW: Truck Haul Crew — 1 crew members

1 Truck Driver, Heavy
1 16-cy Dump Truck

PRODUCTION

16	cy truck
0.90	% fill
7.1	min. for loading
1.14	mi. to disposal location
10	mph haul speed
3.6	min. dump time
50	min/hr
15%	swell factor

QUANTITY PER TRUCK 12.2 cy/truck

DURATION OF HAULING 0.49 hr

25.2 cy/hr →

3.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Hand Excavation, Load and Haul to Disposal Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

EXCAVATE COFFERDAM, LOAD AND HAUL DOWNSTREAM
2-cy Excavator, 3-cy Loader, 16-cy Dump Truck, 6000-foot Haul, 10-mph avg.

CREW NAME: *Excavate Cofferdam, Load and Haul Crew* 10 crew members

1 Eq. Oper. Heavy
1 Oilers
4 Laborers
1 Labor Foreman
3 Truck Driver, Heavy
1 Front End Loader, 3-cy Bucket
3 16-cy Dump Trucks

OVERALL PRODUCTION RATE **8 cy/crew hr**

EXCAVATION

SUB-CREW: Hand Excavation 5 crew members

4 Laborers
1 Labor Foreman

PRODUCTION

7.5 min/cy

8.0 cy/crew hr

LOADING

SUB-CREW: Loading Crew 2.0 crew members

1 Equip. Oper. Heavy
1 Oiler
1 Front End Loader, 3-cy Bucket

PRODUCTION

3 cy bucket
0.90 % fill
50 min/hr
1.15 cycle/min
15% swell factor

135 cy/crew hr 135 cy/crew hr

0.06 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Hand Excavation, Load and Haul to Disposal Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

HAUL TO DISPOSAL SITE

SUB-CREW: Truck Haul Crew — 1 crew members

1 Truck Driver, Heavy
1 16-cy Dump Truck

PRODUCTION

16	cy truck
0.90	% fill
7.1	min. for loading
1.14	mi. to disposal location
10	mph haul speed
3.6	min. dump time
50	min/hr
15%	swell factor

QUANTITY PER TRUCK 12.2 cy/truck

DURATION OF HAULING 0.49 hr

25.2 cy/hr →

3.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavate, Backfill and Compact		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

EXCAVATE, BACKFILL AND COMPACT
2-cy Excavator, 3-cy Loader, Dozer, Vibratory Roller, 3000-Gallon Water Truck

CREW NAME: *Excavate, Load and Haul Crew* — 5 crew members

1 Eq. Oper. Heavy
1 Oilers
3 Eq. Oper. Med.
2 Laborer
1 Truck Driver, Heavy
1 Hydraul. Excavator, 2-cy Bucket
1 Front End Loader, 3-cy Bucket
1 Dozer
1 Vibratory Roller, Double Drum
1 Water Truck, 3000-Gallons

OVERALL PRODUCTION RATE — **84 cy/crew hr**

EXCAVATION

SUB-CREW: Excavation Crew — 2.0 crew members

1 Equip. Oper. Heavy
1 Oiler
1 Hydraul. Excavator, 2-cy Bucket

PRODUCTION

2	cy bucket
0.80	% fill
50	min/hr
1.05	cycle/min

84 cy/crew hr

FILL FROM STOCKPILE

SUB-CREW: Fill From Stockpile Crew — 3 crew members

2 Eq. Oper. Med.
1 Laborer
1 Front End Loader, 3-cy Bucket
1 Dozer

PRODUCTION

3	cy bucket
0.80	% fill
50	min/hr
0.70	cycle/min

84 cy/crew hr

1.00 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavate, Backfill and Compact		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

COMPACT FILL

SUB-CREW: Compaction Crew — 1.5 crew members

1 Laborer
1 Equip. Oper. Medium
1 Vibratory Roller, Double Drum

PRODUCTION 0.24 min/cy — 250 cy/hr

0.34 crews/equipment members to match overall production rate

1.00 total number of crews needed

WATER TRUCK

SUB-CREW: Water Truck Crew — 1 crew members

1 Truck Driver, Heavy
1 Water Truck, 3000-gal

PRODUCTION 0.25 min/cy — 240 cy/hr

0.35 crews/equipment members to match overall production rate

1.00 total number of crews needed

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Structural Excavation		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

STRUCTURAL EXCAVATION
2-cy Excavator, Dozer, Push to Stockpile

CREW NAME: *Structural Excavation Crew* 3 crew members

2 Eq. Oper. Heavy
1 Oilers
1 Hydraul. Excavator, 2-cy Bucket
1 Dozer

PRODUCTION

2	cy bucket
0.80	% fill
50	min/hr
0.37	cycle/min

OVERALL PRODUCTION RATE **30 cy/crew hr**

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Excavation and Stockpile		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

EXCAVATE TO STOCKPILE
2-cy Excavator, Dozer, Push to Stockpile

CREW NAME: *Structural Excavation Crew* 3 crew members

2 Eq. Oper. Heavy
1 Oilers
1 Hydraul. Excavator, 2-cy Bucket
1 Dozer

PRODUCTION

2	cy bucket
0.85	% fill
50	min/hr
1.10	cycle/min

OVERALL PRODUCTION RATE **94 cy/crew hr**

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Hauling Sand to Project Site		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

CSI TASK:

SAND HAUL TO PROJECT SITE
16-cy Dump Truck, 10-mile Haul, 30-mph Avg.

CREW:

	Truck Haul Crew	1 crew members
2.00	Truck Driver, Heavy	
2.00	16-cy Dump Truck	

PRODUCTION

16	cy truck
0.90	% fill
15.0	min. for loading
10	mi. to disposal location
30	mph haul speed
7.5	min. dump time

Quantity per Truck 14.4 cy/truck

Duration of Round Trip 1.04 hr

13.8 cy/hr →

2.00 Number of truck crews in order to have little to no back up on route

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Geotextile Materials		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

Sheet No. 1 of 1

GEOTEXTILE FABRIC

CREW:

Geotextile Fabric Crew — 6 crew members

1 Equip. Oper. Heavy
5 Laborers
1 Crane, 25-ton w/ 80-ft Boom

0.55 min/sy

OVERALL PRODUCTION RATE — **109 sy/hr**

CELLULAR CONFINEMENT SYSTEM

CREW:

Geotextile Fabric Crew — 6 crew members

1 Equip. Oper. Heavy
5 Laborers
1 Crane, 25-ton w/ 80-ft Boom

0.15 min/sf

OVERALL PRODUCTION RATE — **400 sf/hr**

TITLE:	Berryessa Creek Flood Control		
SUBJECT:	Output Rates for Steel Items		
MADE BY:	SKV	JOB NO.:	T26465
CHECKED BY:		DATE:	8/15/2011

Sheet No. 1 of 1

SHEET PILES, DRIVEN

CREW:

Pile Driving Crew — 8 crew members

4 Pile Drivers
2 Equip. Oper. Heavy
1 Oiler
1 Pile Driver Foreman
1 Crane
2 Pile Hammer, Leads
1 Pile Hammer Diesel Engine

1.00 min/vlf

OVERALL PRODUCTION RATE **60 vlf/hr**

SHEET PILES, DRIVEN

CREW:

Pile Driving Crew — 3 crew members

3 Rodment
1 Truck

0.14 min/lb per person
3.00 Crew Members

OVERALL PRODUCTION RATE **425 lbs/hr**

APPENDIX F

Phone Logs and Emails

TETRA TECH, INC.

PHONE LOG

CLIENT:	USACE, Sacramento District
JOB TITLE:	Berryessa Creek Flood Control
PROJECT NO.:	T26465
SUBJECT:	Rock Prices
CONVERSATION DATE:	December 30, 2011
PREPARED BY:	Scott Vose
CONVERSATIONALISTS:	Syar Rock Quarry Representative and Scott Vose of Tetra Tech

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This phone log summarizes the items discussed or issues resolved during the phone conversation to the best of the writer's ability.

Syar Rock Quarry was contacted and a representative was able to provide the following information. The phone number for Syar Rock Quarry is (707) 643-3261:

- The average cost for their riprap product is $28.85 per ton.
- Their riprap meets USACE quality.
- Aggregate Base Course costs $15.90 per ton.
- The quarry does not own any trucks but they mentioned trucks are costing approximately $92.00 per hour for deliveries.
- Below are calculations to develop a unit cost for delivery:
    - Total quantity of riprap needed = 24,675-tons = 16,450-cy
    - Estimated truck size = 12-cy
    - Estimated haul duration = 60-miles / 35-mph = 1.7-hrs one way = 3.4-hrs round trip
    - Estimated loading time = 10-min, estimated dump time = 5-min
    - 16,450-cy x (1-truck/12-cy) x (3.4-hrs/1-truck) x ($92/1-hr) = $26.07/cy
    - Assume 1.5-tons/cy = $26.07/cy ÷ 1.5-ton/cy = $17.38/ton for delivery of rock.

TETRA TECH, INC.

PHONE LOG

CLIENT:	USACE, Sacramento District
JOB TITLE:	Berryessa Creek Flood Control
PROJECT NO.:	T26465
SUBJECT:	Cellular Confinement System
CONVERSATION DATE:	December 30, 2011
PREPARED BY:	Scott Vose
CONVERSATIONALISTS:	Reed & Graham Inc. and Scott Vose of Tetra Tech

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This phone log summarizes the items discussed or issues resolved during the phone conversation to the best of the writer's ability.

Reed & Graham Inc. was contacted and a representative was able to provide the following information. The phone number for Reed & Graham is (888) 381-0800:

- The cost per roll for an average cellular confinement system is approximately $984.00.
- Each roll is 13-ft wide by 246-ft long, for a total area of 359-sy.
- Unit cost = $984.00 / 359-sy = $2.74/sy = $0.31/sf

GEI
Granite Environmental, Inc.
PO Box 780928 Sebastian, FL 32978
Phone: 772-646-0597 Fax:

Quote

Date	QUOTE #
1/2/2012	10569

Name / Address	Ship To
Tetra Tech	
Customer Phone 760-751-8987	
Customer Fax	

Environmental Compliance Product Solutions ~ Metal Storage Cabinets ~ Industrial Supply Products ~ Site Supplies

Terms	REP
To be Established	JMR

Item	Description	Qty	Cost	Total
WOVENSTABILFAB	Woven Stabilization Fabric 12.5' x 360'. 315 LB Tensile	67	375.70	25,171.90T

All credit card payments will incur a 3.5% total balance fee. For your convenience we also accept check by phone at no charge. All shipments destined for Florida will be required to pay sales tax based on that destination county.

Terms for Approved client accounts
VISA, Master Card, American Express and Discover Accepted
Shipping Terms: Ex-works, unless otherwise specified.
Granite Environmental, Inc. Terms & Conditions apply.
NOTE: Dimensions and color will vary and are selected based on production efficiencies. Should a specific color or size be required it must be requested prior to order and confirmed upon invoice.
Prices are valid for 30 days unless otherwise noted. Freight is not included unless otherwise specified.
NO WARRANTY PROVIDED WITHOUT AN APPROVED MSDS

Subtotal	$25,171.90
Sales Tax (0.0%)	$0.00
Total	$25,171.90

The Right Products, Service and peace of mind.

www.GraniteEnvironmental.com

Ask me about our Low Price Guarantee! We will meet or beat a lower price for the same item. Send us a copy of the quote with your order and we will beat it by up to 5%. Same Quality, Better Service! We want your business! ****Subject to Management Approval****

On the Web: www.ErosionPollution.com ~ www.Silt-Barriers.com
Store: www.PollutionControlProducts.com

APPENDIX G

Abbreviated Cost and Schedule Risk Analysis

Abbreviated Risk Analysis

Project (less than $40M): **BERRYESSA CREEK FLOOD CONTROL PROJECT**
Project Development Stage: 35% Estimate Level

Total Construction Contract Cost = **$ 10,473,802**

	WBS	Potential Risk Areas	Contract Cost		% Contingency	$ Contingency	Total
1	02 RELOCATIONS	**Relocations**	**$ 554,743**		14.58%	$ 80,900	$ 635,643
2	09 CHANNELS AND CANALS (Except Navigation Ports and Harbors)	**Mob / Demob / Clearing**	**$ 656,822**		12.50%	$ 82,103	$ 738,925
3		**Dewatering**	**$ 972,219**		25.00%	$ 243,055	$ 1,215,274
4		**Erosion Control / Construction Access**	**$ 419,745**		10.42%	$ 43,723	$ 463,469
5		**Riprap**	**$ 2,164,100**		25.00%	$ 541,025	$ 2,705,125
6		**Railroads**	**$ 533,903**		39.58%	$ 211,337	$ 745,240
7		**CIP Concrete**	**$ 1,637,782**		29.17%	$ 477,687	$ 2,115,469
8		**Geotextiles / Cellular Confinement**	**$ 482,910**		12.50%	$ 60,364	$ 543,274
9		**Asphalt Access Road / Trail**	**$ 2,080,670**		18.75%	$ 390,126	$ 2,470,795
10		**Vegetation**	**$ 41,520**		8.33%	$ 3,460	$ 44,980
11		**Earthwork**	**$ 766,385**		29.17%	$ 223,529	$ 989,914
12		**Remaining Construction Items**	**$ 163,003**	*1.6%*	0.00%	$ -	$ 163,003
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	**$ 1,570,000**		8.33%	$ 130,833	$ 1,700,833
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	**$ 1,047,000**		6.25%	$ 65,438	$ 1,112,438

Totals					
Total Construction Estimate	$ 10,473,802	22.51%	$ 2,357,307	$ 12,831,109
Total Planning, Engineering & Design	$ 1,570,000	8.33%	$ 130,833	$ 1,700,833
Total Construction Management	$ 1,047,000	6.25%	$ 65,438	$ 1,112,438
Total	$ 13,090,802		$ 2,553,578	$ 15,644,380

BERRYESSA CREEK FLOOD CONTROL PROJECT
35% Estimate Level
Abbreviated Risk Analysis

Meeting Date: N/A

Risk Level

	Negligible	Marginal	Significant	Critical	Crisis
Very Likely	2	3	4	5	5
Likely	1	2	4	5	5
Unlikely	0	1	3	3	4
Very Unlikely	0	0	1	2	4

Risk Element	Potential Risk Areas	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Likelihood	Impact	Risk Level
Project Scope						
PS-1	Relocations	Level of design; Scope changes;	The level of design does not include much detail on the utilities at this time and thus all utility relocations have significant gross assumptions applied to them; if the scope of the project changes the amount of utilities and location of utilities (accross bridges) could significantly affect costs;	LIKELY	Significant	4
PS-2	Mob / Demob / Clearing			Very Unlikely	Negligible	0
PS-3	Dewatering	Further investigations needed	Further analysis into amounts of ground water could change the current assumptions for dewatering found in the estimate;	Unlikely	Significant	3
PS-4	Erosion Control / Construction Access	Level of design;	The current design does not have an erosion control plan as of yet, which when fully designed erosion control items could be much different from assumptions currently in estimate	LIKELY	Marginal	2
PS-5	Riprap	Scope changes;	Could alter where riprap is required to be placed and these changes would affect costs.	Unlikely	Significant	3
PS-6	Railroads	Level of design;	There is very little design work on the railroad components. Due to the lack of design, many assumptions had to be made which could be drastically different from future design.	Very LIKELY	Significant	4
PS-7	CIP Concrete	Scope changes;	Changes to the scope of the project, ie the size of the walls, would have a large impact on costs for this item.	Unlikely	Significant	3
PS-8	Geotextiles / Cellular Confinement	Scope changes;	Scope changes could alter the amount of access roads required for the project.	Unlikely	Marginal	1
PS-9	Asphalt Access Road / Trail	Scope changes;	Scope changes could alter the amount of access roads required for the project.	LIKELY	Marginal	2
PS-10	Vegetation	Scope changes;	Current design calls out for the only vegetation item to be seeding. Future design or scope may call out for more expensive vegetation such as trees.	Unlikely	Marginal	1
PS-11	Earthwork	Further investigations needed	Current topo data and boring information is not currently included in the design work. Further investigations into these items could result in different quantities and methods of construction.	Unlikely	Significant	3
PS-12	Remaining Construction Items			Very Unlikely	Negligible	0
PS-13	Planning, Engineering, & Design	Further investigations and design needed	The current level of design is low and would require much more analysis as the project moves forward.	LIKELY	Significant	4
PS-14	Construction Management			Very Unlikely	Negligible	0

Acquisition Strategy						
AS-1	Relocations			Very Unlikely	Negligible	0
AS-2	Mob / Demob / Clearing	Number of contracts	The project schedule and estimate currently is assuming only one contract to be bid for this work. Funding streams and other factors may make multiple contracts a possibility which would impact costs.	LIKELY	Marginal	2
AS-3	Dewatering			Very Unlikely	Negligible	0
AS-4	Erosion Control / Construction Access			Very Unlikely	Negligible	0
AS-5	Riprap			Very Unlikely	Negligible	0
AS-6	Railroads			Very Unlikely	Negligible	0
AS-7	CIP Concrete			Very Unlikely	Negligible	0
AS-8	Geotextiles / Cellular Confinement			Very Unlikely	Negligible	0
AS-9	Asphalt Access Road / Trail			Very Unlikely	Negligible	0
AS-10	Vegetation			Very Unlikely	Negligible	0
AS-11	Earthwork			Very Unlikely	Negligible	0
AS-12	Remaining Construction Items			Very Unlikely	Negligible	0
AS-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
AS-14	Construction Management	Number of contracts	The project schedule and estimate currently is assuming only one contract to be bid for this work. Funding streams and other factors may make multiple contracts a possibility which would impact costs.	LIKELY	Marginal	2

Construction Complexity						
CC-1	Relocations			Very Unlikely	Negligible	0
CC-2	Mob / Demob / Clearing			Very Unlikely	Negligible	0
CC-3	Dewatering	Methods of construction	Current assumptions on dewatering methods could change once more detailed analysis/borings have been completed.	Unlikely	Significant	3
CC-4	Erosion Control / Construction Access			Very Unlikely	Negligible	0
CC-5	Riprap			Very Unlikely	Negligible	0
CC-6	Railroads	Possible hazardous waste; temporary shoo fly construction	encounter hazardous material which would need to handled accordingly and would affect costs; no design exists for temporary shoo-fly thus complexity for construction could vary widely once designed.	LIKELY	Significant	4
CC-7	CIP Concrete	Methods of construction	Upon further analysis and design construction of walls and culverts may be more complex then currently assumed in the estimate.	Unlikely	Significant	3
CC-8	Geotextiles / Cellular Confinement			Very Unlikely	Negligible	0
CC-9	Asphalt Access Road / Trail			Very Unlikely	Negligible	0
CC-10	Vegetation			Very Unlikely	Negligible	0
CC-11	Earthwork	Methods of construction	Further analysis into types of soils and materials found in channel could affect costs of earthwork items.	Unlikely	Significant	3
CC-12	Remaining Construction Items			Very Unlikely	Negligible	0
CC-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
CC-14	Construction Management			Very Unlikely	Negligible	0

Volatile Commodities						
VC-1	Relocations			Very Unlikely	Negligible	0
VC-2	Mob / Demob / Clearing			Very Unlikely	Negligible	0
VC-3	Dewatering	Gas Prices	An increase in gas prices would affect the costs for operating the pumps required for dewatering.	LIKELY	Marginal	2
VC-4	Erosion Control / Construction Access			Very Unlikely	Negligible	0
VC-5	Riprap	Rock prices; Hauling costs	The material costs for the riprap material as well as the quoted hauling rates significantly drive the costs for riprap. As the cost for these items change so will the cost for the riprap	LIKELY	Significant	4
VC-6	Railroads	Steel prices; wood prices	The railroad construction items are heavily dependent on the material prices for the rails and ties, thus changes in prices of these would affect the overall cost for the railroad components	LIKELY	Marginal	2
VC-7	CIP Concrete	concrete material prices; reinforcing steel costs	Changes in prices for the components that go into the concrete as well as steel prices would significantly affect overal costs for the CIP concrete items	LIKELY	Significant	4
VC-8	Geotextiles / Cellular Confinement	material prices	The overall costs for these items are heavily driven by the material costs. If the quoted prices were to increase overall costs would change as well.	LIKELY	Marginal	2
VC-9	Asphalt Access Road / Trail	Asphalt costs; aggregate costs	The overall costs for these items are heavily driven by the material costs. If the quoted prices were to increase overall costs would change as well.	LIKELY	Marginal	2
VC-10	Vegetation			Very Unlikely	Negligible	0
VC-11	Earthwork	Gas Prices	Gasoline price changes would impact costs for equipment operations.	LIKELY	Marginal	2
VC-12	Remaining Construction Items			Very Unlikely	Negligible	0
VC-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
VC-14	Construction Management			Very Unlikely	Negligible	0

Quantities						
Q-1	Relocations			Very Unlikely	Negligible	0
Q-2	Mob / Demob / Clearing			Very Unlikely	Negligible	0
Q-3	Dewatering			Very Unlikely	Negligible	0
Q-4	Erosion Control / Construction Access	General quantity assumptions	The current level of design does not include detailed information on erosion control and construction entrances. Therefore, assumptions may change upon further design and analysis.	LIKELY	Marginal	2
Q-5	Riprap	Quantity assumptions	Current level of design is very low, and upon further analysis quantities may change which could significantly affect costs.	LIKELY	Significant	4
Q-6	Railroads	Shoo Fly quantities	No design exists for the shoo fly structure, and once designed quantities could be different from assumed quantities in current estimate.	LIKELY	Significant	4
Q-7	CIP Concrete	Concrete quantities	The amounts of concrete and reinforcing steel could change if the design/scope changes. Quantity increases would have significan impact on costs.	Unlikely	Significant	3
Q-8	Geotextiles / Cellular Confinement	Quantity assumptions	The level of design increases the quantities for these materials would likely change thus affecting costs.	LIKELY	Marginal	2
Q-9	Asphalt Access Road / Trail	Quantity assumptions	No detailed design has been completed on the access roads, and quantity assumptions could be different than actual design which would impact costs.	LIKELY	Significant	4
Q-10	Vegetation	Quantity assumptions	The level of design increases the quantities for these materials would likely change thus affecting costs.	LIKELY	Marginal	2
Q-11	Earthwork	Quantity confidence	The channel earthwork quantities were based on one typical section per reach due to inadequacies in topo. Thus once better topo is obtained and applied quantities could vary.	LIKELY	Marginal	2
Q-12	Remaining Construction Items			Very Unlikely	Negligible	0
Q-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
Q-14	Construction Management			Very Unlikely	Negligible	0

Fabrication & Project Installed Equipment						
FI-1	Relocations			Very Unlikely	Negligible	0
FI-2	Mob / Demob / Clearing			Very Unlikely	Negligible	0
FI-3	Dewatering			Very Unlikely	Negligible	0
FI-4	Erosion Control / Construction Access			Very Unlikely	Negligible	0
FI-5	Riprap			Very Unlikely	Negligible	0
FI-6	Railroads			Very Unlikely	Negligible	0
FI-7	CIP Concrete			Very Unlikely	Negligible	0
FI-8	Geotextiles / Cellular Confinement			Very Unlikely	Negligible	0
FI-9	Asphalt Access Road / Trail			Very Unlikely	Negligible	0
FI-10	Vegetation			Very Unlikely	Negligible	0
FI-11	Earthwork			Very Unlikely	Negligible	0
FI-12	Remaining Construction Items			Very Unlikely	Negligible	0
FI-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
FI-14	Construction Management			Very Unlikely	Negligible	0

Cost Estimating Method						
CE-1	Relocations	Relocation assumption	Due to level of design a basic assumption of digging up and placing the utility at a greater depth was assumed. Upon further analysis different assumptions could be required for utility relocations	LIKELY	Marginal	2
CE-2	Mob / Demob / Clearing	Tipping Fees	Estimate assumes no tipping fees for cleared earth materials. Estimate assumes soil would be property of contractor, but contractor may have no use for material and would instead dispose of it at landfill.	Unlikely	Significant	3
CE-3	Dewatering	Dewatering methodology	Contractor could choose different methodolgy for dewatering the construction area.	Unlikely	Significant	3
CE-4	Erosion Control / Construction Access			Very Unlikely	Negligible	0
CE-5	Riprap			Very Unlikely	Negligible	0
CE-6	Railroads	Level of design	The current level of design does not include information on the railroad items. Once design is complete, current assumptions could be much different than what is needed.	LIKELY	Significant	4
CE-7	CIP Concrete			Very Unlikely	Negligible	0
CE-8	Geotextiles / Cellular Confinement			Very Unlikely	Negligible	0
CE-9	Asphalt Access Road / Trail			Very Unlikely	Negligible	0
CE-10	Vegetation			Very Unlikely	Negligible	0
CE-11	Earthwork	Hauling Assumptions	Estimate assumes no tipping fee for earthen material that is hauled off-site. The conctractor is assumed to gain possession of the material, but if tipping fees are required for the material costs could change.	Unlikely	Significant	3
CE-12	Remaining Construction Items			Very Unlikely	Negligible	0
CE-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
CE-14	Construction Management			Very Unlikely	Negligible	0

External Project Risks						
EX-1	Relocations	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-2	Mob / Demob / Clearing	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-3	Dewatering	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-4	Erosion Control / Construction Access	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-5	Riprap	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-6	Railroads	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-7	CIP Concrete	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-8	Geotextiles / Cellular Confinement	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-9	Asphalt Access Road / Trail	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-10	Vegetation	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-11	Earthwork	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1
EX-12	Remaining Construction Items			Very Unlikely	Negligible	0
EX-13	Planning, Engineering, & Design			Very Unlikely	Negligible	0
EX-14	Construction Management	Adverse weather;	Weather conditions could impact costs	Unlikely	Marginal	1

BERRYESSA CREEK FLOOD CONTROL PROJECT
35% Estimate Level
Abbreviated Risk Analysis

		Potential Risk Areas													
		Relocations	Mob / Demob / Clearing	Dewatering	Erosion Control / Construction Acc	Riprap	Railroads	CIP Concrete	Geotextiles / Cellular Confinement	Asphalt Access Road / Trail	Vegetation	Earthwork	Remaining Construction Iter	Planning, Engineering, & Design	Construction Management
Typical Risk Elements	Project Scope	4	-	3	2	3	4	3	1	2	1	3	-	4	-
	Acquisition Strategy	-	2	-	-	-	-	-	-	-	-	-	-	-	2
	Construction Complexity	-	-	3	-	-	4	3	-	-	-	3	-	-	-
	Volatile Commodities	-	-	2	-	4	2	4	2	2	-	2	-	-	-
	Quantities	-	-	-	2	4	4	3	2	4	2	2	-	-	-
	Fabrication & Project Installed Equipment	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Cost Estimating Method	2	3	3	-	-	4	-	-	-	-	3	-	-	-
	External Project Risks	1	1	1	1	1	1	1	1	1	1	1	-	-	1

APPENDIX H

MCACES Construction Cost Estimates

BERRYESSA CREEK FLOOD CONTROL

Estimated by	Tetra Tech, Inc.
Designed by	Tetra Tech, Inc.
Prepared by	Tetra Tech, Inc
Preparation Date	1/29/2013
Effective Date of Pricing	1/29/2013
Estimated Construction Time	704 Days

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Description	Quantity	UOM	ContractCost	ProjectCost	C/O
Project Cost Summary Report			**10,473,802**	**10,473,802**	
Berryessa Creek Flood Control	**1.00**	**LS**	**10,473,802**	**10,473,802**	
02 Relocations	**1.00**	**LS**	**554,743**	**554,743**	
02 02 Reach 2	**1.00**	**LS**	**75,058**	**75,058**	
02 02 01 12kv Underground Line - STA 233+00	**75.00**	**LF**	*176.93* **13,270**	*176.93* **13,270**	
02 02 01 01 Demolition	**75.00**	**LF**	*79.54* **5,965**	*79.54* **5,965**	
02 02 01 02 Relocation	**75.00**	**LF**	*97.40* **7,305**	*97.40* **7,305**	
02 02 02 24" CMP Storm Drain - STA 226+00	**30.00**	**LF**	*498.30* **14,949**	*498.30* **14,949**	
02 02 02 01 Demo Concrete Headwall and Pipe	**30.00**	**LF**	*100.51* **3,015**	*100.51* **3,015**	
02 02 02 02 Replace of Outlet Structure	**30.00**	**LF**	*397.80* **11,934**	*397.80* **11,934**	
02 02 02 02 01 RCP Placement	**30.00**	**LF**	*285.83* **8,575**	*285.83* **8,575**	
02 02 02 02 02 Concrete Headwall and Footing	**1.40**	**CY**	*2,312.19* **3,237**	*2,312.19* **3,237**	
02 02 02 02 03 Riprap	**1.40**	**TON**	*87.15* **122**	*87.15* **122**	
02 02 03 350A Underground Line - STA 222+00	**140.00**	**LF**	*128.59* **18,002**	*128.59* **18,002**	
02 02 01 01 Demolition	**140.00**	**LF**	*48.77* **6,827**	*48.77* **6,827**	
02 02 01 02 Relocation	**140.00**	**LF**	*79.82* **11,175**	*79.82* **11,175**	
02 02 04 12kv Underground Line - STA 211+80	**280.00**	**LF**	*102.99* **28,837**	*102.99* **28,837**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			30.99	*30.99*	
02 02 01 01 Demolition	**280.00**	**LF**	**8,678**	**8,678**	
			72.00	*72.00*	
02 02 01 02 Relocation	**280.00**	**LF**	**20,159**	**20,159**	
02 04 Reach 4	**1.00**	**LS**	**11,456**	**11,456**	
			208.30	*208.30*	
02 04 01 12kv Underground Line - STA 208+40	**55.00**	**LF**	**11,456**	**11,456**	
			103.57	*103.57*	
02 02 01 01 Demolition	**55.00**	**LF**	**5,696**	**5,696**	
			104.73	*104.73*	
02 02 01 02 Relocation	**55.00**	**LF**	**5,760**	**5,760**	
02 06 Reach 6	**1.00**	**LS**	**25,013**	**25,013**	
			173.53	*173.53*	
02 06 01 12kv Underground Line - STA 205+80	**75.00**	**LF**	**13,015**	**13,015**	
			79.54	*79.54*	
02 02 01 01 Demolition	**75.00**	**LF**	**5,965**	**5,965**	
			94.00	*94.00*	
02 02 01 02 Relocation	**75.00**	**LF**	**7,050**	**7,050**	
			199.97	*199.97*	
02 06 02 12kv Underground Line - STA 197+60	**60.00**	**LF**	**11,998**	**11,998**	
			95.87	*95.87*	
02 02 01 01 Demolition	**60.00**	**LF**	**5,752**	**5,752**	
			104.10	*104.10*	
02 02 01 02 Relocation	**60.00**	**LF**	**6,246**	**6,246**	
02 08 Reach 8	**1.00**	**LS**	**62,499**	**62,499**	
			394.70	*394.70*	
02 08 01 12" Waterlines	**75.00**	**LF**	**29,602**	**29,602**	
			101.18	*101.18*	
02 08 01 01 Demolition	**75.00**	**LF**	**7,588**	**7,588**	
			293.52	*293.52*	
02 08 01 02 Relocation	**75.00**	**LF**	**22,014**	**22,014**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			731.03	*731.03*	
02 08 02 30" RCP	**45.00**	**LF**	**32,896**	**32,896**	
			95.82	*95.82*	
02 08 02 01 Demolition	**45.00**	**LF**	**4,312**	**4,312**	
			635.22	*635.22*	
02 08 02 02 Relocation	**45.00**	**LF**	**28,585**	**28,585**	
02 12 Reach 12	**1.00**	**LS**	**215,668**	**215,668**	
			156.54	*156.54*	
02 12 01 Telephone Conduit - STA 160+00	**200.00**	**LF**	**31,308**	**31,308**	
			28.34	*28.34*	
02 02 01 01 Demolition	**200.00**	**LF**	**5,667**	**5,667**	
			128.20	*128.20*	
02 02 01 02 Relocation	**200.00**	**LF**	**25,640**	**25,640**	
			846.00	*846.00*	
02 12 02 27" CMP - STA 154+00	**35.00**	**LF**	**29,610**	**29,610**	
			112.04	*112.04*	
02 12 02 01 Demolition	**35.00**	**LF**	**3,921**	**3,921**	
			733.96	*733.96*	
02 12 02 02 Relocation	**35.00**	**LF**	**25,689**	**25,689**	
			347.41	*347.41*	
02 12 03 3-1/0A XLCJ 21 kv - STA 151+00	**70.00**	**LF**	**24,319**	**24,319**	
			150.76	*150.76*	
02 12 03 01 Demolition	**70.00**	**LF**	**10,553**	**10,553**	
			196.64	*196.64*	
02 12 03 02 Relocation	**70.00**	**LF**	**13,765**	**13,765**	
			475.97	*475.97*	
02 12 04 3-700A and 1-350A Underground - STA 149+20	**160.00**	**LF**	**76,155**	**76,155**	
			98.89	*98.89*	
02 12 04 01 Demolition	**160.00**	**LF**	**15,823**	**15,823**	
			377.08	*377.08*	
02 12 04 02 Relocation	**160.00**	**LF**	**60,332**	**60,332**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			98.68	*98.68*	
02 12 05 12kv Underground Line - STA 138+60	**550.00**	**LF**	**54,276**	**54,276**	
			22.31	*22.31*	
02 12 05 01 Demolition	**550.00**	**LF**	**12,268**	**12,268**	
			76.38	*76.38*	
02 12 05 02 Relocation	**550.00**	**LF**	**42,008**	**42,008**	
02 14 Reach 14	**1.00**	**LS**	**165,048**	**165,048**	
			426.82	*426.82*	
02 14 01 Undergroudn Trench/Vault - STA 137+00	**110.00**	**LF**	**46,950**	**46,950**	
			53.25	*53.25*	
02 14 01 01 Demolition	**110.00**	**LF**	**5,858**	**5,858**	
			373.56	*373.56*	
02 14 01 02 Relocation	**110.00**	**LF**	**41,092**	**41,092**	
			684.46	*684.46*	
02 14 02 24" CMP - STA 133+50	**45.00**	**LF**	**30,801**	**30,801**	
			88.56	*88.56*	
02 14 02 01 Demolition	**45.00**	**LF**	**3,985**	**3,985**	
			595.90	*595.90*	
02 14 02 02 Relocation	**45.00**	**LF**	**26,816**	**26,816**	
			158.72	*158.72*	
02 14 03 Underground 3-350A XLCJ 12kv	**550.00**	**LF**	**87,297**	**87,297**	
			36.25	*36.25*	
02 14 03 01 Demolition	**550.00**	**LF**	**19,938**	**19,938**	
			122.47	*122.47*	
02 14 03 02 Relocation	**550.00**	**LF**	**67,358**	**67,358**	
09 Channels	**1.00**	**LS**	**8,596,250**	**8,596,250**	
09 AA Mobilization / Demobilization	**1.00**	**LS**	**278,726**	**278,726**	
			185,023.17	*185,023.17*	
09 AA 01 Mobilization	**1.00**	**EA**	**185,023**	**185,023**	
			93,702.75	*93,702.75*	
09 AA 02 Demobilization	**1.00**	**EA**	**93,703**	**93,703**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
09 BB Dewatering	**1.00**	**LS**	**972,219**	**972,219**	
09 BB 01 Dewatering Reaches 1-2	**1.00**	**LS**	**307,539**	**307,539**	
09 BB 01 01 Coffer Dams	**2.00**	**EA**	*8,833.79* **17,668**	*8,833.79* **17,668**	
09 BB 01 01 01 Cofferdam Installation	**534.00**	**CY**	*27.11* **14,478**	*27.11* **14,478**	
09 BB 01 01 02 Cofferdam Removal	**267.00**	**CY**	*11.95* **3,190**	*11.95* **3,190**	
09 BB 01 02 Dewater Pumping	**1.00**	**LS**	**289,871**	**289,871**	
09 BB 02 Dewatering Reaches 3-8	**1.00**	**LS**	**251,199**	**251,199**	
09 BB 02 01 Coffer Dams	**2.00**	**EA**	*7,218.90* **14,438**	*7,218.90* **14,438**	
09 BB 02 01 01 Cofferdam Installation	**267.00**	**CY**	*42.13* **11,248**	*42.13* **11,248**	
09 BB 02 01 02 Cofferdam Removal	**267.00**	**CY**	*11.95* **3,190**	*11.95* **3,190**	
09 BB 02 02 Dewater Pumping	**1.00**	**LS**	**236,761**	**236,761**	
09 BB 03 Dewatering Reaches 9-10	**1.00**	**LS**	**83,563**	**83,563**	
09 BB 03 01 Coffer Dams	**2.00**	**EA**	*7,482.16* **14,964**	*7,482.16* **14,964**	
09 BB 03 01 01 Cofferdam Installation	**267.00**	**CY**	*44.10* **11,775**	*44.10* **11,775**	
09 BB 03 01 02 Cofferdam Removal	**267.00**	**CY**	*11.95* **3,190**	*11.95* **3,190**	
09 BB 03 02 Dewater Pumping	**1.00**	**LS**	**68,599**	**68,599**	
09 BB 04 Dewatering Reaches 11-12	**1.00**	**LS**	**228,206**	**228,206**	
09 BB 04 01 Coffer Dams	**2.00**	**EA**	*7,218.90* **14,438**	*7,218.90* **14,438**	
			42.13	*42.13*	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
09 BB 04 01 01 Cofferdam Installation	**267.00**	**CY**	**11,248**	**11,248**	
			11.95	*11.95*	
09 BB 04 01 02 Cofferdam Removal	**267.00**	**CY**	**3,190**	**3,190**	
09 BB 04 02 Dewater Pumping	**1.00**	**LS**	**213,769**	**213,769**	
09 BB 05 Dewatering Reaches 13-16	**1.00**	**LS**	**101,711**	**101,711**	
			9,819.76	*9,819.76*	
09 BB 05 01 Coffer Dams	**2.00**	**EA**	**19,640**	**19,640**	
			42.13	*42.13*	
09 BB 05 01 01 Cofferdam Installation	**267.00**	**CY**	**11,248**	**11,248**	
			15.71	*15.71*	
09 BB 05 01 02 Cofferdam Removal	**534.00**	**CY**	**8,391**	**8,391**	
09 BB 05 02 Dewater Pumping	**1.00**	**LS**	**82,072**	**82,072**	
			12,196.66	*12,196.66*	
09 CC Clearing and Grubbing	**31.00**	**ACR**	**378,096**	**378,096**	
			2,294.40	*2,294.40*	
09 CC 01 Clear and Grub	**31.00**	**ACR**	**71,126**	**71,126**	
			24.76	*24.76*	
09 CC 02 Load and Haul Debris	**12,400.00**	**CY**	**306,970**	**306,970**	
09 DD Erosion Control	**1.00**	**LS**	**379,690**	**379,690**	
09 EE Construction Access	**1.00**	**LS**	**40,055**	**40,055**	
			2,149.29	*2,149.29*	
09 EE 01 Access Ramps	**10.00**	**EA**	**21,493**	**21,493**	
			1,856.24	*1,856.24*	
09 EE 02 Temporary Access Roads	**10.00**	**EA**	**18,562**	**18,562**	
09 01 Reach 1	**1.00**	**LS**	**1,179**	**1,179**	
			15.71	*15.71*	
09 01 01 Excavate and Haul	**75.00**	**CY**	**1,179**	**1,179**	
09 02 Reach 2	**1.00**	**LS**	**812,116**	**812,116**	
			12.10	*12.10*	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
09 02 01 Place and Compact Fill	**100.00**	**CY**	**1,210**	**1,210**	
09 02 02 Excavate and Haul	**4,074.00**	**CY**	*15.71* **64,020**	*15.71* **64,020**	
09 02 03 Import and Place Riprap	**5,750.00**	**TON**	*87.69* **504,190**	*87.69* **504,190**	
09 02 04 Geotextile Fabric	**7,700.00**	**SY**	*6.27* **48,291**	*6.27* **48,291**	
09 02 05 Cellular Confinement System	**20,453.00**	**SF**	*2.69* **54,929**	*2.69* **54,929**	
09 02 06 CIP Concrete	**90.00**	**CY**	*1,123.98* **101,158**	*1,123.98* **101,158**	
09 02 06 01 Earthwork	**235.00**	**CY**	*15.82* **3,718**	*15.82* **3,718**	
09 02 06 02 Concrete	**90.00**	**CY**	*1,082.67* **97,440**	*1,082.67* **97,440**	
09 02 07 Reinforcing Steel	**18,000.00**	**LB**	*1.68* **30,274**	*1.68* **30,274**	
09 02 08 Planting - Grasses on Banks	**1.92**	**ACR**	*4,189.70* **8,044**	*4,189.70* **8,044**	
09 03 Reach 3	**1.00**	**LS**	**2,357**	**2,357**	
09 03 01 Excavate and Haul	**150.00**	**CY**	*15.71* **2,357**	*15.71* **2,357**	
09 04 Reach 4	**1.00**	**LS**	**134,167**	**134,167**	
09 04 01 Excavate and Haul	**896.00**	**CY**	*15.71* **14,080**	*15.71* **14,080**	
09 04 02 Import and Place Riprap	**1,000.00**	**TON**	*87.69* **87,692**	*87.69* **87,692**	
09 04 03 Geotextile Fabric	**1,400.00**	**SY**	*6.27* **8,780**	*6.27* **8,780**	
09 04 04 Cellular Confinement System	**8,156.00**	**SF**	*2.68* **21,898**	*2.68* **21,898**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			4,188.77	*4,188.77*	
09 04 05 Planting - Grasses on Banks	**0.41**	**ACR**	**1,717**	**1,717**	
09 05 Reach 5	**1.00**	**LS**	**1,125,734**	**1,125,734**	
			15.71	*15.71*	
09 05 01 Excavate and Haul	**10.00**	**CY**	**157**	**157**	
09 05 02 Temporary Shoo-Fly Structure	**1.00**	**LS**	**376,878**	**376,878**	
			47.21	*47.21*	
09 05 02 01 Embankment	**306.00**	**CY**	**14,447**	**14,447**	
			1,363.95	*1,363.95*	
09 05 02 02 Railroad Track	**250.00**	**LF**	**340,987**	**340,987**	
			85.78	*85.78*	
09 05 02 03 Demolition	**250.00**	**LF**	**21,444**	**21,444**	
			19.75	*19.75*	
09 05 03 Demo, Haul, and Dispose Rails	**120.00**	**LF**	**2,371**	**2,371**	
			13.81	*13.81*	
09 05 04 Demo, Haul, and Dispose Timber	**7,500.00**	**BF**	**103,568**	**103,568**	
			17.21	*17.21*	
09 05 05 Excavate, Backfill and Compact	**250.00**	**CY**	**4,303**	**4,303**	
			1,133.18	*1,133.18*	
09 05 06 Construct Replacement Culvert (Triple Box)	**350.00**	**CY**	**396,613**	**396,613**	
			1.68	*1.68*	
09 05 07 Reinforcing Steel	**70,000.00**	**LB**	**117,732**	**117,732**	
			10,929.91	*10,929.91*	
09 05 08 Construct Wingwalls & Headwalls w/ Rails	**6.00**	**EA**	**65,579**	**65,579**	
			749.81	*749.81*	
09 05 08 01 Cast-in-Place Concrete	**53.00**	**CY**	**39,740**	**39,740**	
			1.68	*1.68*	
09 05 08 02 Reinforcing Steel	**10,600.00**	**LB**	**17,828**	**17,828**	
			66.77	*66.77*	
09 05 08 03 Railing	**120.00**	**LF**	**8,012**	**8,012**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			425.72	*425.72*	
09 05 09 Reconstruct Rails and Ties	**120.00**	**LF**	**51,086**	**51,086**	
			93.71	*93.71*	
09 05 10 Import and Place Riprap	**75.00**	**TON**	**7,028**	**7,028**	
			4,189.61	*4,189.61*	
09 05 11 Planting - Grasses on Banks	**0.10**	**ACR**	**419**	**419**	
09 06 Reach 6	**1.00**	**LS**	**588,336**	**588,336**	
			15.71	*15.71*	
09 06 01 Excavate and Haul	**4,257.00**	**CY**	**66,895**	**66,895**	
			87.68	*87.68*	
09 06 02 Import and Place Riprap	**4,750.00**	**TON**	**416,498**	**416,498**	
			6.27	*6.27*	
09 06 03 Geotextile Fabric	**6,650.00**	**SY**	**41,703**	**41,703**	
			2.69	*2.69*	
09 06 04 Cellular Confinement System	**20,351.00**	**SF**	**54,651**	**54,651**	
			4,189.61	*4,189.61*	
09 02 05 Planting - Grasses on Banks	**2.05**	**ACR**	**8,589**	**8,589**	
09 07 Reach 7	**1.00**	**LS**	**2,891**	**2,891**	
			48.19	*48.19*	
09 07 01 Excavate and Haul	**60.00**	**CY**	**2,891**	**2,891**	
09 08 Reach 8	**1.00**	**LS**	**126,391**	**126,391**	
			15.71	*15.71*	
09 08 01 Excavate and Haul	**1,222.00**	**CY**	**19,203**	**19,203**	
			87.69	*87.69*	
09 08 02 Import and Place Riprap	**1,000.00**	**TON**	**87,692**	**87,692**	
			6.27	*6.27*	
09 08 03 Geotextile Fabric	**1,400.00**	**SY**	**8,780**	**8,780**	
			2.68	*2.68*	
09 08 04 Cellular Confinement System	**3,419.00**	**SF**	**9,166**	**9,166**	
			4,190.08	*4,190.08*	
09 08 05 Planting - Grasses on Banks	**0.37**	**ACR**	**1,550**	**1,550**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
09 09 Reach 9	**1.00**	**LS**	**99,306**	**99,306**	
09 09 01 Excavate and Haul	**200.00**	**CY**	*15.71* **3,143**	*15.71* **3,143**	
09 09 02 Excavate, Backfill and Compact	**100.00**	**CY**	*17.21* **1,721**	*17.21* **1,721**	
09 09 03 Sheet Piling	**1,200.00**	**SF**	*75.08* **90,096**	*75.08* **90,096**	
09 09 04 Import and Place Riprap	**50.00**	**TON**	*86.93* **4,346**	*86.93* **4,346**	
09 10 Reach 10	**1.00**	**LS**	**350,881**	**350,881**	
09 10 01 Excavate and Haul	**2,600.00**	**CY**	*15.71* **40,857**	*15.71* **40,857**	
09 10 02 Import and Place Riprap	**3,000.00**	**TON**	*87.69* **263,076**	*87.69* **263,076**	
09 10 03 Geotextile Fabric	**4,200.00**	**SY**	*6.27* **26,341**	*6.27* **26,341**	
09 10 04 Cellular Confinement System	**5,967.00**	**SF**	*2.68* **15,999**	*2.68* **15,999**	
09 10 05 Planting - Grasses on Banks	**1.10**	**ACR**	*4,189.61* **4,609**	*4,189.61* **4,609**	
09 11 Reach 11	**1.00**	**LS**	**82,121**	**82,121**	
09 11 01 Excavate and Haul	**200.00**	**CY**	*15.71* **3,143**	*15.71* **3,143**	
09 11 02 Excavate, Backfill and Compact	**100.00**	**CY**	*17.21* **1,721**	*17.21* **1,721**	
09 11 03 Sheet Piling	**1,200.00**	**SF**	*60.76* **72,907**	*60.76* **72,907**	
09 11 04 Import and Place Riprap	**50.00**	**TON**	*87.01* **4,350**	*87.01* **4,350**	
09 12 Reach 12	**1.00**	**LS**	**2,501,878**	**2,501,878**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			12.10	*12.10*	
09 12 01 Place and Compact Fill (Piedmont Creek Confluence)	**75.00**	**CY**	**908**	**908**	
			15.71	*15.71*	
09 12 02 Excavate and Haul	**24,278.00**	**CY**	**381,509**	**381,509**	
			17.21	*17.21*	
09 12 03 Excavate and Regrade Onsite	**25.00**	**CY**	**430**	**430**	
			87.69	*87.69*	
09 12 04 Import and Place Riprap	**7,750.00**	**TON**	**679,612**	**679,612**	
			6.27	*6.27*	
09 12 05 Geotextile Fabric	**10,500.00**	**SY**	**65,851**	**65,851**	
			2.69	*2.69*	
09 12 06 Cellular Confinement System	**34,227.00**	**SF**	**91,910**	**91,910**	
			113.93	*113.93*	
09 12 07 Roadway Base	**3,000.00**	**CY**	**341,799**	**341,799**	
			5.70	*5.70*	
09 12 08 Access Road Surface	**54,000.00**	**SF**	**307,821**	**307,821**	
			1,067.32	*1,067.32*	
09 12 09 Cast-in-Place Concrete	**440.00**	**CY**	**469,619**	**469,619**	
			15.85	*15.85*	
09 02 12 01 Earthwork	**1,203.00**	**CY**	**19,065**	**19,065**	
			1,023.99	*1,023.99*	
09 02 12 02 Concrete	**440.00**	**CY**	**450,554**	**450,554**	
			1.68	*1.68*	
09 12 10 Reinforcing Steel	**88,000.00**	**LB**	**148,006**	**148,006**	
			4,189.71	*4,189.71*	
09 12 11 Planting - Grasses on Banks	**3.44**	**ACR**	**14,413**	**14,413**	
09 13 Reach 13	**1.00**	**LS**	**11,357**	**11,357**	
			151.43	*151.43*	
09 13 01 Excavate and Haul	**75.00**	**CY**	**11,357**	**11,357**	
09 14 Reach 14	**1.00**	**LS**	**671,261**	**671,261**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			15.71	*15.71*	
09 14 01 Excavate and Haul	**6,861.00**	**CY**	**107,815**	**107,815**	
			87.69	*87.69*	
09 14 02 Import and Place Riprap	**1,250.00**	**TON**	**109,615**	**109,615**	
			6.27	*6.27*	
09 14 03 Geotextile Fabric	**1,750.00**	**SY**	**10,975**	**10,975**	
			2.68	*2.68*	
09 14 04 Cellular Confinement System	**8,803.00**	**SF**	**23,636**	**23,636**	
			113.87	*113.87*	
09 14 05 Roadway Base	**500.00**	**CY**	**56,936**	**56,936**	
			5.70	*5.70*	
09 14 06 Access Road Surface	**9,000.00**	**SF**	**51,304**	**51,304**	
			1,067.27	*1,067.27*	
09 14 07 Cast-in-Place Concrete	**220.00**	**CY**	**234,799**	**234,799**	
			15.84	*15.84*	
09 02 14 01 Earthwork	**601.00**	**CY**	**9,522**	**9,522**	
			1,023.99	*1,023.99*	
09 02 14 02 Concrete	**220.00**	**CY**	**225,277**	**225,277**	
			1.68	*1.68*	
09 14 08 Reinforcing Steel	**44,000.00**	**LB**	**74,003**	**74,003**	
			4,189.94	*4,189.94*	
09 14 09 Planting - Grasses on Banks	**0.52**	**ACR**	**2,179**	**2,179**	
09 15 Reach 15	**1.00**	**LS**	**2,357**	**2,357**	
			15.71	*15.71*	
09 15 01 Excavate and Haul	**150.00**	**CY**	**2,357**	**2,357**	
			35,130.61	*35,130.61*	
09 16 Reach 16	**1.00**	**EA**	**35,131**	**35,131**	
			28.91	*28.91*	
09 16 01 Excavate and Haul	**1,215.00**	**CY**	**35,131**	**35,131**	
14 Recreation	**1.00**	**LS**	**1,322,809**	**1,322,809**	
14 01 Recreation Trails and Access Points	**1.00**	**LS**	**1,322,809**	**1,322,809**	

Description	Quantity	UOM	ContractCost	ProjectCost	C/O
			5.29	*5.29*	
14 01 01 Asphalt-Concrete Trail	**244,000.00**	**SF**	**1,291,539**	**1,291,539**	
			113.93	*113.93*	
14 01 01 01 Roadway Base	**3,012.00**	**CY**	**343,166**	**343,166**	
			3.89	*3.89*	
14 01 01 02 Trail Surface	**244,000.00**	**SF**	**948,373**	**948,373**	
			1,563.50	*1,563.50*	
14 01 02 Access Points	**20.00**	**EA**	**31,270**	**31,270**	
18 Cultural Resources	**1.00**	**LS**	**0**	**0**	
			0.00	*0.00*	
18 01 Cultural Resources	**1.00**	**EA**	**0**	**0**	

Berryessa Creek Project

Santa Clara County, California

Appendix B

Engineering and Design

Part IV: Design and Cost of Alternatives - Geotechnical Evaluation

TETRA TECH

SEPTEMBER 2011

BERRYESSA CREEK PROJECT

APPENDIX B, Part IV: Design and Cost of Alternative - Geotechnical Evaluation

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1.1 INTRODUCTION

Geologic and geotechnical conditions along the Berryessa Creek Project alignment between Calaveras Boulevard and Old Piedmont Road were summarized in the Geotechnical Office Report prepared by Parikh Consultants, Inc. (Parikh Consultants 2004). The report included data from several previous geotechnical and environmental studies performed along or adjacent to the creek alignment. A total of 70 boring logs were compiled in the Parikh report. Although many of the borings do not include data that would be necessary for final design of the project, the number and depth of the existing borings are considered adequate for feasibility-level design purposes. The preliminary geotechnical assessment did not encounter geotechnical or geologic factors that would preclude successful completion of this project, however, there are a number of issues that will need to be considered and addressed in the final design.

1.2 GEOLOGIC CONDITIONS

Several different soil units were identified along the creek alignment and included:

- Basin Deposits (Holocene) – Composed predominantly of clays and silty clays
- Young Alluvial Fan Deposits (Holocene) – Composed of gravelly sand and sandy and clayey gravel near the fan heads and upstream, grading to sandy and silty clay within downstream reaches.
- Older Alluvial Fan Deposits (Holocene) – Composed of gravelly sand and sandy and clayey gravel near the fan heads and upstream, grading to sandy and silty clay within downstream reaches.
- Alluvial Fan Deposits (Upper Pleistocene) – Composed of gravel and cobbles with clayey and sandy matrix.

The report by Parikh Consultants (2004) describes the Hayward Fault as being 1.2 miles from the project site, however the State of California maps active faulting closer to the eastern limits of the project (CDMG 1982). It should be noted that immediately east of the project alignment (east of Old Piedmont Road) is hilly terrain that has been impacted by both faulting and landslides. The Berryessa Formation (composed of mudstone, sandstone, and conglomerate) is mapped in this area; however, the geology has been significantly disturbed by northwest-southeast trending faulting associated with the Hayward Fault Zone. Numerous southwest trending landslides have developed in the terrain. The current project limits for Berryessa Creek do not extend into the faulting and landslide areas, however, any future project development east of Old Piedmont Road (e.g., upstream detention basins) needs to consider the impacts of both active faulting and landslides.

1.3 GROUNDWATER CONDITIONS

Groundwater was encountered in many of the borings within the most downstream section of the creek alignment (Calaveras Boulevard to Montague Expressway) at depths varying from approximately 8 to 12 feet below existing grade. In the vicinity of I-680 groundwater was encountered at a depth of greater than 30 feet below existing grade. Within the upper portion of the creek alignment (upstream of I-680) groundwater was not noted in any of the exploratory borings presented in the Parikh report except for one boring upstream of Old Piedmont Road where groundwater was encountered approximately 17 feet below existing grade. The Parikh report did note that groundwater levels could vary in the future due to seasonal groundwater fluctuations, water elevation in the creek, surface run-off, and other hydrologic conditions.

1.4 SEISMIC CONDITIONS

The Parikh report estimated a potential for high seismic activity for the project alignment (peak bedrock acceleration of 0.7). Design of floodwalls, channel walls, bridges and levees will need to incorporate the appropriate seismic factors to account for this high potential for seismic activity. Depending on the results of pseudo-static analysis of structures and levees, more extensive dynamic analysis may be needed to evaluate potential deformation.

The Parikh report did recognize that deposits of loose to medium dense sands and silty sands encountered within the creek alignment may be susceptible to liquefaction. These deposits were predominantly encountered in the upstream portion of the creek. The overall liquefaction potential was preliminarily judged by the Parikh report to be low because of the discontinuous nature of the liquefaction-susceptible soils and the lack of high groundwater in the areas that they were encountered. However, further investigation and groundwater monitoring was recommended during the final design phase of the project. If a higher degree of liquefaction is identified, then the effects of seismic settlement and lateral spread on structures and levees will need to be considered.

1.5 STRUCTURE FOUNDATIONS

Structures for this project may include floodwalls, vertical channel walls, culverts, and bridge crossings. Due to the significant variability of soil conditions along the creek alignment, it is anticipated that each structure will require site specific foundation design. Foundation support for bridge replacements will likely require deep pile foundations. Culverts and low to medium height wall structures can likely be supported on grade, although removal and re-compaction of existing subgrade soils may be necessary. Higher walls (>10 feet height) may require pile foundation support depending on their location along the alignment. Where significant retained soil heights are required (channel walls), importing of select granular backfill may be preferable over on-site clayey soils.

1.6 LEVEE EMBANKMENTS

New or raised levees should be designed and constructed in accordance with U.S. Army Corps of Engineers Manual EM 1110-2-1913 ([USACE] 2000).

Seepage analysis of the proposed levee should consider both seepage through the levee embankment and under-seepage through the foundation soils. The potential for high uplift pressures and high exit gradients near the landside toe of the levee must be evaluated, particularly where more granular foundation soils exist near the surface. If the potential for these detrimental factors exist then some form of mitigation (impermeable cutoffs, slurry trenches, relief drains) will need to be considered.
Stability analysis of levee embankments should consider the following conditions.

- End of Construction – Utilizing undrained shear strength for clayey soils
- Sudden Drawdown – Including unbalanced pore pressures within the riverside slope.
- Long-Term Seepage Conditions – Utilizing long-term or steady state seepage
- Earthquake – Utilizing pseudo-static stability analysis. If soil liquefaction is an issue, an analysis using post-liquefied strengths should also be performed. Where factors of safety are less than 1.2, a seismic deformation analysis may also be required.

Immediate and long-term settlement of new and raised levee should be performed and the impact on required freeboard be evaluated. Mitigation of settlement can be achieved by several methods including pre-loading, ground improvement, or over-building of embankments.

1.7 CHANNEL/BASIN SLOPES

Slope stability analysis should be performed on channel slopes for static, pseudo-static conditions and sudden drawdown conditions. Constructed slopes should be suitably protected against erosion from local runoff and stream flow.

1.8 FUTURE INVESTIGATION

Additional investigation and analysis will be necessary during the final design phase of the project. In some areas it is anticipated that information from existing borings will be utilized in the design, however, where specific field or laboratory test data required for analysis and design is lacking, supplemental field exploration will be necessary. A preliminary guideline for future investigation and analysis is presented in Table 1.

Table 1 Additional Investigation and Analysis

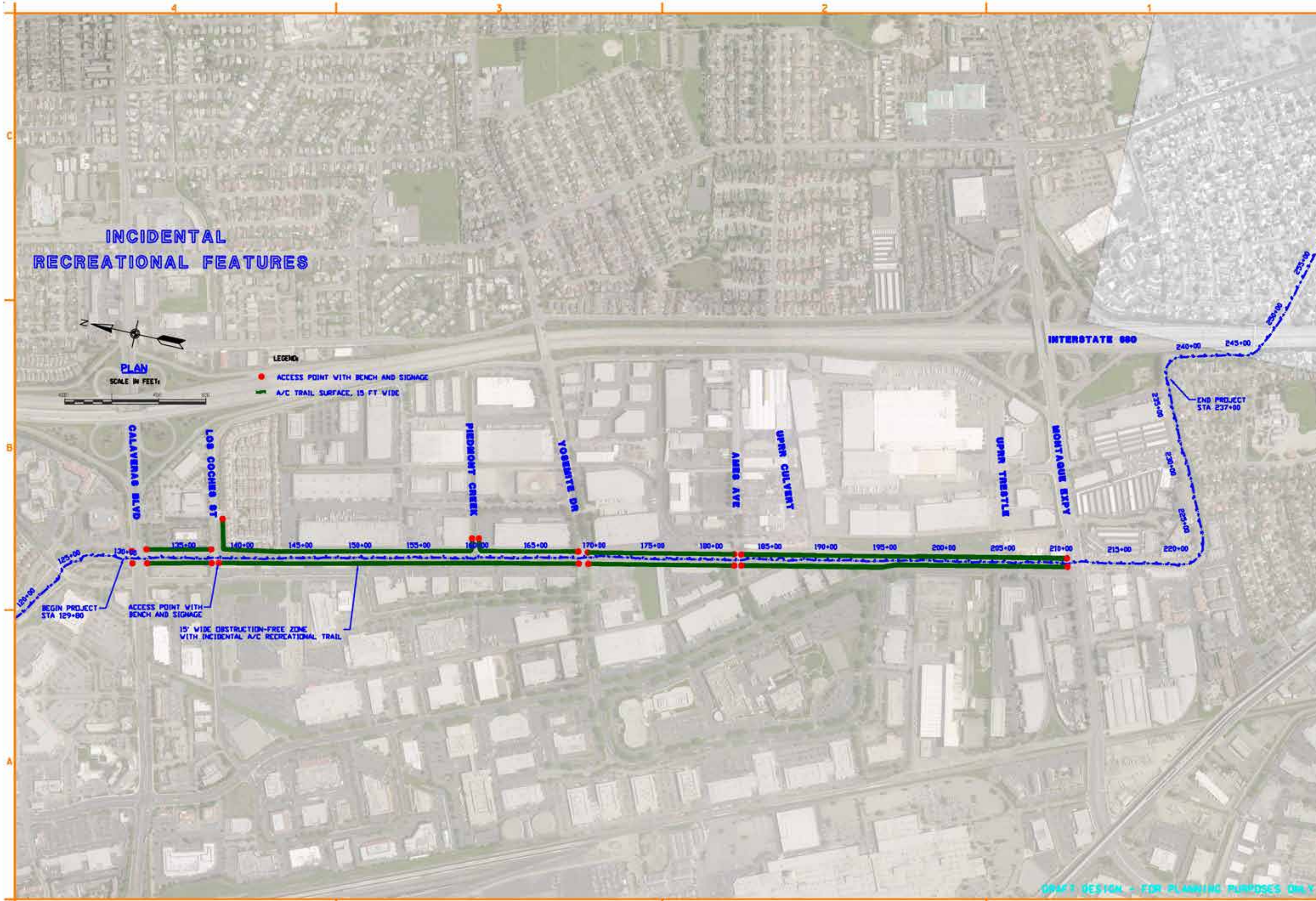
Project Components	Field Exploration	Laboratory Testing	Analyses
Levee Embankments/ Channel Slopes	Frequency: Minimum 1 boring / 500 ft. Depth: At least 3 x levee/slope height, and at least 5 feet below potentially liquefiable soils.	• Dry Density • Moisture Content • Shear Strength • Consolidation • Gradation • Permeability	• Seepage Analysis • (through seepage and under-seepage) • Slope Stability Analysis • Settlement Analysis • Scour Potential
Floodwalls/ Channel Walls	Frequency: Minimum 1 boring/500 ft. Depth: At least 3 x wall/culvert, and at least 5 feet below potentially liquefiable soils	• Dry Density • Moisture Content • Shear Strength • Consolidation • Gradation • Corrosion	• Earth Pressures • Vertical & Lateral Bearing Capacity • Settlement • Overturning/Sliding
Bridge Replacements	Frequency: 1 boring/support Depth: Typically 70 to 100 feet depending on loading conditions	• Dry Density • Moisture Content • Shear Strength • Consolidation • Gradation • Corrosion Potential	• Footing Bearing Capacity • Vertical and Lateral Pile Capacity • Earth Pressures • Seismic Design Parameters

1.9 REFERENCES

California Division of Mines and Geology (CDMG), 1982. State of California Special Studies Zone, Calaveras Reservoir. Effective January 1, 1882.

Parikh Consultants Inc., 2004. Geotechnical Office Report, Coyote and Berryless Creek, General Re-Evaluation Study for Proposed Project Modifications, Santa Clara County, California. April 2004).

United States Army Corps of Engineers (USACE), 2000. Engineers Manual EM 1110-2-1913 Design and Construction of Levees. April 30, 2000.



US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Date: JAN 17, 2012 | Rev. N/A
Design file no: N/A
Drawing Code:
File name: BER PP C-2R
Plot date: DEC 27, 2011
Plot scale: 50/100

Designed by: PRELIMINARY
Dwn by: KP | Spec No.: N/A
Reviewed by: RN
Submitted by:
CADD/CIS CHD 905 SEC 8

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17885 VON KARMAN AVE STE 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

INCIDENTAL
RECREATIONAL FEATURES

Sheet reference number:
R1
Sheet 1 of 1

US Army Corps
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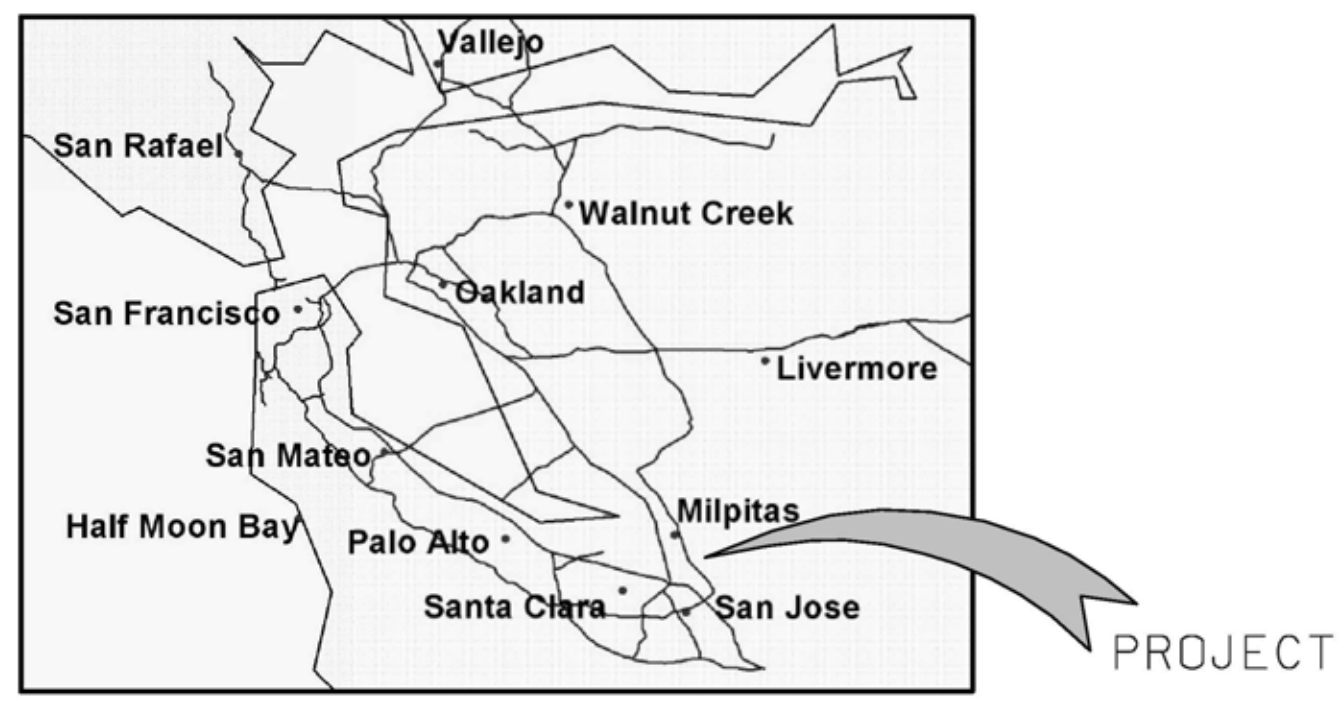
Sacramento District

BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

SANTA CLARA COUNTY
CALIFORNIA

PLAN AND PROFILE VIEWS

FY_12



VICINITY MAP

DRAFT DESIGN - FOR PLANNING PURPOSES ONLY

US Army Corps of Engineers
Sacramento District

Date Approved
Description
Symbol

Designed by: PRELIMINARY
Dwn by: KP
Reviewed by: RM
Submitted by: CHIEF, CIV ENGR DES SEC A
Date: JAN 17, 2012
Rev: N/A
Design file no: N/A
Drawing Code:
File name: BER PP C-4X
Plot date: DEC 22, 2011
Plot scale: 30/100

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT
PREPARED BY:
TETRA TECH, INC.
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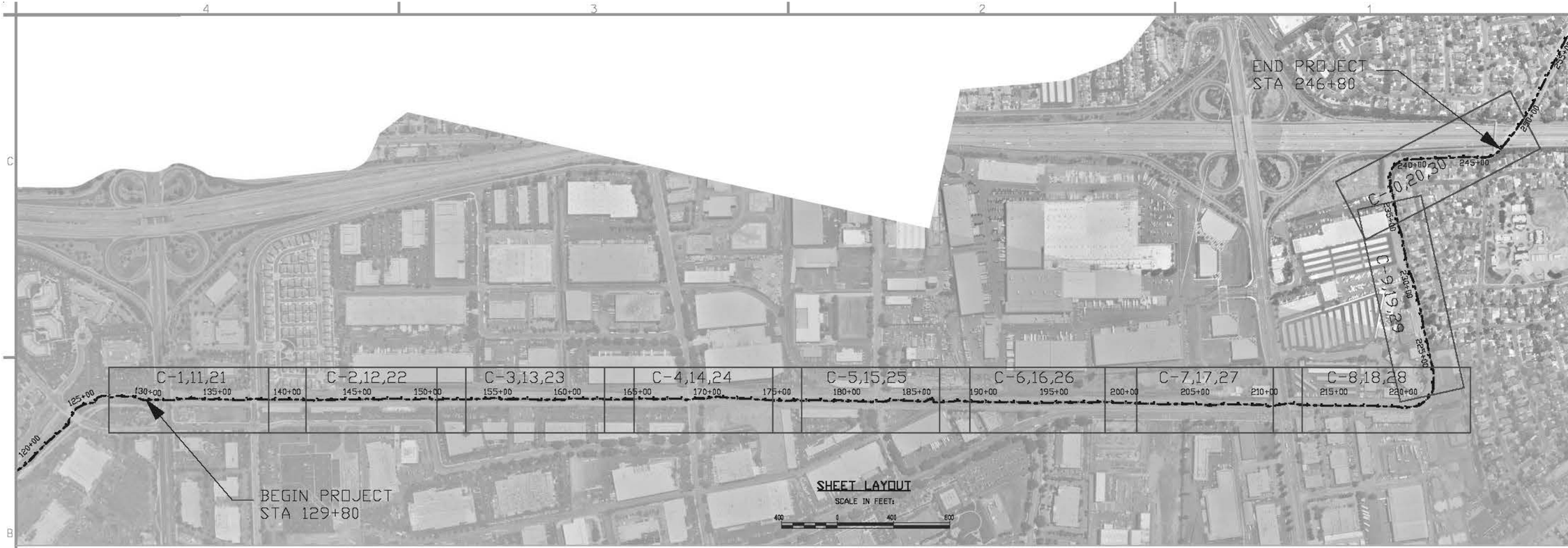
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
PROJECT ALTERNATIVES
PLAN AND PROFILE VIEW
TITLE SHEET

Sheet reference number:
G1
Sheet 1 of 35



ABBREVIATIONS

ACC	ACCORDING
APPROX	APPROXIMATE
BDY	BOUNDARY
BOB	BASIS OF BEARING
BM	BENCHMARK
CH	CHANNEL
CL	CENTERLINE
CMP	CORRUGATED METAL PIPE
CY	CUBIC YARD
D/S	DOWNSTREAM
DIA	DIAMETER
EG	EXISTING GROUND
FG	FINISH GRADE
E	EAST, EASTING
EA	EACH
EL	ELEVATION
EXIST	EXISTING
FT	FOOT, FEET
IE	INVERT ELEVATION
INV	INVERT
LF	LINEAR FOOT
MAX	MAXIMUM
MIN	MINIMUM
N	NORTH, NORTHING
NAD	NORTH AMERICAN DATUM
N/A	NOT APPLICABLE
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NTS	NOT TO SCALE
PCL	PRIMARY CONTROL LINE
PROP	PROPOSED
PT	POINT
RCP	REINFORCED CONCRETE PIPE
ROW	RIGHT OF WAY
S	SOUTH
SCVWD	SANTA CLARA VALLEY WATER DISTRICT
SHT	SHEET
SS	SIDE SLOPE
SF	SQUARE FEET
STA	STATION
TOB	TOP OF BANK
TOW	TOP OF WALL
TYP	TYPICAL
U/S	UPSTREAM
UPRR	UNION PACIFIC RAILROAD
USACE	UNITED STATES ARMY CORPS OF ENGINEERS
VCP	VITRIFIED CLAY PIPE
VERT	VERTICAL
W	WEST
WSEL	WATER SURFACE ELEVATION

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24	C-19	ALTERNATIVE 2B/d PLAN AND PROFILE STA 223+00 TO 236+00
25	C-20	ALTERNATIVE 2B/d PLAN AND PROFILE STA 235+00 TO 248+00
ALTERNATIVE 2B/d: WALLED TRAPEZOIDAL CHANNEL, FEMA-CERTIFIABLE PROTECTION		
26	C-21	ALTERNATIVE 4/d PLAN AND PROFILE STA 127+00 TO 140+00
27	C-22	ALTERNATIVE 4/d PLAN AND PROFILE STA 139+00 TO 152+00
28	C-23	ALTERNATIVE 4/d PLAN AND PROFILE STA 151+00 TO 164+00
29	C-24	ALTERNATIVE 4/d PLAN AND PROFILE STA 163+00 TO 176+00
30	C-25	ALTERNATIVE 4/d PLAN AND PROFILE STA 175+00 TO 188+00
31	C-26	ALTERNATIVE 4/d PLAN AND PROFILE STA 187+00 TO 200+00
32	C-27	ALTERNATIVE 4/d PLAN AND PROFILE STA 199+00 TO 212+00
33	C-28	ALTERNATIVE 4/d PLAN AND PROFILE STA 211+00 TO 224+00
34	C-29	ALTERNATIVE 4/d PLAN AND PROFILE STA 223+00 TO 236+00
35	C-30	ALTERNATIVE 4/d PLAN AND PROFILE STA 238+00 TO 248+00

NOTES

1. ALL PROJECT FEATURES SHOWN ARE PRELIMINARY IN NATURE AND ARE TO BE USED FOR PLANNING PURPOSES ONLY.
2. CONTROL LINE FROM HEC-GEORAS STATIONING, USACE 2004.
3. 2' CONTOUR INTERVAL TOPOGRAPHY AND DIGITAL ORTHOPHOTO USACE 2002.
4. PARCEL DATA FROM SCVWD 2009 BOUNDARY SURVEY.
5. ALL MAPPING IS PROJECTED TO NAD 83 STATE PLACE CALIFORNIA ZONE 3. VERTICAL DATUM IS NAVD 88. UNITS ARE SURVEY FEET.
6. WATER SURFACE ELEVATIONS ARE SHOWN FOR BASED ON HEC-RAS MODELING BY TETRA TECH USING UNSTEADY FLOWS WITHOUT UPSTREAM PROJECT IMPROVEMENTS IN PLACE.
7. DESIGN WATER SURFACE ELEVATION PROFILE FOR ALTERNATIVE 2A/d IS THE 0.01 WSEL AT 50% CERTAINTY ASSUMING NO FUTURE UPSTREAM IMPROVEMENTS BY SCVWD.
8. UPPER DESIGN WATER SURFACE ELEVATION PROFILE FOR ALTERNATIVES 2B/d AND 4/d IS THE 0.01 WSEL AT 50% CERTAINTY ASSUMING FUTURE UPSTREA,M IMPROVEMENTS (SCVWD OBJECTIVE). DESIGN FLOODWALL HEIGHTS AND TOP OF BANK ELEVATIONS ARE BASED ON 95% CERTAINTY CRITERIA APPLIED TO THIS WSEL.
9. LOWER DESIGN WATER SURFACE ELEVATION PROFILE FOR ALTERNATIVES 2B/d AND 4/d IS THE 0.01 WSEL AT 50% CERTAINTY ASSUMING NO FUTURE UPSTREAM IMPROVEMENTS BY SCVWD.
10. CROSS SECTIONS ARE SHOWN LOOKING DOWNSTREAM AND ARE NOT TO SCALE.

LEGEND

EXISTING FEATURES (PLAN VIEW)

- 2' CONTOUR
- PARCEL LINE
- STRUCTURE
- WATER/SEWER/STORM UTILITY
- ELEC/TEL/CABLE UTILITY

PROPOSED FEATURES (PLAN VIEW)

- CONTROL LINE
- STRUCTURE
- TOP OF SLOPE
- TOE OF SLOPE
- LIMIT OF CONSTRUCTION
- TEMPORARY CONSTRUCTION EASEMENT
- TEMPORARY STAGING AREA

EXISTING FEATURES (PROFILE VIEW)

- TOP OF BANK
- THALWEG

PROPOSED FEATURES (PROFILE VIEW)

- TOP OF WALL/MAT
- WATER SURFACE ELEVATION
- VEGETATED BENCH
- THALWEG

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Sacramento District

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Dwn by: KP
Spec No.: N/A
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Submitted by:
File name: BER PP C-XX
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Plot scale: 50:100
CHIEF, CIV ENGR DES SEC A

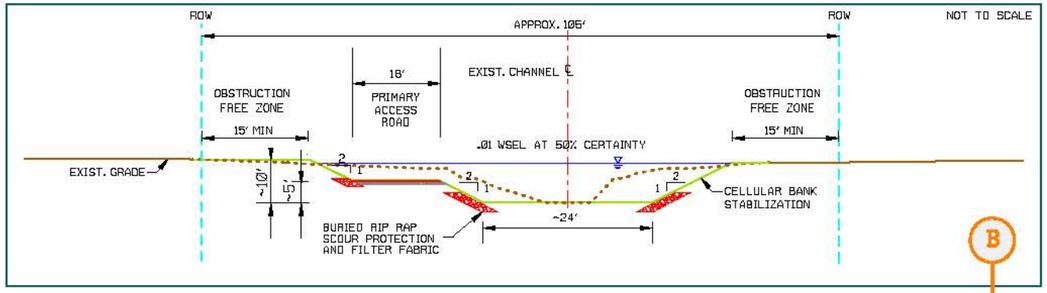
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17887 VON KARMAN AVE STE 500
IRVINE, CA 92614

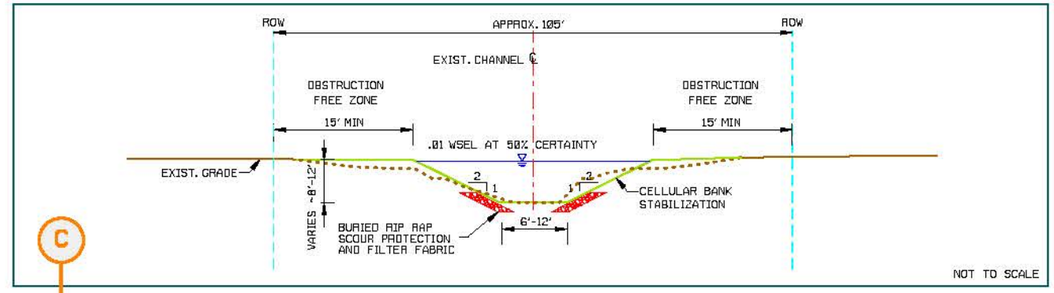
SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
PROJECT ALTERNATIVES
PLAN AND PROFILE VIEW
INDEX, LEGEND, AND ABBREVIATIONS

Sheet reference number:
G2
Sheet 2 of 35

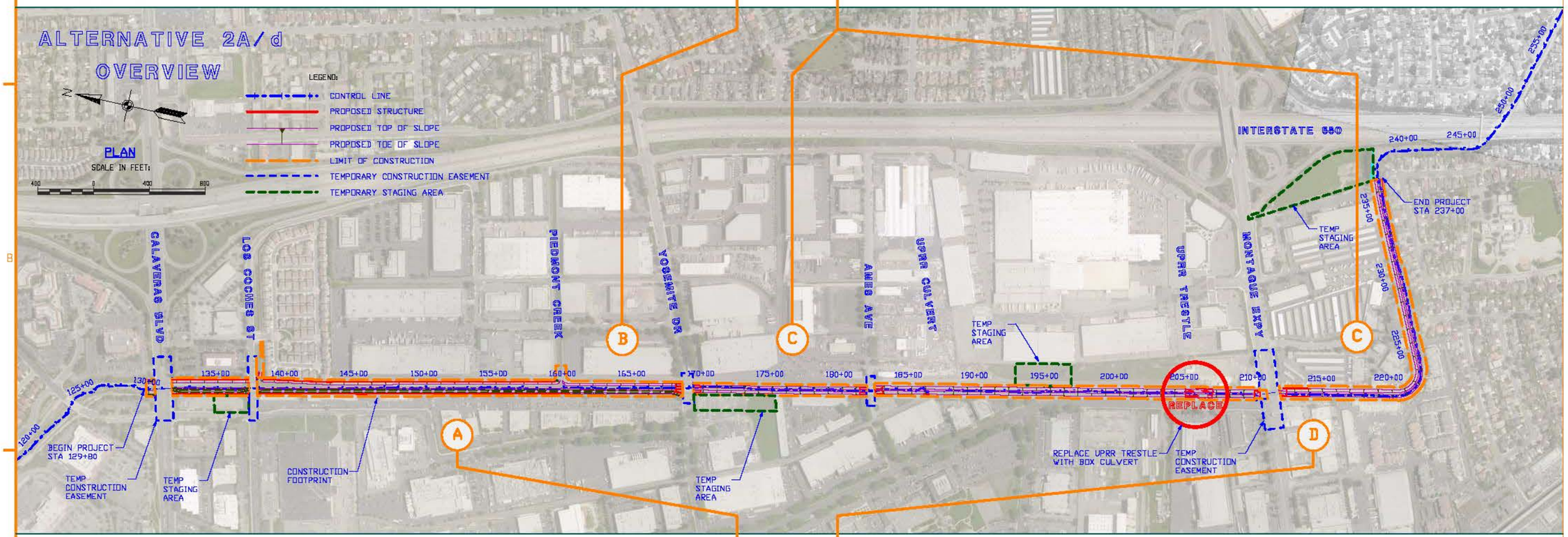
B.1.1

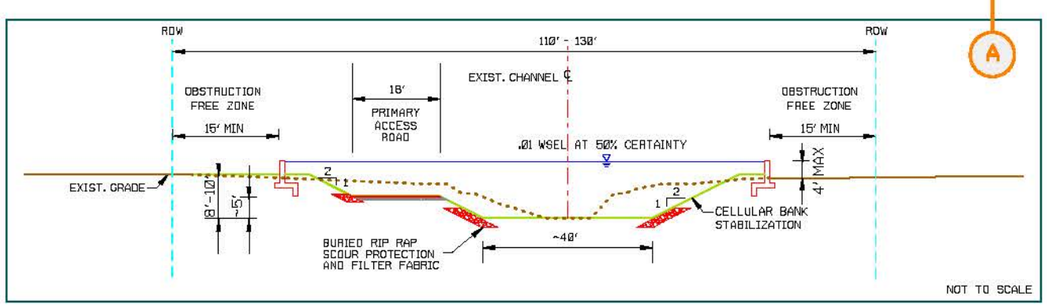


TYPICAL CROSS SECTION, PIEDMONT CREEK TO YOSEMITE DR (STA 160 TO 170)



TYPICAL CROSS SECTION YOSEMITE DR TO I-680 (STA 170 TO 212 AND 214 TO 237)





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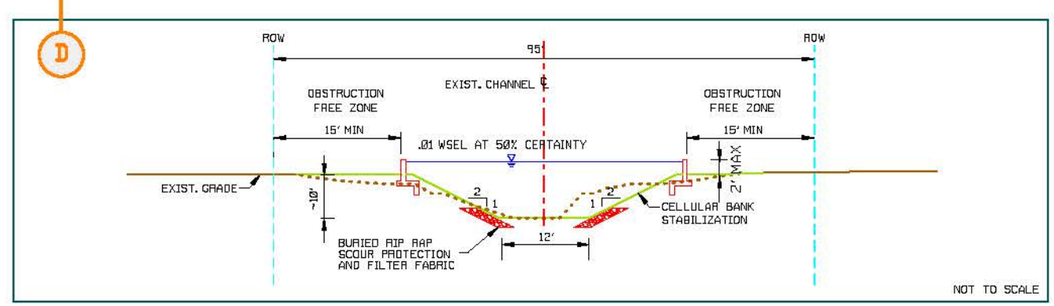

TYPICAL CROSS SECTION, MONTAGUE EXPY TO 200' UPSTREAM (STA 212 TO 214)

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Submitted by: CHIEF, CIV ENGR DES SEC A

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TETRA TECH, INC.
17885 VON KARMAN AVE STE 500
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SANTA CLARA COUNTY CALIFORNIA
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ALTERNATIVES FORMULATION

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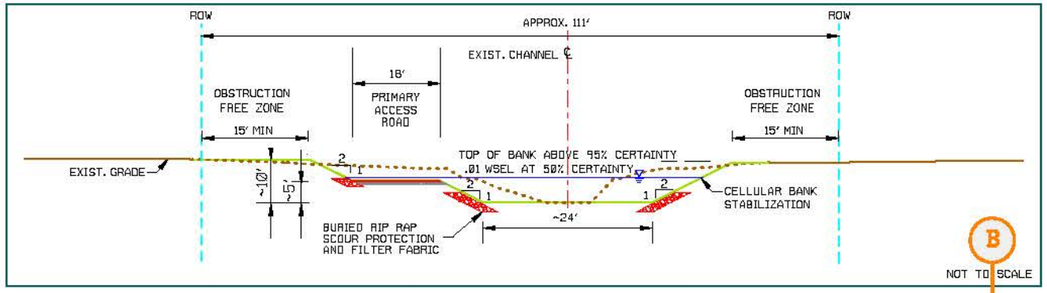

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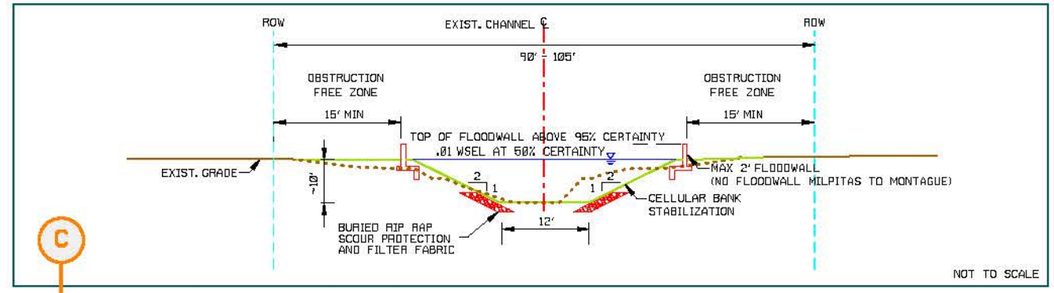
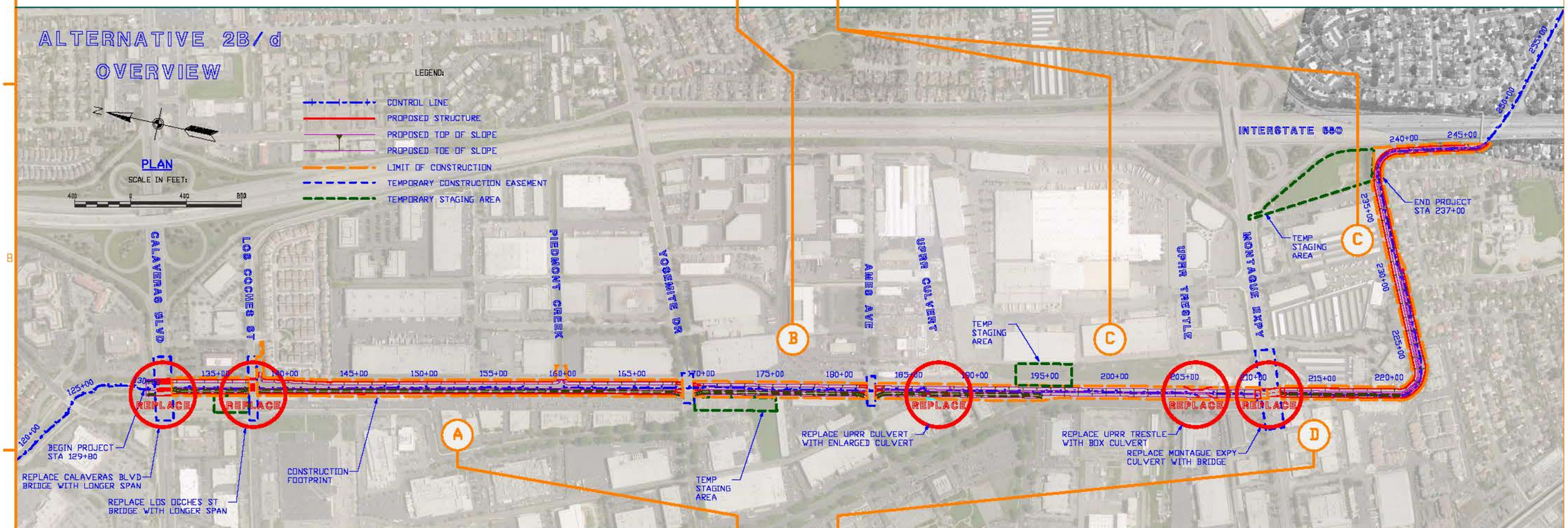
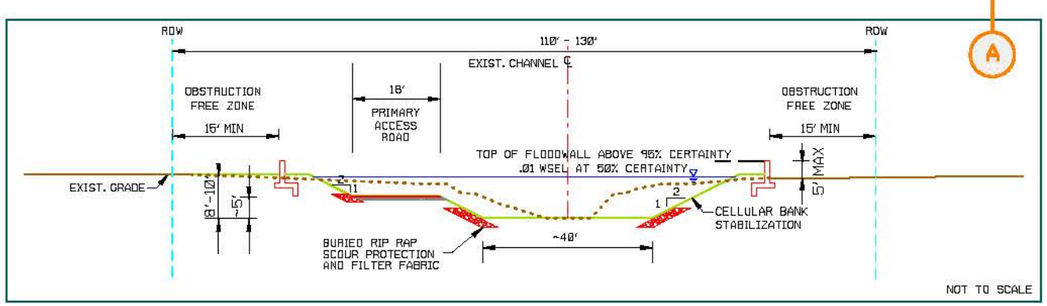


TYPICAL CROSS SECTION MILPITAS BLVD TO I-680 (STA 195 TO 212 AND 230 TO 248)





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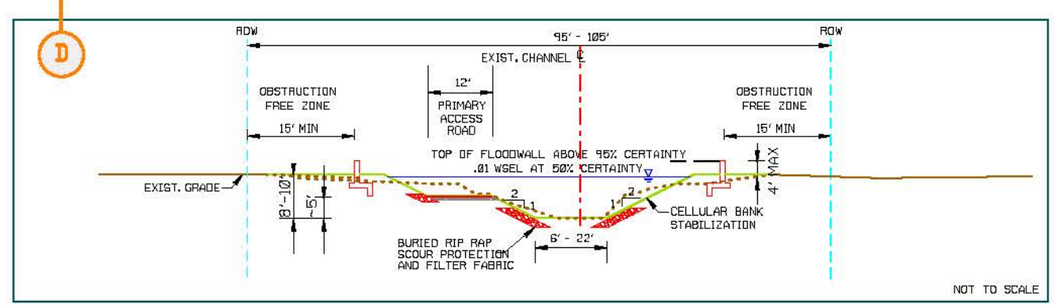

TYPICAL CROSS SECTION, MONTAGUE EXPY TO LAKEWOOD CT (STA 212 TO 230)

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17887 VON KARMAN AVE STE 500
IRVINE, CA 92614

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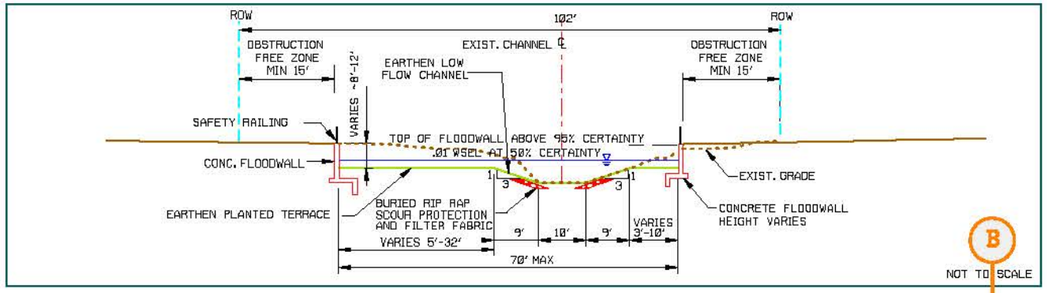
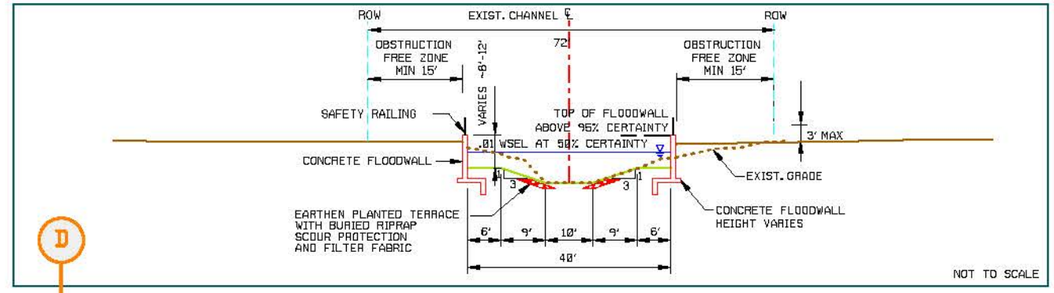
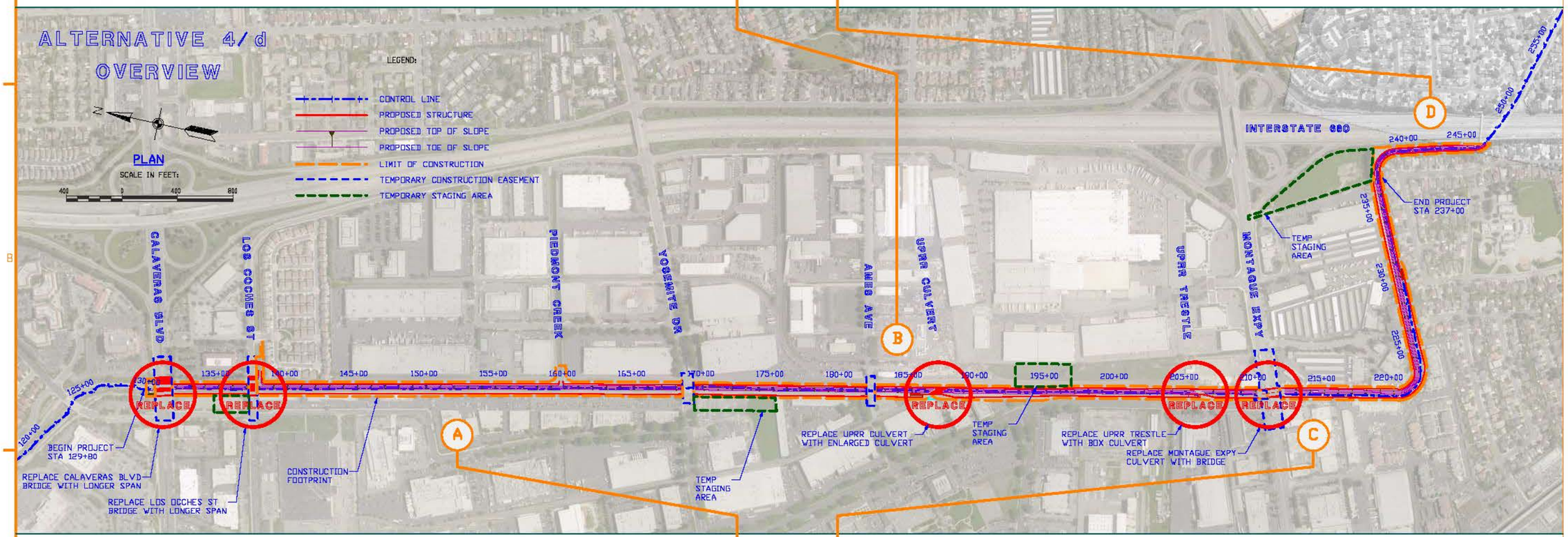
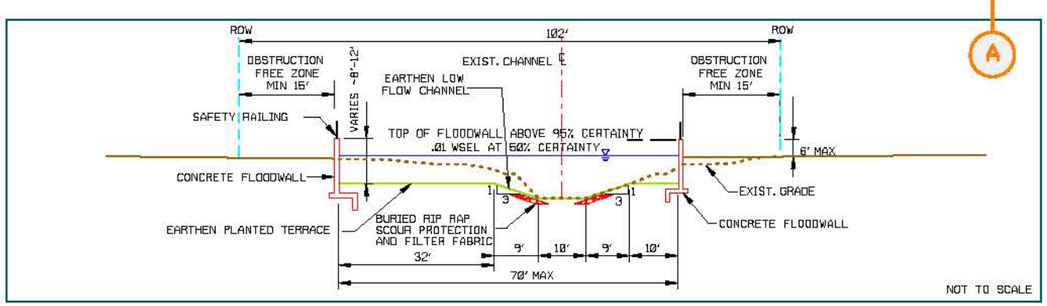


TYPICAL CROSS SECTION, AMES AVE TO MILPITAS BLVD (STA 182 TO 195)

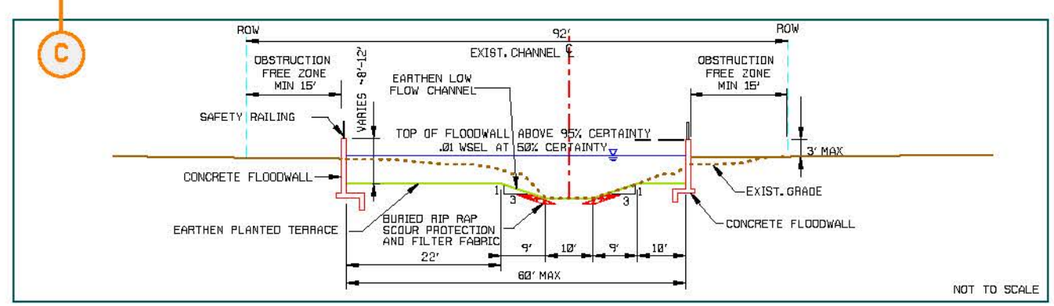


TYPICAL CROSS SECTION LAKEWOOD CT TO I-680 (STA 230 TO 248)





TYPICAL CROSS SECTION, CALAVERAS BLVD TO AMES AVE (STA 130 TO 182)



TYPICAL CROSS SECTION, MILPITAS BLVD TO LAKEWOOD CT (STA 195 TO 230)

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Submitted by: CHIEF, CIV ENGR DES SEC A
Date: JAN 17, 2012
Rev. N/A
Design file no: N/A
Drawing Code:
File name: BER PP D-XX
Plot date: DEC 22, 2011
Plot scale: 50:100

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17887 VON KARMAN AVE STE 500
IRVINE, CA 92614

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BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
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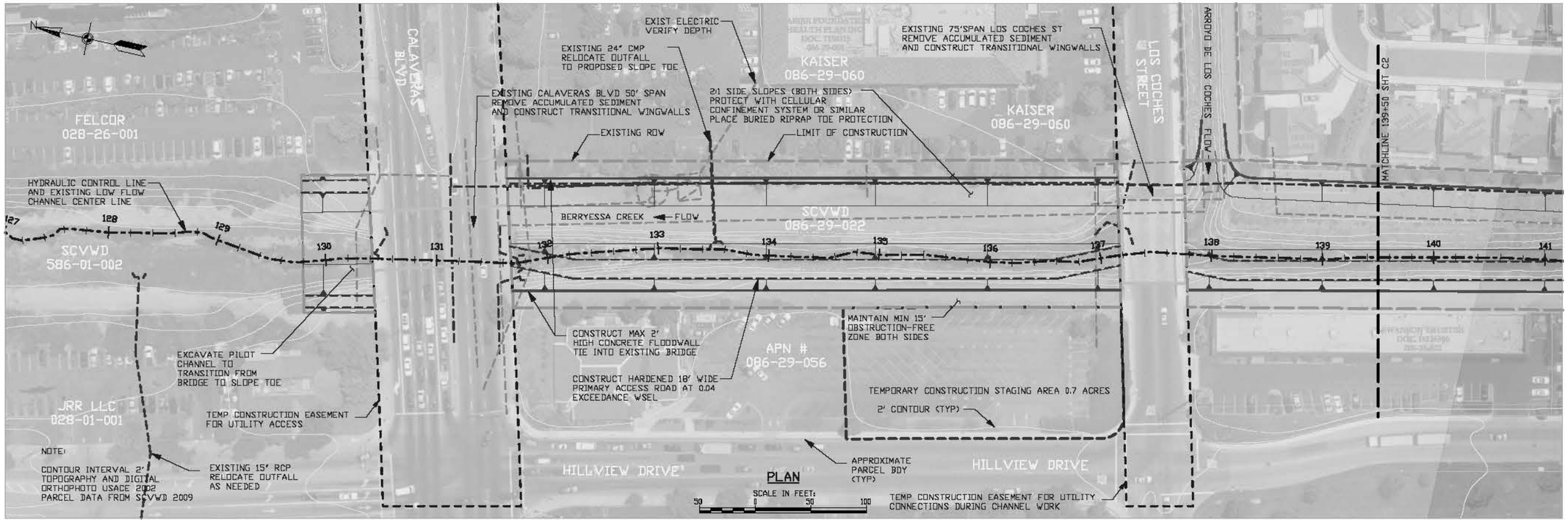

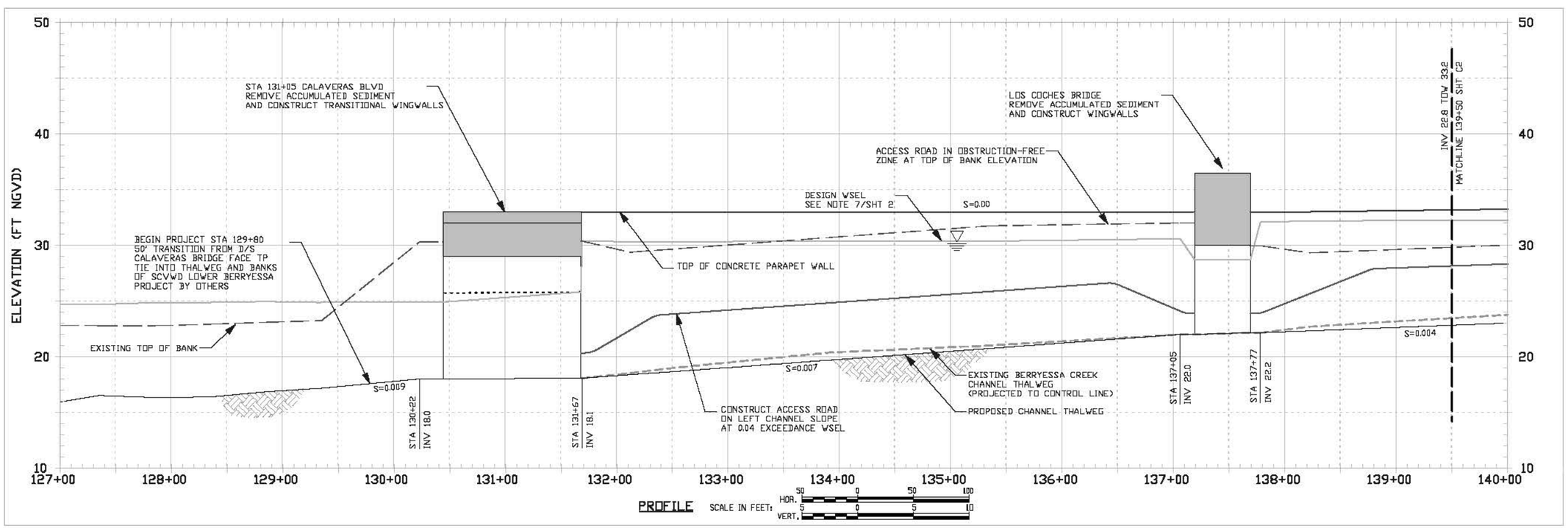

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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
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SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
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17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

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ALTERNATIVE 2A/d
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STA. 127+00 TO 140+00

Sheet reference number:
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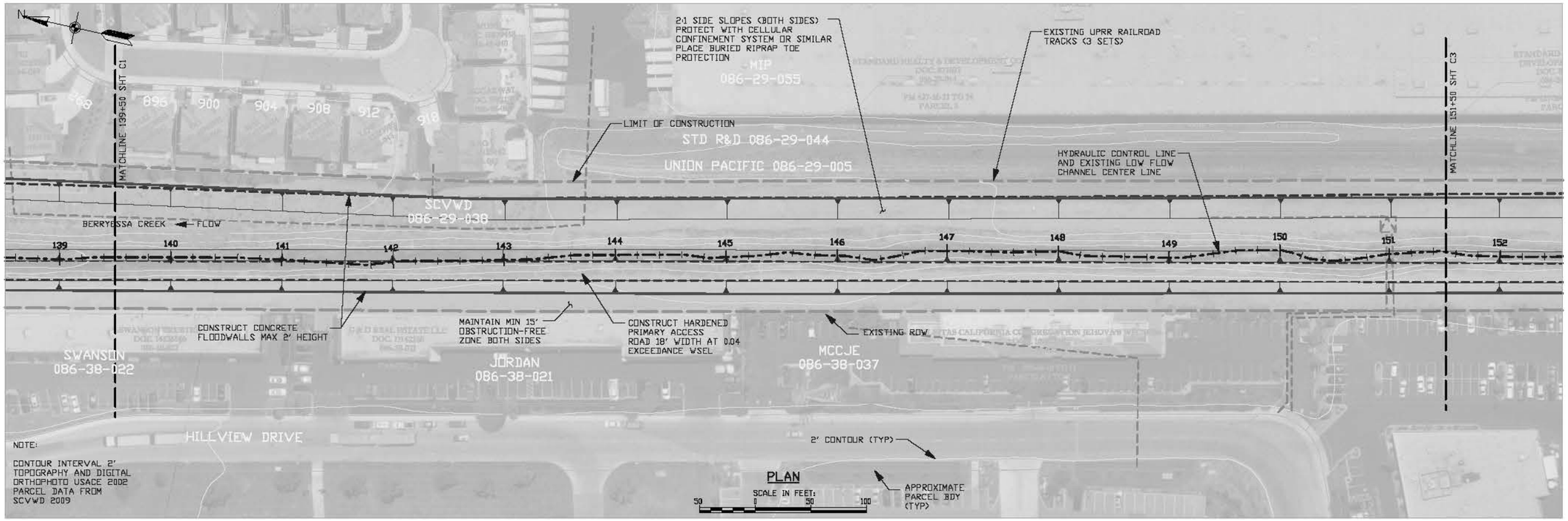

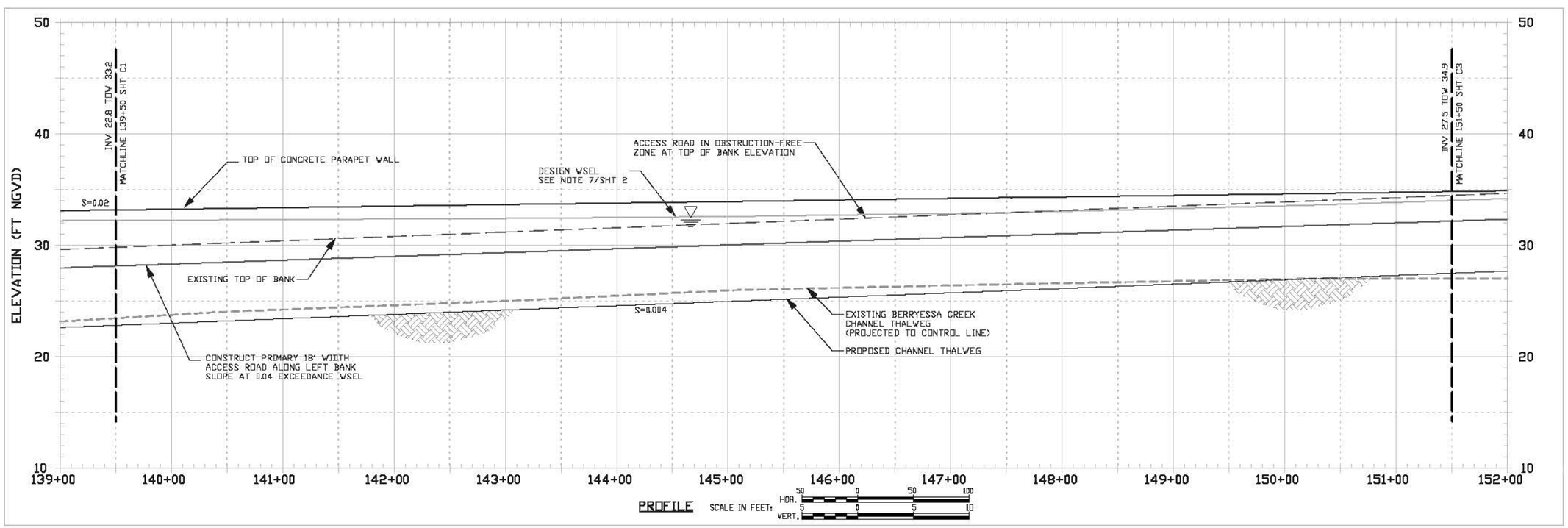

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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
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Sheet reference number:
C2
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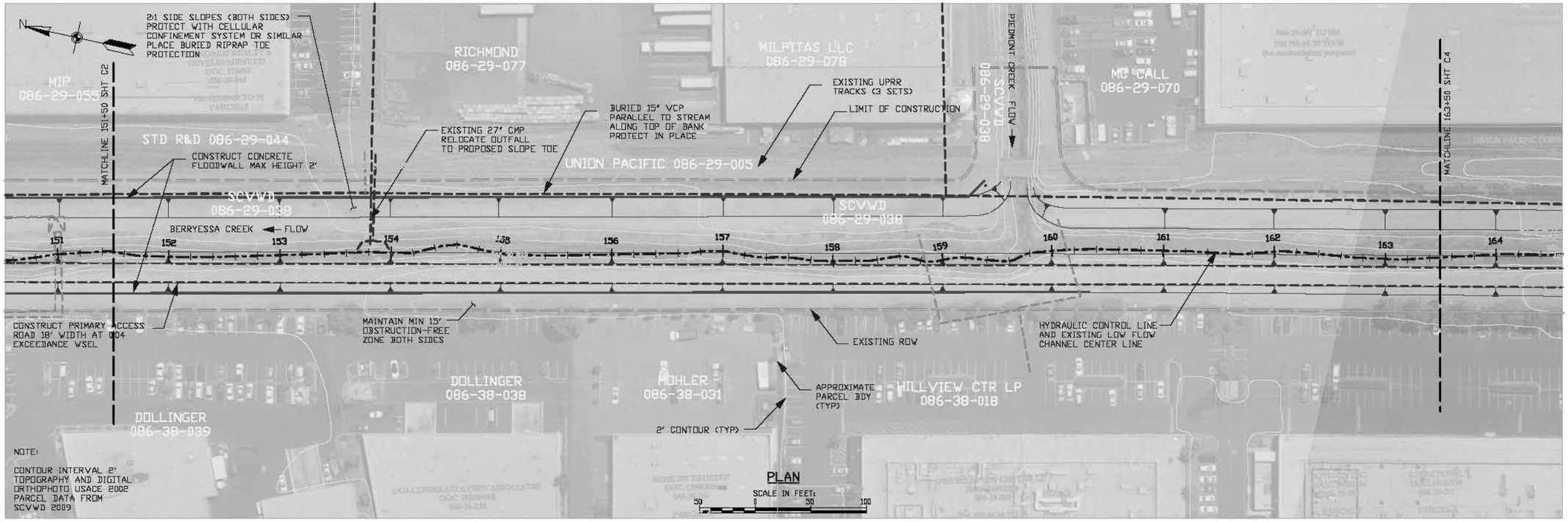

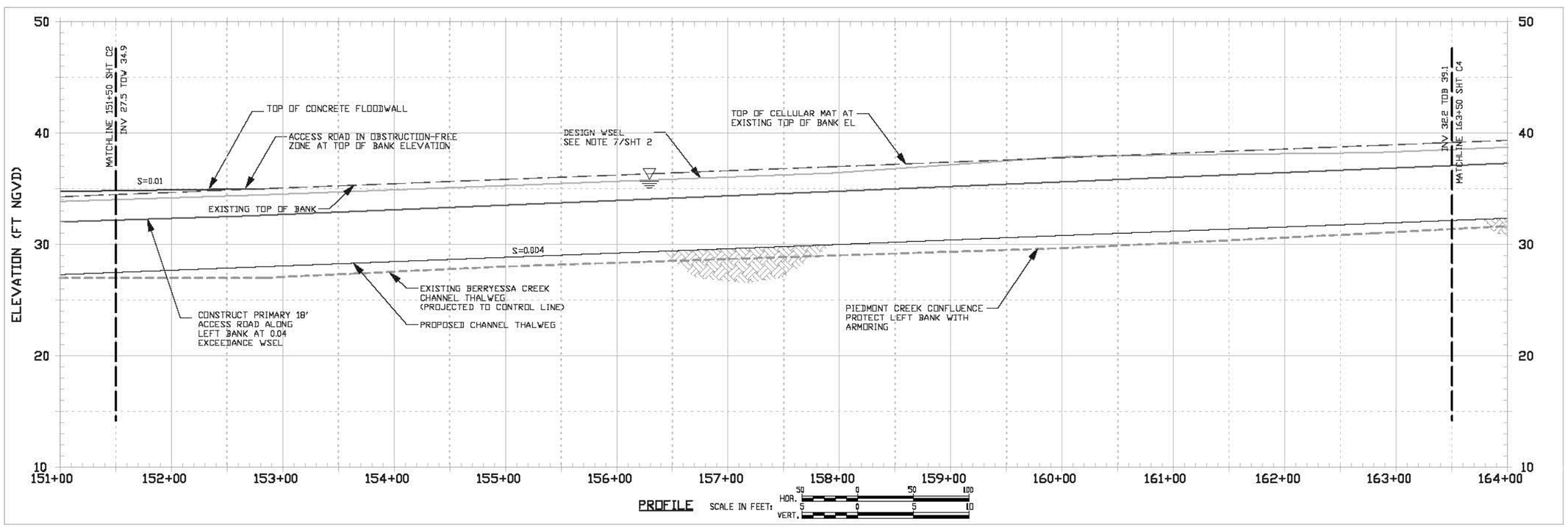

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U.S. ARMY CORPS OF ENGINEERS
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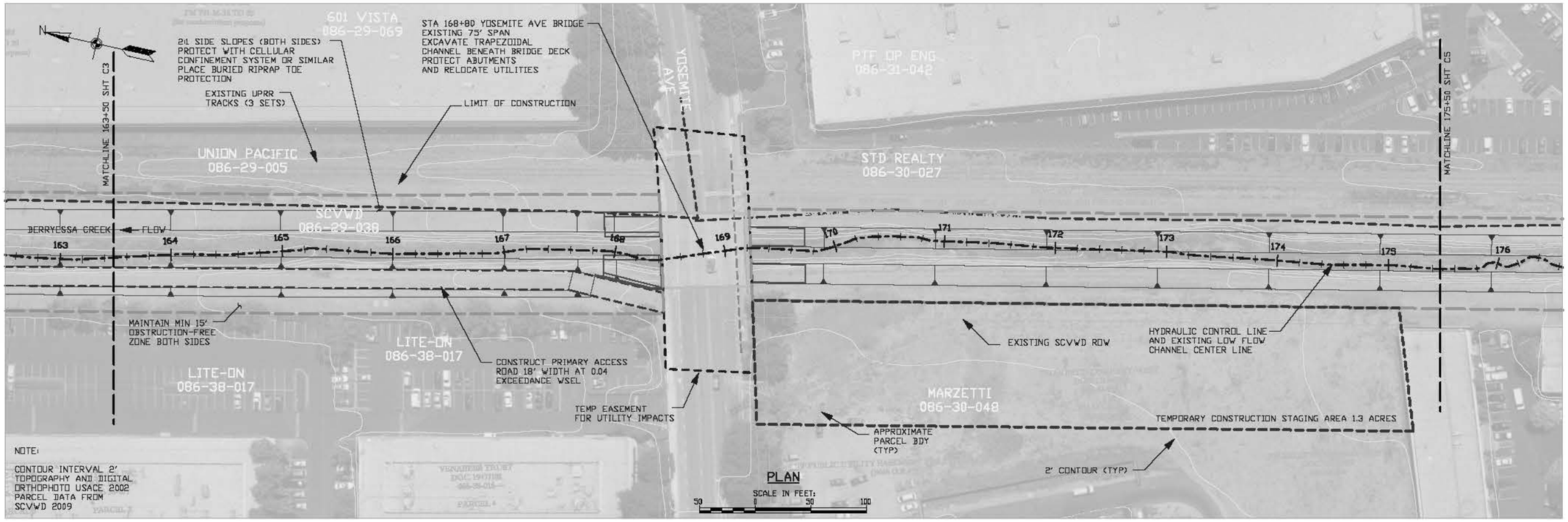
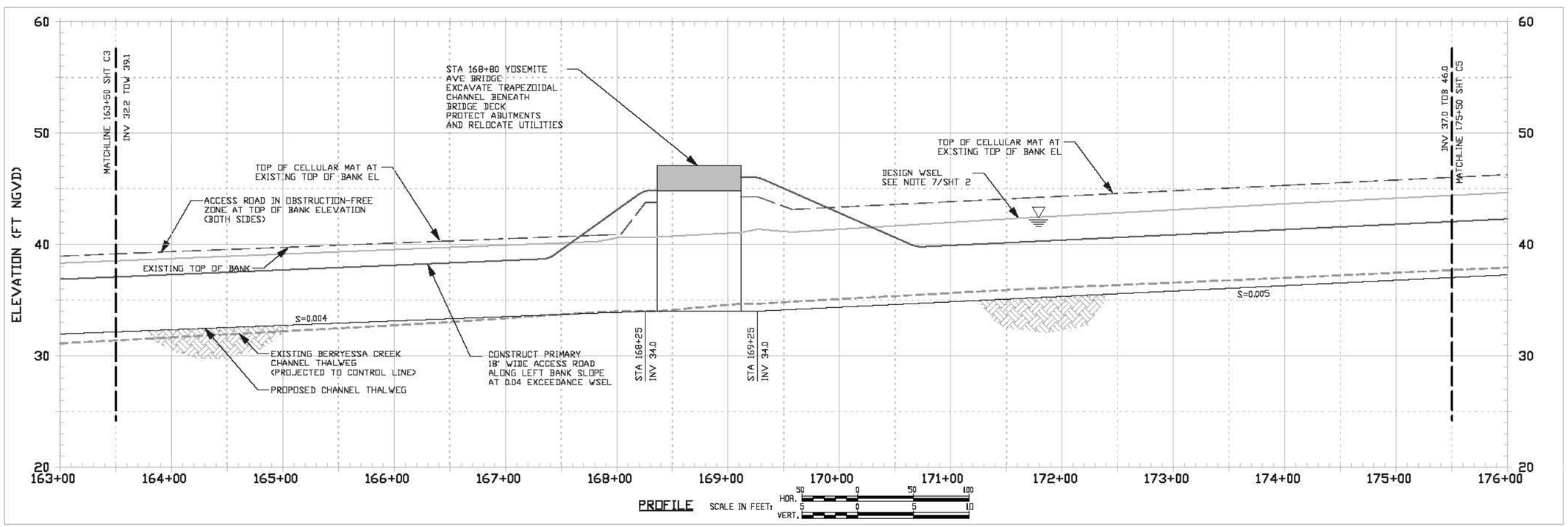
ALTERNATIVE 2A/d
PLAN AND PROFILE VIEW
STA. 151+00 TO 164+00

Sheet reference number:
C3
Sheet 8 of 35





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U.S. ARMY CORPS OF ENGINEERS
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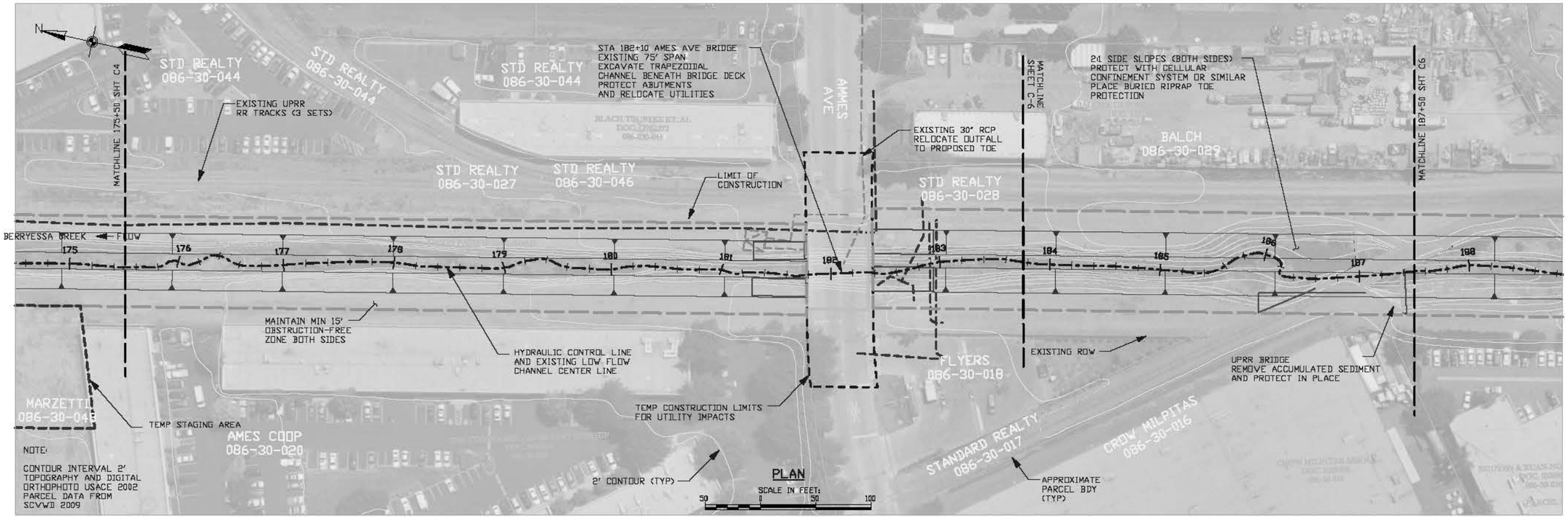

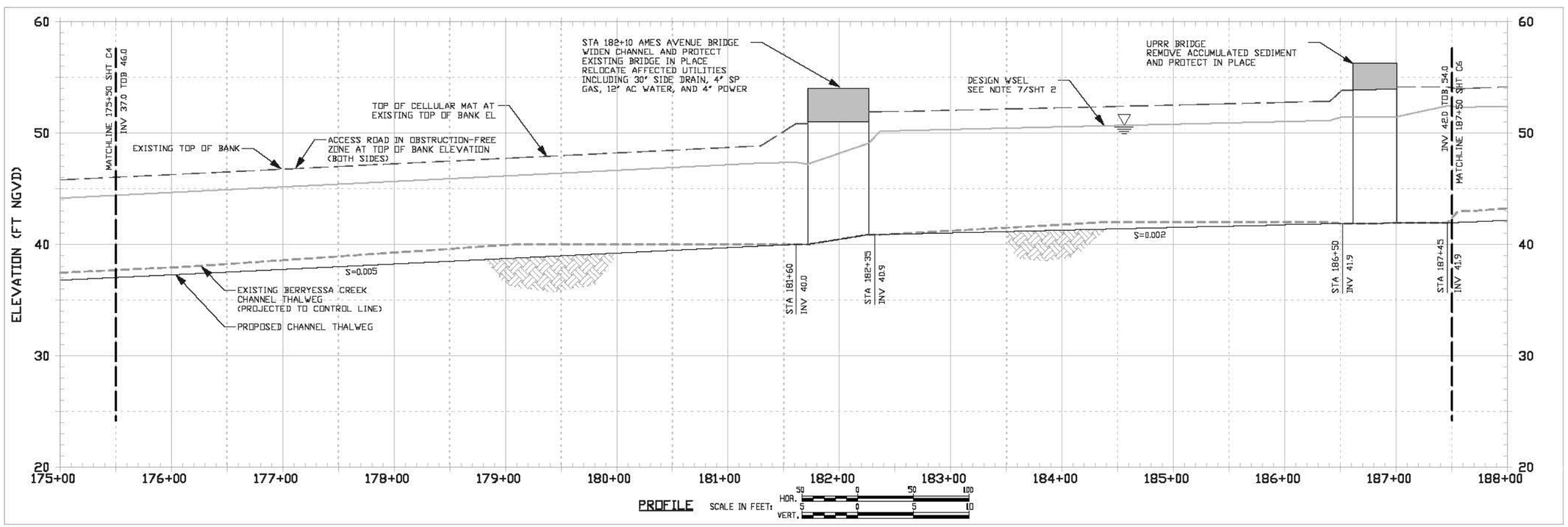

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U.S. ARMY CORPS OF ENGINEERS
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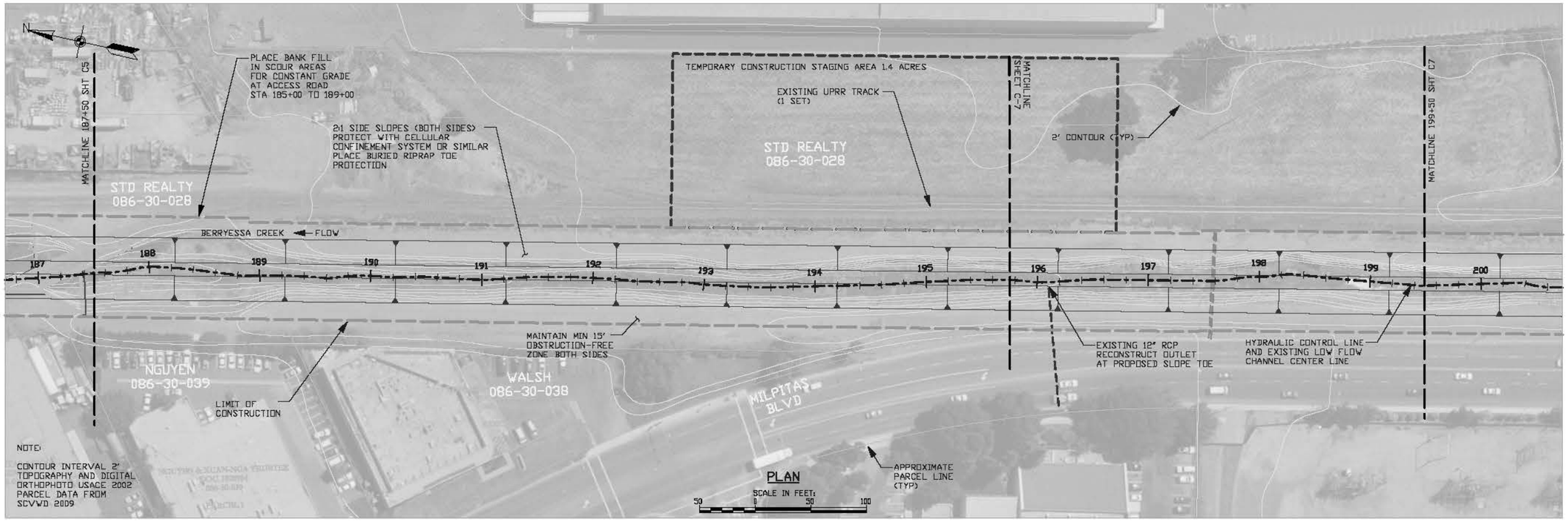
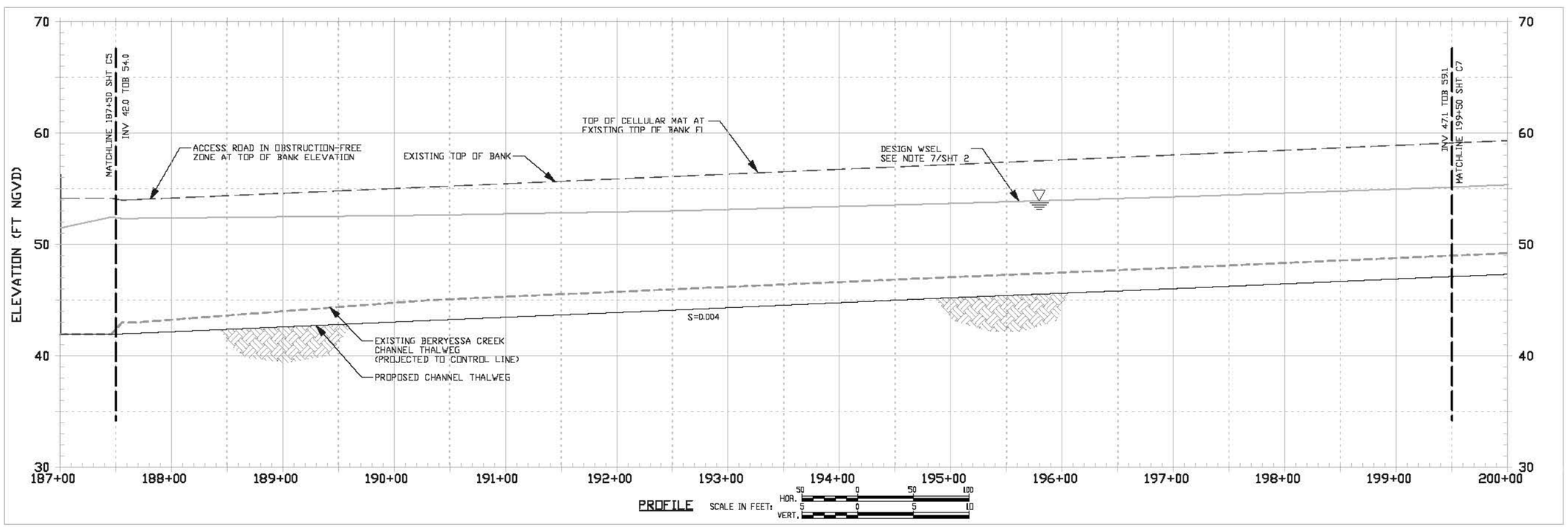
STA. 175+00 TO 188+00

Sheet reference number:
C5
Sheet 10 of 35





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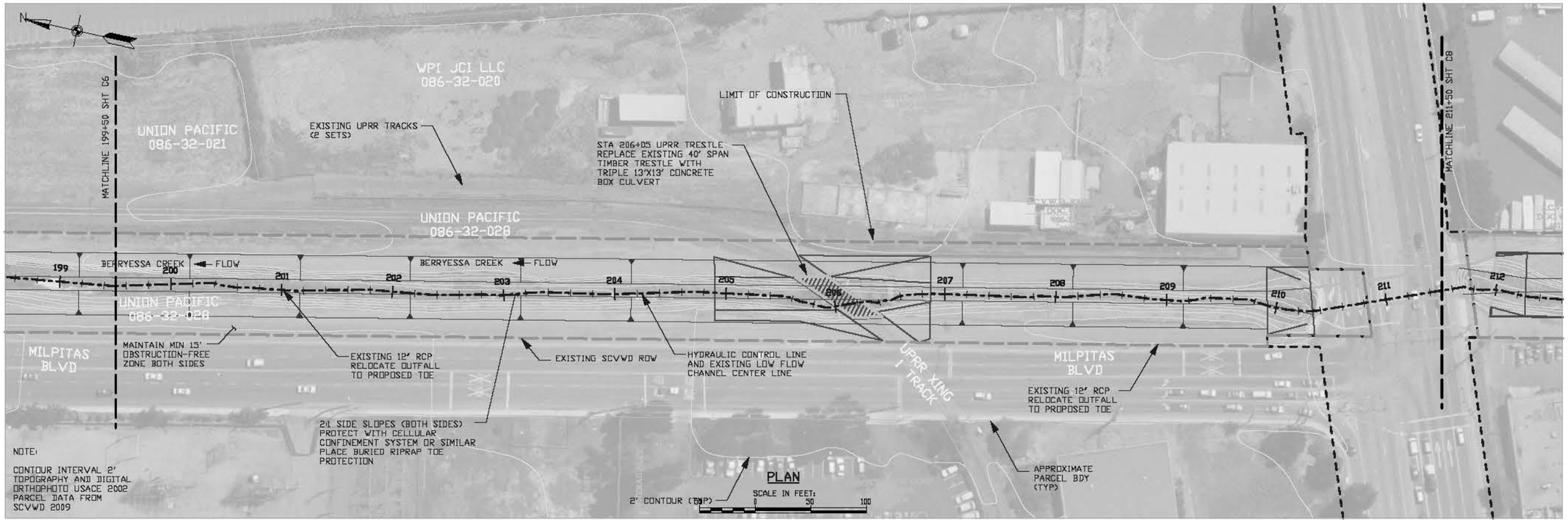
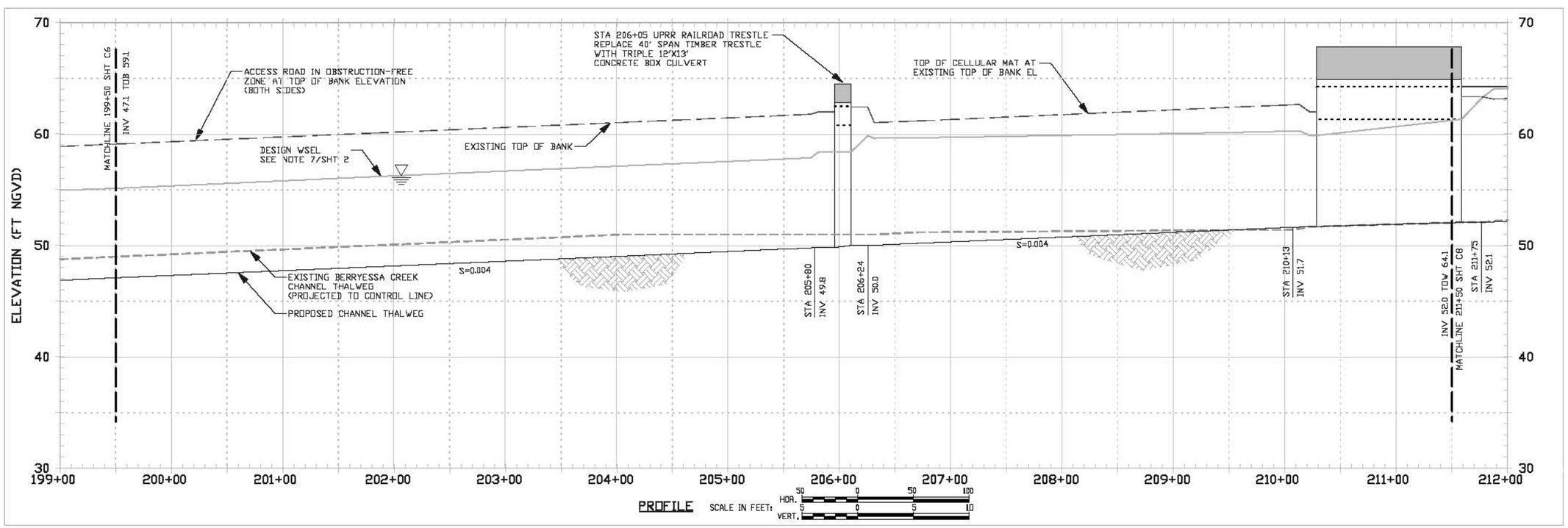
STA. 184+00 TO 197+00

Sheet reference number:
C6
Sheet 11 of 35





DRAFT DESIGN - FOR PLANNING PURPOSES ONLY

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date Approved

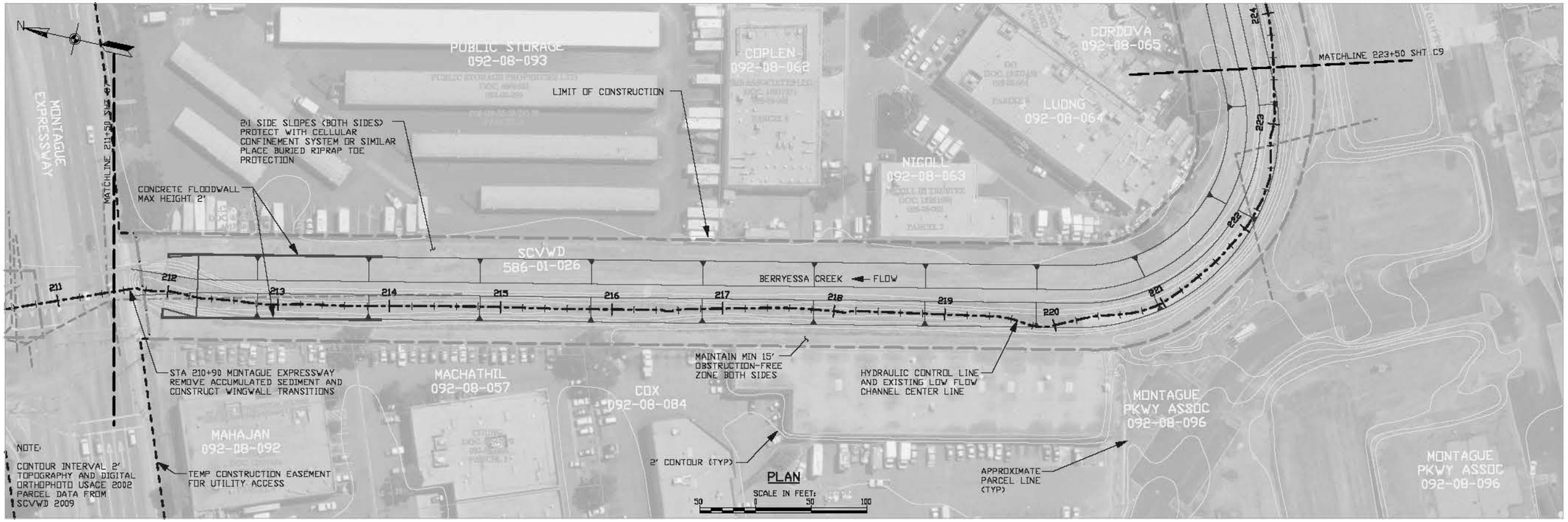
Designed by: PRELIMINARY
Dwn by: KP
Reviewed by: RM
Submitted by: CHIEF, CIV ENGR DES SEC A
Date: JAN 17, 2012
Rev. N/A
Design file no: N/A
Drawing Code:
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

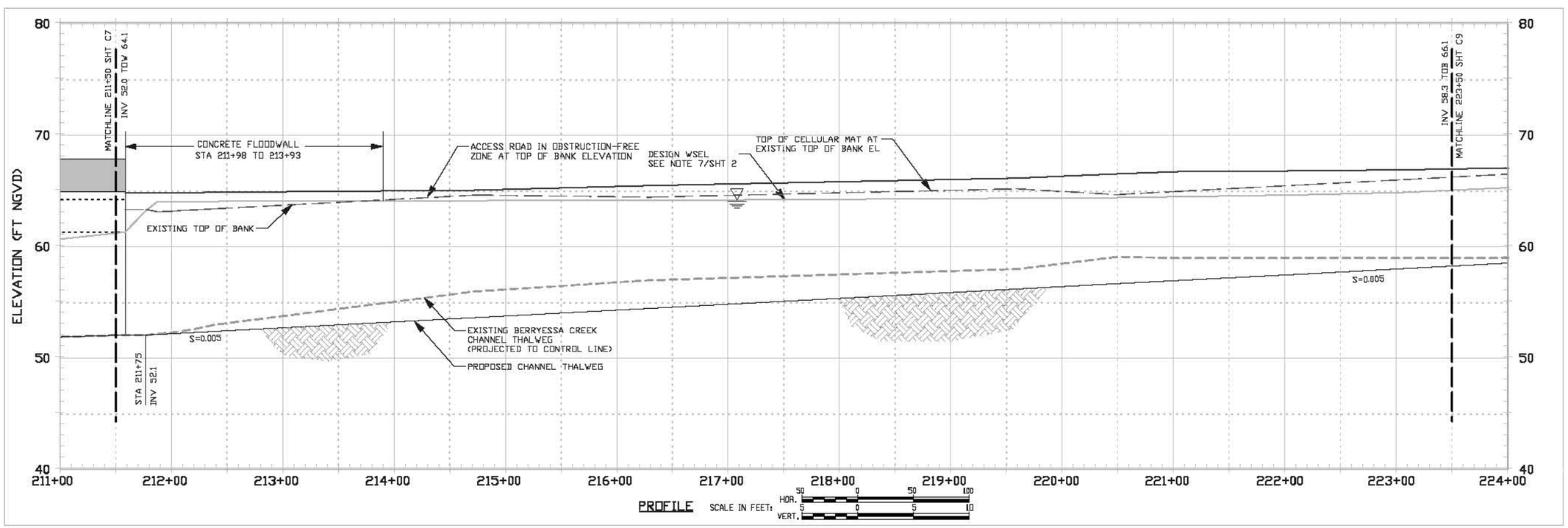
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 2A/d
PLAN AND PROFILE VIEW
STA. 199+00 TO 212+00

Sheet reference number:
C7
Sheet 12 of 35





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Sacramento District

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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
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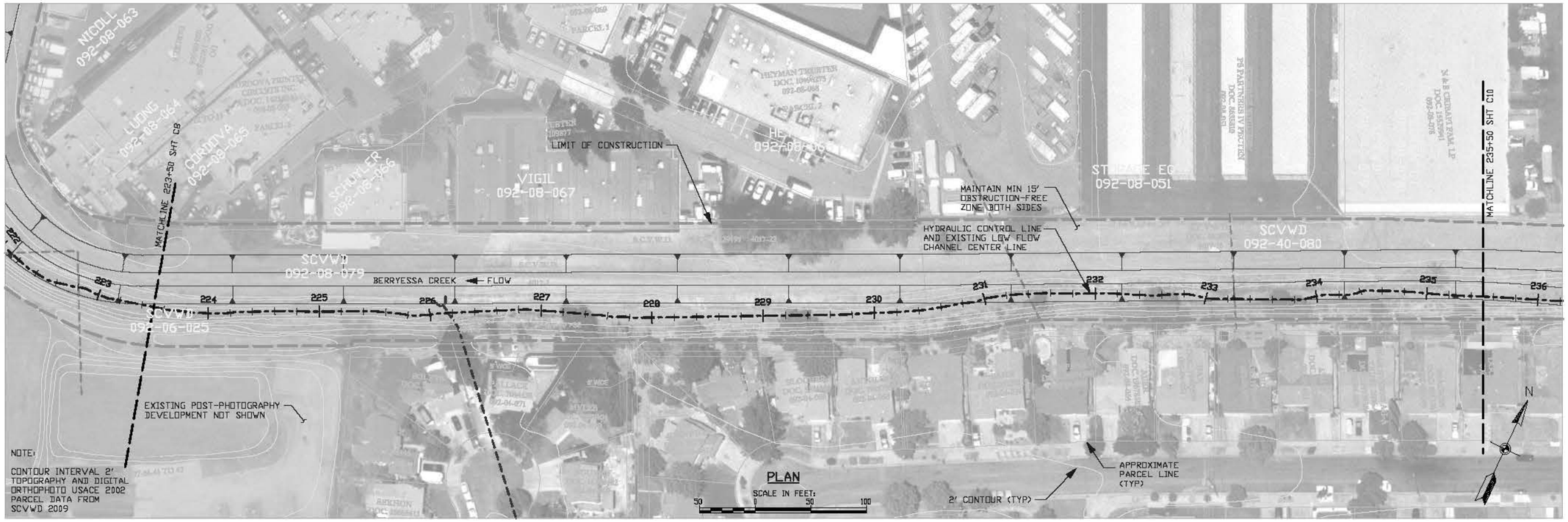
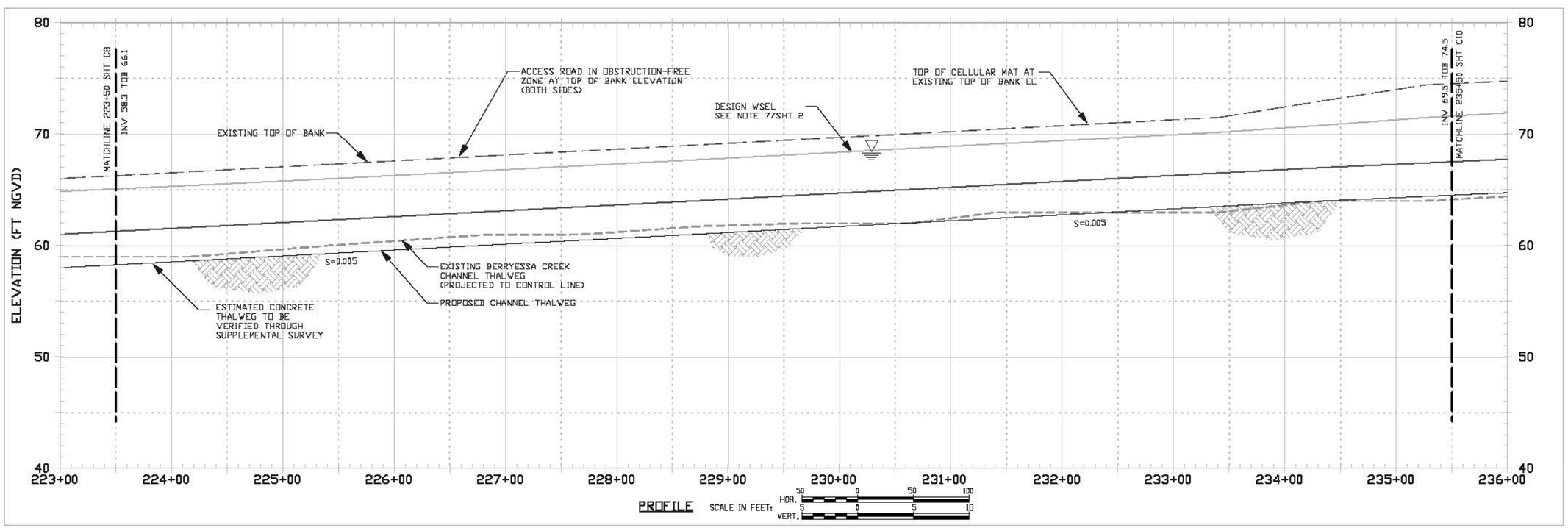
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2A/d
PLAN AND PROFILE VIEW
STA. 211+00 TO 224+00

Sheet reference number:
C8
Sheet 13 of 35





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Sacramento District

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Plot date: DEC 22, 2011
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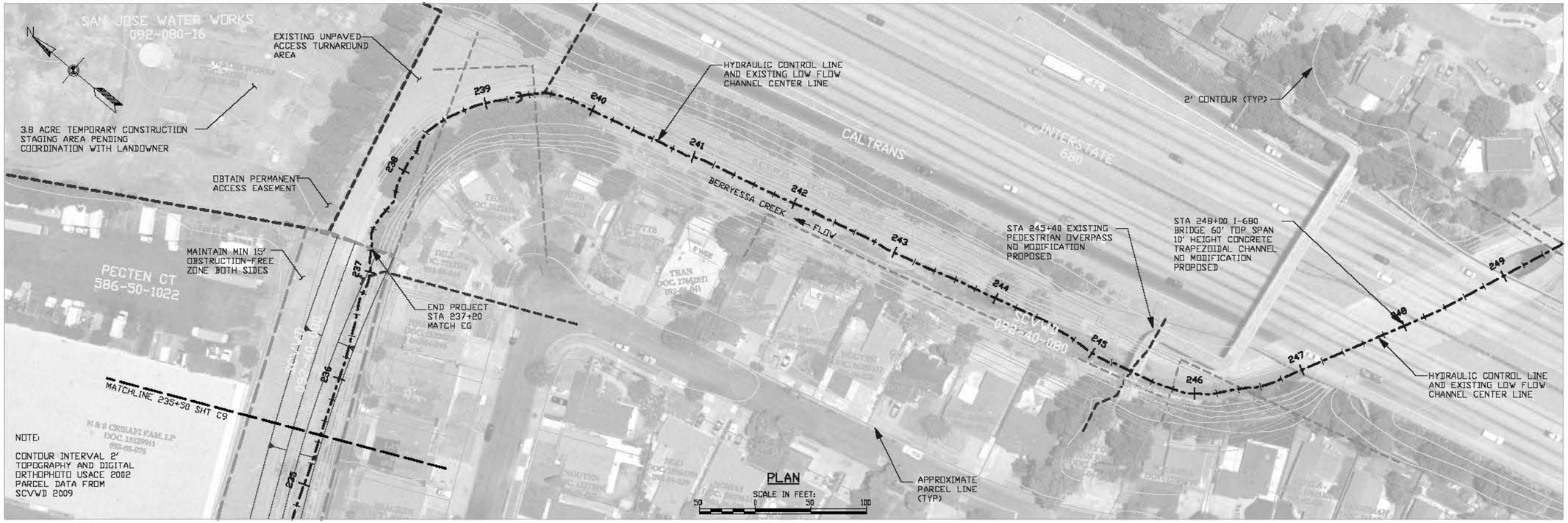
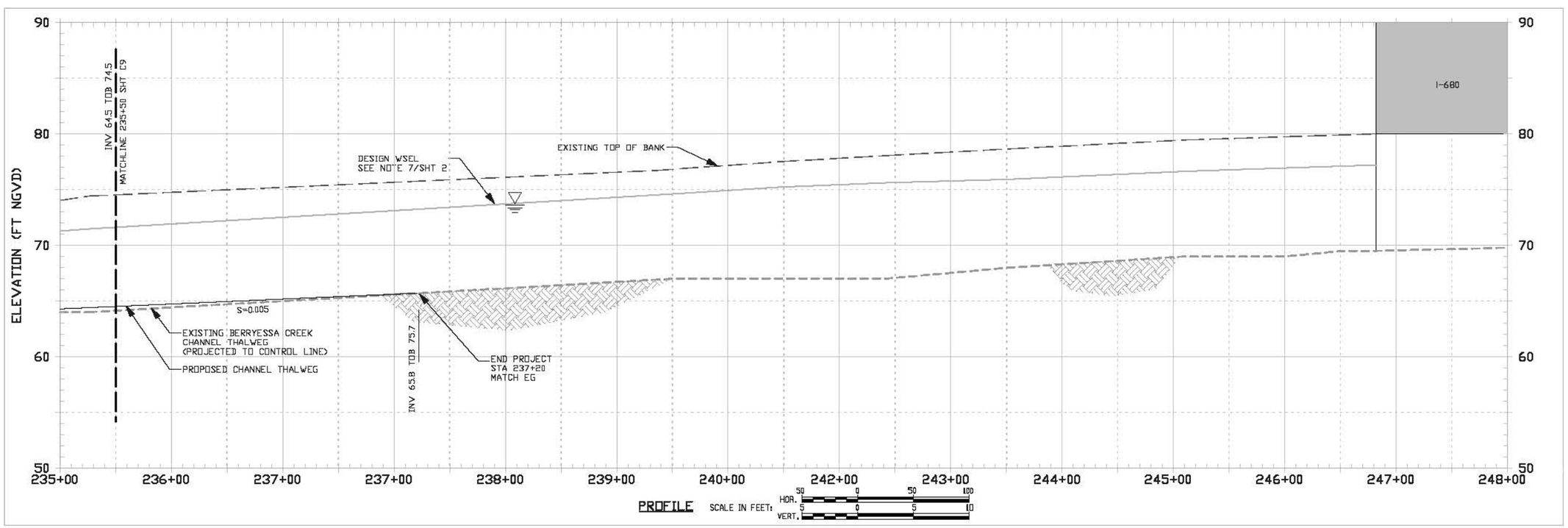
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 2A/d
PLAN AND PROFILE VIEW
STA. 220+00 TO 233+00

Sheet reference number:
C9
Sheet 14 of 35





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Sacramento District

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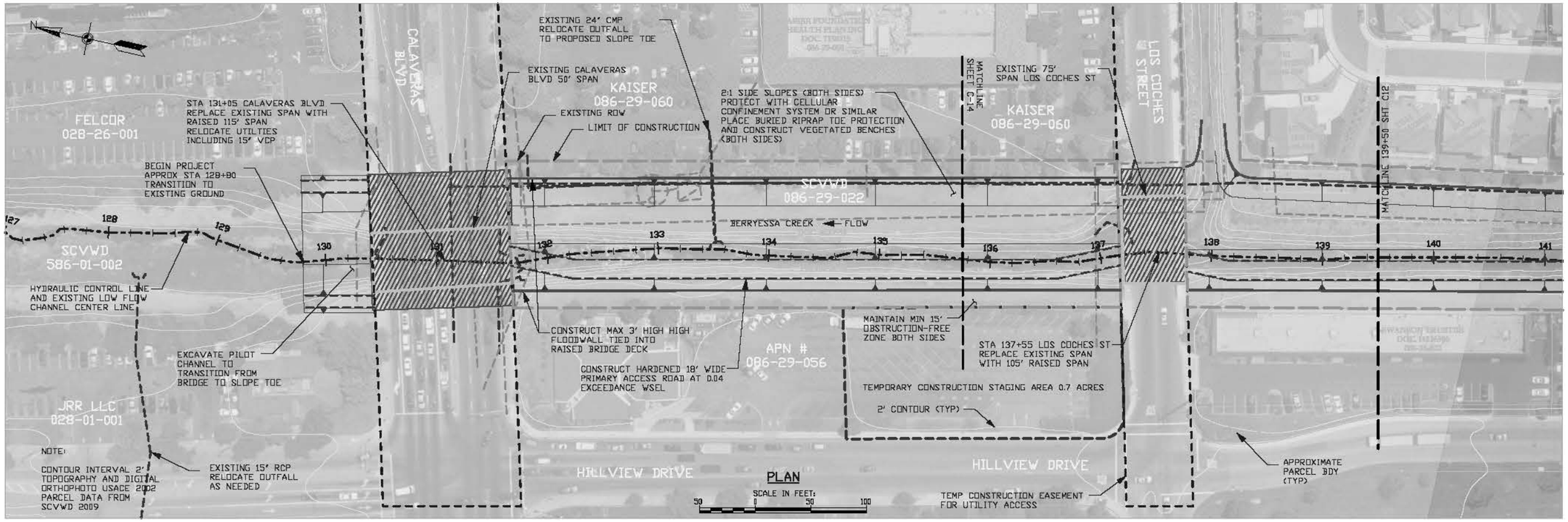
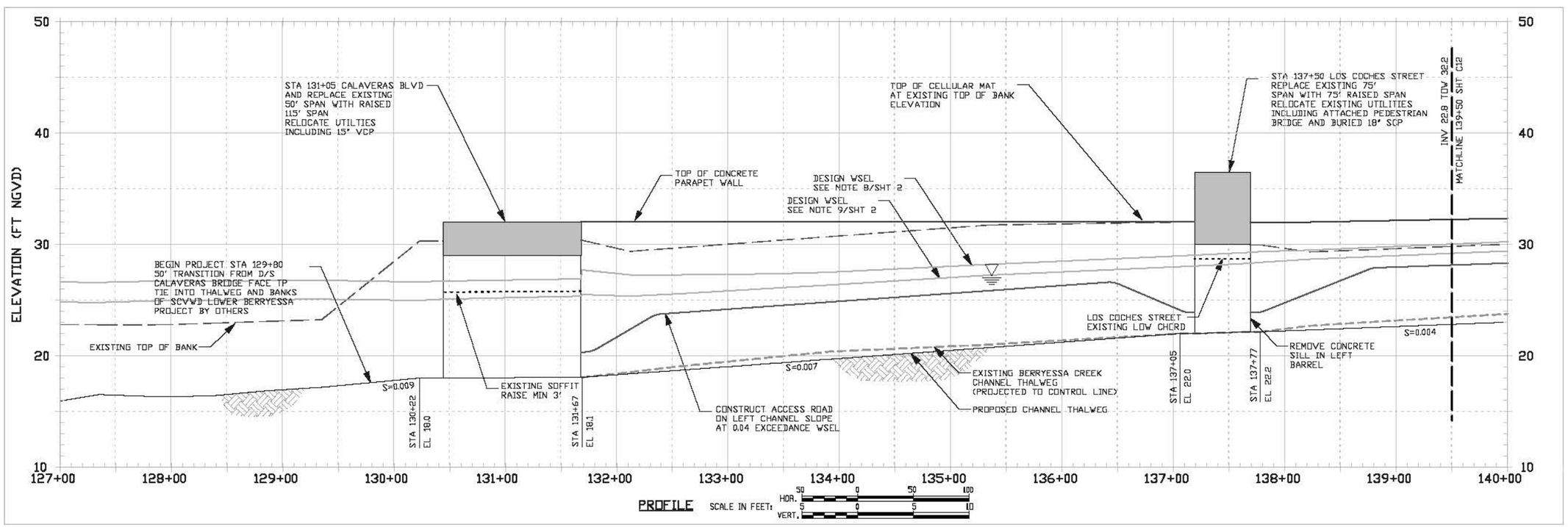
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

CALIFORNIA
SANTA CLARA COUNTY
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 2A/d
PLAN AND PROFILE VIEW
STA. 235+00 TO 248+00

Sheet reference number:
C10
Sheet 15 of 35





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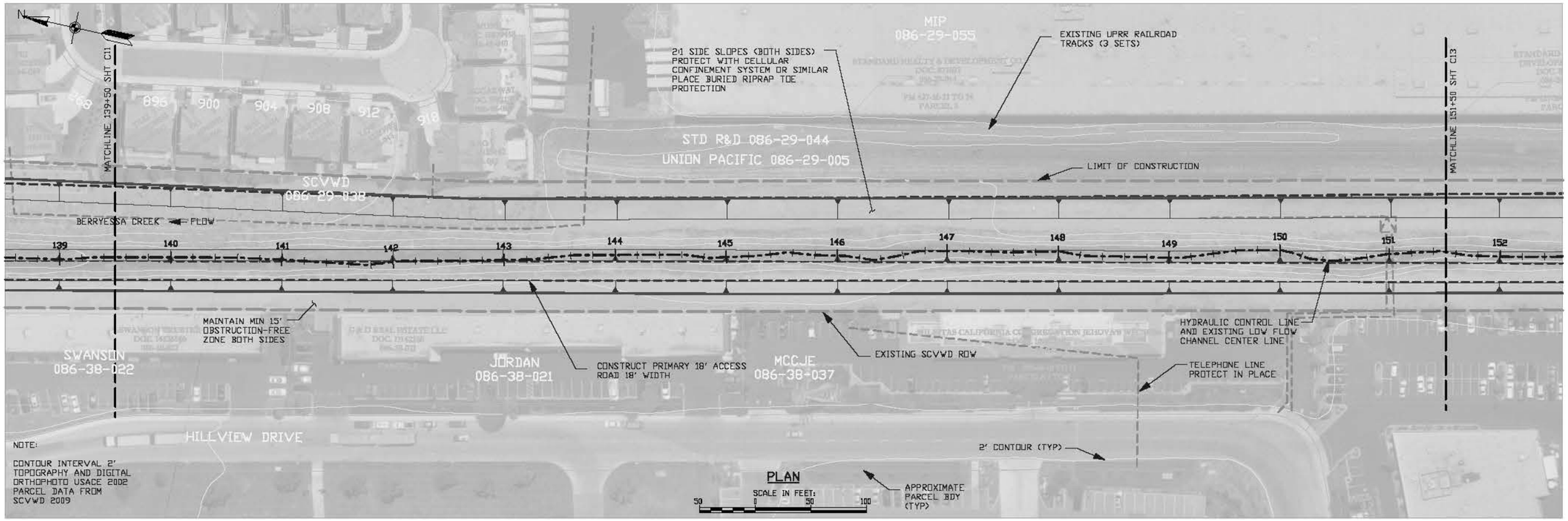
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

CALIFORNIA
SANTA CLARA COUNTY
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 127+00 TO 140+00

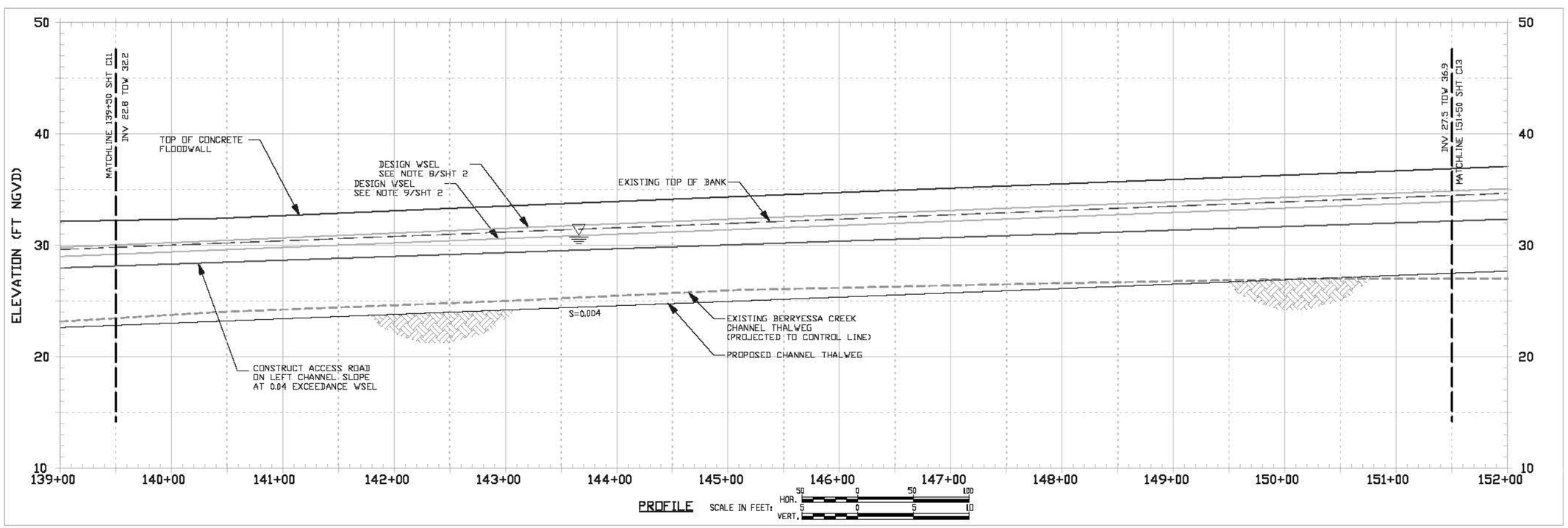
Sheet reference number:
C11
Sheet 16 of 35



NOTE:

CONTOUR INTERVAL 2'
TOPOGRAPHY AND DIGITAL ORTHOPHOTO USACE 2002
PARCEL DATA FROM SCVWD 2009

PLAN



PROFILE SCALE IN FEET:

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US Army Corps of Engineers
Sacramento District

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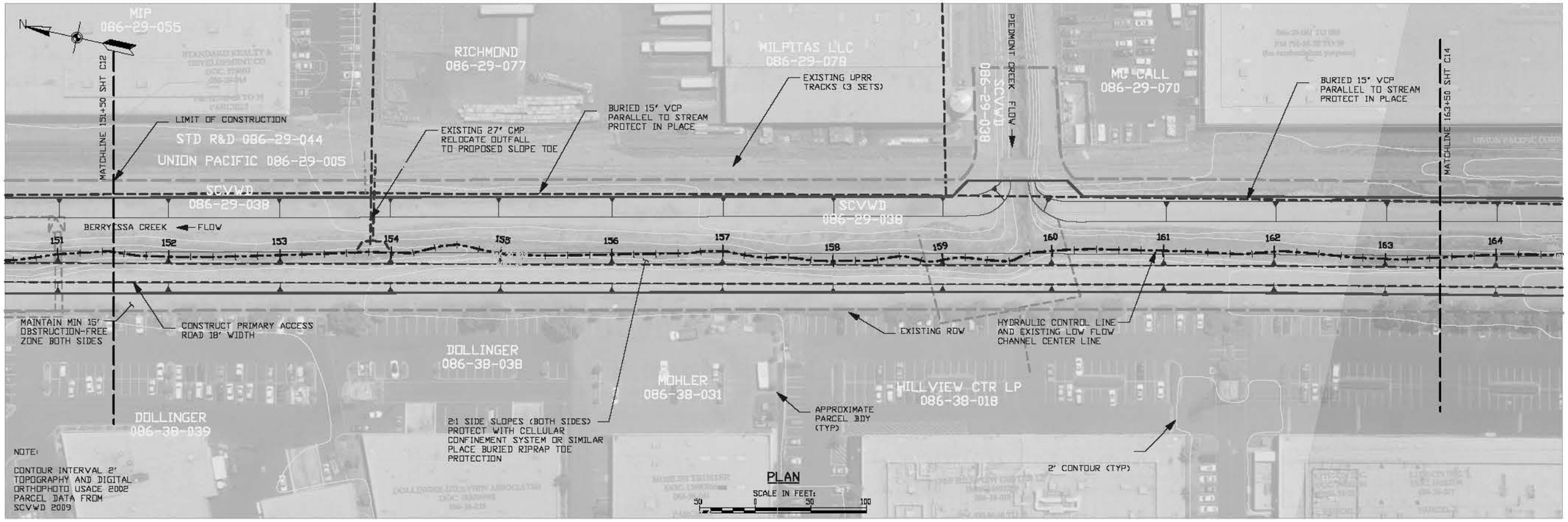
Plot scale: 50/100

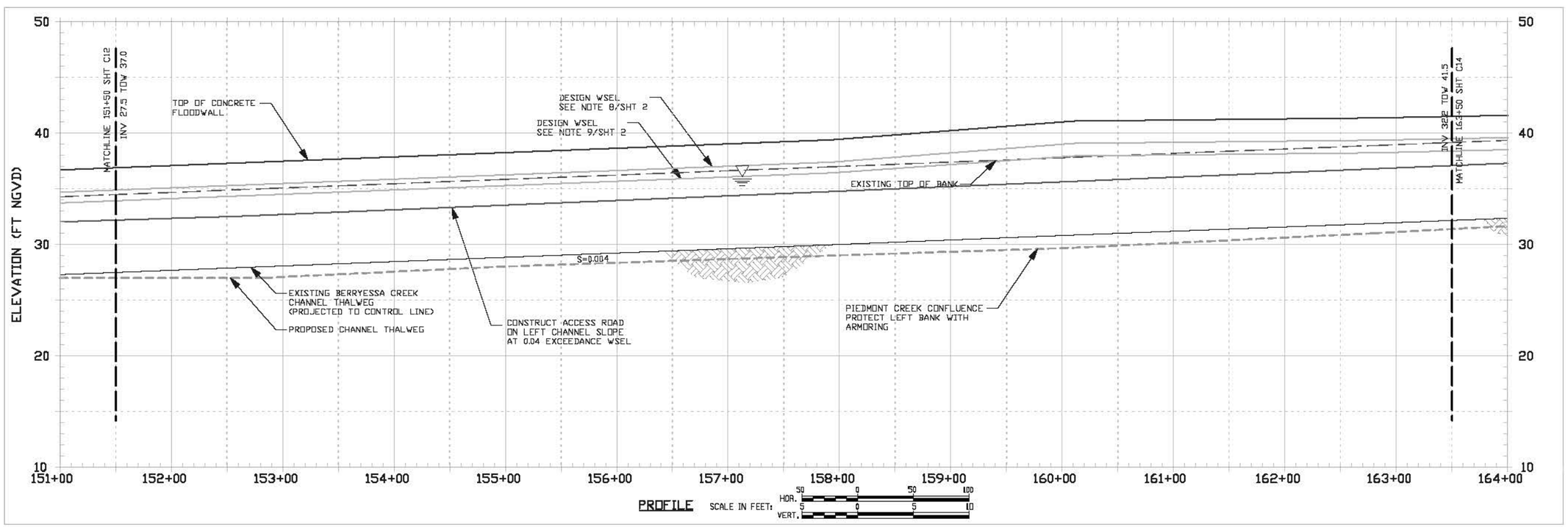
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 139+00 TO 152+00

Sheet reference number:
C12
Sheet 17 of 35





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Plot date: DEC 22, 2011
Plot scale: 50/100

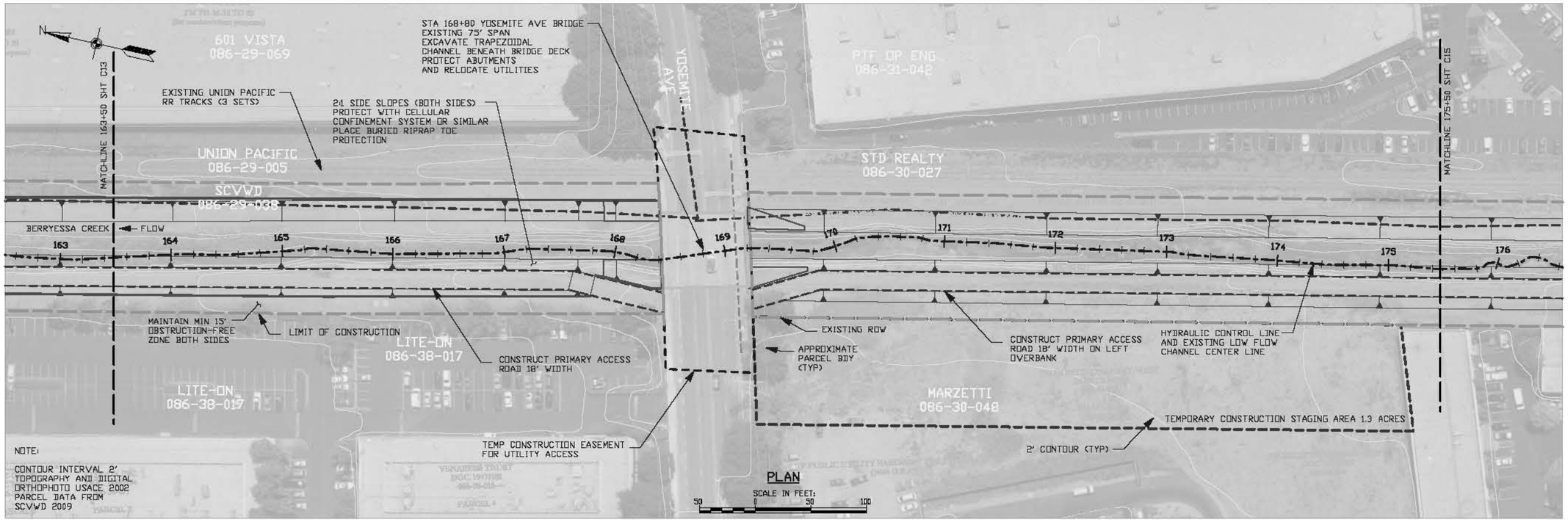
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

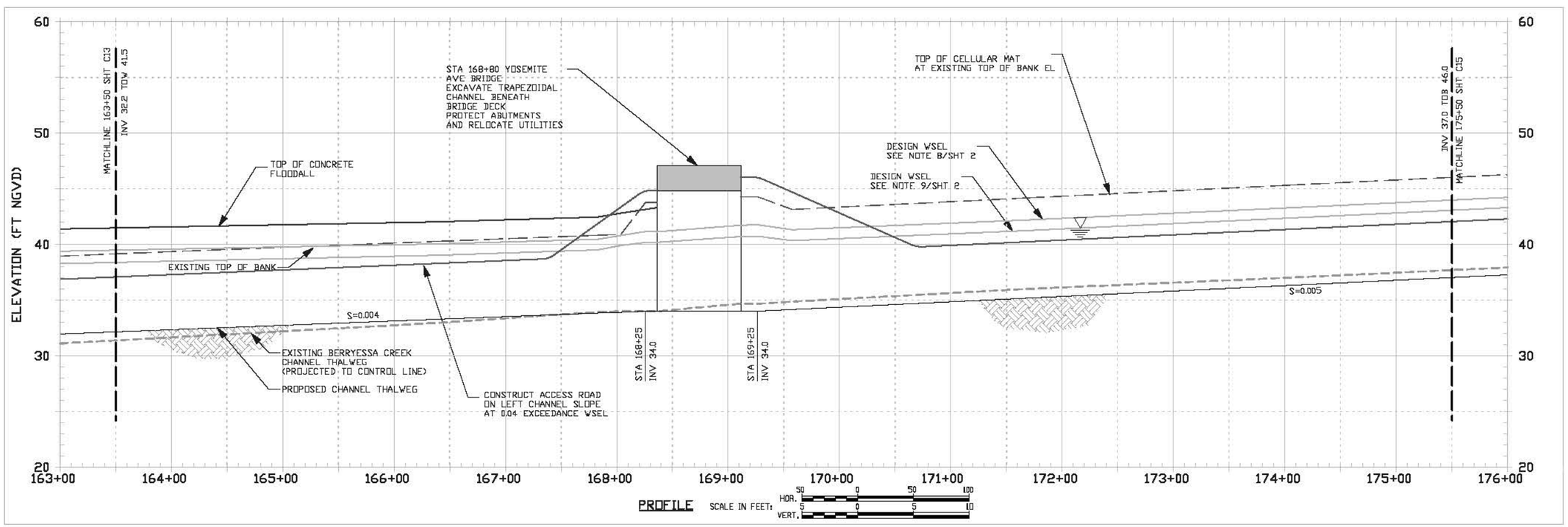
PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 151+00 TO 164+00

Sheet reference number:
C13
Sheet 18 of 35





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US Army Corps of Engineers
Sacramento District

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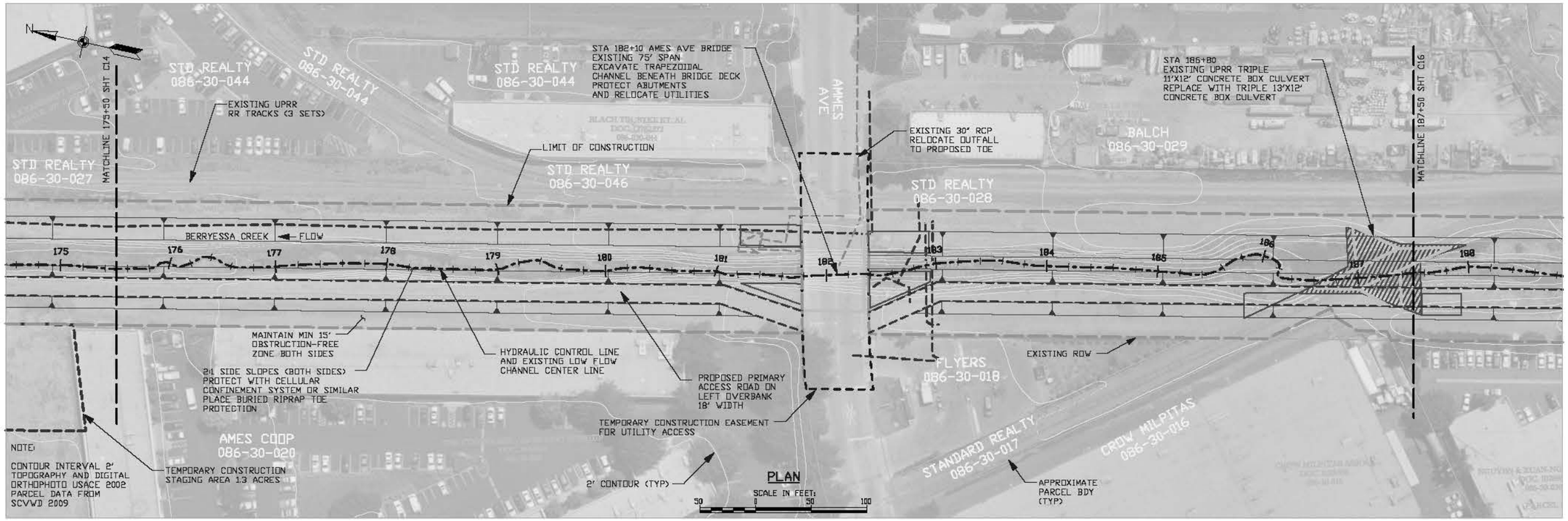
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

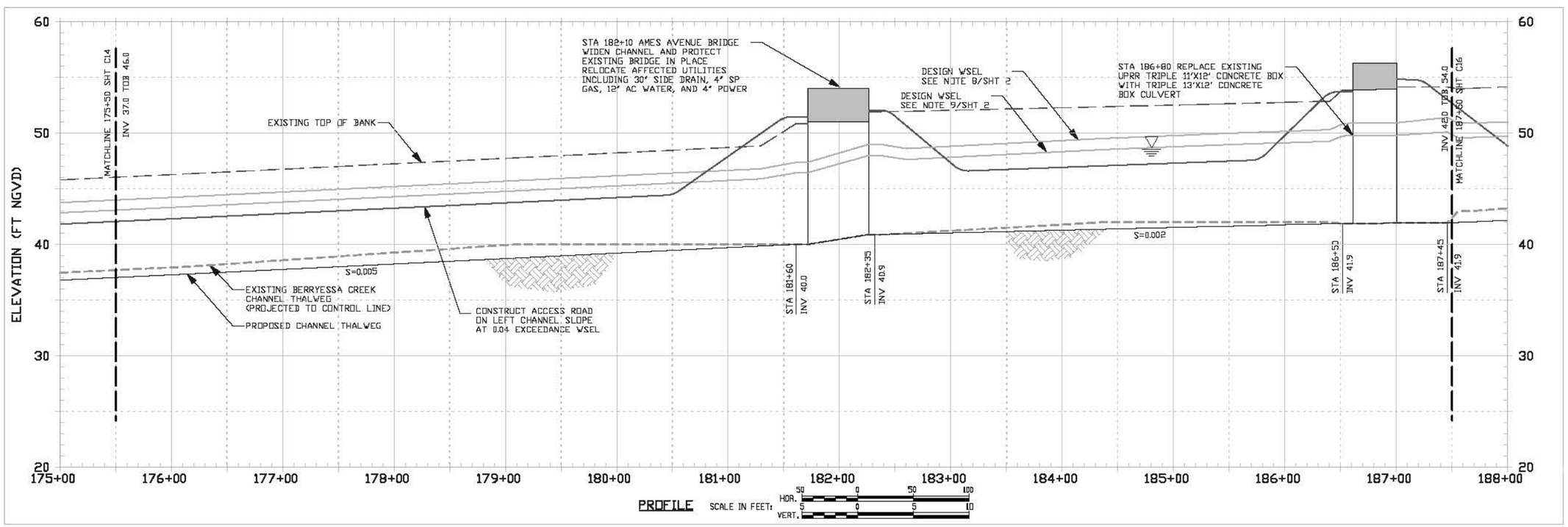
PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 163+00 TO 176+00

Sheet reference number:
C14
Sheet 19 of 35





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US Army Corps of Engineers
Sacramento District

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Designed by: PRELIMINARY
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Scale No.: N/A
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CHIEF, CIV ENGR DES SEC A
Date: JAN 17, 2012
Rev. N/A
Design file no: N/A
Drawing Code:
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

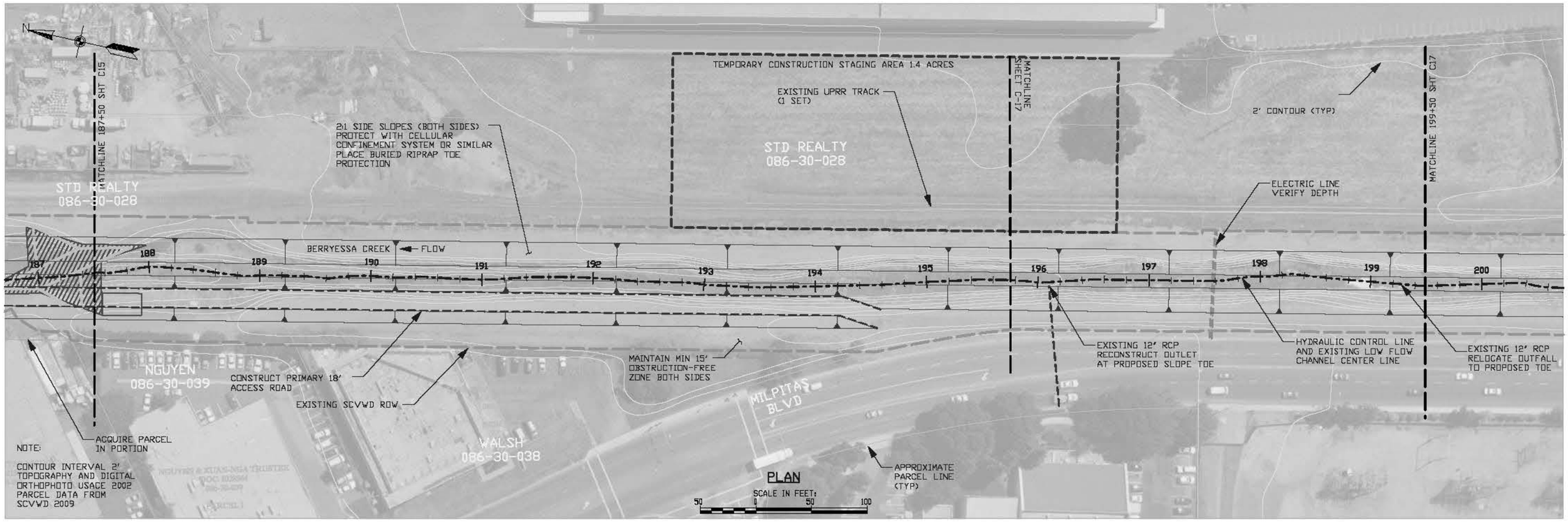
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

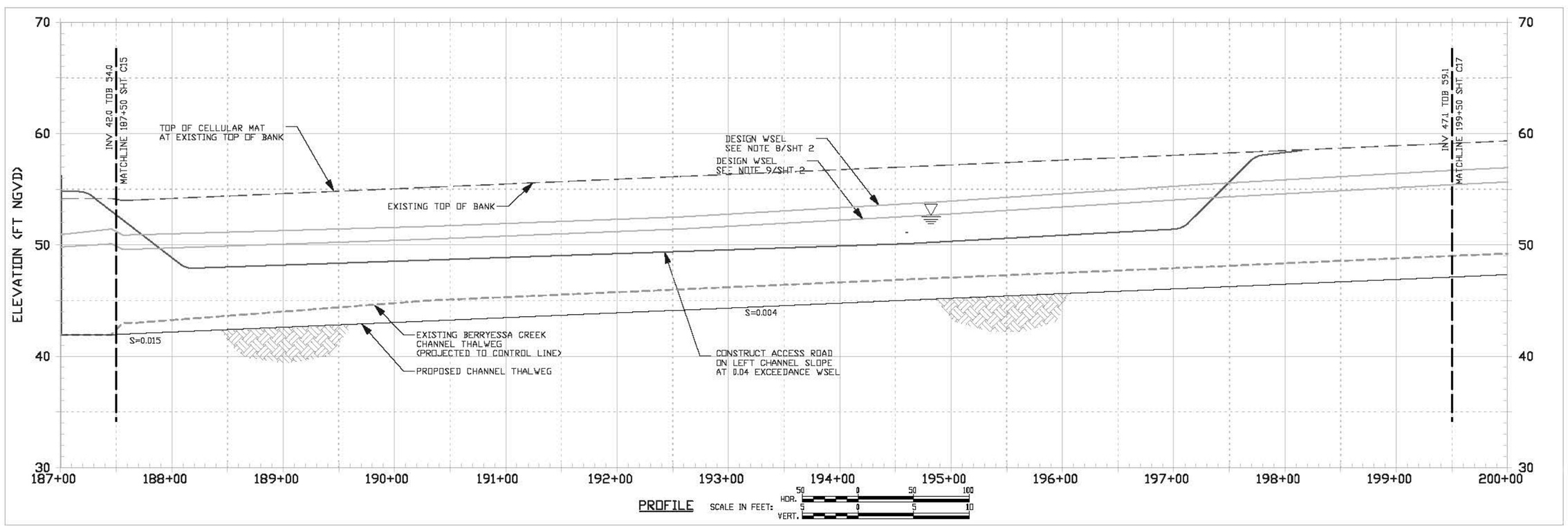
PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 175+00 TO 188+00

Sheet reference number:
C15
Sheet 20 of 35





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US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Designed by: PRELIMINARY	Date: JAN 17, 2012
Dwn by: KP	Scale No.: N/A
Reviewed by: RM	Design file no: N/A
Submitted by: CHIEF, CIV ENGR DES SEC A	Drawing Code:
	File name: BER PP C-3X
	Plot date: DEC 22, 2011
	Plot scale: 40/100
	Rev: N/A

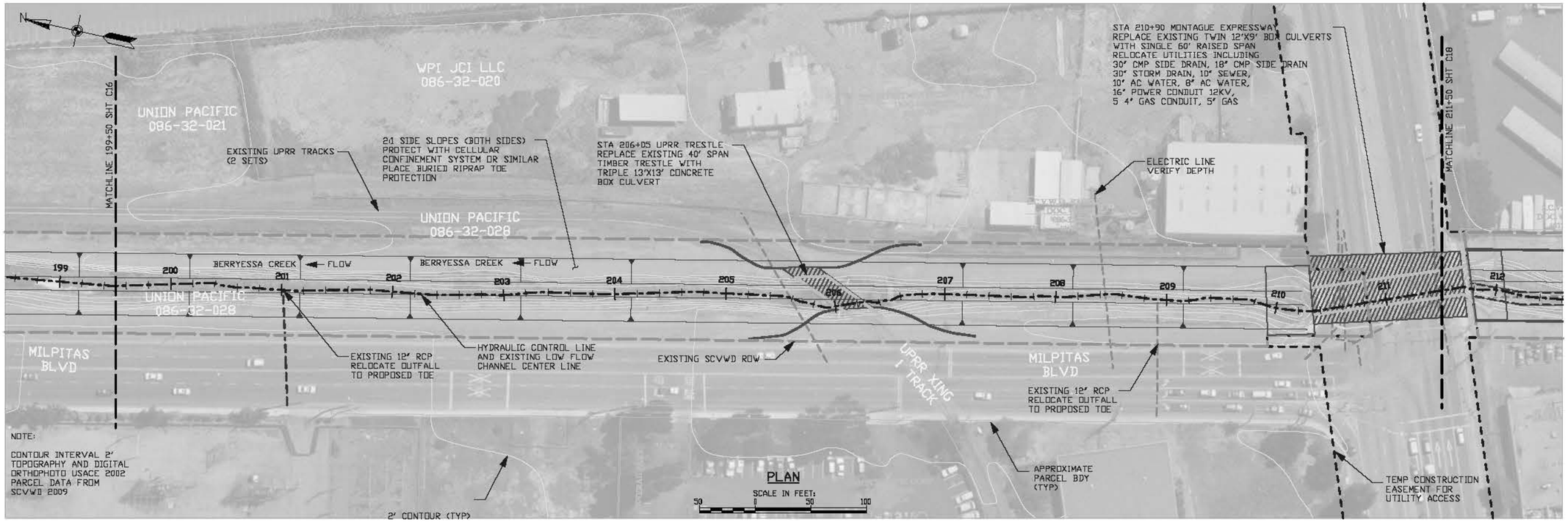
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

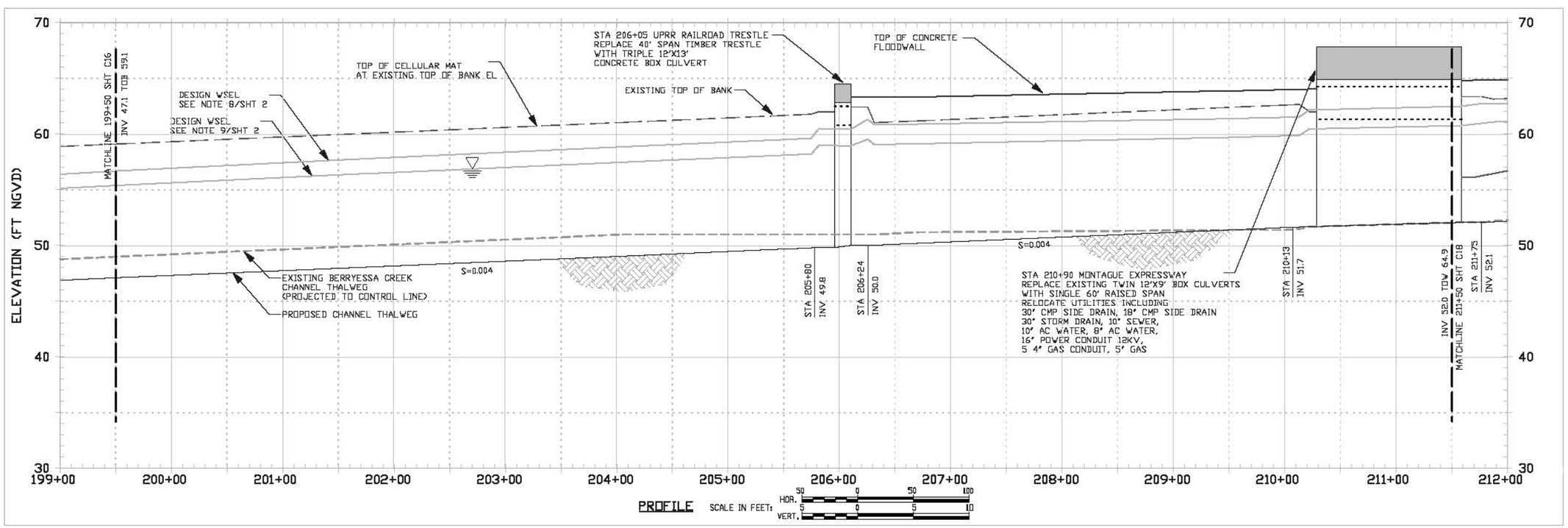
PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 187+00 TO 200+00

Sheet reference number:
C16
Sheet 21 of 35





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Sacramento District

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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
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TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

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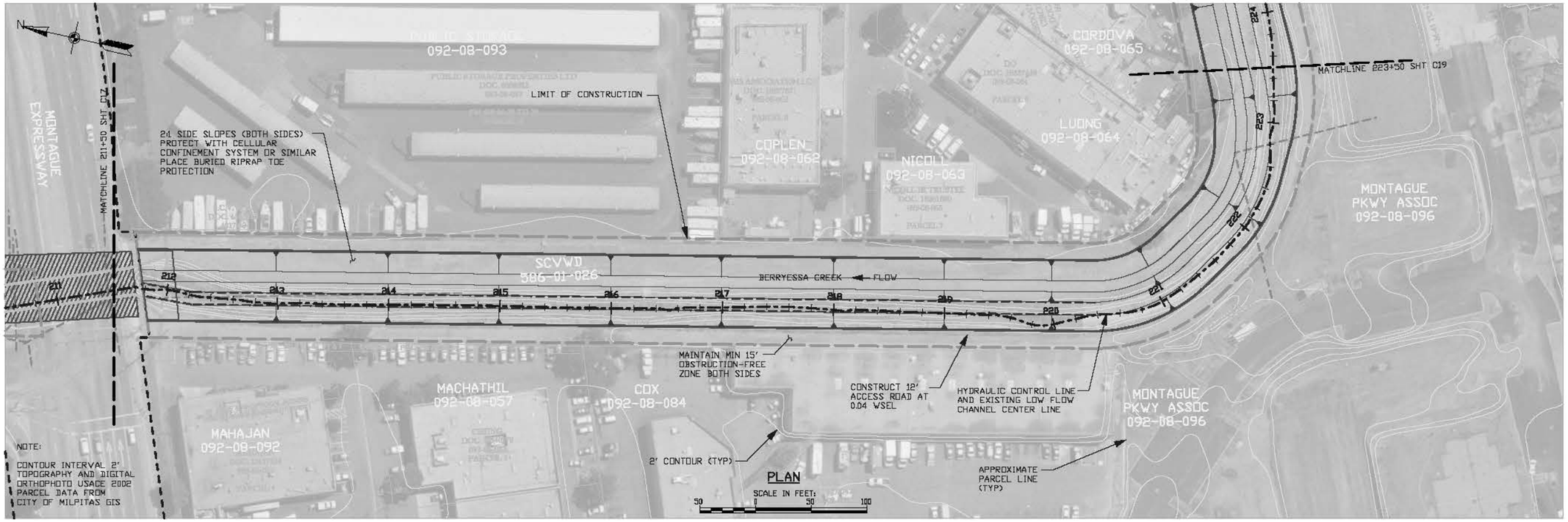
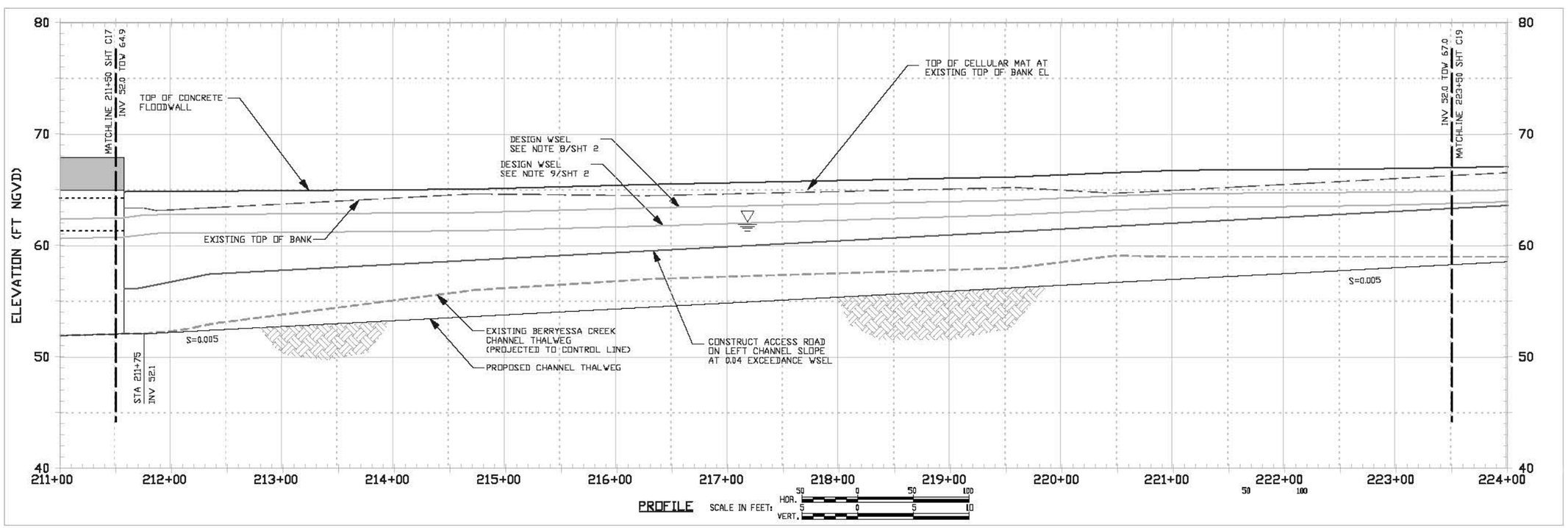
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 199+00 TO 212+00

Sheet reference number:
C17
Sheet 22 of 35





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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
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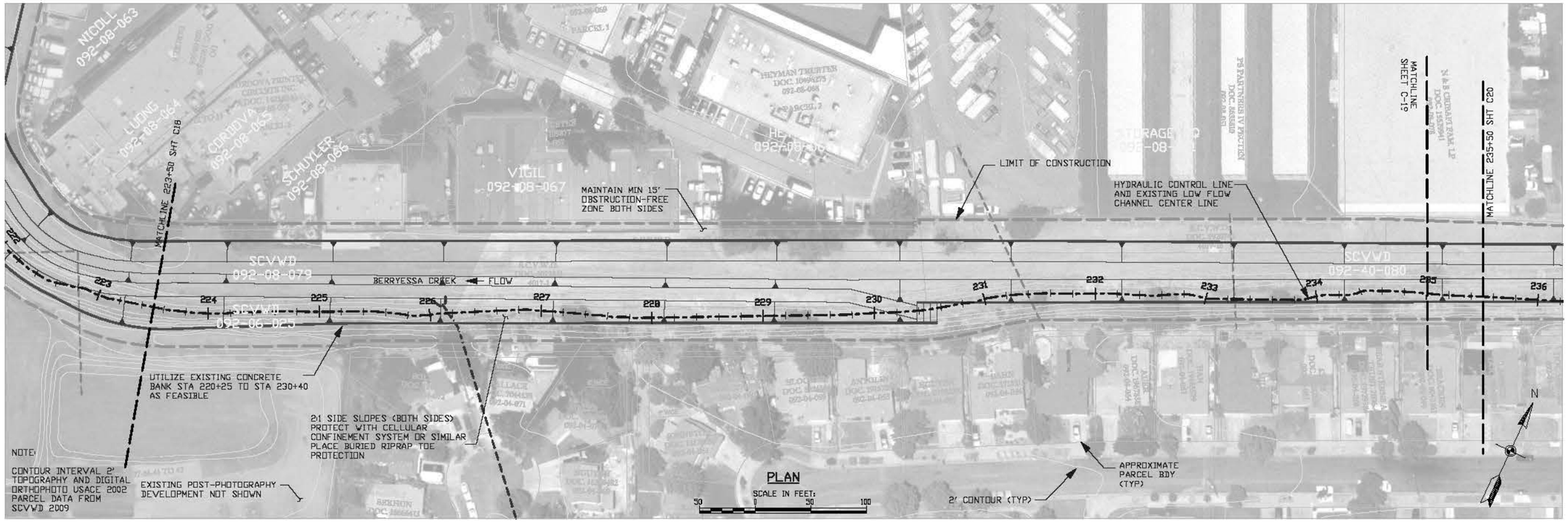
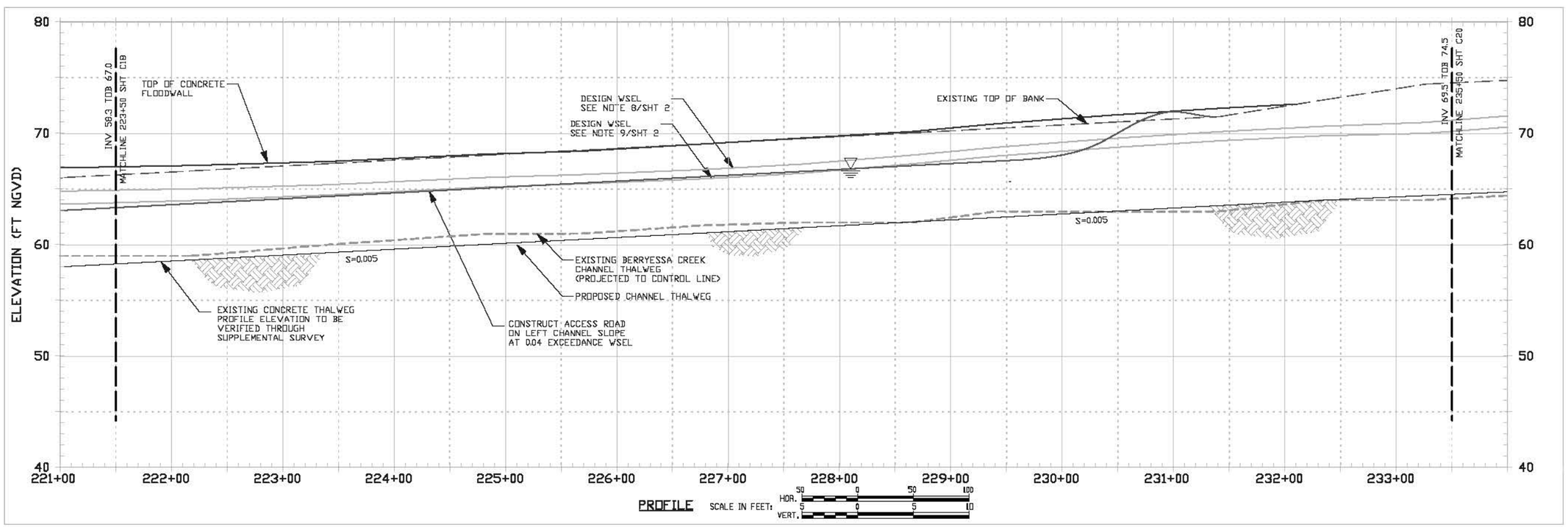
ALTERNATIVES FORMULATION
ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 211+00 TO 224+00

Sheet reference number:
C18
Sheet 23 of 35





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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
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TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
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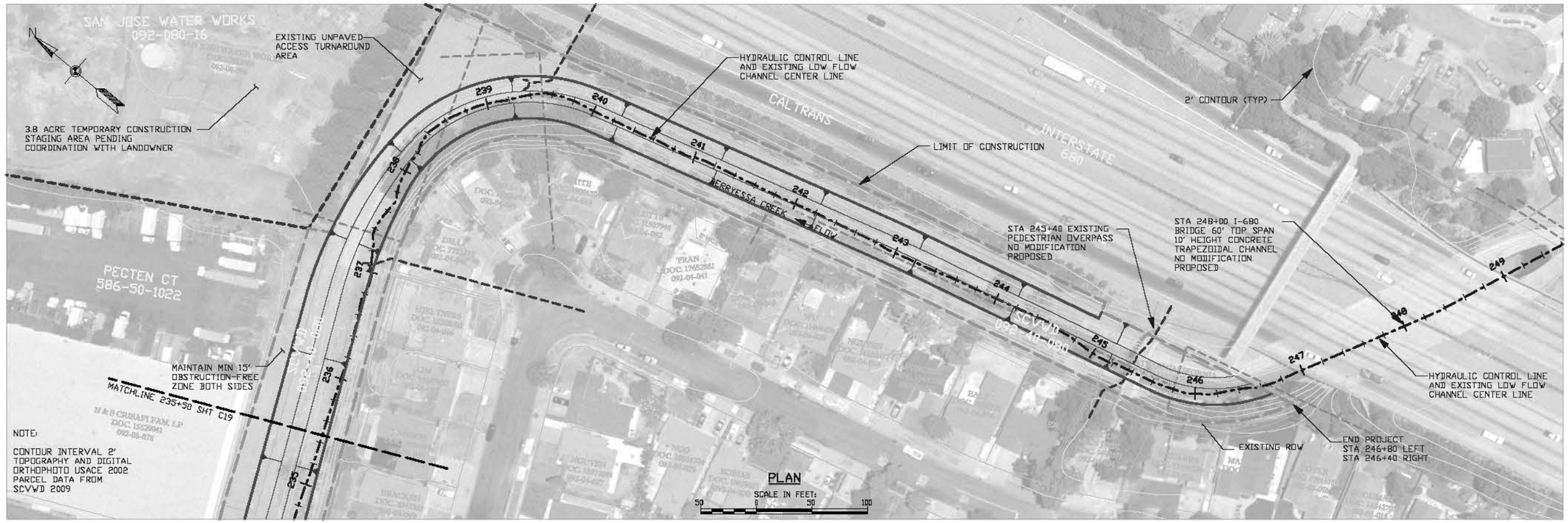
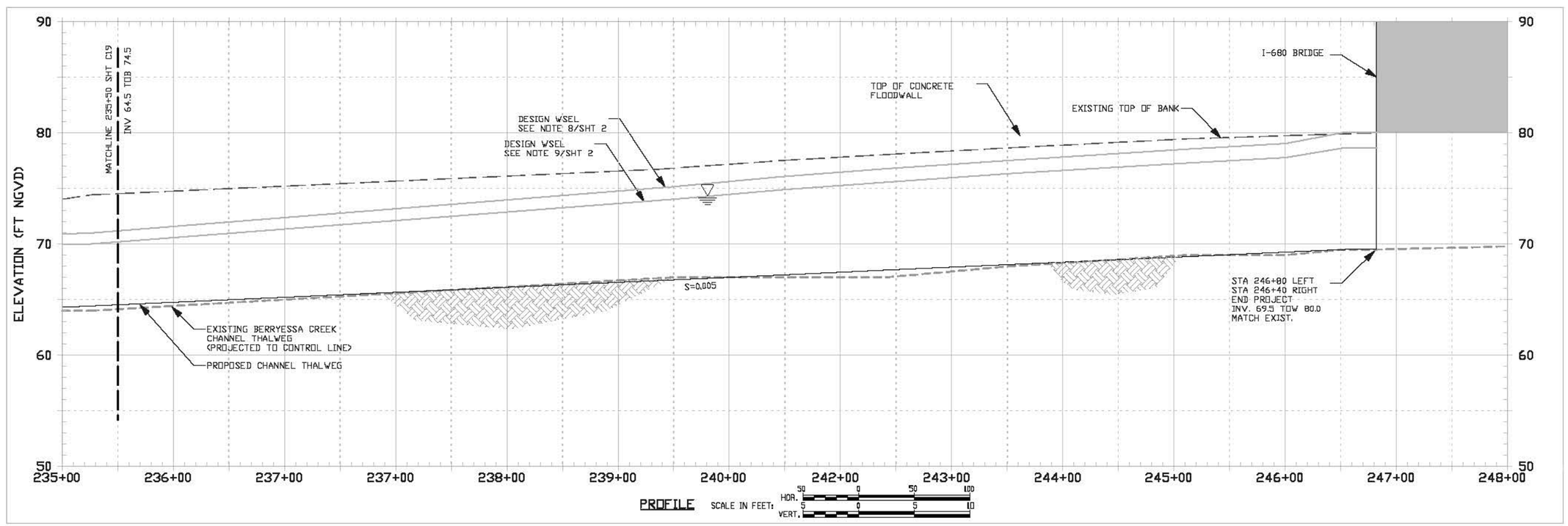
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 223+00 TO 236+00

Sheet reference number:
C19
Sheet 24 of 35





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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
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GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
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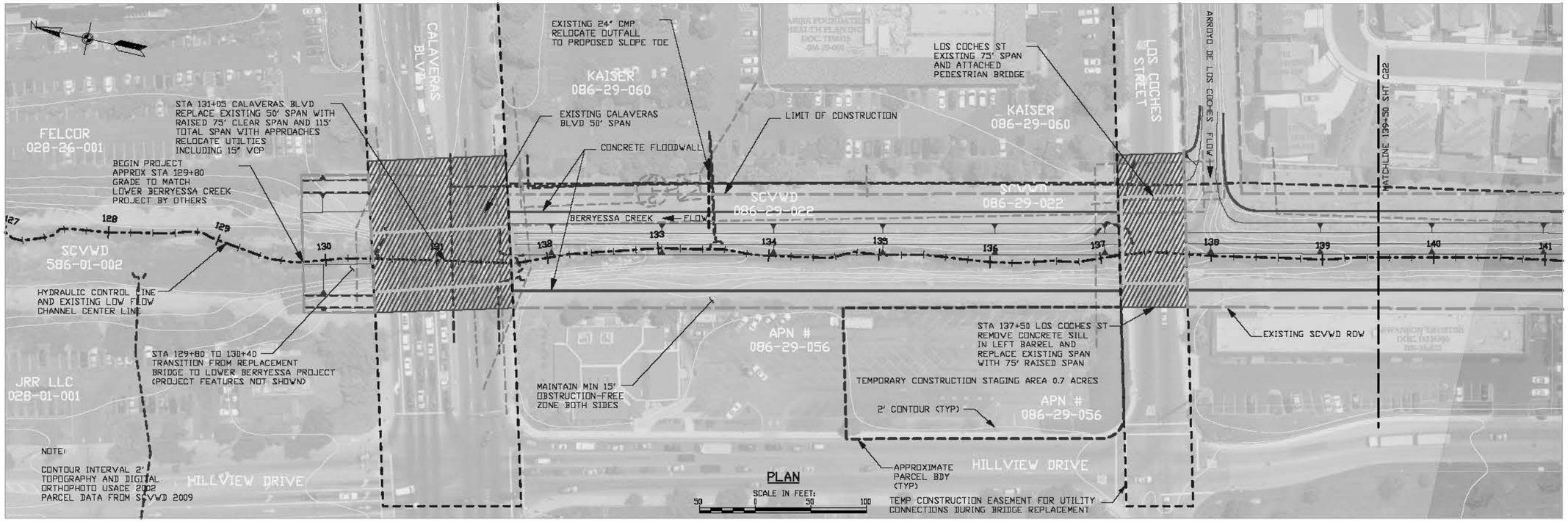
STA. 232+00 TO 245+00

Sheet reference number:
C20
Sheet 25 of 35



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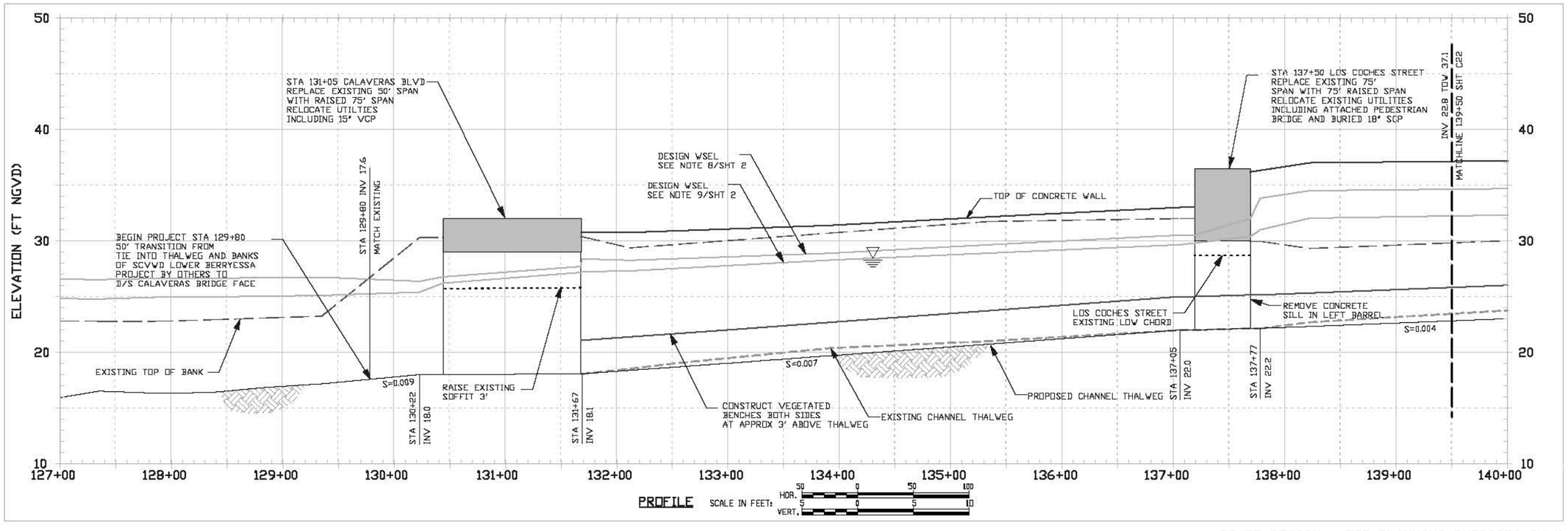


PROFILE SCALE IN FEET:

DRAFT DESIGN - FOR PLANNING PURPOSES ONLY

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date Approved

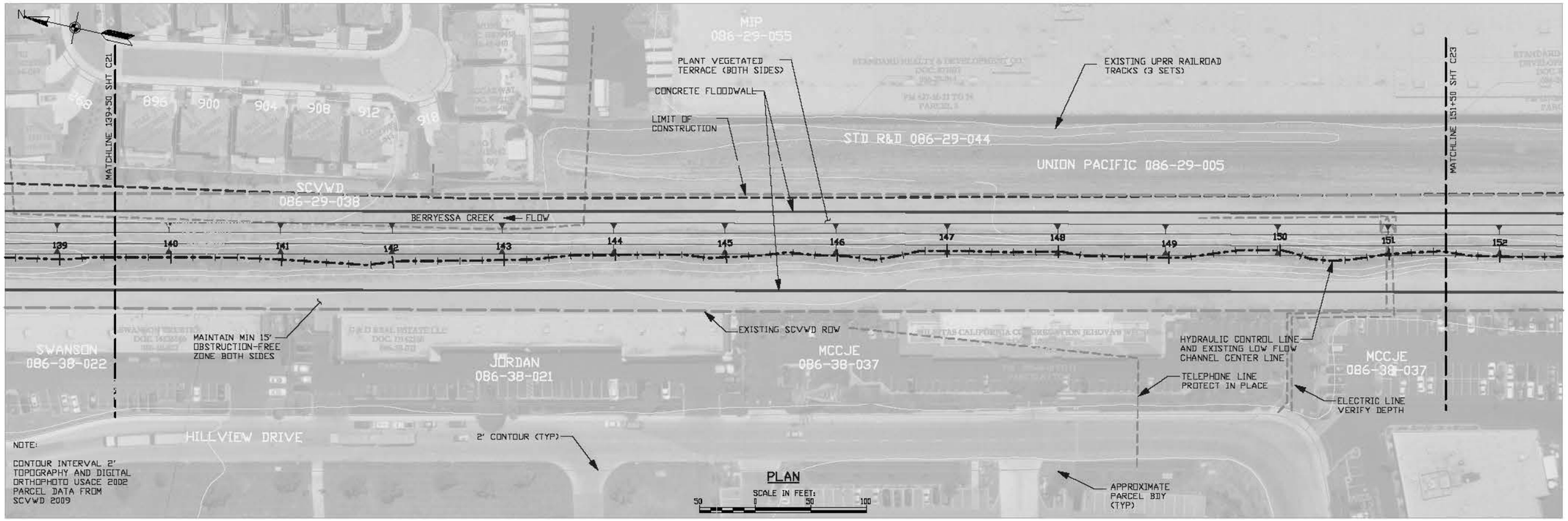
Designed by: PRELIMINARY
Dwn by: KP
Rev'd by: RM
Submitted by: CHIEF, CIV ENGR DES SEC A
Date: JAN 17, 2012
Rev. N/A
Spec No.: N/A
Dwg No.: Design file no:
Drawing Code:
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

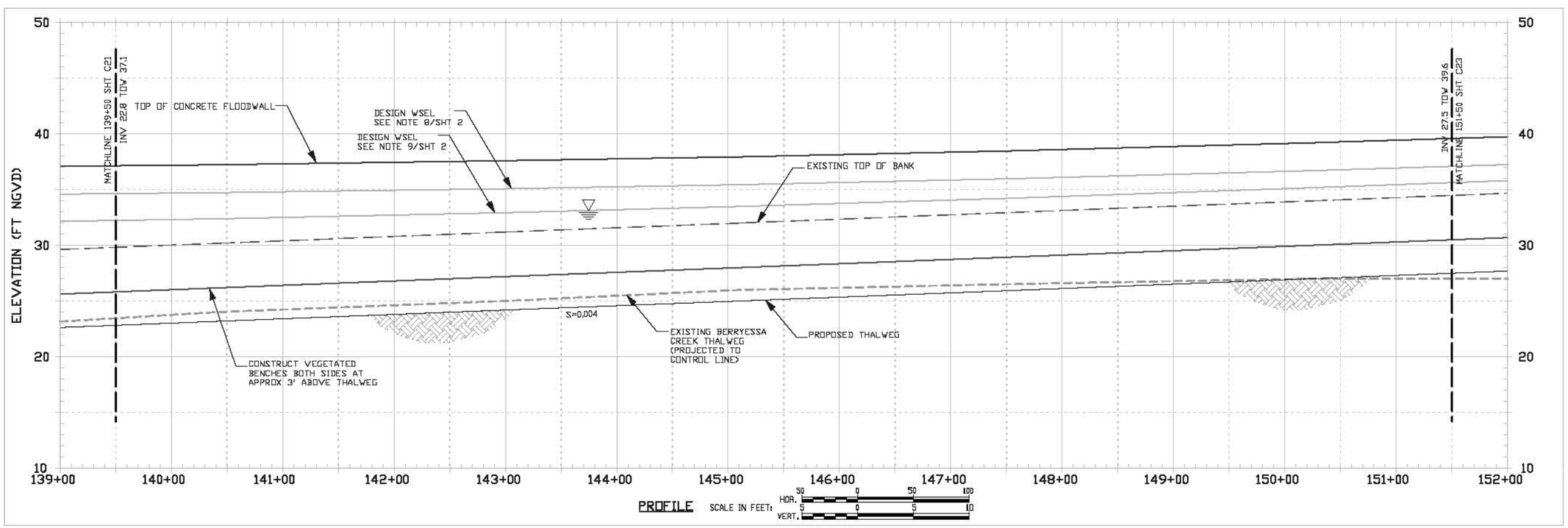
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 127+00 TO 140+00

Sheet reference number:
C21
Sheet 26 of 35





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US Army Corps of Engineers
Sacramento District

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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 139+00 TO 151+00

Sheet reference number:
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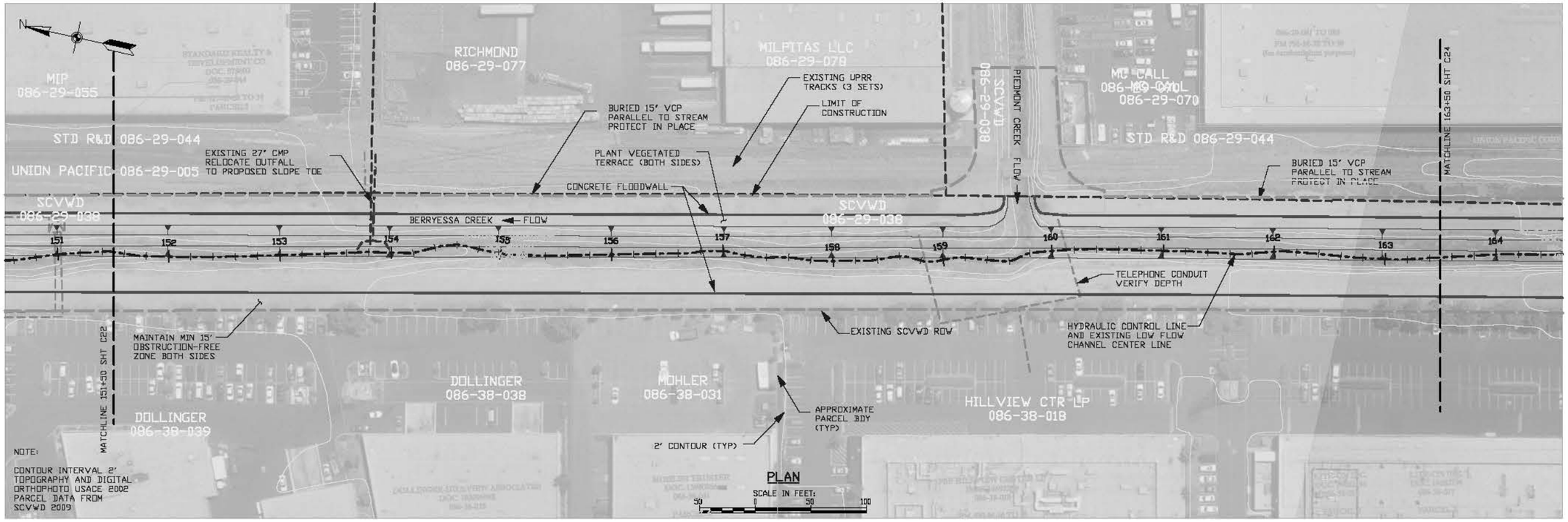
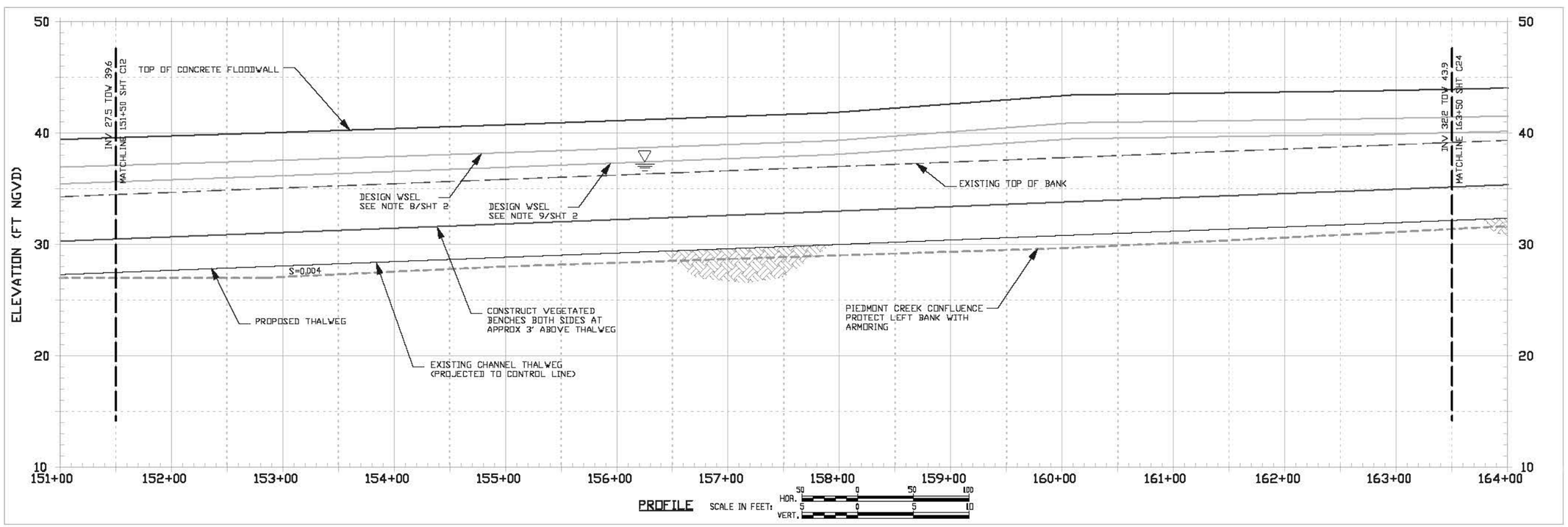
Sheet 27 of 35





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Sacramento District

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Spec No.: N/A
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CHIEF, CIV ENGR DES SEC A
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File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 151+00 TO 164+00

Sheet reference number:
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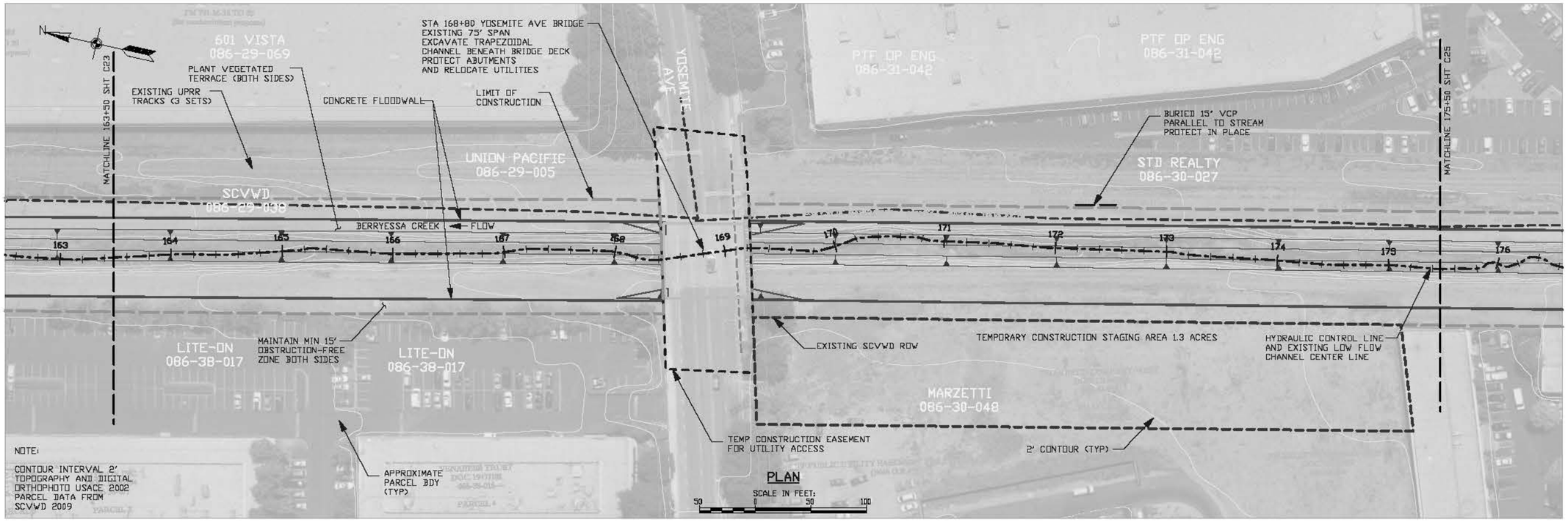

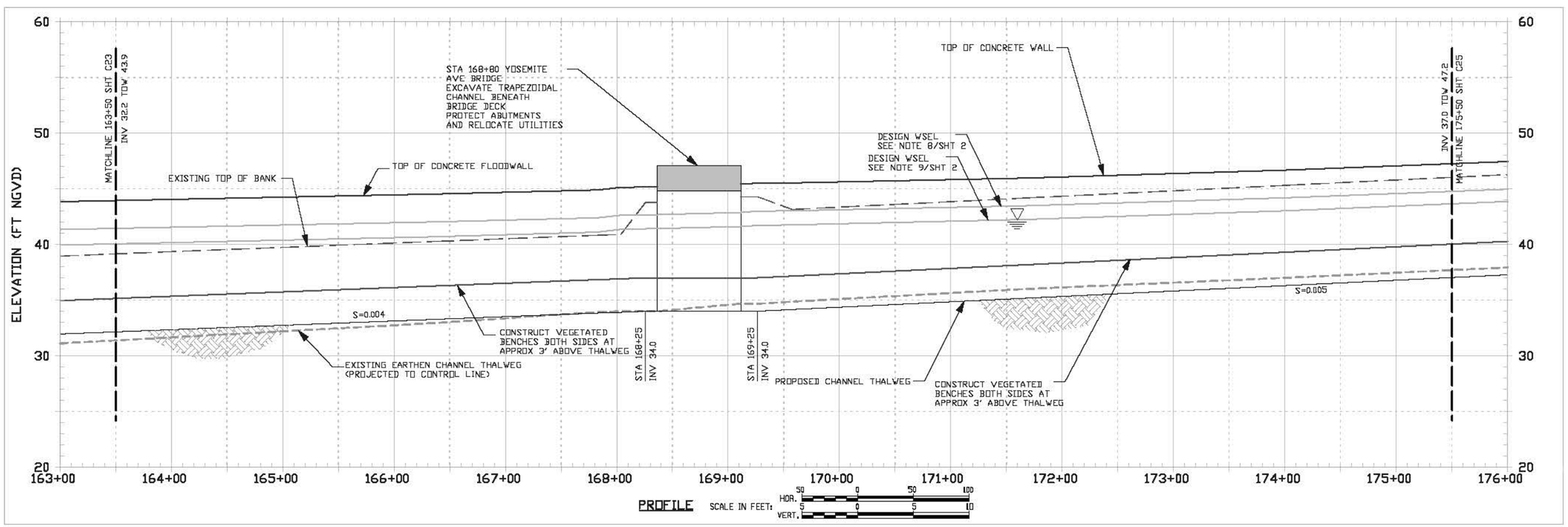

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Sacramento District

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CHIEF, DIV ENGR DES SEC A
Date: JAN 17, 2012
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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 163+00 TO 176+00

Sheet reference number:
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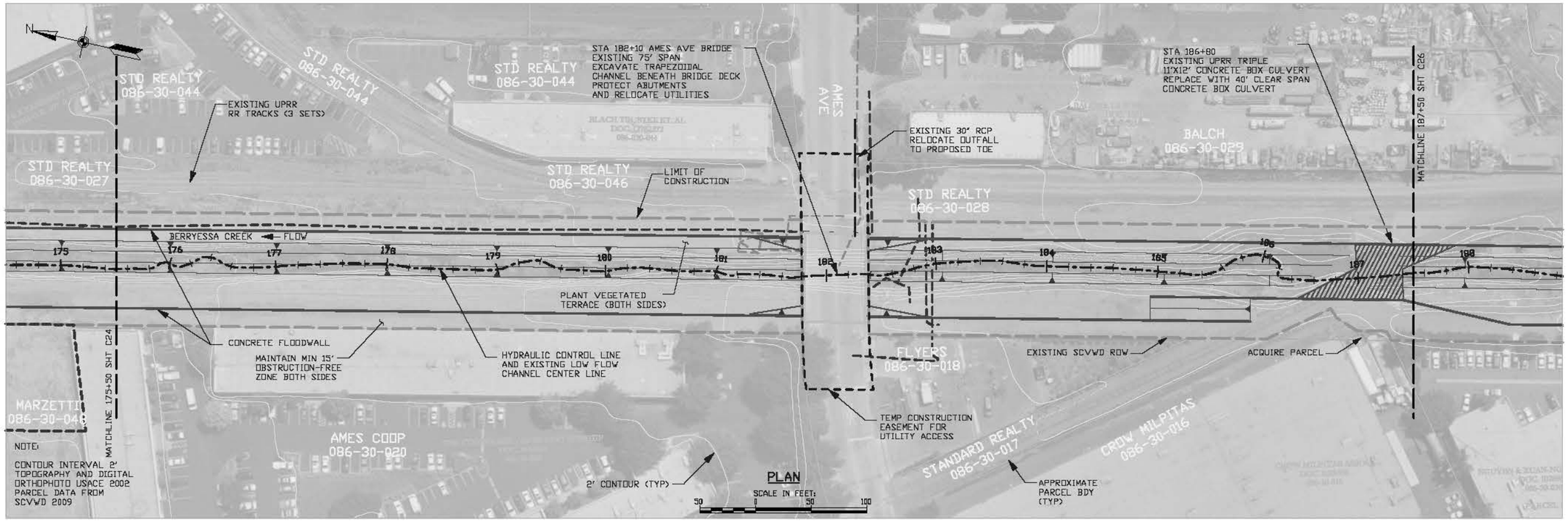
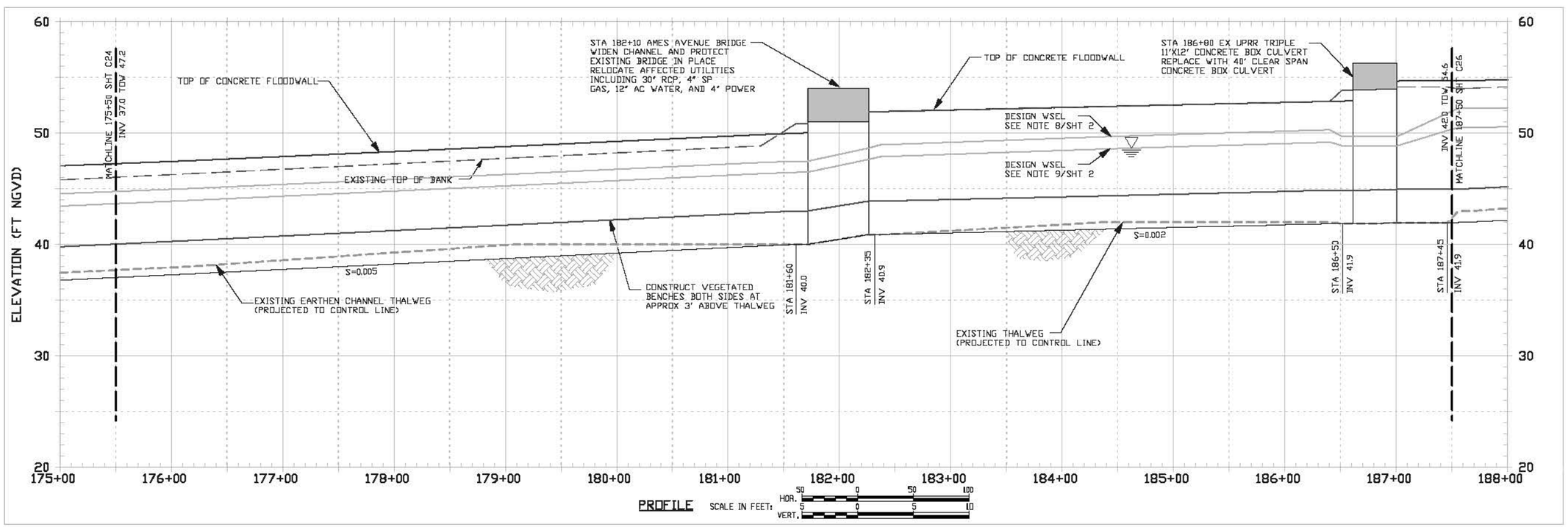
Sheet 29 of 35



PLAN



PROFILE SCALE IN FEET:

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US Army Corps of Engineers
Sacramento District

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Submitted by:
CHIEF, DIV ENGR DES SEC A
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 2B/d
PLAN AND PROFILE VIEW
STA. 175+00 TO 188+00

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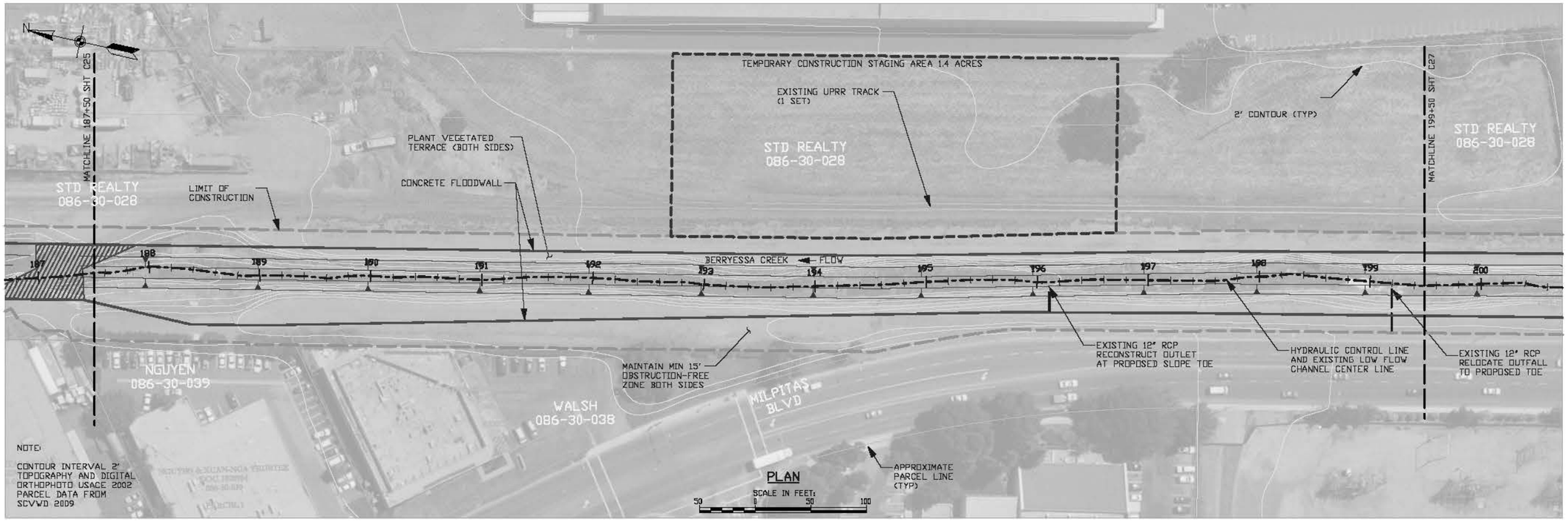

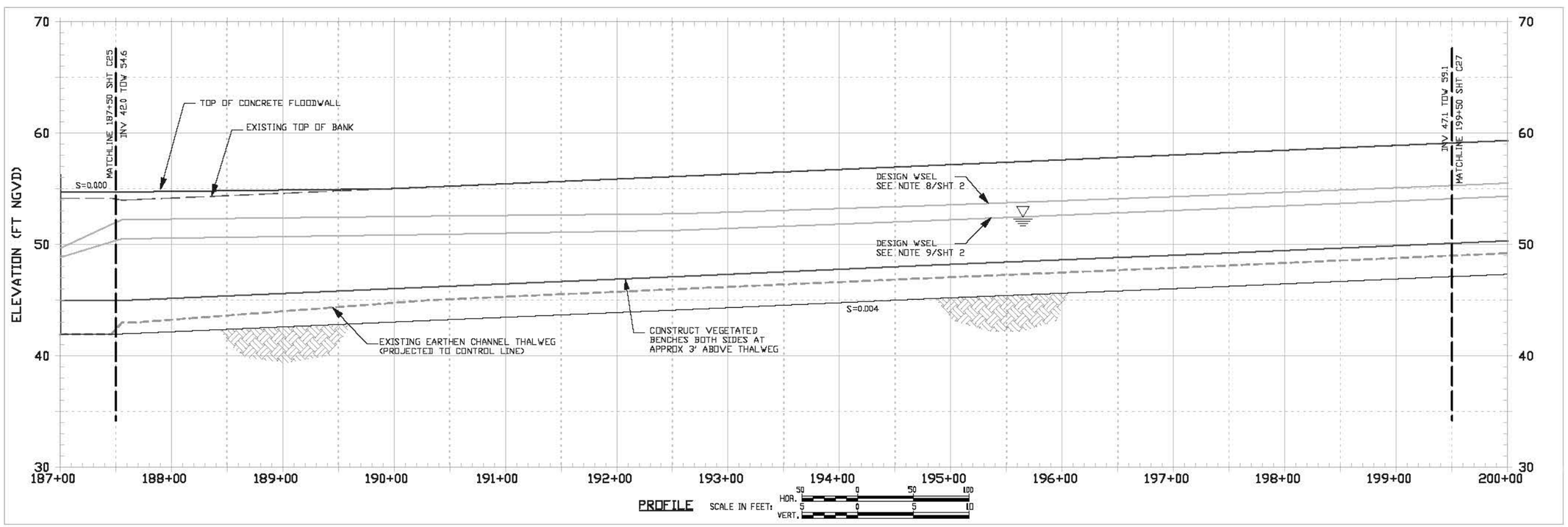

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US Army Corps of Engineers
Sacramento District

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Designed by: PRELIMINARY
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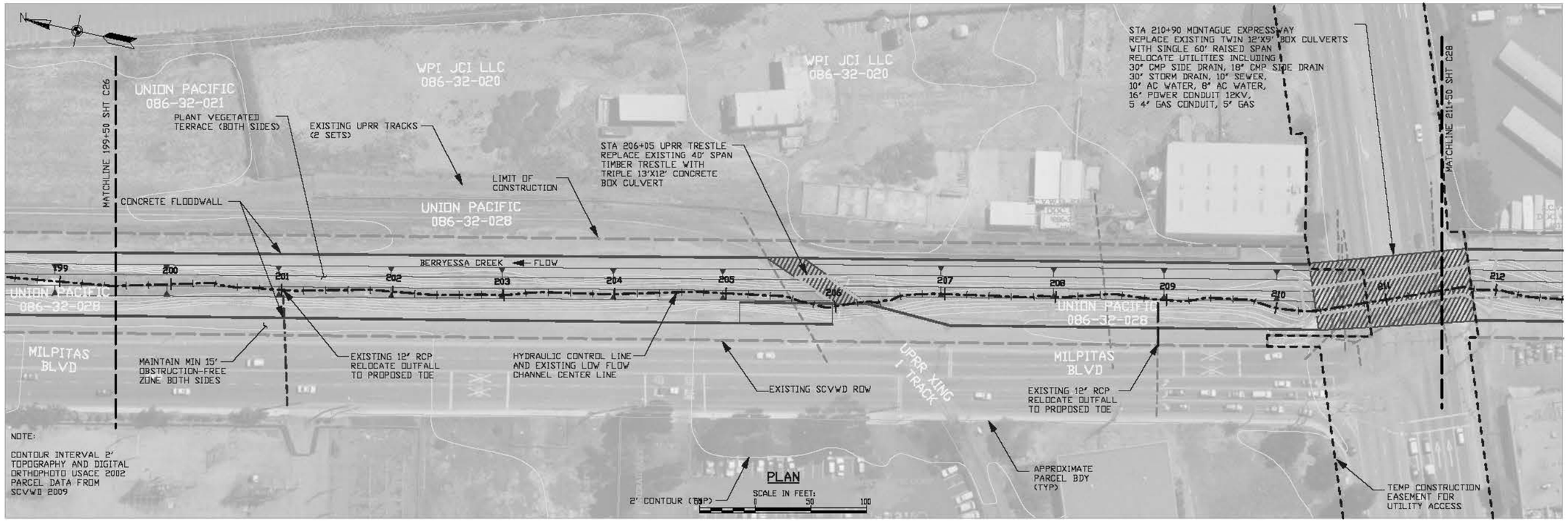
Drawing Code:
Submitted by: CHIEF, CIV ENGR BES SEC A
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

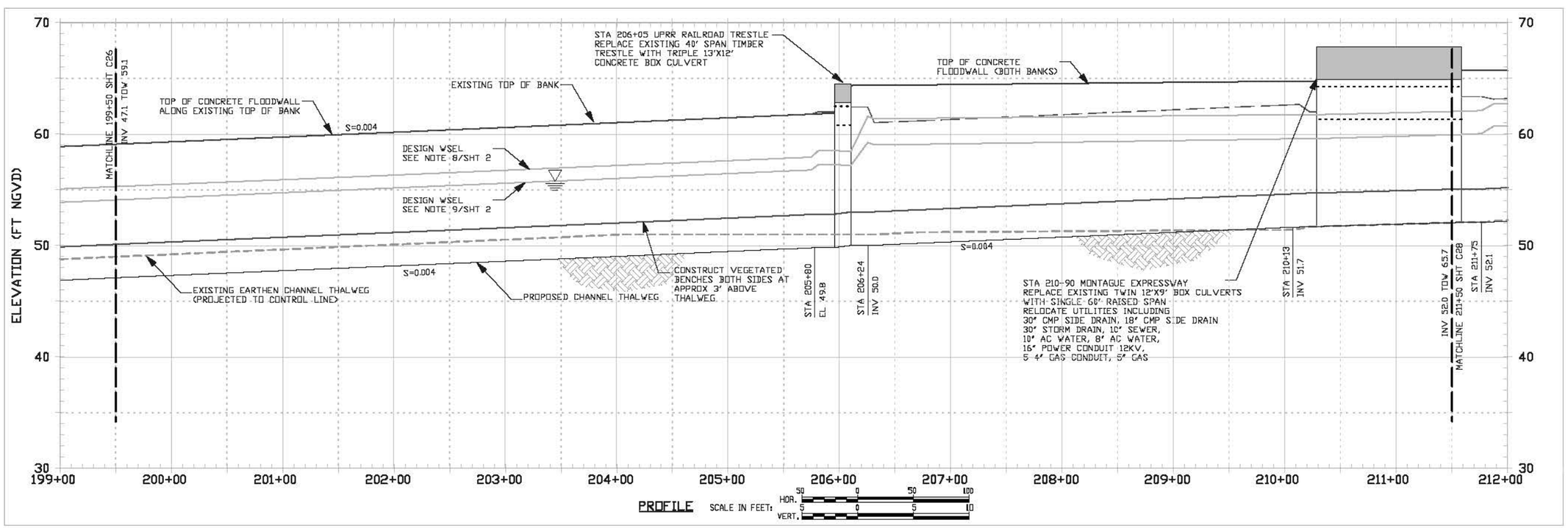
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 187+00 TO 200+00

Sheet reference number:
C26
Sheet 31 of 35





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US Army Corps of Engineers
Sacramento District

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Designed by: PRELIMINARY
Dwn by: KP
Rev'd by: RM
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Date: JAN 17, 2012
Rev. N/A
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Design file no: N/A
Drawing Code:
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 199+00 TO 212+00

Sheet reference number:
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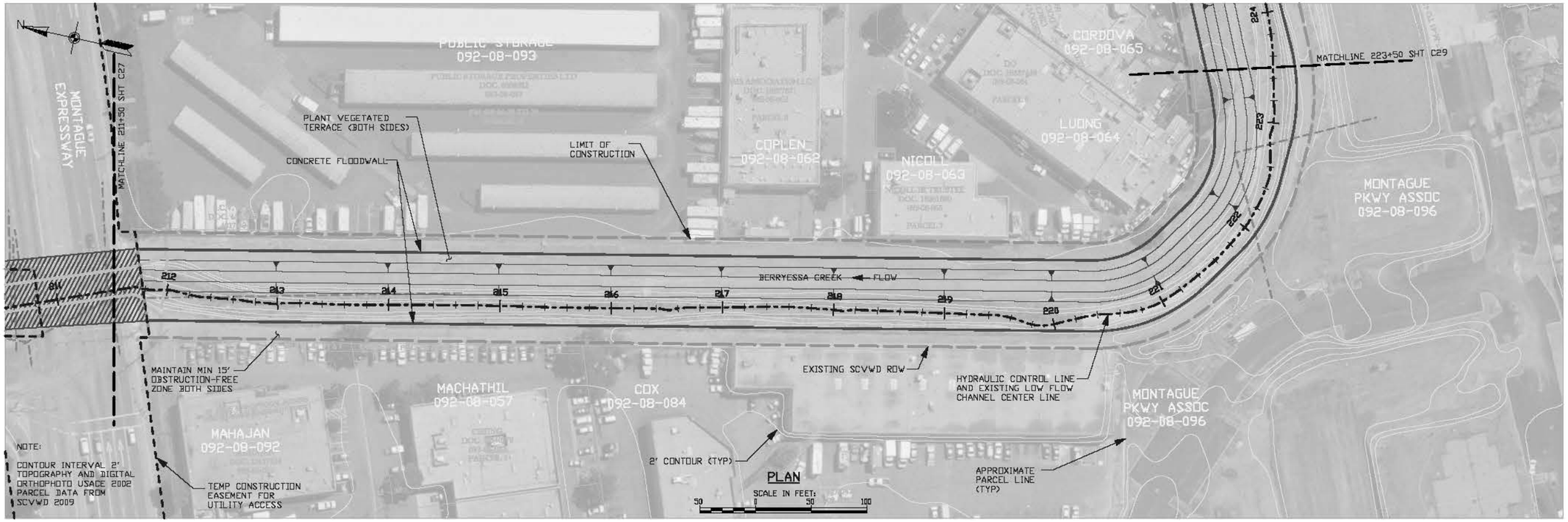

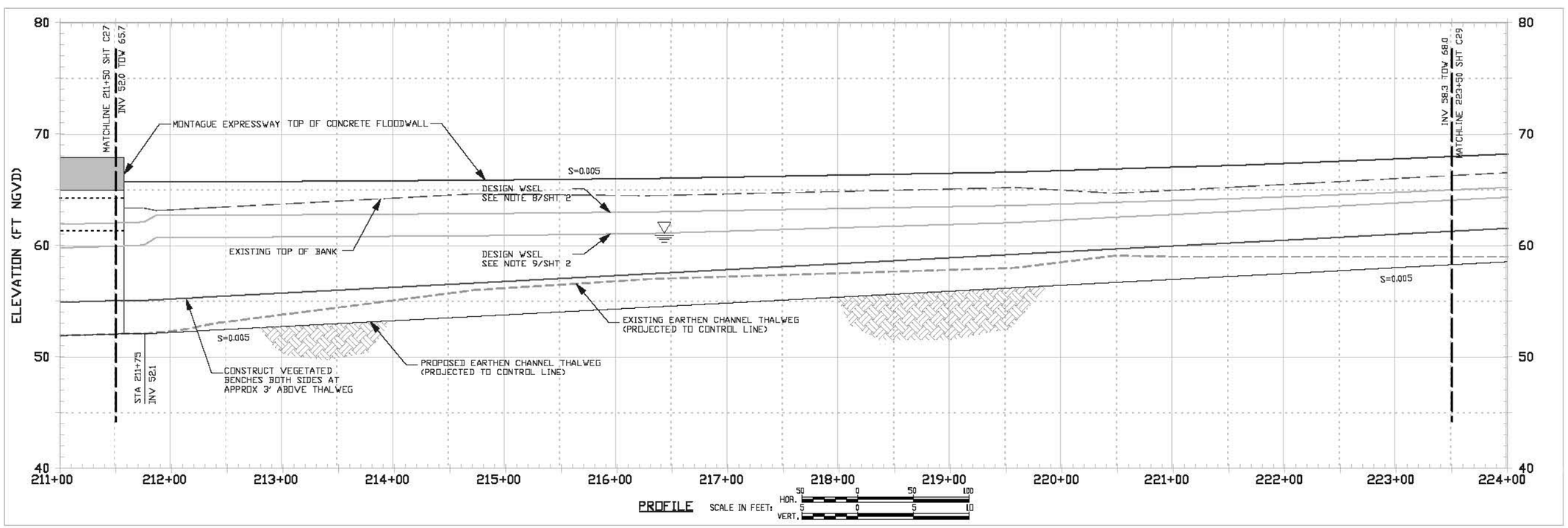

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US Army Corps of Engineers
Sacramento District

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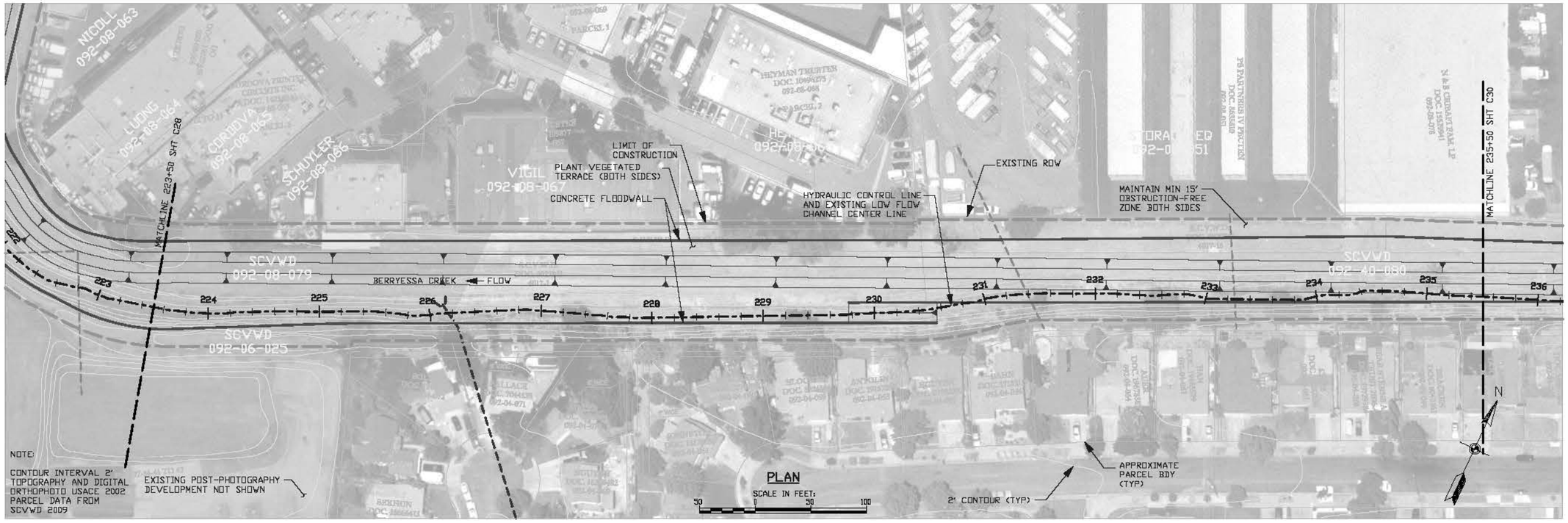
Dwn by: KP
Reviewed by: RM
Submitted by: CHIEF, CIV ENGR DES SEC A
Date: JAN 17, 2012
Rev. N/A
Spec No.: N/A
Design file no: N/A
Drawing Code:
File name: BER PP C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

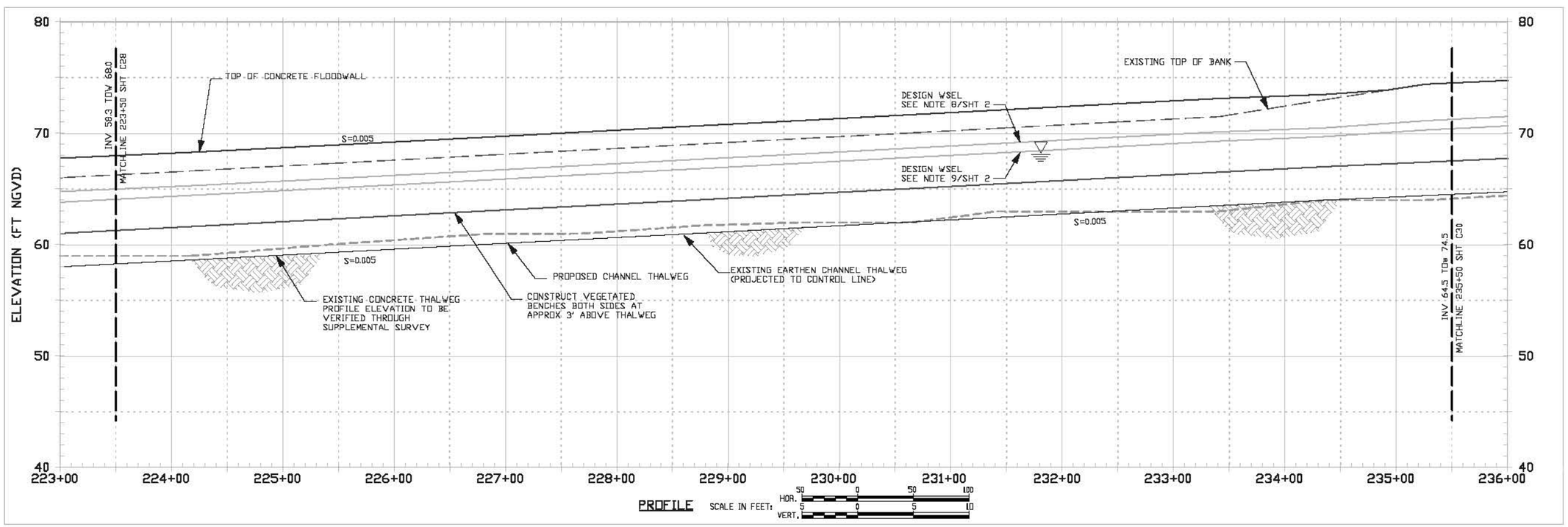
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY
CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION
ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 211+00 TO 224+00

Sheet reference number:
C28
Sheet 33 of 35





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US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Date: JAN 17, 2012 | Rev. N/A
Spec No.: N/A | Design file no: N/A
Drawing Code:
File name: BER P8 C-XX
Plot date: DEC 22, 2011
Plot scale: 50/100

Designed by: PRELIMINARY
Dwn by: KP
Reviewed by: RM
Submitted by:
CHIEF, CIV ENGR DES SEC A

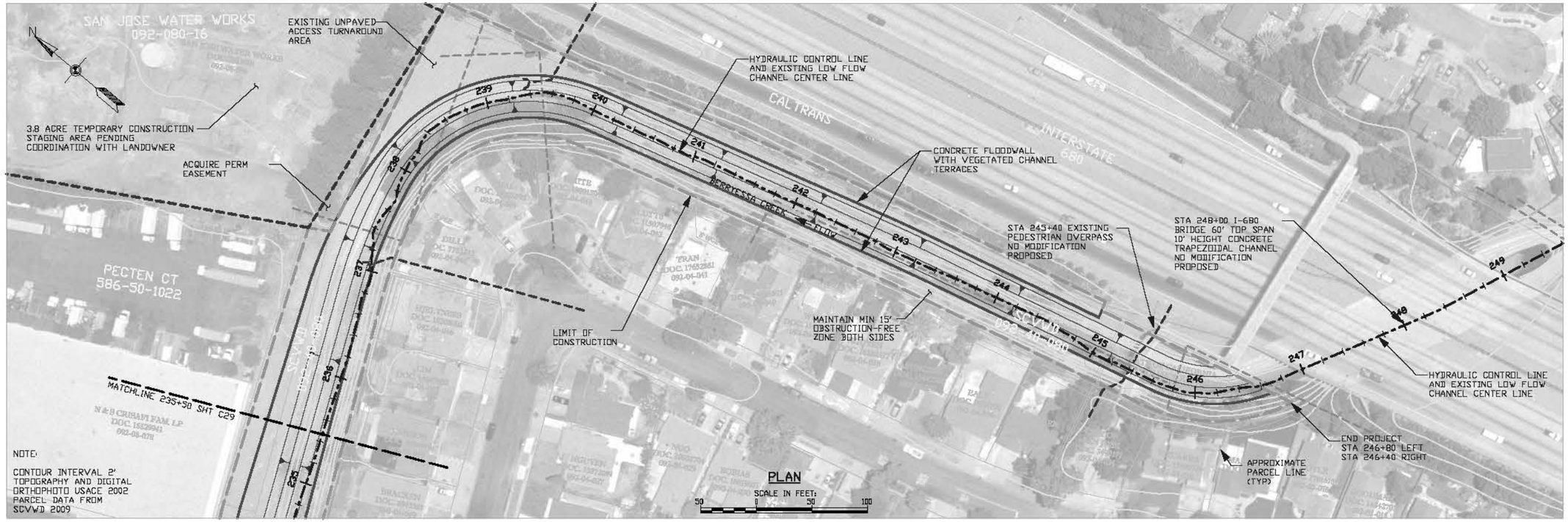
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
SANTA CLARA VLY WATER DISTRICT

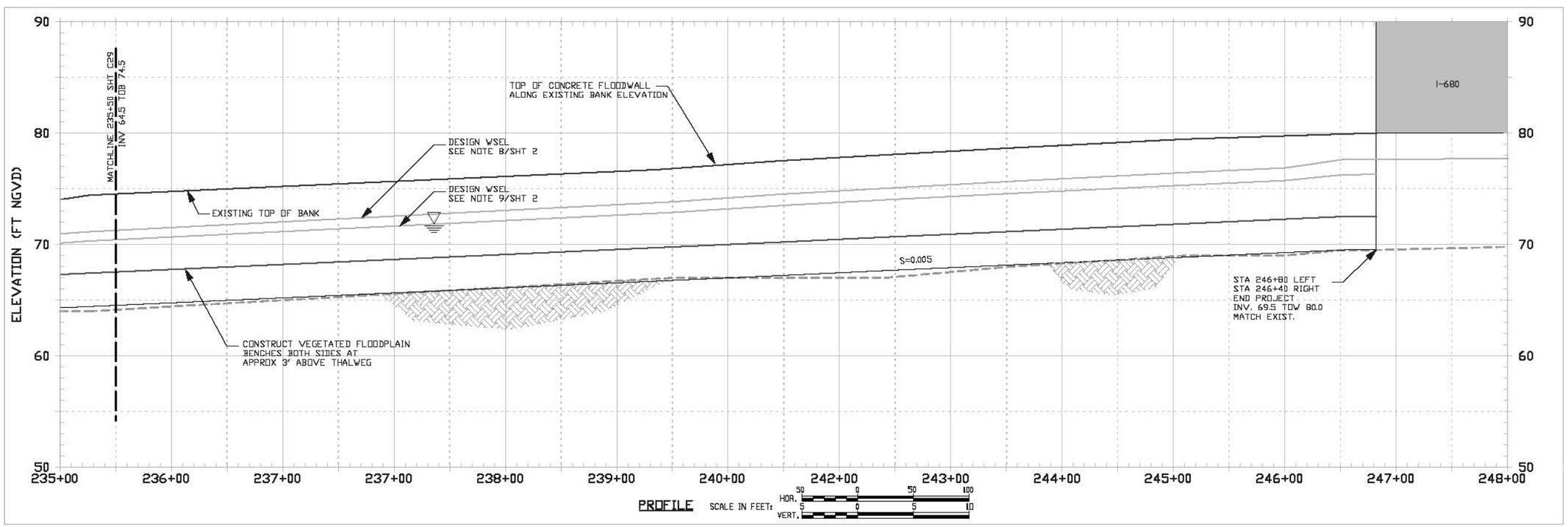
PREPARED BY:
TETRA TECH, INC.
17770 CARTWRIGHT, STE. 500
IRVINE, CA 92614

SANTA CLARA COUNTY CALIFORNIA
BERRYESSA CREEK PROJECT
GENERAL REEVALUATION STUDY
ALTERNATIVES FORMULATION

ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 223+00 TO 236+00

Sheet reference number:
C29
Sheet 34 of 35





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Sacramento District

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Designed by: PRELIMINARY
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U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT
IN PARTNERSHIP WITH:
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SANTA CLARA COUNTY
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ALTERNATIVES FORMULATION
ALTERNATIVE 4B/d
PLAN AND PROFILE VIEW
STA. 232+00 TO 245+00

Sheet reference number:
C30
Sheet 35 of 35