Ventura County
Watershed Protection District

FEMA PAL Response Report

Ventura County, California

SANTA CLARA RIVER LEVEE (SCR-1)
HIGHWAY 101 TO SATICOY

FEMA ID No. 18

NOVEMBER 2009

FEMA PAL Response Report
Ventura County, California

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

FEMA ID No. 18

November 2009

Prepared for:

Ventura County
Watershed Protection District
800 S. Victoria Avenue
Ventura, CA 93009

Prepared by:

TETRA TECH

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TETRA TECH

November 20, 2009

Norma Camacho
Director, Watershed Protection District
Ventura County
800 South Victoria Avenue
Ventura, CA 93009

Subject: FEMA ID No. 18 Santa Clara River Levee (SCR-1)

Dear Ms. Camacho:

Tetra Tech, Inc. (Tetra Tech) has partially completed the contracted levee study in general accordance with the scope of work dated May 5, 2009. The focus of this study was to determine compliance of the subject levee system with the criteria set forth in the Code of Federal Regulation Title 44, Section 65.10 of the NFIP regulations (44 CFR 65.10). Based on our findings from this study, we have determined the subject levee system **does not meet** the requirements of 44 CFR 65.10.

Enclosed with this letter, you will find documentation of each of the disciplines of our study (e.g., hydrology and hydraulics) including the criteria used, assumptions made, and the analyses conducted to assist with the levee certification determination. Each of the discipline analyses was performed by a professional engineer who is competent in that discipline of the project.

For any questions regarding this letter, please contact Ike Pace, P.E., of Tetra Tech, Inc., at 949-250-6788. For questions about levee accreditation or the NFIP, please contact Ed Curtis, P.E., CFM of FEMA Region 9 at 510-627-7207.

Sincerely,

Tetra Tech, Inc.

Ike Pace, P.E.
Project Manager

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1.0 SYSTEM DESCRIPTION

1.1 Location

The Santa Clara River Levee (SCR-1), Federal Emergency Management Agency (FEMA) ID No. 18, is located in the City of Oxnard in Ventura County, California. SCR-1 is 4.72 miles long and is located along the southeast bank of the Santa Clara River between Highway (Hwy) 101 and Saticoy (Figure 1 and Figure 2).

1.2 Project Authorization

The project was authorized in June 1948 under Section 203 of the Flood Control Act of 1948 (Public Law 80-858). An excerpt of the Act reads as follows:

> *"Section 203. That the following works of improvement for the benefit of navigation and the control of destructive floodwaters and other purposes are hereby adopted and authorized to be prosecuted under the direction of the Secretary of the Army and the supervision of the Chief of Engineers in accordance with the plans in the respective reports hereinafter designated and subject to the conditions set forth therein:"*

1.3 Main Features

SCR-1 was originally designed (1958) to control the U.S. Army Corps of Engineers' (Corps) Standard Project Flood discharge of 225,000 cubic feet per second (cfs) from the 1,600-square mile Santa Clara River watershed. The levee height varies from approximately 4 feet to 13 feet. The compacted fill embankment has a top width of 18 feet, and the levee embankment slopes are 2(H):1(V) on both the landward side and riverward side. The riverward side of the embankment has a 1.5-to 2-foot thick rock revetment and was concreted in the vicinity of highway bridges. The rock revetment extends from the top of the embankment to varying depths. The lowest depth of rock revetment is referred herein as toe-down.

The reasoning for the varying rock revetment depths is described in the Corps 1958 General Design Memorandum (GDM) titled, *"Santa Clara River Levee, Design Memorandum No. 2 (General Design)"* (Corps, 1958b), which documented the differences between the project-document plan and the recommended plan. A board of consultants provided recommendations on the configuration of the rock revetment. Excerpts from the GDM are included herein: *"The board of consultants recommend that (a) instead of a levee with a deep toe-down (the toe-down would extend 12 feet below the streambed), where a 200-foot berm of undisturbed granular streambed material exists between the levee and the main-stream channel, the depth of the toe-down to be extended only 5 feet below the top elevation of this undisturbed material or (b) in the absence of this undisturbed material and at locations subject to direct attack by streamflow, groins extending 150 feet into the stream and spaced 225 feet – with slight deflection in the downstream direction – be built."*

The revetment toe-down varies from 5 to 10 feet below the river streambed between Hwy 101 and a distance approximately 8,500 linear feet upstream, at which point the toe-down changes significantly from approximately 5 feet below the streambed to approximately 10 feet above the streambed. From this point, approximately 10 feet above the streambed, the toe-down changes to approximately 5 feet above the streambed at Hwy 118. From Hwy 118, the toe-down depth changes from approximately 5 feet above the streambed to approximately 18 feet above the streambed at the upstream end of the levee. In this reach, the bottom of the rock groins and levee toe are also above the current Santa Clara River (SCR) streambed. If the existing groins fail to restrain the flow within the main channel, the levee would potentially be undercut. The rock groins recommended in the GDM were constructed to divert flows away from the levee rock revetment. In addition, a weighted stone toe section along the levee toe-down was designed to launch into the river to protect the rock revetment from undermining.

1.4 Local Ownership

The Santa Clara River Levee is owned and operated by the Ventura County Watershed Protection District (VCWPD). The levee is identified as Levee No. 18 by FEMA and as Levee System SCR-1 by the VCWPD. The Provisionally Accredited Levee (PAL) Agreement Form for this levee system is provided as Figure 3. Figure 4 shows the FEMA preliminary DFIRM for the levee.

Figure 1 – Santa Clara River Levee (SCR-1) Vicinity Map

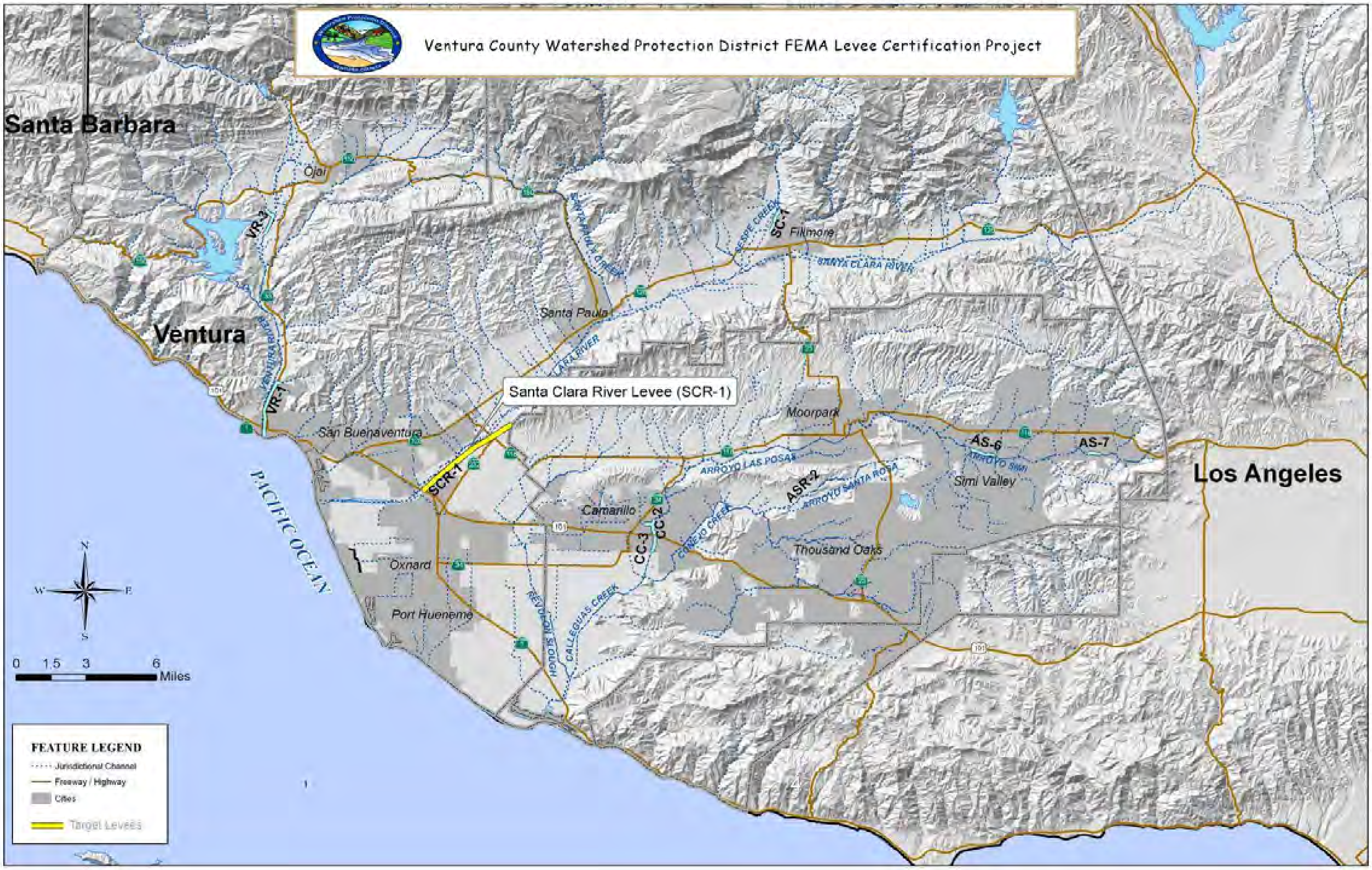

Figure 2 – Santa Clara River Levee (SCR-1) Location Map

Figure 3 – PAL Agreement Form

Ventura County Watershed Protection District

Public Works Agency
Jeff Pratt
Agency Director

October 22, 2008

Ms. Sally Ziolkowski, Director
Mitigation Division
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

Subject: SCR-1, Santa Clara River Levee, Highway 101 to Saticoy – FEMA ID # 18 – Letter of Agreement and Request for Provisionally Accredited Levee (PAL) Designation and Agreement to Provide Adequate Compliance with the Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10)

Dear Ms. Ziolkowski:

Ms. Sally Ziolkowski
October 22, 2008
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We understand that this documentation will be provided by the Ventura County Watershed Protection District (District) to FEMA before December 1, 2009. Providing the information described in 44 CFR 65.10 will allow FEMA to move forward with the flood mapping for Ventura County.

We fully understand that if complete documentation of compliance with 44 CFR 65.10 is not provided by the District to FEMA within the designated timeframe which will end December 1, 2009, FEMA will initiate a revision to the Flood Insurance Rate Map for Ventura County to redesignate the area as flood prone.

Levee Owner: Ventura County Watershed Protection District (VCWPD)

Representative (signature): ____________ Date: 10/22/08
Representative (print name): Tom Lagier, Director, VCWPD

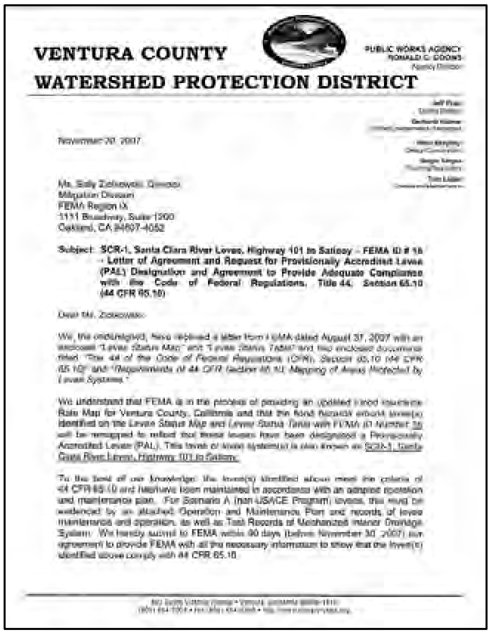
Affected Community: County of Ventura

CEO or designee (signature): ____________ Date: 10/22/08
Community CEO (print name): Marty Robinson, CEO, County of Ventura

Affected Community: City of Oxnard

CEO or designee (signature): ____________ Date: 10/22/08
Community CEO: Edmund Sotelo, City Manager, City of Oxnard

Pc: Jeff Pratt, Director, Public Works Agency County of Ventura



VENTURA COUNTY WATERSHED PROTECTION DISTRICT

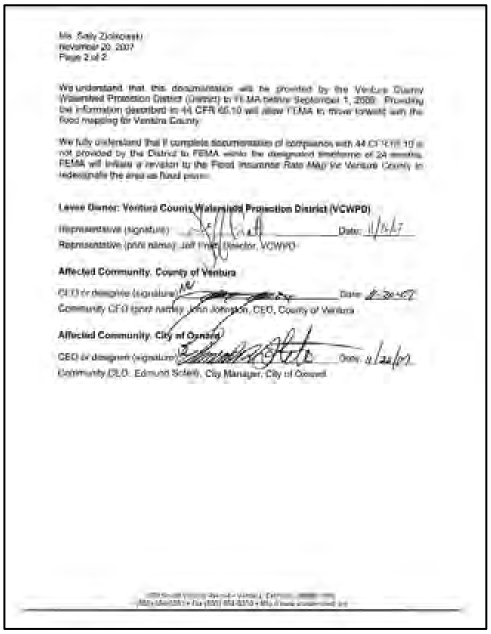
PUBLIC WORKS AGENCY
RONALD C. COONS
Agency Director

November 20, 2007

Ms. Sally Ziolkowski, Director
Mitigation Division
FEMA Region IX
1111 Broadway, Suite 1200
Oakland, CA 94607-4052

Subject: SCR-1, Santa Clara River Levee, Highway 101 to Saticoy – FEMA ID # 18 – Letter of Agreement and Request for Provisionally Accredited Levee (PAL) Designation and Agreement to Provide Adequate Compliance with the Code of Federal Regulations, Title 44, Section 65.10 (44 CFR 65.10)

Dear Ms. Ziolkowski:



Ms. Sally Ziolkowski
November 20, 2007
Page 2 of 2

Levee Owner: Ventura County Watershed Protection District (VCWPD)

Representative (signature): ____________ Date: 11/15/07
Representative (print name): Jeff Pratt, Director, VCWPD

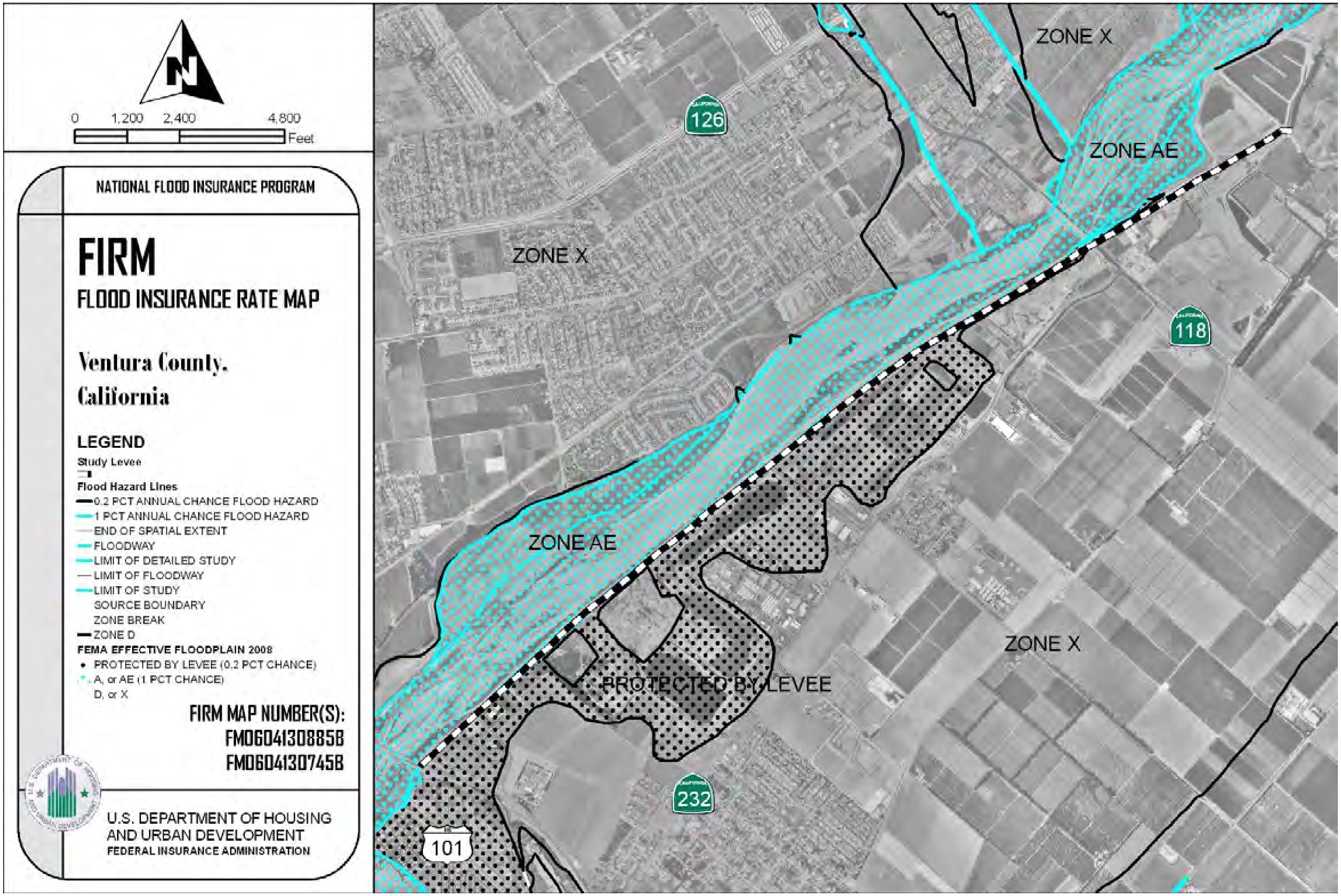
Affected Community: County of Ventura

CEO or designee (signature): ____________ Date: 11-20-07
Community CEO (print name): John Johnston, CEO, County of Ventura

Affected Community: City of Oxnard

CEO or designee (signature): ____________ Date: 11/20/07
Community CEO: Edmund Sotelo, City Manager, City of Oxnard

Figure 4 – FEMA DFIRM



2.0 REFERENCES

The following documents provided reference information and were used in the completion of this PAL Response report.

Federal Emergency Management Agency, 1990. *National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification)*. Revised as of October 1, 1990.

Federal Emergency Management Agency, 2002. *Appendix C: Guidance for Riverine Flooding Analyses and Mapping (Guidelines and Specifications for Flood Hazard Mapping Partners)*.

Stillwater Sciences, 2007. *Santa Clara River Parkway Floodplain Restoration Feasibility Study - Assessment of Geomorphic Processes for the Santa Clara River Watershed, Ventura and Los Angeles counties, California*, prepared for the California Costal Conservancy, prepared by the Stillwater Sciences, Berkeley, California, August 2007.

U.S. Army Corps of Engineers, 1958a. *California: Santa Clara River Levee, Design Memorandum No. 1 (Hydrology)*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1958b. *Santa Clara River Basin, California: Santa Clara River Levee, Design Memorandum No. 2 (General Design)*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1968, *Flood Plain Information, Santa Clara River (Saticoy to Pacific Ocean)*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1969, *Floods in Southern California during January and February, 1969*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1971, *Santa Clara River Levee, Levee and Channel Restoration Project*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1994. *Engineering and Design – Hydraulic Design of Flood Control Channels. Engineering Manual 1110-2-1601, Change 1*. Department of the Army, Washington D.C.

U.S. Army Corps of Engineers, 1996. *Design and Construction of Levees. Engineering Manual 1110-2-1913, Revision 1*. Department of the Army, Washington D.C., 177 p., 1996.

U.S. Army Corps of Engineers, 2008. *EC-1110-2-6067, Certification of Levee Systems for the National Flood Insurance Program (NFIP)*. 30 September 2008.

USGS, 1982. *Guidelines for Determining Flood Flow Frequency, Bulletin 17B.* Interagency Committee on Water Data, March 1982.

Ventura County Watershed Protection District, 2006. *Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line*. December 2006.

Ventura County Watershed Protection District, 2008. *Review of 2008 FEMA Santa Clara River Flood Insurance Study for City of Fillmore.* December 2008.

3.0 LETTER OF INTENT, MEMORANDUM OF AGREEMENT, OR SCOPE OF WORK

The Notice-to-Proceed (NTP) to initiate Phase III of the levee certification program was given by the VCWPD to Tetra Tech, Inc. on May 5, 2009. The NTP and Scope of Work are included in this report under Appendix D1.

4.0 OVERALL PERFORMANCE HISTORY

4.1 Inspection Reports

In addition to the field inspection performed on December 8-10, 2008, as part of levee certification, previous reports prepared by the VCWPD were reviewed to identify any conditions or performance issues and provide some history of condition of the levee. According to a field inspection log, dated October 27, 2008, SCR-1 was in acceptable condition (see Appendix A1).

4.2 Past Flood Events and Associated Flood-Fighting Activities

Several severe storms prior to the completion of SCR-1 had been documented in the Corps 1968 report titled, *"Flood Plain Information, Santa Clara River (Saticoy to Pacific Ocean), Ventura County, California"* (Corps, 1968). The February/March 1938 flood damaged the Hwy 118 Bridge (Los Angeles Avenue). The January 1943 flood caused severe damage to agriculture land and crops and bridges. The January 1952 flood was severe enough to cause damage to the properties along the river. No details of flood damages for the above mentioned floods were documented. The estimated peak discharges were 95,000 cfs, 72,000 cfs and 45,000 cfs for 1938, 1943, and 1952 floods, respectively. These values were obtained from Table 1 of the Ventura County Hydrology report titled, *"Santa Clara River 2006 Hydrology Update, Phase I – From Ocean to County Line"* (VCWPD, 2006). This report is included in the attached CD.

The floods of January and February 1969 were the most damaging floods of record along the Santa Clara River in Ventura County. The estimated peak discharge of the 1969 flood is 165,000 cfs before the gage data adjustment shown in 'Table 1' of the above mentioned 2006 VCWPD report. The following are excerpted from the Corps report titled, *"Floods in Southern California during January and February, 1969"* (Corps, 1969) pertaining to the reach from Hwy 118 to Hwy 101:

> *"The only significant damage that occurred in this reach during the January flood was damage to the revetment of an existing levee constructed by the Corps of Engineers.*
>
> *February floodflows washed out about 500 feet of State Route 118 bridge, damaged agricultural property and utilities, and severely damaged flood-control improvements constructed by the Corps of Engineers. … The flood eroded the south bank near the existing Corps levee, damaging some groins; then deflected, ricocheted from the State Route 118 bridge, and returned to the south bank - where the floodflows cut in close to the Corps levee, bounced off to the north bank, and carved a long arch.. The floodflows then deflected to the south bank where they undercut the toe protection on the Corps levee, causing the failure of about 2,000 feet of levee and eroding the ground behind the levee for a distance of about 100 feet."*

The original construction, completed in 1961 contained 40 groins. After the 1969 flood damage, the Corps repaired 7 of the original 40 groins (station 330+00 to station 344+50), restored 2,100 linear feet of levee embankment with deeper rock revetment (station 311+00 to station 332+00), and added 35 additional groins (station 246+00 to station 330+00 and station 421+80 to station

436+80), which were completed in 1971. A total of 75 groins are now in place along the study reach of the SCR from station 246+00 to station 470+00. In December 1985, Ventura County restored five groins (between as-built station 316+45 and station 356+45, see Figure 3, Appendix D3) in the vicinity of the 1969 levee failure location. The damages may have been due to the 1983 flood with a peak discharge of 100,000 cfs. The damage to the groins was likely due to the low-flow channel encroaching and washing out the top portion of the groin tips. After the 1983 floods, the riverward tips of five groins extending between 40 to 100 feet along the groins were damaged. The County repaired these groins which included one of the original 1961 groins and four of those added in 1971 (station 321+00 to station 333+07). The repair included removal of approximately 2 feet of existing rock and placement of 2-ton rock riprap back to the original design dimensions and backfilling with uncompacted fill. This is the only known non-Corps stone that was added to the system.

4.3 Operation and Maintenance

No maintenance records were available for review.

5.0 ENGINEERING STUDIES, INVESTIGATIONS, AND ANALYSES

5.1 Site Visit Summary

Field investigations of SCR-1 were conducted on December 8-10, 2008. The team included representatives from the VCWPD, Tetra Tech, and AMEC. The investigation was conducted by walking the entire length of the levee system while visually assessing the existing conditions of the flood protection elements. During the investigation, crews conducted a visual assessment of 13 different evaluation items including, but not limited to: unwanted vegetation growth, signs of depression/rutting, erosion/bank caving, slope stabilities, and penetrations. The description of these 13 items can be found in the Levee Inspection Log of the Evaluation Report (Appendix A). Separate inspection logs were completed by Tetra Tech and AMEC at the end of the field visit. The inspection log is a team log that comprises the assessments from the individual inspection logs. Notable findings from the site investigations are as follows:

Riverward Side of Levee:

1. Removal of sediment that has accumulated in most pipe penetrations/structures is required to allow drainage and proper operation of the closure devices (flap gates).
2. Restoration of top and embankment is required in certain locations due to unauthorized vehicle ramps, off-road vehicle rutting, rock revetment sloughing, and runoff erosion.
3. Rock revetment is of several different types (sandstone/igneous/conglomerate) of rock, a lot of which is desiccated and broken down into smaller pieces along the entire length of the levee. The ability of this rock revetment to provide the appropriate level of protection is questionable.
4. Restoration of top and embankment is required in extensive stretches of the levee due to unauthorized dumping/washing out of concrete trucks obscuring any observation of riprap.

5. Restoration of top and embankment is required due to unauthorized dumping of large quantity of material on the levee adjacent to the concrete plant obscuring any observation of riprap.
6. Groins near Hwy 101 have been exposed and are actively washing away. This erosion is within 200 feet of the levee embankment. Some of the river erosion has a 20 to 25-foot deep cut that is trending towards the levee embankment.
7. Removal of one tree within 15 feet of levee toe is required at the downstream end near Hwy 101. Also mowing of vegetation (approximately 900 linear feet) within 15 feet of the levee toe to a height less then 12 inches is required.

Landward Side of Levee:

1. The stop logs for the Stroube Drain outlet are not on-site. County personnel stated that the stop logs are at the Saticoy maintenance yard and are transported to the site during events that require their installation. The stop logs and their installation procedures need to be verified.
2. There has been a lot of dumped stone, debris, and random soil along the toe of the levee and beyond. In some locations, the toe goes right up to the fence leaving no room for maintenance.
3. Restoration of top and embankment is required in certain locations due to unauthorized vehicle ramps, off-road vehicle rutting, and runoff erosion.
4. Restoration of top and embankment is required due to unauthorized dumping of large quantity of material on the levee adjacent to the concrete plant.
5. Removal and relocation of a utility pole and guy-wire anchors within the levee embankment prism may be required.
6. Removal of vegetation (trees and shrubs) within 15 feet of levee toe is required between Central Avenue Drain and concrete plant (approximately 75-100 large trees).
7. The quarry pits along the levee are quite deep and will require geotechnical consideration for seepage and deep stability.
8. Removal of vegetation (trees and shrubs) within 15 feet of levee toe is required between the Nursery and South Mountain (approximately 25 large trees).
9. Multiple animal burrows were observed in the field.

5.2 Hydrology and Hydraulic Evaluation

5.2.1 Hydrologic Evaluation

A. Introduction

Discharge frequency determinations, including the FEMA base flood (one-percent annual exceedance probability flood event), were based on methodology prescribed in FEMA regulations (44 CFR 65.10) as well as *Appendix C: Guidance for Riverine Flooding Analyses and Mapping* of the FEMA document titled, *Guidelines and Specifications for Flood Hazard*

Mapping Partners, dated February 2002 (http://www.fema.gov/pdf/fhm/frm_gsac02.pdf). This guidance describes the scope and methodologies acceptable for hydrologic analyses that support FEMA flood hazard mapping. Paragraph C.1.1 of these guidelines states:

> *"Where appropriate, the Mapping Partner that is performing the hydrologic analysis shall use all available flood flow-frequency information and shall not duplicate previous work by Federal, State, or local agencies, or work performed as part of a new or revised Flood Insurance Study (FIS) for FEMA. Where such data are not available, where conditions have changed invalidating the published information, or where the methodologies or data used in the previous FIS(s) are not appropriate, a new hydrologic analysis will be required."*

The paragraph C.1.1 guidelines are pertinent to this study since the adopted discharge frequency relationship, including the base flood peak discharge value, is taken directly from a prior hydrologic study performed by the VCWPD in 2006. The following sections provide a brief summary of the hydrologic methods used in the 2006 VCWPD report along with a presentation of discharge frequency values adopted.

B. Previous Hydrology Reports

The following reports were reviewed to obtain hydrologic information pertaining to the levee:

1. *"Santa Clara River 2006 Hydrology Update, Phase I, from Ocean to County Line,"* Ventura County Watershed Protection District, December 2006.
2. *"Design Memorandum No. 1, Hydrology for the Santa Clara River Levee, Ventura County, California,"* U.S. Army Corps of Engineers, Los Angeles District, October 1958.
3. *"Design Memorandum No. 2, General Design for the Santa Clara River Levee, Ventura County, California,"* U.S. Army Corps of Engineers, Los Angeles District, November 1958.

The Corps reports of October and November 1958 provide the basis of design including hydrology for the SCR-1 project. As part of a coordinated watershed planning and management effort, the 2006 VCWPD report, which updated an earlier 1994 report, was reviewed by HDR Engineering Inc., the Corps, and the Los Angeles County Department of Public Works. Comments received from the various agencies were addressed in finalizing the 2006 report. Per the recommendation of the VCWPD's review comments of the preliminary FIS study, the updated FIS 100-year discharge of 226,000 cfs was used for the study instead of the 231,576 cfs, which was the original discharge used for the preliminary FIS study model. The 100-year peak discharge of 226,000 cfs was also verified by Tetra Tech through a separate hydrologic evaluation (Appendix D2).

C. U.S.G.S. Stream Gages

The U.S. Geological Survey (USGS) streamgage on the Santa Clara River at Montalvo, CA (#11114000), near the mouth of the Santa Clara River measures runoff from a 1,594-square mile drainage area. The period of record used in the 2006 VCWPD report spanned 68 years (1932 to 2005). Table 1 of the 2006 VCWPD report provides a list of the annual peak discharges for the period of record through 2005.

D. *Flood Frequency Analyses*

The discharge frequency values presented in the 2006 VCWPD report are directly applicable for SCR-1 certification purposes. This report was developed through a collaborative effort among hydrologic engineering staff at VCWPD, the Corps, and the Los Angeles County Department of Public Works. The study results are current in that flow data through water year 2005 were used in the hydrologic analysis, and there have been no flood events in the interim that are large enough to significantly alter the discharge frequency values in the report. Water Resource Council Bulletin #17B—"*Guidelines for Determining Flood Flow Frequency (1982)*"—procedures were applied as prescribed by FEMA guidelines as the basis for the hydrologic analysis. Section III (Frequency Analysis) of the 2006 VCWPD report presents the details of the discharge frequency analysis for the Santa Clara River. The gage station skew of -0.515 was weighted with a generalized skew of -0.3 to produce the weighted skew of -0.5 for use in the Log Pearson Type III analysis. Flood Frequency Analysis (HEC-FFA) computer runs for the statistical analysis of the Santa Clara River at Monvalvo gage record are presented in Appendix 2 of the VCWPD report.

Adopted discharge frequency values for the Santa Clara River at Montalvo streamgage and for SCR-1 levee certification are shown in Table 1 below. As previously mentioned, the Montalvo streamgage measures discharge from 1,594 square miles of the 1,600-square mile drainage area upstream of SCR-1; hence it is directly applicable for the discharge frequency relationship at the levee. The discharge frequency values were taken directly from Table 3 of the 2006 VCWPD report. Figure 2 of the 2006 VCWPD report presents a graphical representation of the frequency curves at key locations on the Santa Clara River.

Table 1 – Adopted Discharge Frequency Values for Santa Clara River Levee (cfs)

Location	Return Period (year)							
	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
Montalvo	12,800	41,900	72,800	111,000	172,000	226,000	286,000	373,000

5.2.2 Hydraulic Evaluation

Steady-state water surface profiles were computed using the HEC-River Analysis System (HEC-RAS) program version 4.0 (March 2008), developed by the Corps for open channel reaches. The primary basis for the HEC-RAS model input data was the preliminary 2008 FEMA Santa Clara River FIS provided by the VCWPD. Modifications made to this HEC-RAS model are discussed in the Hydraulic Analysis Appendix (Appendix D3).

A. *Hydraulic Analysis Results*

Several analyses were performed to determine if SCR-1 is certifiable under FEMA's regulatory requirements as identified in 44 CFR 65.10. These analyses include a freeboard evaluation; a review of historical aerial photographs; levee revetment toe-down depth evaluation, groin rock size evaluation; rock revetment size evaluation; weighted stone toe evaluation; and scour analysis.

Freeboard Evaluation

FEMA certification requires the height of a levee to include an additional height (freeboard) above the water surface elevation of the 100-year flood event (one-percent chance exceedance flood or base flood). The required freeboard is 3 feet according to 44 CFR 65.10 criteria. An additional one foot of freeboard is required for 100 feet upstream/downstream of structures (such as bridges) and 0.5 feet at the upstream end of a levee.

For SCR-1, water surface profiles were computed using the HEC-RAS model described above. Table 2 shows computed channel hydraulics of the 100-year peak discharge based on the subcritical flow regime analysis. The top of levee elevations based on the VCWPD's 2009 survey, instead of those from the as-built plans, were used for the analysis and are reflected in Table 2 along with the available freeboard at each cross section.

Table 2 – SCR-1 Levee Freeboard Analysis

HEC-RAS River Station	**Channel Thalweg Elevation (ft)**	**Water Surface Elevation (ft)**	**Top of Levee Elevation (ft)**	**Freeboard (ft)**	
				Actual	**Required by FEMA**
Upstream End of SCR-1 Levee					
493+87	117.04	134.75	157.27	22.52	3.50
488+43	114.36	133.39	150.90	17.51	3.00
484+19	112.99	132.73	148.95	16.22	3.00
478+00	112.26	131.68	147.08	15.40	3.00
471+90	111.04	131.16	143.98	12.82	3.00
465+70	108.28	130.62	141.93	11.31	3.00
459+47	106.25	129.55	140.62	11.07	3.00
452+95	105.30	128.87	139.66	10.79	4.00
Los Angeles Avenue (Hwy 118) Bridge					
448+78	103.47	126.78	138.29	11.51	4.00
443+00	102.11	125.39	137.13	11.74	3.00
437+29	101.21	123.22	136.70	13.48	3.00
430+40	98.74	121.27	134.10	12.83	3.00
423+57	97.54	116.38	132.02	15.64	3.00
418+40	96.42	114.29	130.01	15.72	3.00
413+20	94.45	112.06	127.99	15.93	3.00
407+99	93.96	111.00	125.60	14.60	3.00
401+00	92.22	109.85	124.20	14.35	3.00
394+24	91.24	108.64	122.84	14.20	3.00
387+00	88.84	107.71	121.97	14.26	3.00
379+60	87.88	106.78	121.00	14.22	3.00
374+50	86.90	106.23	119.10	12.87	3.00
369+50	85.75	105.31	115.40	10.09	3.00
364+41	84.68	103.83	113.10	9.27	3.00
359+30	83.51	102.23	111.10	8.87	3.00
354+30	82.31	100.72	109.25	8.53	3.00
349+28	81.43	99.46	107.72	8.26	3.00
342+20	80.59	97.44	106.12	8.68	3.00

Table 2 – SCR-1 Levee Freeboard Analysis

HEC-RAS River Station	Channel Thalweg Elevation (ft)	Water Surface Elevation (ft)	Top of Levee Elevation (ft)	Freeboard (ft)	
				Actual	Required by FEMA
335+26	78.60	95.15	103.11	7.96	3.00
330+00	76.72	92.93	100.55	7.62	3.00
324+80	75.21	91.21	98.18	6.97	3.00
319+62	73.41	89.79	96.85	7.06	3.00
314+50	72.89	88.70	95.60	6.90	3.00
309+00	71.63	87.49	93.55	6.06	3.00
303+52	70.44	86.27	91.75	5.48	3.00
296+50	68.95	84.61	89.95	5.34	3.00
289+32	67.13	83.22	87.90	4.68	3.00
282+20	66.10	81.91	87.00	5.09	3.00
275+00	63.38	79.84	85.50	5.66	3.00
269+30	60.92	78.90	84.14	5.24	3.00
263+56	58.29	78.19	82.19	4.00	3.00
257+50	55.48	77.52	82.39	4.87	3.00
251+32	53.37	76.33	79.27	**2.94**	4.00
Downstream End of SCR-1 Levee/Highway 101 Bridge					

Based on Table 2, the computed water surface elevations with respect to the top of levee elevations indicate the top of levee is a minimum of 2.94 feet higher than the 100-year flood event. The levee meets the FEMA freeboard criteria except in the vicinity of the Hwy 101 Bridge. As previously mentioned, in the area within 100 feet of the upstream side of the bridge, the required freeboard is 4 feet; however, the actual calculated freeboard is only 2.94 feet and is therefore deficient in this reach.

Detailed information on the analysis and results are presented in the Hydraulic Analysis Appendix (Appendix D3).

5.2.3 Characterization of the Flood Hazard

Due to the large amount of residential housing communities located in the floodplain behind the levee, the majority of transportation and communication infrastructure has also been located in the floodplain in order to serve the needs of the ever-growing community. If the levee system fails due to a major flood event, it has the potential to severely impact the overall economy of the surrounding communities as well as the County of Ventura.

In general, a major flood event and failure of the levee system would create a wide variety of problems similar to a large, damage-causing earthquake. Transportation routes and utilities would be greatly affected, local first response agencies would be totally overwhelmed, and many personnel may not be able to report for duty due to their location in the floodplain. Health and environmental issues would result due to contaminated floodwaters and wells, hazardous materials released into floodwaters, and even dead animals. Recovery efforts would focus on reopening and/or rebuilding transportation routes, reestablishing essential facilities and governmental services, cleaning debris, cleaning and decontaminating homes and businesses, and reconstruction of the flood control facilities.

5.2.4 Levee Revetment Analysis

A. Levee Revetment Toe-down Depth Evaluation

The levee protection of SCR-1 includes a rock revetment with an average thickness of 18 inches extending from the top of embankment to varying depths. A review of the bed thalweg profiles was conducted to determine if there is adequate toe-down to prevent undermining of the levee protection. The adequacy of levee toe-down was initially assessed based on whether the channel thalweg is below the toe-down depth of the levee rock revetment and the burial depth of the groins. The groins are intended to protect the levee by preventing the migrating channel thalweg from directly impinging against the toe of of the rock revetment. Therefore, the stability of the groins is key to protecting the levee. The current thalweg elevations were compared to the 1971 as-built elevations to determine if the channel thalweg has exhibited a trend toward aggradation or degradation. This determination was made to assess whether a continuation of historic elevation change trends will increase or decrease the potential for failure of the rock revetment by undermining.

Current versus As-Built Streambed (Thalweg) Comparison

An initial assessment of whether the Santa Clara River is aggrading or degrading was performed by comparing the 1971 as-built thalweg elevation and the current thalweg elevation based on 2005 LIDAR information. The historical streambed profiles presented in Appendix D3 show the current thalweg of the Santa Clara River to be approximately 6 feet lower than the 1971 as-built thalweg elevation in the upstream vicinity of Hwy 101 and then matching approximately 2,500 linear feet upstream. The middle reach along SCR-1 has experienced either aggradation or degradation ranging from only 1 to 2 feet. In the upstream reach, from approximately 3,000 linear feet downstream of Hwy 118 to the upstream side of Hwy 118, the current thalweg of the Santa Clara River is approximately 2 to 5 feet lower than the 1971 as-built thalweg elevation. The streambed profiles provided in Appendix D3 also indicates the current channel thalweg and portions of the 1971 as-built channel thalweg to be lower than the groin toe elevations from station 360+00 and upstream toward the end of the levee system.

The changes of the thalweg elevation have occurred locally and not uniformly throughout the entire channel section, and the wide bank-to-bank distance results in insignificant variations of the computed water profiles with similar discharges. The overall reach just upstream of the Hwy 101 Bridge indicates aggradation has occurred, possibly from the constriction at the bridge crossing. Channel thalweg trends between 1949 and 2005, shown from the Stillwater Science report (2007) titled, "*Assessment of Geomorphic Processes for the Santa Clara River Watershed*" also reflects this aggradation.

Levee Revetment Toe-down Depths Conclusion

The streambed profiles, included in Appendix D3, indicate that the channel thalweg is lower than the toe-down of the rock revetment starting at station 335+00 and continuing upstream through the Hwy 118 Bridge (approximately station 441+00). For this portion of the levee, it is critical that the groins are adequate to prevent potential lateral migration of the thalweg from contacting the levee. If the thalweg were to impinge upon the levee, failure of the levee by erosion would be likely since the rock revetment would be undermined. Reviewing the 1971 as-built toe-down of the riverward tips of the groin indicates that between stations 360+00 and 392+00, the burial depth of the groin tips is above the current thalweg location. Therefore, migration of the channel thalweg would result in undermining of these groins and would potentially lead to failure of the levee by erosion. In addition, there are no groins installed between stations 392+00 to 421+00.

Based on a review of the rock revetment toe-downs (designed to prevent erosion of the levee material) and rock groins (designed to prevent migration of the thalweg to the toe of the levee), it was determined that there is insufficient burial depth of both features to prevent the erosion of the levee in the event the channel thalweg migrates toward the levee. This condition exists from stations 360+00 to 421+00. The current position of the thalweg in the downstream portion of the study area as well as review of the historic behavior of the channel indicate that the channel thalweg is active and can migrate sufficiently to threaten these areas of inadequate levee protection. Therefore, the levee is considered deficient because of lack of adequate toe-down for erosion protection. It should be noted, that this conclusion was reached without considering the potential for scour at the tips of the groins or the toe of the levee. Scour would further increase the thalweg depth and may result in additional locations to be considered deficient. Scour is evaluated in a later section.

B. Levee Revetment Rock Size Analysis

On May 6, 2009, Tetra Tech, and their geotechnical sub-consultant AMEC, conducted field reconnaissance and geotechnical investigation along SCR-1. Three test pits were excavated (Figure 7, Appendix D3) after initial field observations indicated the possibility of poor rock revetment gradation. Test pits generally identified that the levee embankment was composed of 2 to 3 feet of rock revetment material overlying fill material. The thickness of the rock revetment material was as much as 4 feet in limited areas. However, the rock revetment materials were generally composed of 8-inch or smaller-sized stone, with some material as much as 24 inches in diameter, infilled with silty sand. Rock revetment material was predominantly comprised of sandstone with lesser amounts of basalt and rhyolite. The underlying levee fill material generally consisted of silty sand, silty sand with gravel, and coarse sand with gravel. The estimated gradation of the three test pits are listed in Table 3. The detailed analysis is presented in Appendix D3.

Table 3 – Test Pit Revetment Rock Gradation

Test Pit	Rock Weight (lbs)				
	490	260	40	5.5	1.5
	Percent Lighter by Weight				
#1	100.0	85.7	68.7	40.5	3.1
#2	100.0	70.6	35.9	13.2	4.1
#3	100.0	49.9	35.1	24.6	1.4

Two representative HEC-RAS sections were selected for rock revetment size analysis. HEC-RAS station 354+30 and station 407+99 were selected based on regions of the high channel flow velocities and for location with respect to the test pits. The average channel hydraulics near the levee toe were computed by HEC-RAS and utilized to determine the required levee rock revetment size. Figures 8 and 9 of Appendix D3 show velocity distributions of these representative sections prepared for the 100-year flood event. From the HEC-RAS velocity distributions, average flow velocities acting on the levee rock revetment were computed to be 10.29 feet per second (fps) and 12.17 fps, and the average hydraulic flow depths were estimated to be 11.40 feet and 11.64 feet for stations 354+30 and 407+99, respectively. The Corp' Channel Protection Design (CHANLPRO) computer program was used to determine the required levee revetment rock size as summarized in Table 4. The resulting required diameter ranges of D_{50} are between 10.5 and 12 inches and 14 and 16 inches computed by the CHANLPRO program for stations 354+30 and 407+99, respectively.

Table 4 – Computed Revetment Rock Gradations

By Weight (lbs)						
HEC-RAS Station	W_{100}		W_{50}		W_{15}	
	Max	Min	Max	Min	Max	Min
354+30	400	160	120	80	60	20
407+99	950	380	280	190	140	60
By Size (in)						
HEC-RAS Station	D_{100}		D_{50}		D_{15}	
	Max	Min	Max	Min	Max	Min
354+30	18.0	13.3	12.0	10.5	9.5	7.1
407+99	24.0	17.7	16.0	14.0	12.7	9.5

The estimated gradation of the rock revetment observed in the field was plotted alongside the gradation calculated by the CHANLPRO program for the two sections (HEC-RAS station 354+30 and station 407+99). Station 354+30 is closest to Test Pits #1 and #2. In general, the large revetment rock, D_{60} and higher, sampled in the field at Test Pits #1 and #2, is heavier than the computed rock weights for the hydraulic conditions at station 354+30. For rock sizes from less than the D_{60} to about the D_{50}, Test Pit #1 material is slightly larger than the lower bound of the calculated rock size envelope. For the D_{50} to the D_{40}, Test Pit #1 material is slightly smaller than the lower bound of the calculated required rock size. For sizes below the D_{40}, Test Pit # 1 material is about 50 percent smaller than the rock required by the lower bound. In contrast, Test Pit #2 sizes remain larger than the upper bound of the required rock size from the D_{100} down to about the D_{20}, where it is equal to the upper bound. The gradation of Test Pit #2 is heavier than the required computed rock size; however, it is poorly distributed and does not fit within the computed gradation envelope as shown in Figure 10 of Appendix D3.

The hydraulics and the associated required rock revetment sizes near Test Pit #3 are best represented by those calculated for station 407+99. The gradation of Test Pit #3 is heavier than the required computed rock size; however, it is poorly distributed and does not fit within the computed gradation envelope as shown on Figure 11 of Appendix D3.

The extent of the levee that would have rock revetment similar to Test Pit #1, based on a visual assessment, is approximately 9,000 linear feet from as-built station 262+00 to station 350+00 (near Central Avenue Drain) and approximately 7,000 linear feet from station 420+00 to station 490+90 (upstream terminus). Based on the visual assessment, the remainder of the levee would have rock revetment similar to Test Pits #2 and #3. Additionally, the poor gradation distribution of the field observed rocks from all the test pits may result in the rock being unable to interlock properly. For the reasons stated above, the current SCR-1 rock revetment is deemed inadequate to provide 100-year flood protection.

C. Groin Rock Size Analysis

The importance of groins, as stated in a previous section, is to deflect the main flows and erosive forces of the river away from the levee embankment. Evaluation of the adequacy of the rock size used to construct the groins was assessed for the levee reach from station 360+00 to Hwy 101 (station 249+37). The as-built groin rock size was compared with the computed required groin rock size based on the river hydraulics. The as-built gradation specification of groin and toe stone is presented in Table 5.

Table 5 – As-built Groin and Toe Stone Gradation Specification

Weight (lbs)	Percent of Total by Weight (%)
1,000 to 400	30
400 to 100	40
100 to 10	20
10 or less	10

Channel hydraulics can vary locally in the proximity of the groins; therefore as an initial test, the average channel hydraulics at HEC-RAS station 354+30 (approximate as-built station 344+65) was used in estimating the required groin rock size. The average channel hydraulic parameters included a flow velocity of 12.88 fps and depth of 11.33 feet. The methods used for sizing rock erosion protection presented in EM 1110-2-1601 (Corps, 1994) were assumed for an initial sizing of the rock required for the groins. These methods are utilized as a comparison and may not be appropriate for design. Future design efforts should consider a more detailed analysis to account for hydraulic variations in the proximity of the groins. The CHANLPRO computer program, based on EM 1110-2-1601, was used to compute the minimum groin rock size (see Table 6). Comparison of computed rock size versus the as-built rock size indicates that the as-built groin rock does not meet the current design criteria, and the groin rocks are predicted to be unable to withstand the average channel hydraulics during a 100-year flood event without accounting for anticipated hydraulic variations in the proximity of the groins (Figure 6, Appendix D3). For example, comparing the required median rock size from the analysis indicates the need for a D_{50} in the range of 270 to 400 lbs. In contrast, the as-built rock gradation indicates a D_{50} of 30 to 200 pounds.

Table 6 – Required Groin Rock Gradations

By Weight (lbs)					
W_{100}		W_{50}		W_{15}	
Max	Min	Max	Min	Max	Min
1,350	540	400	270	200	80
By Size (in)					
D_{100}		D_{50}		D_{15}	
Max	Min	Max	Min	Max	Min
27.0	19.9	18.0	15.8	14.3	10.7

The results of this evaluation are consistent with the observed damage to the groins from the 1969 and early 1980s flood events where river flows came into direct contact with them. The rock groins were likely damaged due to the rock being too small to resist the hydraulics. It is also possible that the rock groins could have been undermined during the peak flows. During peak flows, direct attack from a migrating thalweg can exhibit velocities greater then the channel average further exacerbating the failure potential.

D. Weighted Stone Toe

In addition to the SCR-1 rock revetment and groins, weighted stone toe protection was placed along the levee toe during construction. The levee revetment stone toe has a dual purpose: (1) to anchor the entire levee length of rock revetment from vertical movement, and (2) to act as launching stone to protect the levee from undermining in the event of scour. Procedures for sizing launching stone toe volumes are presented in EM 1110-2-1601 (Corps, 1994). The launch slope for a non-cohesive soil material is assumed to be 2(H):1(V); the thickness after launching is equal to 1.5 times the thickness of the levee rock revetment. Using these assumptions, the volume of stone toe required is equal to 3.35 times the thickness of the levee rock revetment times the estimated historic degradation depth (or depth to the measure channel thalweg from the levee toe-down). Table 7 summarizes the stone toe volume analysis for the reach where current channel thalweg elevation is lower than the groin toe elevation.

Table 7 – Stone Toe Volume Analysis

As-Built Station		Historic Degradation Depth[1] (ft)	Type[2] of Weighted Stone Toe	Required Volume[3] (ft^3/ft)	Available Volume[4] (ft^3/ft)	Deficiency (Yes/No)
Upstream	Downstream					
491+75	470+00	18.18	A	121.78	27.64	Yes
470+00	455+00	18.18	A	121.78	27.64	Yes
455+00	443+00	13.77	A	92.29	27.64	Yes
443+00	442+50	9.37	A	62.80	27.64	Yes
442+50	434+00	6.02	A	40.33	27.64	Yes
434+00	425+00	8.89	A	59.57	27.64	Yes
425+00	399+90	8.89	B	59.57	77.64	No
399+90	391+75	8.89	B	59.57	77.64	No

Table 7 – Stone Toe Volume Analysis

391+75	369+00	13.04	A	87.40	27.64	Yes
369+00	345+00	13.04	A	87.40	27.64	Yes
345+00	335+50	11.00	A	73.71	27.64	Yes

1. Estimated between levee toe-down elevation and current channel thalweg elevation.
2. Stone toe: Type A is an upside-down triangle (base width of 0 ft and top width of 10 feet); Type B is a trapezoid (base width of 10 ft and top width of 30 feet. The height of the toe stone is 5 ft and the side slope is 2(H):1(V).
3. Volume required covering the historic degradation depth with a thickness of 1.5 times the revetment thickness.
4. Available volume based on as-built plan typical section drawings.

The results in Table 7 estimate that the as-built weighted stone toe volume is insufficient, from as-built station 335+50 to station 391+75 and from station 425+00 to station 490+90, to be able to protect the current channel thalweg if it migrated towards the levee, neglecting the influence of scour or future channel degradation.

5.2.5 Sediment / Scour Analysis

Single-event scour is normally computed as the sum of general scour, bed-form depth, low-flow incisement, local scour, and bend scour. Detailed information on the analysis and results are presented in Appendix D3. Table 8 below shows the maximum total scour as computed for the SCR-1 leveed reach.

Table 8 – Total Single Event Scour Summary

Santa Clara River (River Station)	General Scour Depth Zgs (ft)	Bed Form Trough Depth Zbf(ft)	Low-Flow Thalweg Depth, Zlft (ft)	Bend Scour Depth Zbs (ft)	Sum of Components ∑Zi	Total Scour Depth Zt = 1.3∑Zi (ft)
423+57	3.3	4.8	2.00	0.00	10.1	13.1

The total computed maximum potential scour was computed at station 423+57 and considers all components, except local scour, and is estimated to be 10.1 feet. Multiplying by a safety factor of 1.3 increases the total potential scour depth to 13.1 feet for a single 100-year flood event. At and immediately downstream of the Hwy 118 Bridge, an additional local scour (pier scour) depth of 18.3 feet should be included.

These scour estimates are typically used in the initial design of flood control facilities like the SCR-1. As stated in the above ‘Levee Description’ section, SCR-1 was originally designed with 12 feet of rock revetment toe-down below the streambed, which is very close to what has been computed here. As documented in GDM #2 (Corps 1958b) and reflected on the as-built plans, the rock revetment toe-down depths were changed significantly during the design process with the addition of rock groins. As shown on the plan and profile exhibit in Appendix D3, the current rock revetment toe-down only provides 5 to10 feet of scour protection from Hwy 101 to as-built station 335+50 and provides no scour protection from station 335+50 to the upstream terminus of the levee at station 490+93. In addition, the rock groins have been buried to a depth of 10 to

15 feet below the streambed from Hwy 101 to station 330+00, and then the rock groins lose burial depth gradually from 5 feet at station 332+50 to zero at station 358+00. Upstream of station 358+00 to station 470+00, the rock groins would be undermined if the channel thalweg migrated towards the levee without consideration of the total single-event scour.

5.2.6 Capacity Exceedance / Criteria and System Performance

The hydraulic analysis indicates that the base flood cannot be contained between the levees with appropriate freeboard. The base flood has been estimated at 226,000 cfs. The critical location, where adequate freeboard is not available, is upstream of the Hwy 101 Bridge.

5.2.7 Conclusions

Based on the analyses performed in pursuit of compliance with FEMA's regulatory requirements of 44 CFR 65.10, SCR-1 cannot be certified for the 100-year flood event due to the following reasons:

1. In the area within 100 feet upstream of the Hwy 101 Bridge, the required freeboard is 4 feet; however, the actual calculated freeboard is only 2.94 feet and is therefore deficient in this reach.
2. Based on historical aerial photos and lateral migration evaluation, the Santa Clara River has the potential to erode the river bank and expose the rock revetment and groins during a single large flood event.
3. Current channel thalweg elevation is below the levee rock revetment toe-down elevation along the levee from the 1969 levee failure location (in the vicinity of as-built station 330+00) to the upstream end of the levee system (station 490+90).
4. Current channel thalweg elevations are lower than the groin toe elevations from station 360+00 to the upstream end of the levee system (station 490+90).
5. Comparison of computed groin rock size versus the as-built groin rock size indicates the as-built groin rock does not meet the current design criteria for rock sufficiently sized to withstand the predicted hydraulic forces during a 100-year event. The results of this evaluation are consistent with the observed damage to the groins from the 1969 and early 1980s flood events where river flows came into direct contact with the groins and caused portions of the groins to fail.
6. Three test pits were dug to test the rock revetment along the levee sides slopes. Hydraulic calculations were also performed to identify the gradation of the rock required to protect the side slopes in these locations during the 100-year event. The results indicated that the lower portion of the rock gradation, D_{40} and finer, at Test Pit #1 is smaller than the lower bound of the required rock size. The extent of the levee that would have rock revetment similar to the undersized rock from Test Pit #1, based on a visual assessment, is approximately 9,000 linear feet from as-built station 262+00 to station 350+00 (near Central Avenue Drain) and approximately 7,000 linear feet from station 420+00 to station 490+90 (upstream terminus). Based on the visual assessment, the remainder of the levee would have rock revetment similar to Test Pits #2 and #3, which have poorly distributed gradations. Additionally, the poor gradation distribution of the field observed

rocks from all the test pits may result in the rock being unable to interlock properly.

7. The as-built weighted stone toe volume is insufficient by a factor of 3, from as-built station 335+50 to station 391+75, to be able to protect the current scour depth if the channel thalweg migrated towards the levee.
8. The rock groins were intended to prevent the channel from migrating against the levee side slopes. As a result of the groin placement, and the design intent of preventing the channel thalweg from contacting the levee slope, the levee slope protection toe-down was not designed for the condition of the channel thalweg impinging on the levee toe. However, the rock groins are not adequate to prevent the migration of the channel for two reasons:
    a. The rock groins are undersized to withstand the hydraulic forces of the 100-year flood event.
    b. The rock groins for much of their length are not buried sufficiently to prevent failure due to undermining.
9. Since the rock groins are insufficient to prevent migration of the channel thalweg against the levee side slope, the levee, to remain stable, must resist the hydraulic forces and scour that would occur with the thalweg against the toe of the levee. However, the levee protection is not adequate to resist the resulting forces and scour for several reasons:
    a. The estimated maximum potential total scour depth of 13.1 feet below the existing channel thalweg during a 100-year flood would undercut the entire levee rock revetment toe-down.
    b. The additional volume of material placed as the weighted stone toe is insufficient to launch and protect the levee against the current scour depth from the toe-down.
    c. Based on three test pits, the size of the riprap blanket on the levee side slope is suspect in terms of its size at some locations and quality of the gradation at others.
10. The inadequacy of the current configuration of levee protection has been demonstrated by past failures of the system. The levee failed in the 1969 floods with a peak discharge of 165,000 cfs, which is only 73 percent of the 100-year discharge of 226,000 cfs that is required for certification.

5.3 Structural Evaluation

Because of other issues identified that prevent levee certification, no structural evaluation was performed to determine if levee certification criteria would be met.

5.4 Geotechnical Evaluation

Because of other issues identified that prevent levee certification, no geotechnical evaluation was performed to determine if levee certification criteria would be met.

5.5 Electrical and Mechanical

Neither electrical nor mechanical components of the interior drainage system are located within the SCR-1 system. Therefore, no additional analysis would be required for this process.

5.6 Operation and Maintenance Manual

An Operation and Maintenance (O&M) Manual has been prepared for SCR-1 by the Corps. This manual specifies the policies and procedures with regard to the operation and maintenance of this particular facility. This manual was developed to meet the requirements of Section 65.10 of the National Flood Insurance Program (NFIP) regulations. Essential instructions are provided in detail to ensure proper operation and maintenance of this flood control facility to ensure that their overall integrity and functionality during flood events are sustained.

The Manual includes discussion of the following:

- Operation: Guidance and direction on operation of the levees during and following flood events.
- Maintenance and Inspection: Recommended maintenance measures and inspection requirements.
- Inspection Reports: Reporting requirements and forms to be used.

6.0 SYSTEM EVALUATION

Because of other issues identified that prevent levee certification, no system evaluation was performed for this levee.

7.0 RESIDUAL RISK AND PUBLIC SAFETY

7.1 Emergency Response Plan and Status

Appendix F, Watershed Protection Emergency Procedures, of Ventura County’s Integrated Emergency Procedures Manual will be adopted as the Emergency Response Plan for the levees within the County. The manual specifies procedures and guidance on flood-fighting activities during different phases of storm emergencies based on the severity of the storm events. Per the manual, upon receipt of advance information indicating possibility of disaster or emergency (i.e. reports of approaching major storms, seismic sea waves, or possible earthquakes), Division Heads and Deputies will keep the Director of Public Works and their immediate subordinates informed through daily telephone contacts. In flood emergencies, the primary agency responsibility and command rests with the Director of Public Works. Based on the direction of the Director, a flood threat and warning will be disseminated to the Watch Commander of the Sheriff’s Department. Evacuation of the residents and coordination for housing and feeding of evacuees will be directed and conducted by the Sheriff’s Department in coordination with the Director of Public Social Services and representatives of the American Red Cross. The Engineer Manager, Watershed Protection District Operations and Maintenance, is designated Department of Operations Center (D.O.C.) for emergencies. During flood emergencies, the D.O.C.

Commander is charged with the responsibility of planning and directing the mobilization and utilization of the total resources of the Department to minimize flood damage.

APPENDIX A

Site Evaluation Report

Ventura County
Watershed Protection District

FEMA Levee Certification

Ventura County, California

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Evaluation Report

February 13, 2009

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FEMA Levee Certification
Ventura County, California

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Evaluation Report

February 2009

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Ventura County
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Executive Summary

As nation-wide efforts to certify all the existing flood control levees, FEMA has identified existing levee facilities within Ventura County. As part of this effort FEMA has requested the Ventura County Watershed Protection District (District) to evaluate the Santa Clara River Levee (SCR-1) and prepare documents for the certification process based on FEMA's regulatory requirements as identified in Title 44 of the Code of Federal Regulations (CFR), Section 65.10 (44 CFR 65.10).

Certification Criteria are as follows:

- Design criteria (freeboard, closures, embankment protection, embankment and foundation stability, settlement, and interior drainage)
- Operation plans and criteria (for closures and interior drainage)
- Maintenance plans and criteria
- Actual certification requirements (i.e. as-builts, forms, documentation, and data)

As part of the Phase 1 process, Tetra Tech was contracted by the District to evaluate the SCR-1 levee system and to recommend a levee categorization to facilitate the levee certification.

Levee Categorizations are as follows:

- Category 1 – Levees meet 44 CFR 65.10 requirements and all data or complete documentation is available
- Category 2 – Levees may meet 44 CFR 65.10, but additional data or documentation is needed
- Category 3 – Levees do not currently meet 44 CFR 65.10
- Not a Levee – Based on physical conditions, low WSEL, no SFHA, and/or not providing flood protection

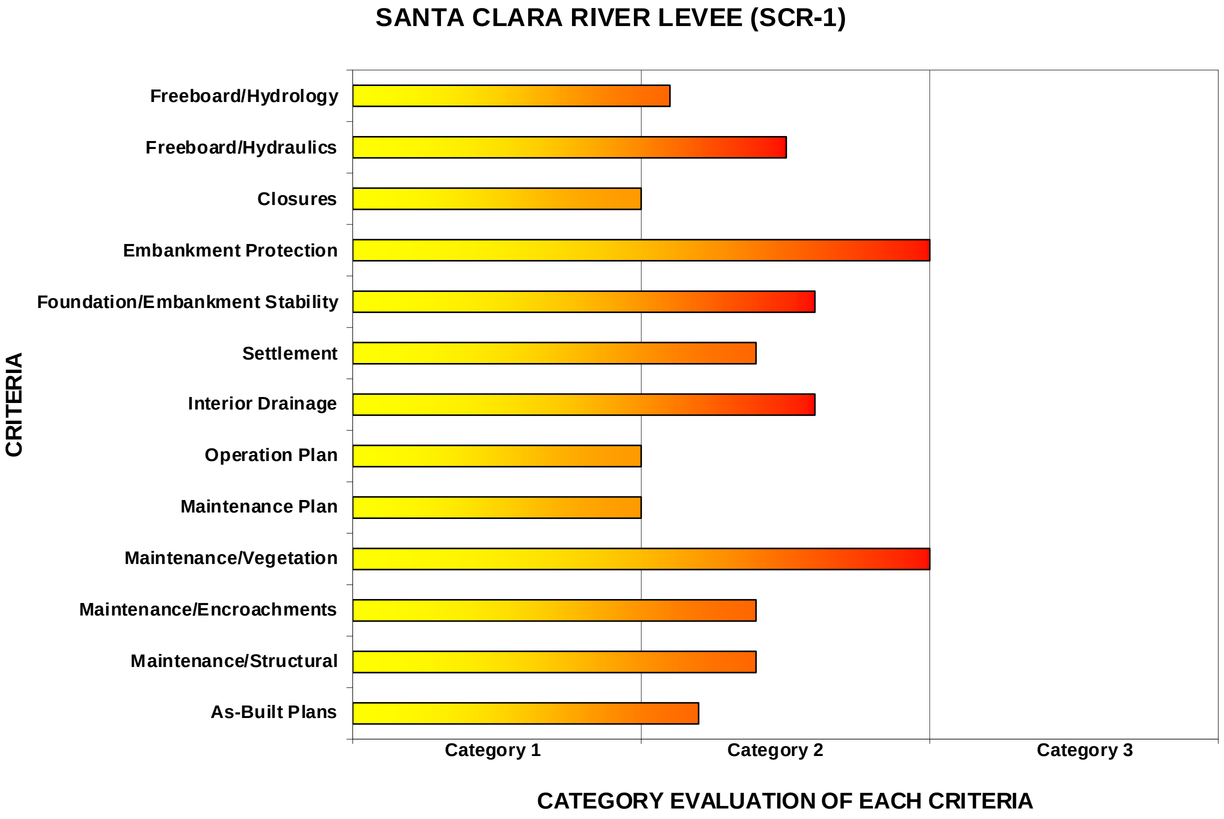
A levee that is assigned a Category 1 or 2 ratings will be further evaluated in the Phase 2 or 3 processes, respectively, in order to finalize its certification status. A levee that is assigned a Category 3 rating will require a Pre-Design Study in the Phase 4 process and implementation of the required improvements to achieve certification status.

Data collection efforts have been performed to determine what information is available in support of levee certification. Existing information collected and reviewed at the time of preparation of this report includes the following:

- Hydrologic Analysis
- LiDAR Topographic data
- As-built Plans
- Operation and Maintenance Manual
- Inspection/Maintenance Records

A field investigation conducted in early December identified several maintenance issues that will need to be addressed prior to levee certification. Additional field investigations to obtain geotechnical data and additional engineering analyses to support certification requirements will be required to complete levee certification. The specifics of the work required are discussed in this report.

The graphic presented below identifies the extent of work to be accomplished related to each criterion for levee certification. The longer the task bar the more work required to complete certification. This is a subjective analysis that can be best used to compare the relative amount of work required for all the levees being considered as part of the Levee Certification program within Ventura County. The extent of work required can also be used to categorize the levee. The longest task bar determines the recommended categorization of the levee.



Based on the review of existing data and observations from the field investigation, it is recommended that the SCR-1 levee system be classified as a Category 2 Levee. The suggested critical path to achieve levee certification for the SCR-1 levee system is outlined in Section F Recommendation.

FEMA Levee Certification

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Evaluation Report

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EXHIBITS

A) Introduction

The Santa Clara River Levee (VCWPD ID No: SCR-1) is located in the City of Oxnard in Ventura County. The location of the levee system is from the Highway 101 to Saticoy and is shown on Figure 1. The SCR-1 levee system is located along the left side of the Santa Clara River. The levee system consists of embankment levee with loose rock revetment, rock groins, and side drainage penetrations. The protective works of the Santa Clara River Levee were designed to provide protection from the 1-percent-annual-chance discharge (base flood) in conformance with FEMA required freeboard and other regulations. The levee system is intended to protect existing commercial, industrial, agricultural, and potentially developable property in low lying areas within the base flood floodplain of the Santa Clara River Watershed.

The levee system begins at Highway 101 in Ventura County and continues upstream to South Mountain. The length of the levee along the Santa Clara River is approximately 4.73 miles, with an embankment height varying between 2 feet to 15 feet above natural ground on the landward side. The levee’s earthen berm is protected by loose riprap and grouted riprap with an access road that runs along the top which is approximately 18 feet wide.

For purposes of the NFIP, FEMA will only recognize in its flood hazard and risk mapping effort those levee systems that meet, and continue to meet, minimum design, operation, and maintenance standards that are consistent with the level of protection sought through the comprehensive floodplain management criteria established by Section 60.3 of the NFIP regulations. Section 65.10 of the NFIP regulations describes the types of information FEMA needs to recognize, on NFIP maps, that a levee system provides protection from the flood that has a 1-percent chance of being equaled or exceeded in any given year (base flood). This information must be supplied to FEMA by the community or other party seeking recognition of a levee system at the time a study or restudy is conducted, when a map revision under the provisions of Part 65 of the NFIP regulations is sought based on a levee system, and upon request by the Administrator during the review of previously recognized structures. The FEMA review is for the sole purpose of establishing appropriate risk zone determinations for NFIP maps and does not constitute a determination by FEMA as to how a structure or system will perform in a flood event. (FEMA, 2007a)

B) Design Criteria

For the purposes of the NFIP, FEMA has established levee design criteria for freeboard, closures, embankment protection, embankment and foundation stability, settlement, interior drainage, and other design criteria. These criteria are summarized in subsections below.

B.1) Freeboard

Section 65.10(b)(1) of the NFIP regulations identifies a minimum freeboard requirement of 3 feet along river levees with an additional 0.5 feet required at the upstream limit of the levee and an additional 1.0 foot on both sides of structures (such as bridges). Freeboard is determined by comparing the 100-year water surface elevation with the top of levee elevation. The water surface elevation is derived from hydrologic and hydraulic analyses.

The discharge frequency values presented in the December 2006 Ventura County Watershed Protection District report (VCWPD) entitled “Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line” are directly usable for Santa Clara River and Sespe

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Figure 1 – Location Map

Creek levee certification purposes. This report was developed through a collaborative effort among hydrologic engineering staff at VCWPD, Corps of Engineers (Los Angeles District), and Los Angeles County Department of Public Works. The study results are current in that flow data through water year 2005 was used in the hydrologic analysis, and there have been no flood events in the interim that are large enough to significantly alter the discharge frequency values in the report. Water Resource Council Bulletin #17B discharge frequency procedures were applied as prescribed by FEMA guidelines as the basis for the hydrologic analysis.

An issue has been raised regarding the use of a discharge frequency value transfer function on the Santa Clara River between the Montalvo gage and the SCR-1 levee. Proposed revisions would result in a lower discharge than what has currently been published by FEMA. The recommendation for the levee evaluation is to use the higher discharge. If the criteria are met for the higher discharge they would be met for the lower discharge. If the criteria are not met with the higher discharge this issue would be revisited during the analysis process.

There will be a need to generate baseflood hydrographs for geotechnical evaluation of levee stability considering seepage therefore a volume duration frequency analysis will need to be performed. Baseflood hydrographs would be generated using a “balanced hydrograph” approach in which the baseflood hydrograph would be consistent with respect to volume duration frequency relationships for the Santa Clara River levee. A pattern hydrograph based on either a hypothetical flood event such as Standard Project Flood or a large historical flood event would be used to shape the baseflood hydrographs.

The current FEMA FIS hydraulic model for the Santa Clara River is available. The current FEMA FIS hydraulic model will be useful as a base model to develop the freeboard analysis. In addition, the existing topographic information may need to be verified with a survey due to vegetation that may have created inaccuracies in the LiDAR data.

In addition sedimentation and scour analyses will need to be performed to support the freeboard analysis and embankment stability analysis.

B.2) Closures

Section 65.10(b)(2) of the NFIP regulations requires that all openings be provided with closure devices that are structural parts of the system.

Review of the as-built plans and results from the field investigation (Field Investigation Report included as Exhibit 1) indicate that the system includes a stop log system at Stroube Drain that acts as a closure. The stop log structure includes aluminum beams that are stored at the Districts maintenance yard (SOY) for installation during flooding conditions.

Documentation of this structure is required as part of the certification.

B.3) Embankment Protection

Section 65.10(b)(3) of the NFIP regulations requires that engineering analyses be submitted that demonstrate that no appreciable erosion of the levee embankment can be expected during the 100-year flood.

Data needed to perform this analysis includes results from the hydraulic analysis, scour analysis, as-built plans, and field verification of the existing embankment protection. The hydraulic analysis and scour analysis would be developed as part of the freeboard assessment. As-built plans are available and field verification has been completed.

A preliminary evaluation of the levee system's current top, toe, toedown and river thalweg has been prepared and is presented in Exhibit 2.

Field investigations have identified several locations where the levee embankment has been impacted and requires restoration/mitigation. The existing rock revetment is of several different types (sandstone/igneous/conglomerate) of rock and a lot of it is desiccated and broken down into smaller pieces along the entire length of the levee. The ability of this rock revetment to provide the appropriate level of protection is questionable and will be determined in this analysis.

B.4) Embankment and Foundation Stability

Section 65.10(b)(4) of the NFIP regulations requires that engineering analyses be submitted that evaluate the levee embankment stability. Borings of the levee are required to support this analysis.

Test pit and boring logs from the original levee design are available for review. These include a total of about 32 exploration points with laboratory testing. Available data includes Standard Penetration Test (SPT) blow counts, in-situ moisture contents, and the results of soil classification testing. Several Corps reports are available for review. A Corps report dated November 1958 provides basic soil engineering properties for compacted fill and foundation material. The report also provides gradation requirements for revetment stone and groin stone. However, no information regarding the original geotechnical design, such as seepage or slope stability evaluations, is available.

The rip-rap over a significant portion of the levee riverside was observed to be either missing or buried under soil and/or construction debris. In addition, a large portion of the rip-rap material did not appear to meet the requirements for rip-rap with regard to rock size and soundness.

Further analysis and evaluations would include the following:

- Geotechnical borings for determining existing geologic conditions, obtaining geologic samples, and performing in-situ permeability testing.
- Test pits for evaluation of rip-rap conditions.
- Laboratory testing consisting of soil classification, shear strength, and permeability.
- Seepage analyses.
- Slope stability analyses.

B.5) Settlement

Section 65.10(b)(5) of the NFIP regulations requires that engineering analyses be submitted that assess the potential and magnitude of future losses of freeboard as a result of levee settlement.

The referenced geotechnical information did not address settlement of the levee. As of January 22, 2009, no geotechnical design or construction information regarding settlement potential has been made available for review.

During field inspections, no obvious evidence of adverse settlement was observed.

Further analysis and evaluations would include the following:

- Geotechnical borings for determining existing geologic conditions, obtaining geologic samples, and performing in-situ permeability testing.
- Laboratory testing to evaluate consolidation potential.
- Analyses of potential long term settlement and seismic deformation.

B.6) Interior Drainage

Section 65.10(b)(6) of the NFIP regulations requires that an analysis be submitted that indentifies the sources, extent, and depth of interior flooding.

Interior drainage analyses would be required at all storm drain penetrations. Based on the field investigation and review of the as-built plans, there are 8 storm drain penetrations through the levee. All storm drains have flap gates with the exception of two locations at Side Drain 1A and a 12” metal pipe commercial drain (possibly abandoned). GPS locations and descriptions for each are included in Table 1 of the field investigation report included as Exhibit 1. Photographs of the outlets are also included in the report. For storm drains that continue underground into the City of Oxnard, additional documents will be required including the master plan of drainage to develop the interior drainage analyses.

C) Operation Plans and Criteria

Section 65.10(c) of the NFIP regulations requires submittal of appropriate documentation of the operation of the system.

An operation plan exists that is in use for this levee. For certification this operation plan will need to be updated to meet the NFIP requirements including the attachment of the County’s Flood Warning System and Emergency Response Plan. The operation plan will need to include the procedures for operating the entire system including the stop log structure as well as the interior drainage system.

D) Maintenance Plans and Criteria

Section 65.10(d) of the NFIP regulations requires submittal of appropriate documentation for the maintenance of the system.

A maintenance plan exists that is in use for this levee. For certification this maintenance plan will need to be updated to meet the NFIP requirements.

The field investigation report included as Exhibit 1 documents maintenance issues that were identified during the field investigation. Those issues are summarized in Table 2 of that report. The District has been unable to implement certain maintenance improvements due to permitting and environmental constraints. However these locations need to be repaired or remediated in order for the levee system to meet the levee certification criteria set by USACE and FEMA and to be fully operational. Table 2 also provides possible repair or remediation actions for the locations along with the GPS points. Photos taken at the maintenance required locations are included in Appendix C of the report. Major maintenance issues are related to vegetation and debris removal, power pole relocation, buried groin exposure, inoperable storm drain flap gates due to sediment deposition, sloughing embankment protection, and levee erosion due to runoff, pedestrian and vehicle traffic.

E) Certification Requirements

Section 65.10(e) of the NFIP regulations requires that in addition to the above-described analyses, certified as-built plans of the levee must be submitted.

Most as-built plans obtained through data collection efforts have appropriate approvals to be used for certification however there are some outstanding as-built documents that still need to be obtained to complete the analysis and certification process. A list of the as-built plans and their status for this project is presented in Exhibit 3.

A complete system and structural evaluation should be performed as part of the certification. This analysis will address some concerns identified in the field investigation including spalling at concrete structures.

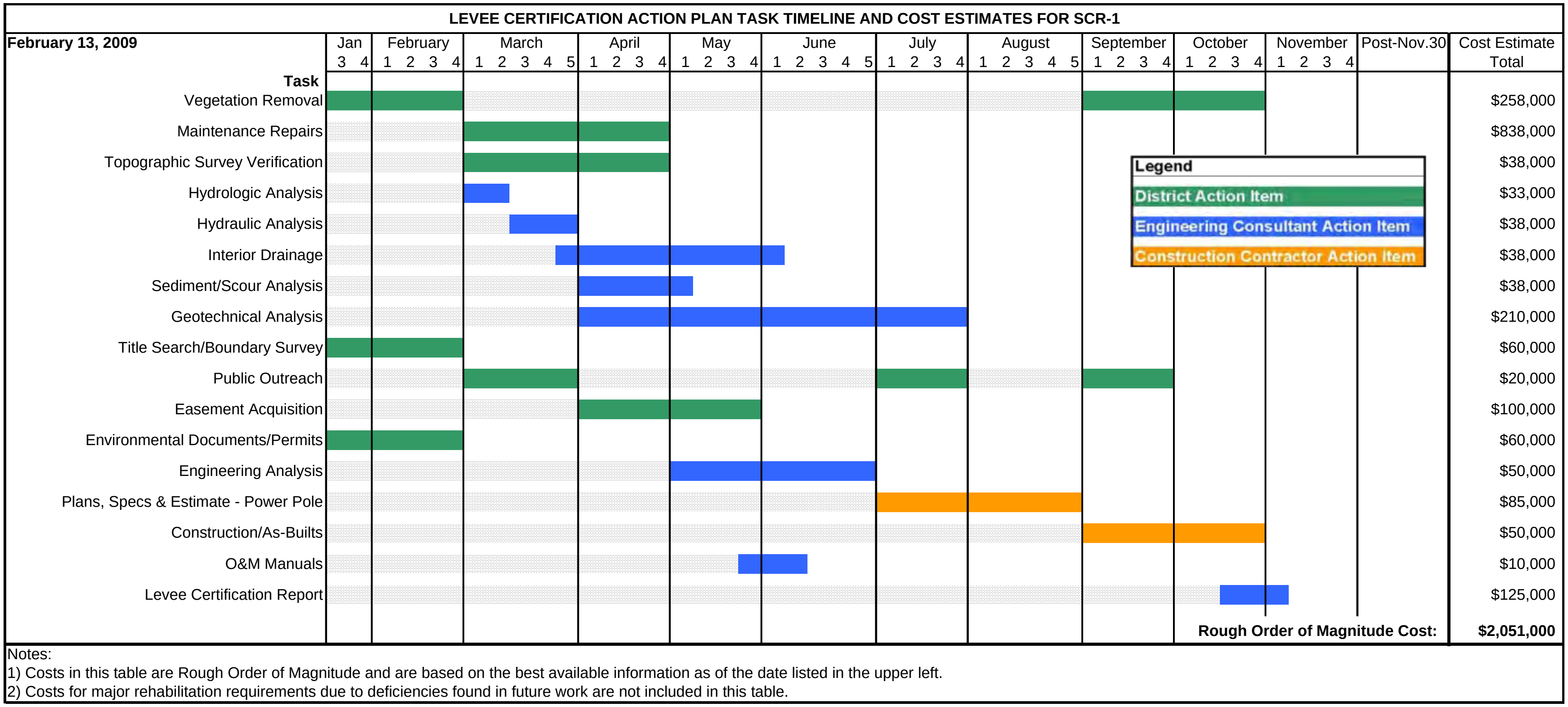
Additional work to complete this task includes preparation of a Levee Certification Report that includes all analyses to meet the Section 65.10 NFIP requirements as well as the FEMA MT-2 application package.

F) Recommendation

The field investigation identified several critical issues that must be resolved prior to certification. The most significant issues are unwanted vegetation along the landward side levee toe, possible power pole relocation, exposure of buried groins due to river erosion, inoperable storm drain flap gates due to sediment deposition, and levee erosion due to runoff, pedestrian, and vehicle traffic. Other issues that require major attention are debris removal throughout the levee and sloughing embankment protection. Engineering analyses will also need to be performed to verify that this levee meets the NFIP Section 65.10 requirements. Based on the review of existing data and observations from the field investigation, it is recommended that the SCR-1 levee system be classified as a Category 2 Levee.

The suggested critical path to achieve levee certification for the SCR-1 levee system is outlined below and a tentative schedule of actions is shown on Figure 2.

- Vegetation Removal
- Maintenance Repairs
- Topographic Survey
- H&H Analyses/Interior Drainage
- Sediment/Scour Analyses
- Geotechnical Field Investigation and Analyses
- Title Search and Boundary Survey
- Public Outreach/Workshop
- Easement Acquisition (if needed)
- Environmental Documents/Permits
- Engineering Analysis and Design
- Plans, Specifications and Estimate
- Construction/As-builts
- Operation and Maintenance Manuals
- Levee Certification Report



LEVEE CERTIFICATION ACTION PLAN TASK TIMELINE AND COST ESTIMATES FOR SCR-1

February 13, 2009	Jan		February				March					April				May				June					July				August					September				October				November				Post-Nov.30	Cost Estimate Total
Task	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2	3	4	1	2	3	4	1	2	3	4		
Vegetation Removal	🟩	🟩	🟩	🟩	🟩	🟩																												🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩						$258,000
Maintenance Repairs							🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																$838,000
Topographic Survey Verification							🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																																$38,000
Hydrologic Analysis							🟦	🟦																																							$33,000
Hydraulic Analysis									🟦	🟦	🟦																																				$38,000
Interior Drainage											🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																											$38,000
Sediment/Scour Analysis												🟦	🟦	🟦	🟦	🟦																															$38,000
Geotechnical Analysis												🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																			$210,000
Title Search/Boundary Survey	🟩	🟩	🟩	🟩	🟩	🟩																																									$60,000
Public Outreach							🟩	🟩	🟩	🟩	🟩														🟩	🟩	🟩	🟩						🟩	🟩	🟩	🟩										$20,000
Easement Acquisition												🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																												$100,000
Environmental Documents/Permits	🟩	🟩	🟩	🟩	🟩	🟩																																									$60,000
Engineering Analysis																🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦																							$50,000
Plans, Specs & Estimate - Power Pole																									🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧														$85,000
Construction/As-Builts																																		🟧	🟧	🟧	🟧	🟧	🟧	🟧	🟧						$50,000
O&M Manuals																			🟦	🟦	🟦																										$10,000
Levee Certification Report																																								🟦	🟦	🟦					$125,000
Rough Order of Magnitude Cost:																																															**$2,051,000**

Legend
- 🟩 District Action Item
- 🟦 Engineering Consultant Action Item
- 🟧 Construction Contractor Action Item

Notes:
1) Costs in this table are Rough Order of Magnitude and are based on the best available information as of the date listed in the upper left.
2) Costs for major rehabilitation requirements due to deficiencies found in future work are not included in this table.

Figure 2 – Tentative Schedule of Actions

G) References

FEMA. 2005a. *Title 44 of the Code of Federal Regulations (CFR), Section 65.10 (44 CFR 65.10),* Federal Emergency Management Agency.

FEMA. 2005b. *Procedural Memorandum 34 – Interim Guidance for Studies Including Levees,* Federal Emergency Management Agency.

FEMA. 2007a. *Fact Sheet Requirements of 44 CFR, Section 65.10 Mapping of Areas Protected by Levee Systems,* Federal Emergency Management Agency.

FEMA. 2007b. *Revised Procedural Memorandum 43 – Guidelines for Identifying Provisionally Accredited Levees,* Federal Emergency Management Agency.

Tetra Tech. 2008. *Santa Clara River Levee (SCR-1) Highway 101 to Saticoy, Field Investigation Report.* Prepared for the Ventura County Watershed Protection District, Ventura, California.

U.S. Army Corps of Engineers. 2006. *Levee Owner's Manual for Non-Federal Flood Control Works*. Prepared for the Rehabilitation and Inspection Program, Public Law 84-99.

U.S. Army Corps of Engineers. 2008. *EC 1110-2-6067 - Certification of Levee Systems for the National Flood Insurance Program (NFIP).*

Ventura County Watershed Protection District. 2006. *Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line.*

Ventura County Watershed Protection District. 2007. *Santa Clara River Levee, Highway 101 to Saticoy, Operation and Maintenance Manual.*

Exhibit 1

Field Investigation Report

Ventura County
Watershed Protection District

FEMA Levee Certification

Ventura County, California

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Field Investigation Report

February 13, 2009

TETRA TECH, INC.
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FEMA Levee Certification
Ventura County, California

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Field Investigation Report
February 2009

Prepared for:

Ventura County
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FEMA Levee Certification

Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Field Investigation Report

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Santa Clara River Levee (SCR-1)
Highway 101 to Saticoy

Field Investigation Report

Introduction

Santa Clara River Levee (VCWPD ID No: SCR-1) is located between Highway 101 and Saticoy in the City of Oxnard, Ventura County. The location of the levee system is shown on Figure 1.

As part of the FEMA levee certification process, field investigations of the Santa Clara River Levee (SCR-1) were conducted on December 8-10, 2008. The team included representatives from the Ventura County Watershed Protection District (District), Tetra Tech, and AMEC. The investigation was conducted by walking the entire length of the levee system while visually assessing the existing conditions of the flood protection elements. The visual assessment included thirteen (13) different evaluation items such as unwanted vegetation growth, signs of depression/rutting and erosion/bank caving, slope stabilities, penetration, etc. The description of these 13 items can be found in the Levee Inspection Log (Appendix A). Separate inspection logs were completed by Tetra Tech and AMEC at the end of the field visit. The log in Appendix A is a team log that comprises the assessments from the individual inspection logs.

Any notable findings and existing conditions of the levee during the walk were documented with photos and their geo-referenced locations were recorded with a GPS unit. Photos taken during the field investigation along with maps showing their location are presented in Appendix B and Appendix C.

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Figure 1 – Location Map

General Descriptions

- The levee system is located along the left side of the Santa Clara River. The levee system consists of embankment levees and side drainage penetrations.
- The protective works of the Santa Clara River levee were designed to provide protection from the 1-percent-annual-chance discharge (base flood) in conformance with FEMA required freeboard and other regulations.
- The levee system begins at the Hwy 101 Bridge and extends 4.73 miles upstream of the Santa Clara River.
- The FIRM dated October 31, 1985 shows containment of Zone A.
- The levee system is intended to protect existing residential, commercial, industrial, or potentially developable property in low lying areas within the base flood floodplain of the Santa Clara River Watershed.
- The levee’s earthen berm is protected by ungrouted riprap and the access road that runs along the top is approximately 18 feet wide.
- The height of the embankment ranges from 4 feet to 13 feet above the existing ground surface.

General Field Observations

a) Riverward side of Levee:

1. Removal of sediment that has accumulated in most pipe penetrations/ structures is required to allow drainage and proper operation of the closure devices (flap gates).
2. Restoration of top and embankment is required in certain locations due to unauthorized vehicle ramps, off-road vehicle rutting, rock revetment sloughing, and runoff erosion.
3. Rock revetment is of several different types (sandstone/igneous/ conglomerate) of rock and a lot of it is desiccated and broken down into smaller pieces along entire length of the levee. The ability of this rock revetment to provide the appropriate level of protection is questionable.
4. Restoration of top and embankment is required in extensive stretches of the levee due to unauthorized dumping/washing out of concrete trucks obscuring any observation of rip-rap.
5. Restoration of top and embankment is required due to unauthorized dumping of large quantity of material on the levee adjacent to the concrete plant obscuring any observation of rip-rap.
6. Downstream buried groins near Hwy 101 have been exposed and are actively washing away. This erosion is within 200 feet of the levee embankment. Some

of the river erosion has a 20-25 ft deep cut that is tending towards the levee embankment.

7. Removal of one tree within 15 feet of levee toe is required at downstream end near Hwy 101. Also mowing of the other vegetation within the 15 feet of the levee toe to a height less then 12-inches is required. (Approximately 900 lf).

b) Landward side of Levee:

1. The stop logs for the Stroube Drain outlet are not on-site. County personnel stated that the stop logs are at the Saticoy maintenance yard and are transported to the site during events that require their installation. The stop logs and their installation procedures need to be verified.
2. There has been a lot of dumped stone, debris and random soil along the toe and beyond along the levee. In some locations the toe goes right up to the fence leaving no room for maintenance.
3. Restoration of top and embankment is required in certain locations due to unauthorized vehicle ramps, off-road vehicle rutting, and runoff erosion.
4. Restoration of top and embankment is required due to unauthorized dumping of large quantity of material on the levee adjacent to the concrete plant.
5. Removal and relocation of a utility pole and guy-wire anchors within the levee embankment prism must be relocated.
6. Removal of vegetation (trees and shrubs) within 15 feet of levee toe is required between Central Ave Drain and concrete plant (approximately 75-100 large trees).
7. The quarry pits along the levee are quite deep and will require geotechnical consideration for seepage and deep stability.
8. Removal of vegetation (trees and shrubs) within 15 feet of levee toe is required between the Nursery and South Mountain (approximately 25 large trees).
9. Multiple animal burrows were observed in the field.

Levee Penetrations

Levee closure of the Santa Clara River Levee (SCR-1) system during storm events must consider the existing storm drain outlets and the existing stop log structure. The storm drain outlets should include closure devices at the end of each storm drain penetration. The Stroube Drain stop log structure includes aluminum beams located at the Saticoy maintenance yard for installation during flooding conditions. A summary of levee system penetrations is presented in Table 1.

Table 1 – Summary of Levee Penetration

River Station	GPS		*Photo No.	Description
	Lat	Long		
Santa Clara River Levee (SCR-1)				
491+45	N34.28293	W119.12251	P1	Side Drain 1-A, 4' x 4' x 23.5' R.C.B located at upstream end of levee
480+00	N34.28128	W119.12649	P2	Side Drain No. 1, 42" RCP and flap gate (on landward side)
442+00	N34.27578	W119.13717	P3	Side Drain No. 2, 48" RCP and flap gate (on landward side) located just U/S of Los Angeles Ave.
422+25	NA	NA		Commercial drain from asphalt plant (not found in December 9, 2008 field inspection)
410+60	N34.27117	W119.14602	P4	Side Drain No. 3, 48" RCP and flap gate (on landward side)
385+77	N34.26742	W119.15291	P5	12" metal pipe commercial drain from process plant
351+50 (+/-)	N34.26138	W119.16201	P6	Central Avenue Drain, 2-72" RCP with flap gates
316+60	N34.25530	W119.17042	P7	Side Drain No. 4, 48" RCP and flap gate (on landward side)
282+00	N34.24892	W119.17903	P8	Side Drain No. 6, 48" RCP and flap gate (on landward side)
246+20	N34.24340	W119.18577	P9, P10	Stroube Drain – Unit I, Stop Log Structure & 10'W x 8'H RCB

* Photos can be found in Appendix B.

Maintenance Required Locations

During the field inspection, locations where maintenance is required were documented and are summarized in Table 2. The District has been unable to implement certain maintenance improvements due to permitting and environmental constraints. However these locations need to be repaired or remediated in order for the levee system to meet the levee certification criteria set by USACE and FEMA and to be fully operational. Table 2 also provides possible repair or remediation actions for the locations along with the GPS points. Photos taken at the maintenance required locations are included in Appendix C.

Inspection Conclusion

Once maintenance at the locations identified in Table 2 are complete, the field inspection of the levee system indicates that the Santa Clara River Levee (SCR-1) system may be certified as providing base flood protection if all other criteria are satisfied. Some maintenance improvements may require additional engineering analyses, design, construction and preparation of as-constructed documents.

Table 2 – Summary of Maintenance Required Locations

GPS		*Photo No.	Description	Action Required
Lat	Long			
Santa Clara River Levee (SCR-1)				
N34.28292	W119.12323	M1, M2	Damaged concrete on Side Drain 1A headwall with rebar exposed (riverward side)	Repair the concrete headwall of outlet structure
N34.28300	W119.12337	M3	Sediment spoils (riverward side)	Remove spoils from levee
N34.28128	W119.12649	M4, M5	Sediment deposition in Side Drain No. 1, 42” RCP inlet and outlet. Flap gate is stuck open by debris and sediment	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)
N34.27899	W119.13102	M6, M7	Wood debris (riverward side)	Remove debris from the levee
N34.27848	W119.13181	M8, M9	Broken stone revetment (riverward side)	Stone revetment may need to be repaired, additional engineering analysis is recommended
N34.27828	W119.13232	M10	Animal burrows at levee toe (riverward side)	Fill voids with impervious material and firmly compact
N34.27513	W119.13823	M11, M12	Levee embankment erosion (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.27498	W119.13871	M13	Concrete debris has been spread over levee embankment (riverward side)	Remove unauthorized concrete cover from levee embankment
N34.27418	W119.14011	M14	A low point along top of levee causing concentrated flow and surface erosion on levee embankment (riverward side)	Regrade top of levee to meet design profile of top of levee. Fill embankment voids with impervious material and firmly compact
N34.27306	W119.14247	M15, M16, M17	Levee embankment erosion (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.27202	W119.14444	M18	Levee embankment erosion caused by vehicles (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.27188	W119.14478	M19	Broken stone revetment (riverward side)	Stone revetment may need to be repaired, additional engineering analysis is recommended
N34.27117	W119.14602	M20	Sediment deposition in Side Drain No. 3, 48” RCP outlet (riverward side)	Remove sediment and establish a clear passage from pipe to channel

GPS		*Photo No.	Description	Action Required
Lat	Long			
Santa Clara River Levee (SCR-1)				
N34.27086	W119.14668	M21	Broken stone revetment (riverward side)	Additional engineering analysis is recommended
N34.26952	W119.14963	M22, M23	Erosion on top of levee caused by vehicular traffic (landward side)	Reestablish top of levee to meet design elevations
N34.26663	W119.15408	M24	Levee embankment erosion caused by vehicular traffic (riverward side)	Reestablish levee revetment with design specifications. Fill voids with impervious material and firmly compact
N34.26585	W119.15552	M25	Broken stone revetment (riverward side)	Additional engineering analysis is recommended
N34.26352	W119.15907	M26	Broken concrete pipe debris along levee toe (riverward side)	Remove unauthorized concrete pipe debris from levee embankment
N34.25950	W119.16435	M27	Unauthorized ramp on levee (riverward side)	Remove unauthorized earthen ramp
N34.25604	W119.16931	M28	Debris stock piles along levee toe (riverward side)	Remove unauthorized debris stockpiles from levee toe
N34.25530	W119.17042	M29	Sediment deposition in Side Drain No. 6, 48” RCP outlet (riverward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)
N34.25059	W119.17676	M30	Unauthorized ramp on levee	Remove unauthorized debris stockpiles from levee toe
N34.24912	W119.17862	M31	Sloughing levee embankment protection (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.24892	W119.17903	M32	Sediment deposition in Side Drain No. 4, 48” RCP outlet (riverward side)	Remove sediment and establish a clear passage from pipe to channel (riverward & landward sides)
N34.24664	W119.18184	M33, M34	Tip of buried groin is exposed and sink holes are present in soil covering groins (riverward side)	Repair sinkholes and fill voids with impervious material and firmly compact. (Safety Hazard) Additional engineering analysis is recommended for exposed groins
N34.24605	W119.18254	M35, M36	Tip of buried groin is exposed and sink holes are present in soil covering groins (riverward side)	Repair sinkholes and fill voids with impervious material and firmly compact. (Safety Hazard) Additional engineering analysis is recommended for exposed groins

GPS		*Photo No.	Description	Action Required
Lat	Long			
Santa Clara River Levee (SCR-1)				
N34.24565	W119.18301	M37	Tip of buried groin is exposed (riverward side)	Additional engineering analysis is recommended for exposed groins
N34.24565	W119.18301	M38	Unauthorized ramp with missing levee embankment protection (riverward side)	Remove unauthorized earthen ramp and reestablish levee embankment and embankment protection
N34.24491	W119.18396	M39	Concrete washout poured over rock protection down to Highway 101 (riverward side)	Remove unauthorized concrete cover from levee embankment
N34.24425	W119.18471	M40	Dumped concrete debris, unauthorized PVC pipe in levee embankment (riverward side)	Remove unauthorized debris and PVC pipe
N34.24297	W119.18643	M41	Vegetation and irrigation lines within 15-feet of levee toe (riverward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact. Remove Irrigation lines.
N34.24326	W119.18564	M42	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.24414	W119.18459	M43	PVC pipe protruding from top of levee (landward side)	Remove unauthorized PVC pipe and fill voids with impervious material and firmly compact
N34.24687	W119.18124	M44	Erosion on top of levee exposing fence posts (landward side)	Reestablish top of levee and fill voids with impervious material and firmly compact
N34.24687	W119.18124	M45	Stone debris approximately 500-feet along levee toe (landward side)	Remove unauthorized stone debris from levee toe
N34.24735	W119.18062	M46	Erosion on top of levee (landward side)	Reestablish top of levee and fill voids with impervious material and firmly compact
N34.24851	W119.17918	M47, M48	Dumped stone and debris approximately 100-feet along the levee (landward side)	Remove unauthorized stone debris from levee toe
N34.24878	W119.17883	M49, M50	Sediment deposition in Side Drain No. 4, 48” RCP inlet structure (landward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)
N34.25935	W119.16430	M51, M52	Erosion on levee embankment (landward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.26012	W119.16325	M53	Animal burrows near top of levee (landward side)	Remove animal burrows, fill voids with impervious material and firmly compact

GPS		*Photo No.	Description	Action Required
Lat	Long			
Santa Clara River Levee (SCR-1)				
N34.26130	W119.16144	M54	Tree within 15' of levee toe (landward side)	Remove tree and root ball, fill voids with impervious material and firmly compact.
N34.26134	W119.16139	M55, M56	Trees within 15' along levee toe (landward side)	Remove trees and root ball, fill voids with impervious material and firmly compact.
N34.26134	W119.16139	M57, M58	Power poles within 15' of levee toe (landward side)	Relocation not required.
N34.26303	W119.15904	M59	Tree within 15' of levee toe (landward side)	Remove trees and root ball, fill voids with impervious material and firmly compact.
N34.26435	W119.15715	M60	Trees, stumps within 15' of levee toe approximately 1,000' along levee toe (landward side)	Remove trees and root ball, fill voids with impervious material and firmly compact
N34.26498	W119.15623	M62	Utility pole and guy wires anchored into embankment (landward side)	Utility poles within levee embankment prism must be relocated.
N34.26498	W119.15623	M61, M63, M64	Fallen trees on levee embankment (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.26918	W119.14969	M65	Trees and fallen trees within 15' along levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.26929	W119.14954	M66	Erosion on top of levee caused by vehicles (landward side)	Reestablish top of levee and fill voids with impervious material and firmly compact
N34.26933	W119.14939	M67	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.27027 to N34.27071	W119.14750 to W119.14673	M68	Vegetation within 15-feet of levee toe approximately 150-feet along levee (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.27071 to N34.27100	W119.14673 to W119.14609	M69	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.27100	W119.14609	M70	Animal burrow on top of levee (landward side)	Remove animal burrows, fill voids with impervious material and firmly compact

GPS		*Photo No.	Description	Action Required
Lat	Long			
Santa Clara River Levee (SCR-1)				
N34.27111	W119.14593	M71	Sediment deposition and metal debris Side Drain No. 3 in 48" RCP inlet (landward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)
N34.27286	W119.14245	M72	Erosion on levee embankment (landward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.27448	W119.13939	M73	Erosion on levee embankment (landward side	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.27545	W119.13752	M74	Erosion caused by vehicles under Los Angeles bridge crossing (landward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact
N34.27564	W119.13711	M75, M76	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.27638	W119.13571	M77	Erosion at top of levee with miscellaneous debris at toe (landward side)	Repair erosion and remove miscellaneous debris
N34.27671	W119.13503	M78	Animal burrows at top of levee (landward side)	Remove animal burrows, fill voids with impervious material and firmly compact
N34.27997 to N34.28052	W119.12884 to W119.12786	M79	Trees within 15-feet of levee toe, approximately 200-feet along levee (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.28123	W119.12643	M80	Sediment deposition and debris in Side Drain No. 1, 42" RCP inlet invert (landward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)
N34.28123 to N34.28155	W119.12643 to W119.12585	M81	Vegetation within 15-feet of toe, approximately 1,200-feet along levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.28220 to N34.28283	W119.12463 to W119.12341	M82	Vegetation within 15-feet of toe, approximately 400-feet along levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.
N34.28246	W119.12401	M83	Animal burrow at toe of levee	Remove animal burrow, fill voids with impervious material and firmly compact

Appendix A

Levee Inspection Log

Levee Inspection Log

Facility Name/ID: SCR-1
Watercourse: Santa Clara River
Reach: Hwy 101 to South Mountain

Date: December 8-10, 2008
By: Ike Pace, Michael Chung (Tt), Doug Dahncke, Bijan Farahani (AMEC), & Bill DuFrain (VCWPD)

RATED ITEM	A	M	U	N/A		EVALUATION	LOCATIONS / REMARKS / RECOMMENDATIONS
1. Unwanted Vegetation Growth					A	The levee has a good grass cover with little or no unwanted vegetation (trees, bushes, or undesirable weeds) and has been recently mowed. Except in those cases where a vegetation variance has been granted by the Corps, a 15' zone, free from all woody vegetation, is maintained adjacent to the landward/riverside toe of the FCW for maintenance and flood-fighting activities. Additionally, a 3' root free zone is maintained to protect the external limits of the levee cross section. Reference EM 110-2-301 and/or local Corps policy.	Removal of vegetation (trees and shrubs) on levee embankment and within 15 feet of the toes is required in various locations. Remove vegetation and root ball, fill voids with impervious material and firmly compact.
					M	Minimal number of trees (2" diameter or smaller) and /or brush present on the levee or within the 15' zone, that will not threaten the integrity of the project but which need to be removed.	
			X		U	Tree, weed, and brush cover exists in the FCW requiring removal to reestablish or ascertain FCW integrity. (Note: if significant growth on levees exists, prohibiting the inspection of animal burrows or other inspection items, then the levee inspection should be ended until this item is corrected.)	
2. Depressions /Rutting					A	There are no ruts, pot holes, or other depressions on the levee. No evidence of levee settlement. The levee crown, embankments, and access road crowns are well established and drain properly without any ponded water.	Re-establishment of top of levee is required at depression in access road near sta. 398+35. Fill depression with suitable material and firmly compact.
					M	Some minor depressions in the levee crown, embankment, or access roads that will not pond water and do not threaten the integrity of the levee.	
			X		U	There are depressions greater than 6 inches deep that will pond water, endangering the integrity of the levee.	
3. Erosion / Bank Caving					A	No active erosion, undermining, or bank caving due to riverbed degradation or flow impingement, observed on the landward or on the riverward side of the levee.	Restoration of top and embankments is required in various locations along the entire length of levee due to unauthorized vehicle ramps, off-road vehicle rutting, rock revetment sloughing, and runoff erosion.
					M	There are areas where active erosion is occurring or has occurred on or near the levee embankment, but levee integrity is not threatened.	
			X		U	Erosion, undermining, or caving is occurring or has occurred along the toes that threatens the stability and integrity of the levee. The erosion or caving has progressed into the levee section or into the extended footprint of the levee foundation and has compromised the levee foundation stability.	
4. Surficial Slope Stability					A	No slides present.	
		X			M	Minor superficial sliding that with deferred repairs will not pose an immediate threat to FCW integrity.	
					U	Surficial instabilities that will require more than typical or periodic repair and that threatens FCW integrity. Repairs are required to reestablish FCW integrity.	
5. Deep Seated Slope Stability	X				A	No slides present.	
					M	Signs of deep seated instability can not be determined from site assessment or evidence may or may not be an indicator of deep seated stability. .	
					U	Evidence of deep seated sliding that threatens FCW integrity. Repairs are required to reestablish FCW integrity.	
6. Cracking	X				A	No cracking observed on the levee greater than 6 inches deep.	
					M	Longitudinal and/or transverse cracking greater than 6 inches deep. No evidence of vertical movement along the crack.	
					U	Longitudinal and/or transverse cracking present and exhibits signs of vertical movement.	
7. Animal Burrows					A	No animal burrows present on the levees.	Multiple animal burrows were observed in the field. Fill voids
					M	Several animal burrows present which may lead to seepage or slope stability problems, and they require immediate attention.	

RATED ITEM	A	M	U	N/A		EVALUATION	LOCATIONS / REMARKS / RECOMMENDATIONS
			X		U	Significant maintenance is required to fill existing burrows, and the levee will not provide reliable flood protection until this maintenance is complete.	with suitable material and firmly compact.
8. Encroachments					A	No trash, debris, excavations, structures, adverse sediment accumulation, or other obstructions present within the project easement area.	There has been extensive dumping of stone, debris and random soil along the landward side toe and beyond along the levee.
					M	Trash, debris, excavations, structures, adverse sediment accumulation, or other obstructions present, or inappropriate activities that will not inhibit project operations and maintenance or emergency operations.	
			X		U	Trash, debris, excavations, structures, adverse sediment accumulation, or other obstructions present, or inappropriate activities that will inhibit project operations and maintenance or emergency operations.	
9. Revetments & Banks					A	Existing revetment protection is properly maintained and is undamaged. Revetment protection clearly visible and revetment materials are of sound quality.	Rock revetment is of several different types. Some of the rock revetment is broken down into smaller pieces along entire length of the levee. Additional engineering analyses are recommended. Observation of extensive stretches of the levee was obscured due to unauthorized dumping/ debris/ washing out of concrete trucks.
					M	No revetment displacement or scouring activity that could undercut banks, erode embankments, or restrict desired flow. Unwanted vegetation must be cleared and sprayed with an appropriate herbicide.	
			X		U	Dense brush, trees, or grasses hide the revetment protection or meandering and/or scour activity is undercutting banks, eroding embankments, or impairing channel flows by causing turbulence or shoaling.	
					N/A	There is no revetment protecting the levee.	
10. Closure Structures (Stop Log, Earthen Closures, or Gates)					A	Closure structure in good repair. Placing equipment, stoplogs, and other materials are readily available at all times. Components of closure clearly marked and installation instructions/procedures readily available.	The stop logs for the Stroube Drain outlet are not on-site.
			X		U	Closure structure in poor condition. Parts missing or corroded. Placing equipment may not be available within normal warning time.	
					N/A	There are no closure structures along the levee.	
11. Underseepage Relief Wells / Toe Drainage Systems					A	Toe drainage systems and pressure relief wells necessary for maintaining FCW stability during flood events functioned properly during the last flood event and no sediment is observed in horizontal system (if applicable). No signs of adverse seepage conditions adjacent to or within the levees. Nothing is observed which would indicate that the system won't function properly during the next flood.	
					M	Toe drainage systems or pressure relief wells are damaged and may become clogged if they are not repaired. Signs of adverse seepage such as sand boils, spring lines, vegetation change or other seepage indicators are present but do not directly affect the stability of the levee.	
					U	Toe drainage systems or pressure relief wells necessary for maintaining FCW stability during flood events have fallen into disrepair or have become clogged. Signs of adverse seepage such as sand boils, spring lines, vegetation change or other seepage indicators are present and directly affect the stability of the levee.	
				X	N/A	There are no relief wells/toe drainage systems along the levee.	
12 Maintenance and Emergency Access					A	Maintenance/emergency accesses are clear of obstructions and in good condition.	For certain stretches of the landward side toe the fence is located at the toe leaving no room for maintenance along the toe.
		X			M	Minor obstructions and/or damages to the maintenance/emergency access are present, but would not directly affect the accessibility of the levee..	
					U	Numerous obstructions and/or damages to the maintenance/emergency access are present that would directly affect the accessibility of the levee.	
13. Deviation from As-Built Plans					A	There are no deviations from the as-built plans.	
					M	There are minor deviations from the as-built plans that would not affect the functionality of the levee.	
			X		U	There are major deviations from the as-built plans that could affect the functionality of the levee. Additional engineering analyses are recommended.	

Key: A = Acceptable. M = Minimally Acceptable; Maintenance is required. U = Unacceptable. N/A = Not Applicable. RODI =Requires Operation during Inspection.

Appendix B

Photos of Penetrations and Typical Levee Features

Appendix B – Locations of Levee Photos for Santa Clara River Levee (SCR-1)

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Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P1 – Side drain 1-A, 4’ x 4’ R.C.B located at upstream end of levee (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P3) – Side Drain No. 2, 48” RCP located just U/S of L.A. Ave. (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P2) – Side Drain No. 1, 42” RCP (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P4) – Side Drain No. 3, 48” RCP (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P5) – 12" metal pipe, commercial drain from process plant (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy. (*Photo No. P7) – Side Drain No. 4, 48" RCP (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P6) – Central Avenue Drain, 2-72" RCP with flap gates (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P8) – Side Drain No. 6, 48" RCP

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P9) – Stroube Drain – Unit I, Stop Log Structure looking downstream

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. F1) – 20’ -25’ high erosion cut eroding towards levee, looking d/s (riverward)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. P10) – Stroube Drain – Unit I, 10’Wx8’H RCB looking upstream

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. F2) – 20’ -25’ high erosion cut eroding towards levee, looking u/s (riverward)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. F3) – Erosion cut eroding towards levee exposing groins, looking d/s (riverward)

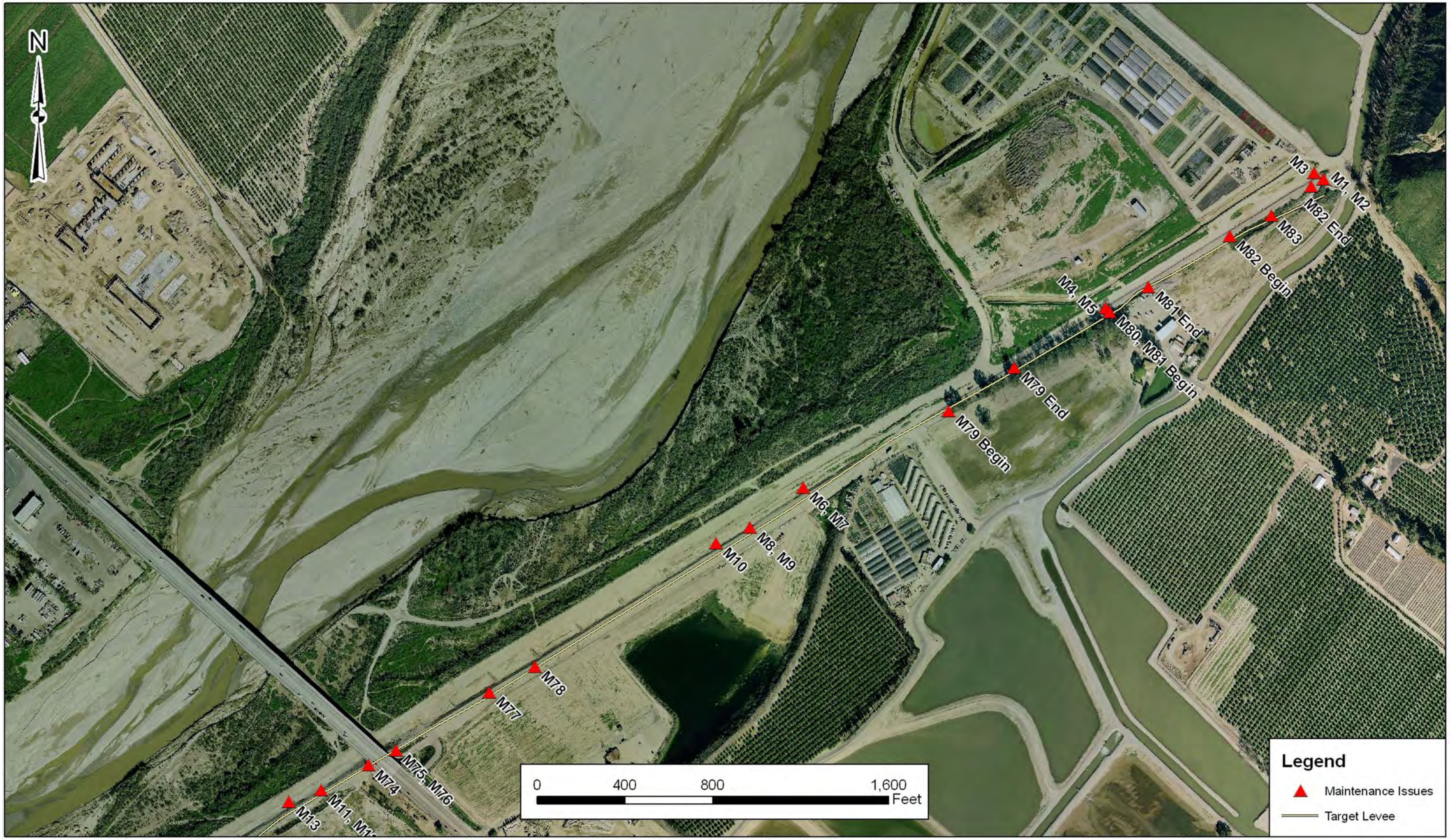
Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. F5) – Levee bank stone protection, two different types of stone (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. F4) – Erosion cut eroding towards levee exposing groins, looking u/s (riverward)

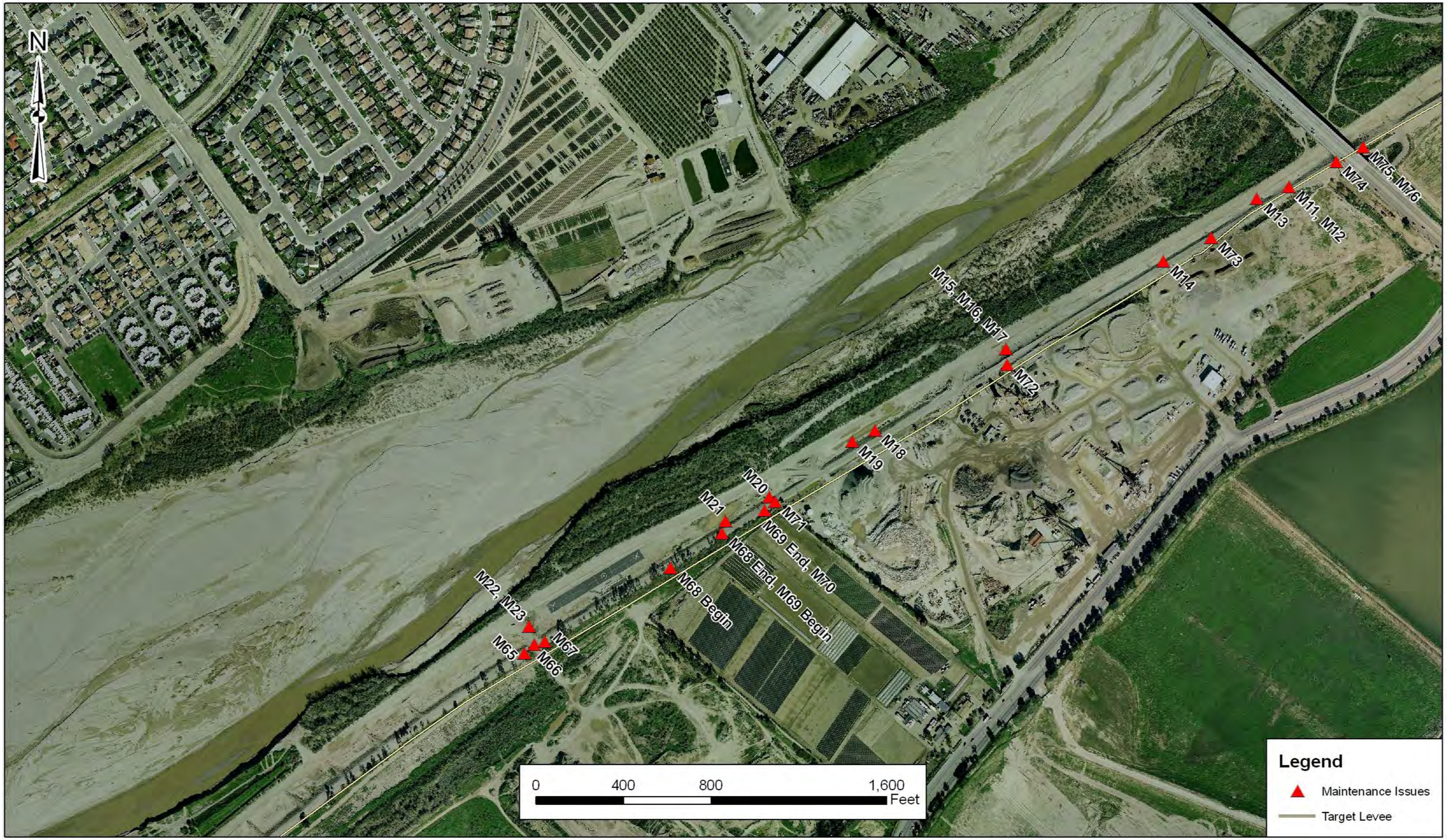
Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. F6) – Groin and levee embankment, looking downstream (riverward side)

Appendix C

Photos for Maintenance Required Locations



Appendix C – Locations of Photos at the Maintenance-Required Sites for Santa Clara River Levee (SCR-1)



Appendix C – Locations of Photos at the Maintenance-Required Sites for Santa Clara River Levee (SCR-1)

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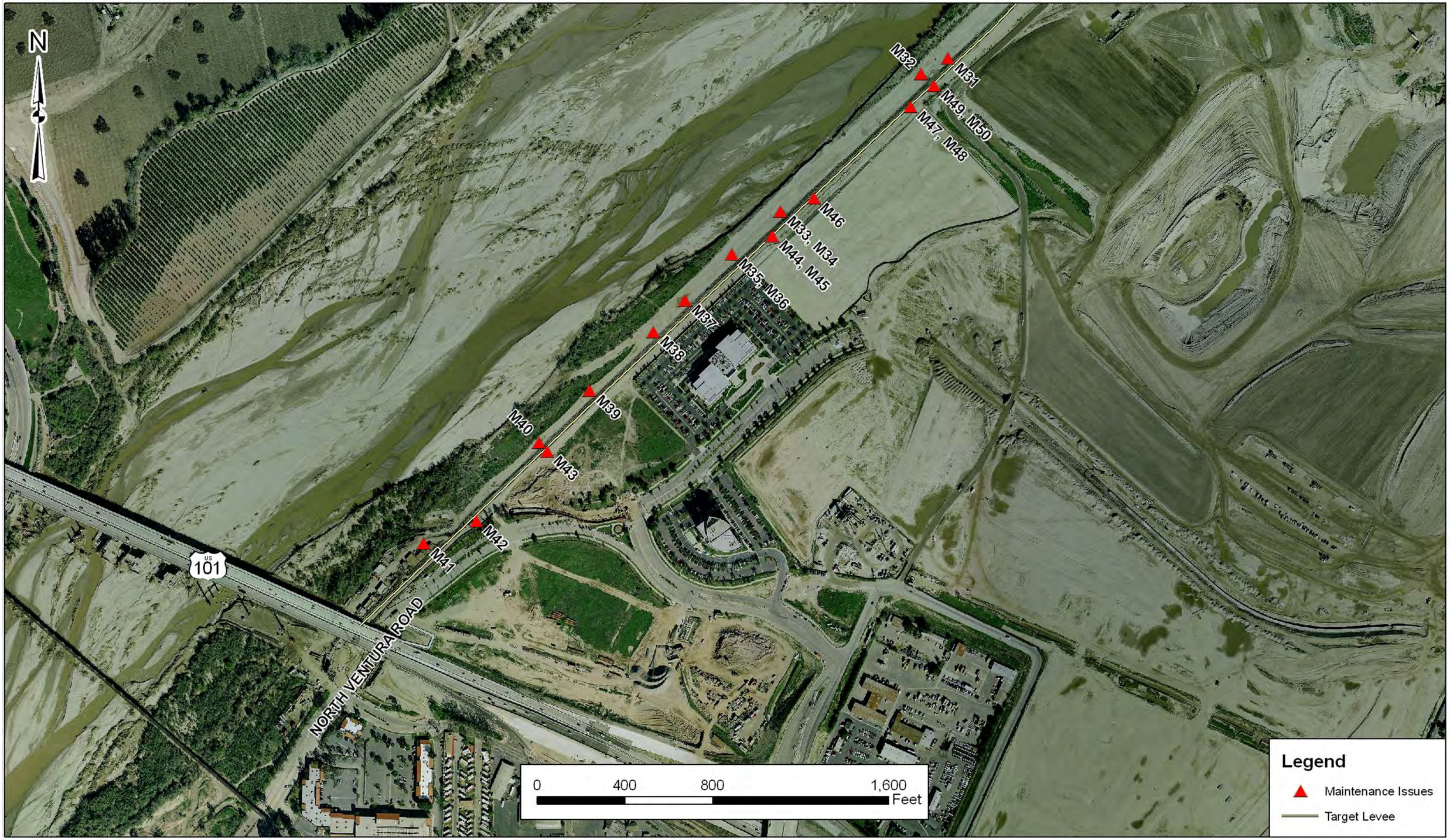


Appendix C – Locations of Photos at the Maintenance-Required Sites for Santa Clara River Levee (SCR-1)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M1) – Damaged concrete on Side Drain 1A headwall with rebar exposed

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M3) – Sediment spoils, upstream end of levee (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M2) – Detail of damaged concrete headwall & exposed rebar (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M4) – Sediment deposition in Side Drain No. 1, 42" RCP outlet (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M5) – Sediment deposition in Side Drain No. 1, 42" RCP inlet (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M7) – Wood debris adjacent to nursery looking upstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M6) – Wood debris adjacent to nursery looking upstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M8) – Broken stone revetment (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M9) – Broken stone revetment (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M11) – Erosion of levee embankment (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M10) – Animal burrows at levee toe (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M12) – Erosion of levee embankment just downstream of L.A. Ave.(riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M13) – Concrete spread over levee embankment, looking d/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M15) – Erosion of levee embankment, looking upstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M14) – Erosion on levee embankment, looking d/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M16) – Erosion of levee embankment, adjacent to asphalt plant (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M17) – Erosion of levee embankment, adjacent to asphalt plant (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M19) – Broken stone revetment (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M18) – Levee embankment erosion caused by vehicles (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M20) – Sediment deposition in Side Drain No. 3, 48" RCP outlet (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M21) – Broken stone revetment (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M23) – Erosion on top of levee caused by vehicles, looking d/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M22) – Erosion on top of levee caused by vehicles (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M24) – Levee embankment erosion caused by vehicles (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M25) – Broken stone revetment (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M27) – Unauthorized ramp on levee (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M26) – Concrete pipe debris along levee toe, looking d/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M28) – Debris along levee toe, looking downstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M29) – Sediment deposition in Side Drain No. 6, 48" RCP outlet (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M31) – Sloughing levee embankment protection (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M30) – Unauthorized ramp on levee (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M32) – Sediment deposition in Side Drain No. 4, 48" RCP outlet (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M33) – Exposure of tip of buried groin looking downstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M35) – Exposure of tip of buried groin looking downstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy.* (Photo No. M34) – Sink hole in soil covering buried groins looking down/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M36) – Sink hole in soil covering buried groins (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M37) – Exposure of tip of buried groin, looking upstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M39) – Concrete washout poured over rock protection, looking d/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M38) – Unauthorized ramp with missing levee embankment protection (riverward)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M40) – Dumped concrete debris at levee toe (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M41) – Vegetation within 15’ levee toe, looking d/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M43) – PVC pipe protruding from levee (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*. (Photo No. M42) – Vegetation within 15-feet of levee toe looking d/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M44) – Erosion on top of levee exposing fence posts, looking d/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M45) – Stone debris approx. 500’ along levee toe, looking u/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Satico*,. (Photo No. M47) – Debris approx. 100’ along levee, looking u/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M46) – Erosion on top of levee, looking downstream (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M48) – Debris approx. 100’ along levee, looking u/s (riverward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy,* (Photo No. M49) – Sediment deposition in Side Drain No. 4, 48” RCP invert (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy,* (Photo No. M51) – Erosion on levee embankment, looking upstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy,* (Photo No. M50) – Looking down at sediment in SD No. 4, inlet structure (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy,* (Photo No. M52) – Erosion on levee embankment, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M53) – Animal burrows at top of levee (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M55) – Trees within 15’ of levee toe, looking downstream (landward side)

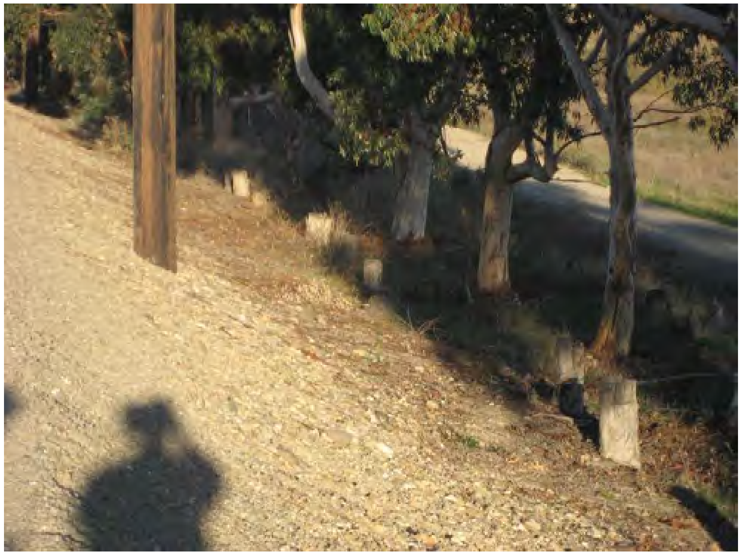
Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M54) – Tree within 15’ of levee toe, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M56) – Trees within 15’ of levee toe, looking upstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M57) – Power poles within 15’ of levee toe, looking upstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M59) – Trees within 15’ of levee toe, looking u/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M58) – Power poles within 15’ of levee toe, looking upstream (landward side)



Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M60) – Trees, power poles & stumps within 15’ of toe, looking u/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M61) – Power poles on levee embankment, looking upstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M63) – Power poles guy wires anchored in levee bank, looking d/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M62) – Power poles on levee embankment, looking upstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M64) – Fallen trees and vegetation on levee bank, looking u/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M65) – Trees and fallen trees within 15’ of levee toe, looking u/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M67) – Vegetation within 15-feet of levee toe, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M66) – Erosion on top of levee caused by vehicles, looking S/E (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M68) – Vegetation within 15-feet of levee toe, looking d/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M69) – Vegetation within 15-feet of levee toe, looking u/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M71) – Sediment & metal debris in Side Drain No. 3 inlet (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M70) – Animal burrow on top of levee (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M72) – Erosion on levee embankment, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M73) – Erosion on levee embankment, looking upstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M75) – Vegetation within 15-feet of levee toe, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M74) – Erosion caused by vehicles under L.A. Ave. Bridge (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M76) – Vegetation within 15-feet of levee toe, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M77) – Erosion at top of levee with debris at toe, looking d/s (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M79) – Trees within 15-feet of levee toe, looking downstream (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M78) – Animal burrows at top of levee (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M80) – Sediment and debris in Side Drain No.1, 42” RCP inlet (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M81) – Vegetation within 15-feet of levee toe, looking upstream (landward side)

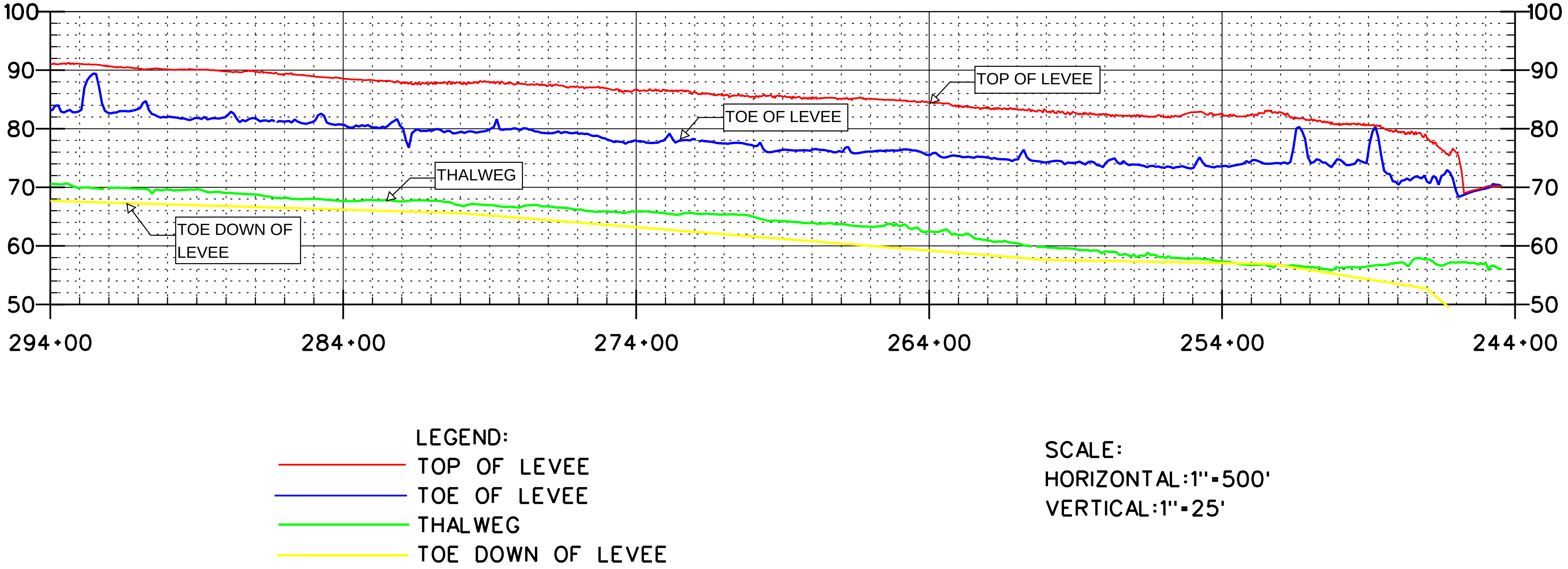
Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M83) – Animal burrows at levee toe (landward side)

Santa Clara River Levee, *From Hwy 101 to Saticoy*, (Photo No. M82) – Vegetation within 15-feet of levee toe, looking downstream (landward side)

Exhibit 2

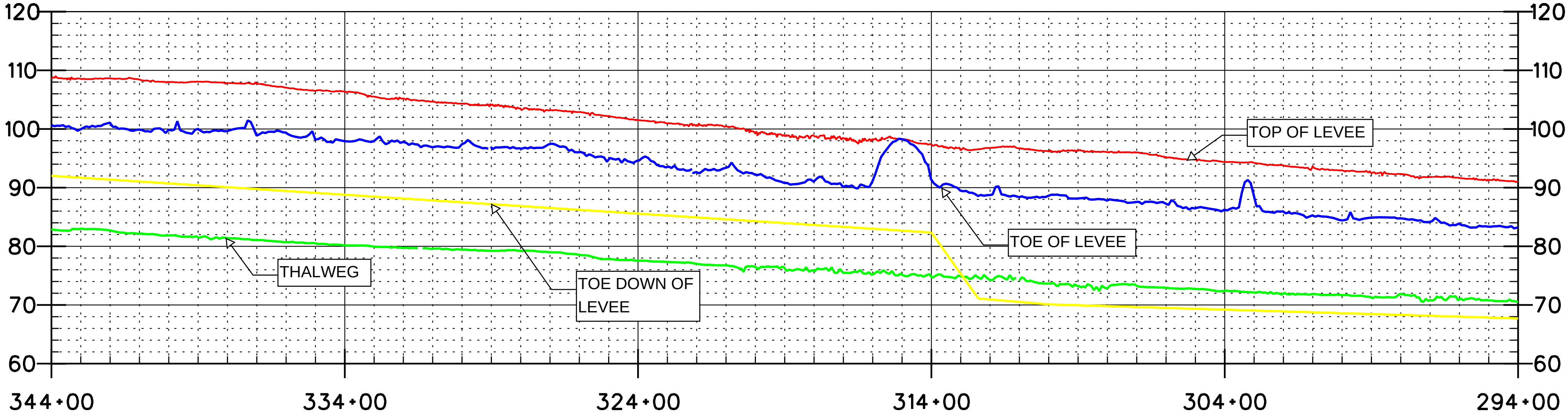
Preliminary Evaluation of Levee System Profiles

SANTA CLARA RIVER (SCR-1)
STATION 244+46 TO 294+00



SCALE:
HORIZONTAL:1"=500'
VERTICAL:1"=25'

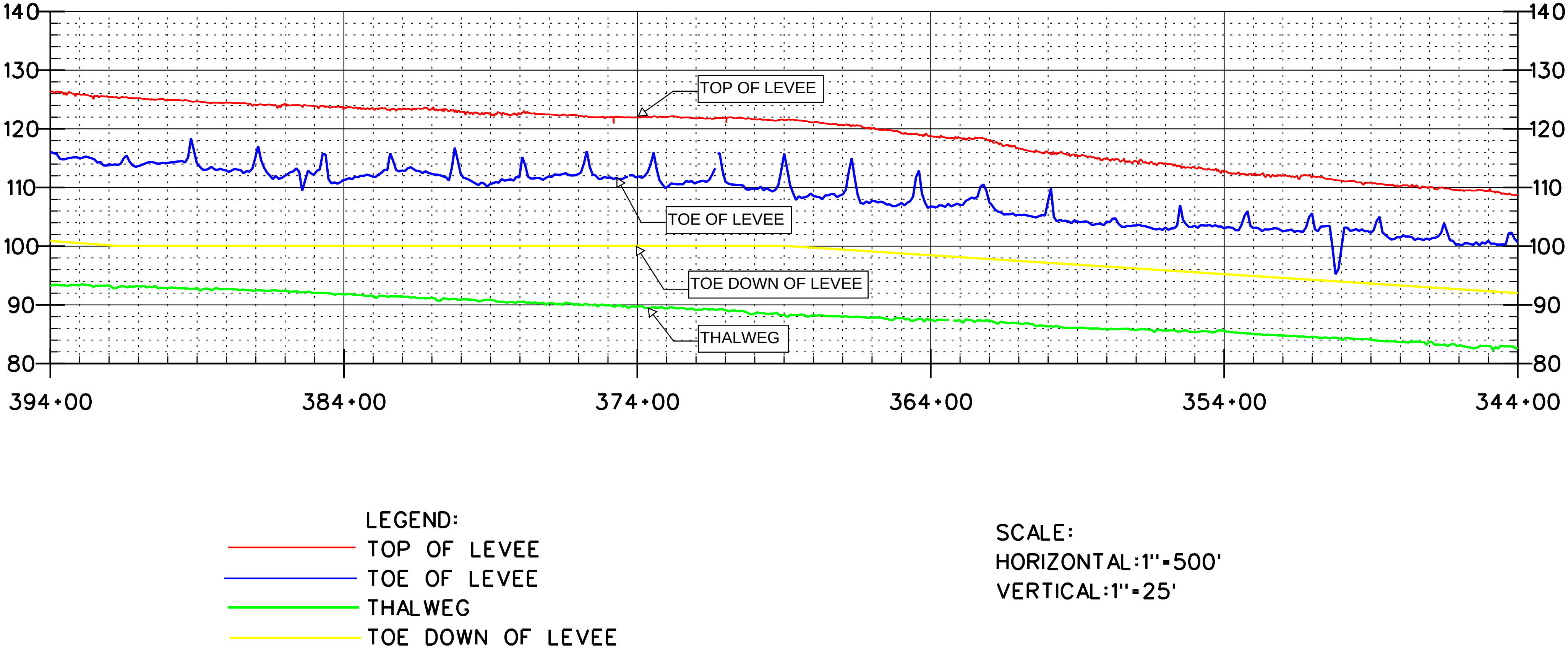
SANTA CLARA RIVER (SCR-1)
STATION 294+00 TO 344+00



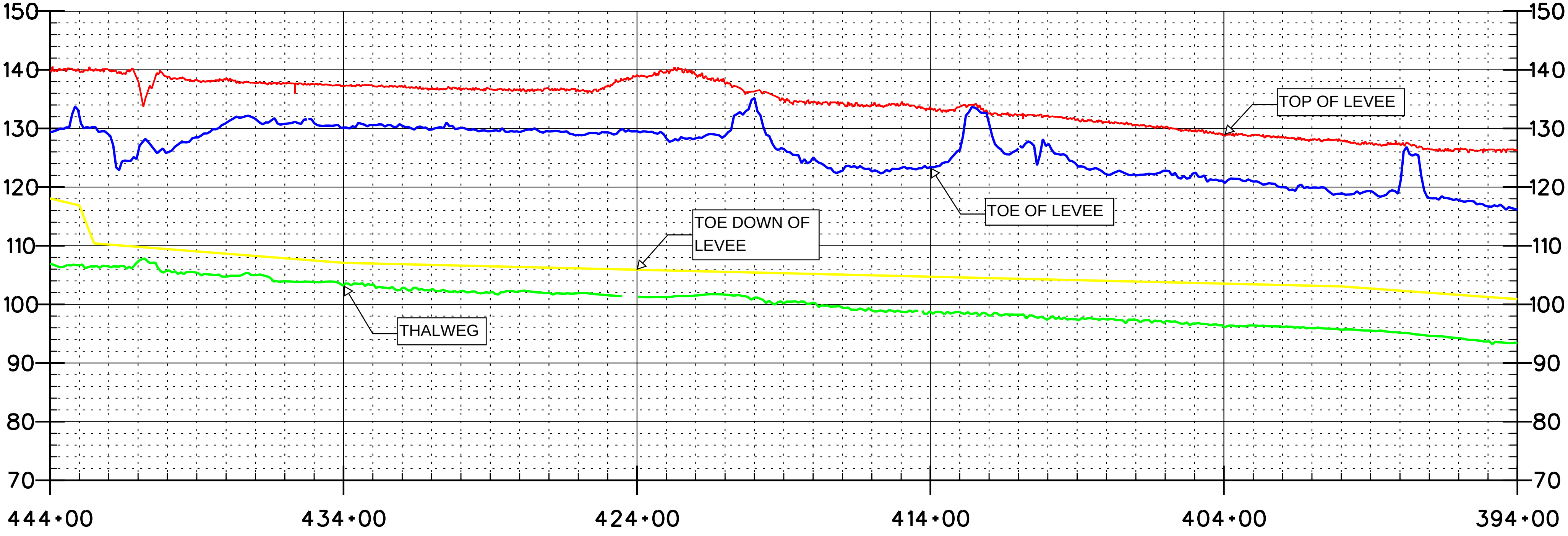
LEGEND:
TOP OF LEVEE
TOE OF LEVEE
THALWEG
TOE DOWN OF LEVEE

SCALE:
HORIZONTAL:1"=500'
VERTICAL:1"=25'

SANTA CLARA RIVER (SCR-1)
STATION 344+00 TO 394+00



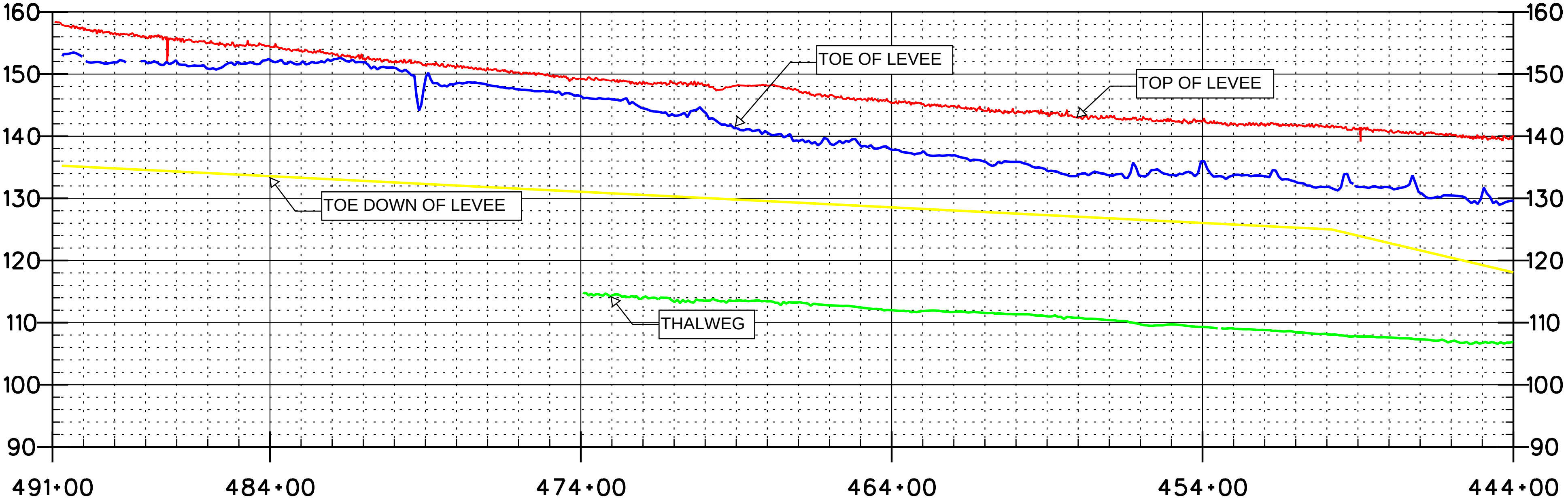
SANTA CLARA RIVER (SCR-1)
STATION 394+00 TO 444+00



LEGEND:
🟥 TOP OF LEVEE
🟦 TOE OF LEVEE
🟩 THALWEG
🟨 TOE DOWN OF LEVEE

SCALE:
HORIZONTAL:1"=500'
VERTICAL:1"=25'

SANTA CLARA RIVER (SCR-1)
STATION 444+00 TO 491+00



LEGEND:

- 🟥 TOP OF LEVEE
- 🟦 TOE OF LEVEE
- 🟩 THALWEG
- 🟨 TOE DOWN OF LEVEE

SCALE:
HORIZONTAL:1"=500'
VERTICAL:1"=25'

Exhibit 3

As-Built Plans Status List

Santa Clara River Levee (SCR-1) - Hwy 101 to Saticoy

Bridge Crossings (U/S to D/S)	**As-Builts Provided to Consultant by County**	**County or USACE Dwg. No.**	**Date***	**Sta. (relative to 1961 Dwgs)**	**Action**
Los Angeles Ave.	No				Request from County.
Hwy 101	No				Request from Caltrans.
Railroad Crossing (D/S Hwy 101)	No				Request from SPRR.
Victoria Ave.	No				Request from County.
Harbor Blvd.	No				Request from County.
Levee System (U/S to D/S)					
Santa Clara River Levee	Yes	187/31 to 51	1961		
Levee and Channel Restoration	Yes	187/161 to 208	1971		
Modification of Canal Structures	Yes	Y-2-142	1959		
Santa Clara River Groin Repair	Yes	Y-2-1829 to 1832	1985		
Penetrations (U/S to D/S)					
Side Drain 1-A, 4' x 4' x 23.5' RCB	No	Y-2-336 to 338	1965	491+45	We have dwgs, but they're not stamped as "Record Dwgs." Request from County.
Side Drain No. 1, 42" RCP	Yes	187/38, 49 & 50	1961	480+00	
Side Drain No. 2, 48" RCP	Yes	187/38, 49 & 50	1961	442+00	
Commercial drain from asphalt plant	Yes	187/39	1961	422+25	
Side Drain No. 3, 48" RCP	Yes	187/39, 49 & 50	1961	410+60	
12" metal pipe commercial drain from plant	Yes	187/39	1961	385+77	
Central Avenue Drain, 2-72" RCP w/ flap gates	Yes	Y-2-2399 to 2410	1997	351+50	
Side Drain No. 6, 48" RCP	Yes	187/40, 49 & 50	1961	316+60	
Side Drain No. 4, 48" RCP w/ flap gate	Yes	187/41, 49 & 50	1961	282+00	
10'W x 8'H RCB (Stroube Drain-Unit I)	Yes	Y-2-2011 to 2023	1989	246+20	

*Date indicates as-built date. Design plan dates were used if the plans were available, but were not stamped and/or signed as-built.

Exhibit 4

Responses to Comments on Draft Evaluation Report

FEMA Levee Certification -VCWPD
Project Team Comments on Tetra Tech's Draft Evaluation Reports
January 2009

Maint. Defect	Description	Recommended Action by Tetra Tech	Recommended Response by O&M Division	Environ. Permit Codes	Environmental Services Section Comments	R.O.W. Issue*	Levee Certification Project Team's Comments to Draft Evaluation Reports	Tetra Tech's Response
Santa Clara River Levee (SCR-1), Category 2								
M1, M2	Spalled concrete on Side Drain 1A headwall with rebar exposed (riverward side)	Repair the concrete headwall of outlet structure	**C1**	E1	Concrete repair during dry season, use BMPs		Does this need a flap gate?	No the inlet to Side Drain 1A is a reinforced concrete channel with wall heights extending to the top of the levee, thus flow from the Santa Clara River would not cause interior flooding.
M3	Sediment spoils (riverward side)	Remove spoils from levee	**C1**	E1	Removal of spoil pile		Why are the spoils an issue?	In this particular case, the unauthorized spoils are precluding a riverward side view of the levee which is required for routine maintenance and inspection.
M4, M5	Sediment deposition in Side Drain No. 1, 42" RCP inlet and outlet. Flap gate is stuck open by debris and sediment	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)	**C1** - to clean drain, **C5** drainage stopped by other property	E1	Removal of debris and dirt		How much removal is required? Water will not drain unless drainage is extended. Is this an issue?	In this particular case, it seems the inlet (landward side) is lower than the outlet (riverward side). Recommend determining how the property behind levee drains to see if this penetration is even valid. If this penetration is no longer required it could be sealed. If it is still required the operation of the flap gate must be restored to prevent interior flooding.
M6, M7	Wood debris (riverward side)	Remove debris from the levee	**C1**	E1	Removal of wood ok, what about hole?			
M8, M9	Broken stone revetment (riverward side)	Stone revetment may need to be repaired, additional engineering analysis is recommended	**C2**	E2	In kind repair, exc. & place new rock	**X**	Are the broken rocks still an issue?	Determination of the revetment protection will require hydraulic and rock sizing analyses. These analyses will be performed during the next phase of work.
M10	Animal burrows at levee toe (riverward side)	Fill voids with impervious material and firmly compact	**C1**	E2	Excavate & recompact existing levee, add IPM		Definition of impervious material	For small isolated burrows, infilling of the burrow with grout is sufficient. The grout should be relatively free flowing to permeate the burrows. A typical grout specification would be similar to CalTrans Specifications Section 41-1. A copy of this section is attached but should be modified to suit the conditions. For areas where a large number of interconnected burrows exist or the amount of burrows present has caused surficial instability, removal and replacement/re-compaction of the impacted material is needed. The attached Figure 1 presents a typical detail and backfilling requirements with in-kind materials. In-kind backfill would be materials free of organic or deleterious debris that has similar or lower permeability than the levee material. These materials could consist of excavated soil, imported soil, concrete, or slurry, and shall be evaluated by the testing and materials lab discussed below. Documentation for the singular burrows shall consist of a documentation of the location, size, volume of grout placed, and other pertinent details. Documentation of the removal and replacement/re-compaction of the impacted material shall be conducted by a certified testing and materials lab that the District is familiar with. The documentation shall include a report provided by the testing and materials lab. AMEC will periodically observe these locations and will require a copy of the report for documentation and review.
M11, M12	Levee embankment erosion (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4,** or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E2	Excavate & recompact existing levee, in kind		Definition of impervious material	Erosion should be repaired as indicated with in-kind material and documented. Documentation of the removal and replacement/re-compaction of the impacted material shall be conducted by a certified testing and materials lab that the District is familiar with. The documentation shall include a report provided by the testing and materials lab. AMEC will periodically observe these locations and will require a copy of the report for documentation and review. In-kind backfill would be materials free of organic or deleterious debris that has similar or lower permeability than the levee material. These materials could consist of excavated soil, imported soil, concrete, or slurry, and shall be evaluated by the testing and materials lab. compaction requirements are detailed on the attached Figure 1. Major repair examples include any erosion feature that is deeper than 1 foot or that is greater than 2 feet wide. Additionally, revetment protection evaluation including rock sizing analysis should be incorporated in repair of revetment material. Additionally, revetment protection evaluation including rock sizing analysis should be incorporated in repair of revetment material.
M13	Concrete debris has been spread over levee embankment (riverward side)	Remove unauthorized concrete cover from levee embankment	**C1/C4**, or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E2	In kind repair ok, what is needed?			
M14	A low point along top of levee causing concentrated flow and surface erosion on levee embankment (riverward side)	Regrade top of levee to meet design profile of top of levee. Fill embankment voids with impervious material and firmly compact	**C1/C4**, or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E2	Regrade levee top, in kind repair			
M15, M16, M17	Levee embankment erosion (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4**, or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E2	Redress levee slope in kind repair			
M18	Levee embankment erosion caused by vehicles (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4**, or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E2	Redress levee slope in kind repair		How do we mitigate these vehicles? What about items repaired and then immediately ruined again?	Facility could be made more secure to prevent vehicles. Anytime damages occur they must be repaired.

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FEMA Levee Certification -VCWPD
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January 2009

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Santa Clara River Levee (SCR-1), Category 2								
M19	Broken stone revetment (riverward side)	Stone revetment may need to be repaired, additional engineering analysis is recommended	**C2**	E2	In kind repair, exc. & replace rock		Are the broken rocks still an issue?	Determination of the revetment protection will require hydraulic and rock sizing analyses. These analyses will be performed during the next phase of work.
M20	Sediment deposition in Side Drain No. 3, 48" RCP outlet (riverward side)	Remove sediment and establish a clear passage from pipe to channel	**C1/C4**	E1	Removal of debris and dirt ok			
M21	Broken stone revetment (riverward side)	Additional engineering analysis is recommended	**C2**	E2	In kind repair, exc. & replace rock	**X**	Are the broken rocks still an issue?	Determination of the revetment protection will require hydraulic and rock sizing analyses. These analyses will be performed during the next phase of work.
M22, M23	Erosion on top of levee caused by vehicular traffic (landward side)	Reestablish top of levee to meet design elevations	**C1/C4**, or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E1	Regrade levee top, in kind repair			
M24	Levee embankment erosion caused by vehicular traffic (riverward side)	Reestablish levee revetment with design specifications. Fill voids with impervious material and firmly compact	**C1/C4**, or **C5** - fencing needed, redesign needed?, How do we stop the vehicle issue?	E2	Redress levee slope in kind repair			
M25	Broken stone revetment (riverward side)	Additional engineering analysis is recommended	**C2**	E2	In kind repair, exc. & replace rock		Are the broken rocks still an issue?	Determination of the revetment protection will require hydraulic and rock sizing analyses. These analyses will be performed during the next phase of work.
M26	Broken concrete pipe debris along levee toe (riverward side)	Remove unauthorized concrete pipe debris from levee embankment	**C1**	E1	Remove debris			
M27	Unauthorized ramp on levee (riverward side)	Remove unauthorized earthen ramp	**C1/C4**	E2	Redress levee slope in kind repair			
M28	Debris stock piles along levee toe (riverward side)	Remove unauthorized debris stockpiles from levee toe	**C1**	E1	Remove debris			
M29	Sediment deposition in Side Drain No. 6, 48" RCP outlet (riverward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)	**C1**	E1	Remove sediment			
M30	Unauthorized ramp on levee	Remove unauthorized debris stockpiles from levee toe	**C1/C4**	E2	Remove ramp, in kind repair			
M31	Sloughing levee embankment protection (riverward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4**	E2	Redress levee slope in kind repair			
M32	Sediment deposition in Side Drain No. 4, 48" RCP outlet (riverward side)	Remove sediment and establish a clear passage from pipe to channel (riverward & landward sides)	**C1/C4**	E2	Excavate sediment to drain properly			
M33, M34	Tip of buried groin is exposed and sink holes are present in soil covering groins (riverward side)	Repair sinkholes and fill voids with impervious material and firmly compact. (Safety Hazard) Additional engineering analysis is recommended for exposed groins	**C5** - D&C to rebuild groin	E3	Excavate/repair groin may need fish permit			
M35, M36	Tip of buried groin is exposed and sink holes are present in soil covering groins (riverward side)	Repair sinkholes and fill voids with impervious material and firmly compact. (Safety Hazard) Additional engineering analysis is recommended for exposed groins	**C5** - D&C to rebuild groin	E2	Likely do in concert with M33, M34			
M37	Tip of buried groin is exposed (riverward side)	Additional engineering analysis is recommended for exposed groins	**C5** - D&C to rebuild groin	E3	Excavate/repair groin may need fish permit			
M38	Unauthorized ramp with missing levee embankment protection (riverward side)	Remove unauthorized earthen ramp and reestablish levee embankment and embankment protection	**C1/C4**	E2	Remove ramp, in kind repair			

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Santa Clara River Levee (SCR-1), Category 2								
M39	Concrete washout poured over rock protection down to Highway 101 (riverward side)	Remove unauthorized concrete cover from levee embankment	**C1/C4**	E2	Remove concrete, repair in kind			
M40	Dumped concrete debris, unauthorized PVC pipe in levee embankment (riverward side)	Remove unauthorized debris and PVC pipe	**C1/C4**	E1	Debris removal			
M41	Vegetation and irrigation lines within 15-feet of levee toe (riverward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact. Remove Irrigation lines.	**C1/C4**	E1	Upland veg ok to remove			
M42	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C5**, PR issue with Developer and City of Oxnard	E1	Landward veg removal not regulated	**X**		
M43	PVC pipe protruding from top of levee (landward side)	Remove unauthorized PVC pipe and fill voids with impervious material and firmly compact	**C1/C4**	E1	Excavate & repair in kind			
M44	Erosion on top of levee exposing fence posts (landward side)	Reestablish top of levee and fill voids with impervious material and firmly compact	**C1/C4**	E1	Repair, redress in kind			
M45	Stone debris approximately 500-feet along levee toe (landward side)	Remove unauthorized stone debris from levee toe	**C1/C4**	E1	Remove debris			
M46	Erosion on top of levee (landward side)	Reestablish top of levee and fill voids with impervious material and firmly compact	**C1/C4**	E1	Regrade levee top & bank, in kind repair			
M47, M48	Dumped stone and debris approximately 100-feet along the levee (landward side)	Remove unauthorized stone debris from levee toe	**C1/C4**	E1	Remove debris			
M49, M50	Sediment deposition in Side Drain No. 4, 48" RCP inlet structure (landward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)	**C1/C4**	E1	Remove sediment & debris			
M51, M52	Erosion on levee embankment (landward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4**	E1	Redress levee slope in kind repair			
M53	Animal burrows near top of levee (landward side)	Remove animal burrows, fill voids with impervious material and firmly compact	**C1**	E1	Excavate & recompact existing levee, add IPM			
M54	Tree within 15' of levee toe (landward side)	Remove tree and root ball, fill voids with impervious material and firmly compact.	**C1/C4**	E1	Landward veg removal not regulated	**X**	Where does the toe start?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
M55, M56	Trees within 15' along levee toe (landward side)	Remove trees and root ball, fill voids with impervious material and firmly compact.	**C1/C4**	E1	Landward veg removal not regulated	**X**	Where does the toe start?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
M57, M58	Power poles within 15' of levee toe (landward side)	May require relocation	**C5** - Planning to coordinate removal of poles with SCE	E1	Unless major reconstruction, no permits	**X**	Are all static poles a problem?	Utility poles within the embankment prism (only 1 on SCR-1) must be relocated. These poles do not require relocation.
M59	Tree within 15' of levee toe (landward side)	Remove tree and root ball, fill voids with impervious material and firmly compact.	**C1/C4**	E1	Landward veg removal not regulated	**X**	Where does the toe start?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
M60	Trees, stumps, power poles within 15' of levee toe approximately 1,000' along levee toe (landward side)	Remove trees and root ball, fill voids with impervious material and firmly compact	**C1** - for tree removal, **C5** - Planning to coordinate removal of poles with SCE	E1	Landward veg removal not regulated, power poles may be issue	**X**	Are all static poles a problem? Where does the toe start?	Utility poles within the embankment prism (only 1 on SCR-1) must be relocated. This pole does not require relocation.
M61, M62, M63, M64	Power pole and fallen trees on levee embankment, guy wires anchored into embankment (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C1** - for tree removal, **C5** - Planning to coordinate removal of poles with SCE	E1	Landward veg removal not regulated, power poles may be issue	**X**		Utility poles within the embankment prism (only 1 on SCR-1) must be relocated. This pole requires relocation.

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Santa Clara River Levee (SCR-1), Category 2								
M65	Trees and fallen trees within 15' along levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C1/C4**	E1	Landward veg removal not regulated			
M66	Erosion on top of levee caused by vehicles (landward side)	Reestablish top of levee and fill voids with impervious material and firmly compact	**C1/C4**	E1	Redress levee slope in kind repair			
M67	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C5** - Planning to assess property issues	E1	Landward veg removal not regulated	**X**		
M68	Vegetation within 15-feet of levee toe approximately 150-feet along levee (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C5** - Planning to assess property issues	E1	Landward veg removal not regulated	**X**		
M69	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C5** - Planning to assess property issues	E1	Landward veg removal not regulated	**X**		
M70	Animal burrow on top of levee (landward side)	Remove animal burrows, fill voids with impervious material and firmly compact	**C1**	E1	Excavate & recompact existing levee, add IPM			
M71	Sediment deposition and metal debris Side Drain No. 3 in 48" RCP inlet (landward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)	**C1/C4**	E1	Landward veg removal not regulated		Does this need a flap gate?	This penetration does have a flap gate. This penetration must be cleaned and the flap gate restored to working order.
M72	Erosion on levee embankment (landward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4**	E1	Redress levee slope in kind repair			
M73	Erosion on levee embankment (landward side	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C1/C4**	E1	Redress levee slope in kind repair			
M74	Erosion caused by vehicles under Los Angeles bridge crossing (landward side)	Reestablish levee embankment and fill voids with impervious material and firmly compact	**C5**, Cal-Trans issue	E1	Remove sediment, repair slopes, in kind repair	**X**	This could be a Cal-Trans issue?	Repair is required
M75, M76	Vegetation within 15-feet of levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C1/C4**	E1	Landward veg removal not regulated			
M77	Erosion at top of levee with miscellaneous debris at toe (landward side)	Repair erosion and remove miscellaneous debris	**C1/C4**	E1	Redress levee slope in kind repair			
M78	Animal burrows at top of levee (landward side)	Remove animal burrows, fill voids with impervious material and firmly compact	**C1**	E1	Excavate & recompact existing levee, add IPM			
M79	Trees within 15-feet of levee toe, approximately 200-feet along levee (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C2**	E1	Landward veg removal not regulated	**X**	Where does the toe start?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
M80	Sediment deposition and debris in Side Drain No. 1, 42" RCP inlet invert (landward side)	Remove sediment and debris and establish a clear passage from pipe to channel (riverward & landward sides)	**C1/C4**	E1	Remove debris and sediment			
M81	Vegetation within 15-feet of toe, approximately 1,200-feet along levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C2**	E1	Landward veg removal not regulated	**X**	Where does the toe start?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
M82	Vegetation within 15-feet of toe, approximately 400-feet along levee toe (landward side)	Remove vegetation and root ball, fill voids with impervious material and firmly compact.	**C2**	E1	Landward veg removal not regulated	**X**	Where does the toe start?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
M83	Animal burrow at toe of levee	Remove animal burrow, fill voids with impervious material and firmly compact	**C1**	E1	Excavate & recompact existing levee, add IPM			

*Right of Way column reflects the Operation and Maintenance Division's preliminary opinion based on their field inspections. That opinion will be vetted through the Real Estate Services Division of the Public Works Agency.

Levee ID	Author	Page Number	Revision Requested	Tetra Tech's Annotations
VR-3	**Zia**	i	Change 'for' to 'in'. Data collection efforts have been performed to determine what information is available for support of levee certification.	**Change made.**
		i	Under LiDAR Topographic data, reviewer requests addition of 1. Compare the river bed vertical elevation and cross section changes by topo & survey. 2. There are some areas always need repair by records. Point out the areas need re-study.	**This entire levee was severely damaged in the 2005 flood. This levee is being re-designed by the Corps of Engineers from Santa Ana Blvd to the Live Oaks Diversion. Tetra Tech would need to review the Corps design to see if new topographic data was used.**
		1	Change 'give year' to 'given year'. "… or exceeded in any give year (base flood).	**Change made.**
		3*	Change 'addition' to 'additional'. "…however addition sedimentation and scour analyses…"	**Change made.**
		3	Change 'the' to 'that'. "…NFIP regulations requires the engineering analyses…"	**Change made.**
		4	Question: Are interior flooding and interior drainage the same? Please clarify the use of these terms. Are they to be used interchangeably?	**Interior flooding is caused from impeded interior drainage.**
		4	To the Levee Penetration portion, add: 1. Is the flap gate work fine? 2. Sediment deposition in the gate area? 3. Describe existing condition and pictures.	**The flap gate is in working order unless it is listed in Table 2 where its condition is described and associated photos are referenced in Appendix C.**
	Jaques	**General Comment**	The middle section of this reach is not a levee. Does it make sense to split this into two separate levees? 1. Near Santa Ana Blvd and 2. Live Oak Creek Diversion to where the levee terminates?	**A determination of segmenting this levee system would have to be made during the hydraulic analysis which is the next phase of work.**
		ii	Why is as-built plan show as Category 3?	**The construction of the Corps' proposed design is not expected to happen with in the PAL time schedule (Nov.30,2009) therefore as-builts would not be prepared.**
		3	Why is a hydrograph needed for levee certification?	**For geotechnical seepage analyses which requires the baseflood stage duration.**
		3	See the Bureau of Reclamation report "Hydrology, Hydraulics, and Sediment Studies for the Meiners Oaks and Live Oak Levees-Draft Report (July 2007) for the information on scour analysis, toe down and rock size requirements.	**Noted, Tetra Tech has obtained this document and will be used during the next phase of work.**
		4	Check with Corps of Engineers on geotechnical available for the levees.	**Noted, all available Corps of Engineers' design work will be obtained for use in the next phase of work.**
		6	Since the levee and floodwall up to Live Oak Creek Diversion will be improved by the Corps with the Matilija project, should we pursue improvements required on the Diversion portion in anticipation of the Corps certifying this entire levee once their work is complete?	**This work needs to be done to certify the entire system however the schedule of this Category 3 levee is to be determined.**
		6	Should we ask Tetra Tech to review Corps construction documents as part of their contract?	**Yes we will need to review design for certification.**
		4	Check with the Corps of Engineers on geotechnical information available for the levees.	**Noted, all available Corps of Engineers' design work will be obtained for use in the next phase of work.**
		6	Table 2-Summary of Maintenance Required, add the River Stations to the table.	**There are many different as-built drawings with different stationing. It was determined the best way to convey the location of the required maintenance was with a Lat. Long. GPS point.**

*Indicates comment made by more than one reviewer.

Levee ID	Author	Page Number	Revision Requested	Tetra Tech's Annotations
VR-1	**Jaques**	3*	Change 'addition' to 'additional'. "…however addition sedimentation and scour analyses…"	**Change made.**
		field investigation report, page 3	Remove "Show desktop.scf"	**Change made.**
		Appendix B, photos of penetrations	P6 (Stanley Drain) missing from map. Please include.	**P6 is shown on pages B-1 and B-2.**
		B-4	per Sec. 2.16 USACE levee Owner Manual, Aluminum stop logs should be supported along entire length where stored.	**Noted this will be evaluated in the structural analysis.**
		Exhibit 2, Preliminary Evaluation of levee system profiles	Station 90+00 to 140+00, is there an additional toe down for green and yellow lines between 140+ and 130+?	**We do not have any additional available information showing additional toe down.**
SC-1	**Jaques**	3	Add 'to' between 'used' and 'shape'. "…flood even would be used shape the base flood…"	**Change made.**
		4	Remove 'it'. Their findings are that only 5% of the rock is breaking down and they do not anticipate it the break down to continue at …"	**Change made.**
		field investigation report, page 1	Insert 'County' between Ventura and Watershed. "The team included representatives from the Ventura Watershed Protection District…"	**Change made.**
		B-2	per Sec. 2.16 USACE levee Owner Manual, Aluminum stop logs should be supported along entire length where stored.	**Noted, this will be evaluated in the structural analysis.**
AS-6	**Jaques**	3	Insert commas as follows: "reference, however, additional sedimentation and scour…" "…dated February 2004 will be useful as a reference however addition sedimentation and scour analyses…"	**Change made.**
		Field investigation report page 3	Change "borrows" to "burrows" throughout.	**Change made.**
		Levee Inspection Log, A-1	Change "borrows" to "burrows" throughout.	**Change made.**
		B-5	per Sec. 2.16 USACE levee Owner Manual, Aluminum stop logs should be supported along entire length where stored.	**Noted, this will be evaluated in the structural analysis.**
		Appendix C, Photos of Maintenance Required Locations	M22R Photo Caption, revise borrow to read "burrow"	**Change made.**
	Joe Lampara	General Comment	Similar to AS-7, this levee system is identified as extending along Arroyo Simi from 1st. Street to Erringer Road. In actuality this reach is a combination of a series of levees, including a floodwall located immediately upstream of 1st Street, and levees located in the immediately vicinity of the channel drop structures, and along one reach of low land at the upstream end adjacent to the channel. Between these locations there are reaches of incised channel which do not meet the definition of a levee or levee system.	**Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis. This analysis will be performed during the next phase of work.**

*Indicates comment made by more than one reviewer.

Levee ID	Author	Page Number	Revision Requested	Tetra Tech's Annotations
AS-7	**Jaques**	General Comment	A LOMR was accepted FEMA on March 4, 2003.	**All Current LOMRs have been requested from FEMA, if the County has a copy Tetra Tech would like to obtain a copy.**
		6	Application of 44 CFR65.10 criteria should be applied only to the reaches of the channel between 1st and Erringer that meet the definition of a levee.	**Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis. This analysis will be performed during the next phase of work.**
		field investigation report, page 1	Insert 'County' between Ventura and Watershed. "The team included representatives from the Ventura Watershed Protection District…"	**Change made.**
		field investigation report, page 4	Table 1-Summary of Penetrations. River Station 120+72 and 125+66.1, reviewer indicates the WSL is below the existing ground.	**Noted**
CC-3	**Jaques**	**General Comment**	If this levee is 2' above adjacent ground (page 1) and FEMA requires 3' minimum levee height above the 100 yr flood, how is this a levee? It looks like this should be re-categorized as Not a Levee.	**The 2' height is based on a visual inspection. Determination of the levee situation will require a hydraulic analysis to compare the 100-yr WS to adjacent ground. This analysis will be performed during the next phase of work. If the analysis shows the 100-yr WS is below adjacent ground then de-listing this stretch of channel as a levee will be pursued.**
		Field Investigation Report, 1	Has the Kasraie Report and Draft D-Firm maps been reviewed? I believe that they show breakout to the east in this reach of Calleguas Creek.	**They have not been reviewed. Tetra Tech has requested all current D-Firm analyses and Appeals from FEMA. If the County has a copy Tetra Tech would like a copy.**
	Joe Lampara	**General Comment**	The efforts under Phase 1 involve the categorization of the nine Provisionally Accredited Levees in Ventura County. Levee categories include: Category 1 – levee meets 44CFR65.10 requirements and all data or complete documentation is available, Category 2 – levee may meet 44CFR65.10 criteria , but additional data or documentation is needed, Category 3 – levee does not currently meet 44CFR65.10 criteria, Not a levee – Based on physical conditions, low WSEL, no SFHA, and/or not providing flood protection. This levee system, which extends along Calleguas Creek from Pleasant Valley Road to Hwy 101, may not be a levee in the sense as a levee is defined. Phase 1 efforts must include this determination prior to the final categorizing of this "levee system." Determination under Phase 3 efforts that Phase 1 efforts were incomplete.	**The 2' height is based on a visual inspection. Determination of the levee situation will require a hydraulic analysis to compare the 100-yr WS to adjacent ground. This analysis will be performed during the next phase of work. If the analysis shows the 100-yr WS is below adjacent ground then de-listing this stretch of channel as a levee will be pursued.**
CC-2	**Joe Lampara**	**General Comment** The reach between Mission Oaks and this point no longer meet the definition of a levee.	This levee system is identified as extending along Calleguas Creek from Mission Oaks Blvd. upstream to Adolfo Road. It includes the reach of Somis Drain from Calleguas Creek up to The reach upstream of Somis Drain along Calleguas Creek to Adolfo Road is not a levee in that the surface of the ground landward of the Calleguas Creek Channel is higher than the streambank protection placed along the channel bank. As originally constructed the levee did extend from Mission Oaks Blvd to Somis Drain. Subsequent to the completion of construction of this levee developers were granted permits to fill in portions of the land behind the levee to allow for industrial development. As a result there is a reach of the original levee extending from Mission Oaks Blvd. upstream for approximately 1500 feet that no longer meets the definition of a levee. The surface of the ground landward of the levee now exceeds base flood elevation in the channel, or is at or above the top of levee elevation. Suggest revising the downstream terminus of CC-2 from Mission Oaks Blvd. to the point upstream where the permitted fill placed behind the original levee alignment ends.	**Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis and verification of the higher adjacent ground due to recent improvements. This analysis will be performed during the next phase of work.**

*Indicates comment made by more than one reviewer.

Levee ID	Author	Page Number	Revision Requested	Tetra Tech's Annotations
ASR-2	**Jaques**	Field investigation report, A-2	Number 8, Encroachments, remarks are included, but no rating is given. Please add an A, M or a U.	**Change made to reflect a U.**
		B-2	per Sec. 2.16 USACE levee Owner Manual, Aluminum stop logs should be supported along entire length where stored.	**Noted, this will be evaluated in the structural analysis.**
		Exhibit 2, Preliminary Evaluation of levee system profiles	Station 120+00 and 130+00, is there an additional toe down for green and yellow lines between 129+ and 128+?	**We do not have any additional available information showing additional toe down.**
All Levee Reports	**Tony Chen**	**General Comment**		
			Please extend the tree removal to a flexible limit. For some trees, the 15' buffer belt is not enough. We need to remove the vegetation and trees within 15' buffer belt. As I learned from FMA classes. I understand some of the special kinds of the tree roots can extend and penetrate the levee. These trees shall be cleaned within a certain distance. I suggest to ask the Environmental Section set up a list of trees need to install an underground buffer wall or remove the special trees within a defined distance.	**The Corps guidelines in EM 1110-2-301 are the current standard for vegetation on levees.**
			There are power poles in the defined levee area. Do we need to relocate them?	**Utility poles within the embankment prism (only 1 on SCR-1) must be relocated.**
			A new aero-photo map is necessary to get for study, planning, design and construction purposes. Please put some budget for survey purposes.	**Noted**
			How to get rid of small animals like gofers.	**According to O&M the WPD currently has a plan to control burrowing animals**
			A levee Certification Work Team is necessary. It could be consisted by Advanced Planning, O&M, Design and Construction, Environmental Section, and Real Estate Section.	**Noted**
			There are many small lateral storm drain pipes, how to prevent the backup water?	**An interior drainage analysis will be performed on each drain to determine if a flap gate is required.**
			There are some developed areas behind the levee. How to get the required land from the land owners?	**This is a County Real Estate issue.**
			The flood control annually budget is limited. How to get the required money to finish the work?	**This is a County Budget issue.**

*Indicates comment made by more than one reviewer.

Levee ID	Author	Page Number	Revision Requested	Tetra Tech's Annotations
All Levee Reports	**Joe Lampara**	**General Comment**		
		All levees categorized as Category 2	Include in the work to be done as noted in Figure 2 for each levee a Right of Way survey to establish in the field the actual limits of County owned property and easements.	**This is part of the Title Search/Boundary Survey task.**
		CC-2, AS-6, SCR 1, VR-1, ASR-2, CC-3	Figure 2 of each report contains a list of work that needs to be completed for levee certification to be done for each levee. One of the items is Topographic Survey Verification. For selected levees, VR-1 being one, there is a time interval indicated for this work. For the majority of the remaining levees no verification is required. Recommend that topographic survey verification being included the levees noted with this comment. The reasoning for including it with VR-1 can be applied to the others, i.e. ASR-1 – concerns exists regarding the elevation of the channel, including the stabilizer, relative to the footing of the floodwall. Without a survey it may not be possible to discern the relationship of these two items. For CC 3, if this levee is not categorized as "not-a-levee" in Phase 1, verification of the topography is required under Phase 3 in order to finalize whether or not CC-3 is a levee.	**Tetra Tech will provide the District with a standard specification sheet and survey topo exhibit describing minimum survey requirements for levee certification requirements for all levees, and additional levee-specific survey requirements and locations of additional topo required.**
All Levee Reports	**Zia**	**General Comment**	What is the plan for soil testing?	**A scope of work detailing the subsurface exploration, laboratory testing and geotechnical assessment is being prepared for the next Phase of work.**
			Why is the consultant requesting consolidation tests?	**The purpose for the consolidation testing is three-fold. The first reason is to determine the existing conditions of the alluvium and levee material and evaluate if any material may experience consolidation with future loads that could be detrimental to the levee. The second, and in this case more critical, is to determine if any consolidation as a result of the original levee construction is anticipated. Secondary compression or consolidation in fine grained soils is dependant on the time needed for the excess pore pressures created by imposed loads to dissipate allowing the soil to consolidate. Typically the finer grained a soil and the thicker the soil deposit, the longer amount of time is needed for consolidation to take place. By running time based consolidation tests on samples collected, we can anticipate the amount of settlement that is to occur, as well as the time needed, as a result of implied loads on the soil. If we have a condition, say, that just meets the 3 feet of freeboard and we are anticipating another 6 inches of settlement in the foreseeable future, something will need to be done to ensure that the levee can maintain that 3 feet of freeboard. The third reason is to evaluate the potential for hydro-collapse. If soils are rapidly deposited and are buried quickly by subsequent depositional events, the soil structure may develop such that they have not been allowed to consolidate fully. Additionally, mineral accumulation, such as salts or caliche, may also develop giving the soil added strength. When these soils are subsequently saturated during a future event, the potential for consolidation of the loose soils or dissolution of the mineral content, collectively know as hydro-collapse, exists. In some cases this collapse can be significant and has caused failure of structures built over the collapsible soils. The testing for this potential is similar to consolidation testing, although slightly less time consuming, and will be conducted if the field investigation reveals the potential.**
			Could the consultant please be more specific when commenting on areas of concern? Please quantify problems, instead of making general comments.	**Tetra Tech would be happy to answer any specific questions, however for most items specific data is not required and with the accelerated schedule detailing and quantifying each problem is not feasible.**

VCWPD OPERATION & MAINTENANCE DIVISION RFI

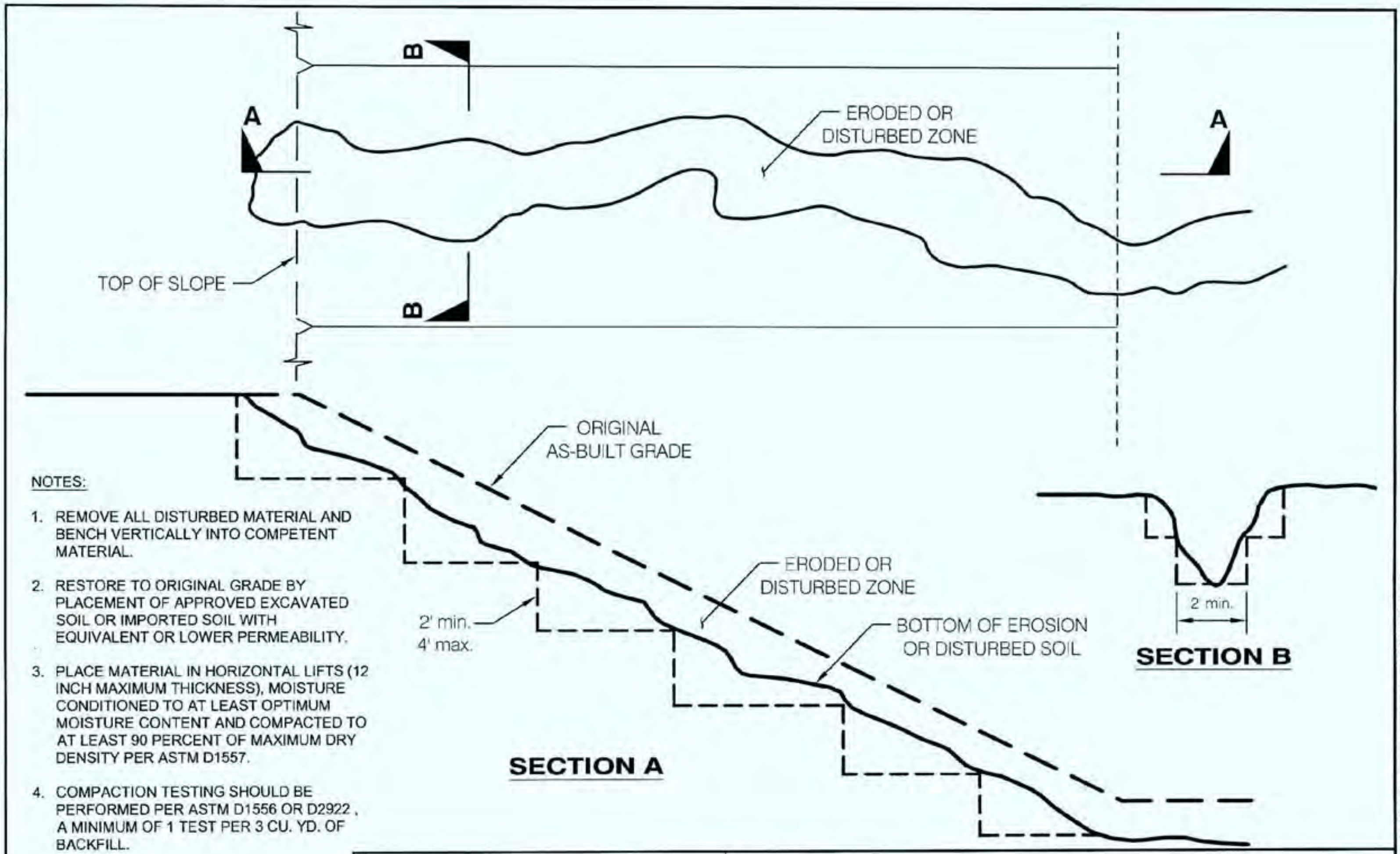
VCWPD O&M QUESTION	TETRA TECH/AMEC RESPONSE
1. Animal burrow/hole repair procedures. Please confirm acceptable methods. Also confirm acceptable documentation method.	For small isolated burrows, infilling of the burrow with grout is sufficient. The grout should be relatively free flowing to permeate the burrows. A typical grout specification would be similar to CalTrans Specifications Section 41-1. A copy of this section is attached but should be modified to suit the conditions. For areas where a large number of interconnected burrows exist or the amount of burrows present has caused surficial instability, removal and replacement/re-compaction of the impacted material is needed. The attached Figure 1 presents a typical detail and backfilling requirements. Documentation for the singular burrows shall consist of a documentation of the location, size, volume of grout placed, and other pertinent details. Documentation of the removal and replacement/re-compaction of the impacted material shall be conducted by a certified testing and materials lab that the District is familiar with. The documentation shall include a report provided by the testing and materials lab. AMEC will periodically observe these locations and will require a copy of the report for documentation and review.
2. Please describe methods for vegetation and rootball removal.	4" DIAMETER TRUNK OR GREATER: Cut the woody vegetation approximately two (2) feet above ground level leaving a prominent stump for use in the rootball extraction process. Remove the stump and rootball by pulling or extracting with a backhoe or similar equipment. Clean the rootball cavity of all loose soil and remaining root system (roots greater than 1/2" diameter). Prepare the cavity by excavating per FIGURE 2. Backfill with excavated soil or imported soil with equivalent or lower permeability. Place material in horizontal lifts no greater than twelve (12) inches. Moisture conditioned to at least optimum moisture content and compacted to at least ninety (90) percent of the maximum dry density of the fill soil per ASTM D1557. Compaction typically requires the use of manually operated compaction equipment or compaction attachment to a backhoe. Compaction testing should be performed per ASTM D1556 or D2922. A minimum of one (1) test per three (3) cubic yards of backfill. 2"-4" DIAMETER TRUNK: Cut the woody vegetation stump flush with the ground. Treat the stump with a protective coating similar to polyurethane to prolong the decay process.

VCWPD O&M QUESTION	TETRA TECH/AMEC RESPONSE
	2" DIAMETER TRUNK OR LESS: Cut the woody vegetation to twelve (12) inches of height above the ground level. For all vegetation removal under 4” trunk diameter, no documentation is necessary. For larger rootball removal in which excavation and compaction is required, documentation of the impacted material shall be conducted by a certified testing and materials lab that the District is familiar with. The documentation shall include a report provided by the testing and materials lab. AMEC will periodically observe these locations and will require a copy of the report for documentation and review.
3. Where is 15’ buffer from toe measured from (buried portion or at ground level)?	The fifteen (15) foot vegetation line is measured from the visual toe of slope to the center line of the trunk (tree), the closest trunk to the toe (multiple trunk trees/plants) or the stock/stem protruding through the soil (large plant connected to a root system)
4. Can Tetra Tech provide specs for compaction and grading requirements? Discuss major and minor repair examples.	Compaction requirements are detailed on the attached Figures 1 and 2. Major repair examples include any erosion feature that is deeper than 1 foot or that is greater than 2 feet wide. Major and minor animal burrows are discussed in item 1.
5. Can in-kind materials be used for backfill?	In-kind backfill would be materials free of organic or deleterious debris that has similar or lower permeability than the levee material. These materials could consist of excavated soil, imported soil, concrete, or slurry, and shall be evaluated by the testing and materials lab.
6. Discuss documentation/inspection requirements for verification of grading.	The requirements for verification of grading are discussed above.

VCWPD O&M QUESTION	TETRA TECH/AMEC RESPONSE
7. Can Tetra Tech provide weekly inspection of work completed to date?	Future work can be observed by AMEC. It is suggested that scheduling field time be conducted to maximize the efficiencies of the site visits. AMEC will provide a site visit to each levee during repair work preferably before backfill commences. Additional site visits would likely incur additional costs.
8. Please provide a procedure for concrete patching.	All repairs should extend at least three (3) inches beyond the area of delaminated or broken concrete and should be chipped out to at least 3/4 inch below any exposed reinforcing. Concrete patch edges should be sawcut without damaging embedded reinforcing bars. Sandblast clean all exposed concrete and steel surfaces in repair opening and paint any exposed reinforcing bars and tensioning posts with a protective anti-corrosive coating. After coating cure, recast the repair opening using concrete patching material. In the case of minor chipping of concrete surface – no deep concrete cracks or steel exposure – a high performance urethane polymer or industrial bonding epoxy may be used to restore the concrete surface. The documentation shall include a report documenting the statement of work, list of materials used and photos. Tetra Tech will make a final inspection of the completed work.
9. Is a headwall needed for flap gate attachment?	No. Different styles of heavy-duty flap gates can be attached directly to an exposed corrugated pipe. If the pipe already ends directly at a headwall or culvert, then it is recommended the flap gate be attached to the concrete surface. In either application the flap gate needs to remain operational and achieve the goal of backflow prevention. The documentation shall include a report documenting the statement of work, list of materials used and photos. Tetra Tech will make a final inspection of the completed work.
10. Are rock or soil piles (or ramps) a problem for certification?	Any trash, debris or other obstructions that inhibit operations and maintenance performance and visual inspection of a levee will affect the completion of certification. Unauthorized levee debris that causes obstruction from routine levee inspection and management, obstruction to flood-fighting zones, and debris flow/breeching during storm events must be removed.

VCWPD O&M QUESTION	TETRA TECH/AMEC RESPONSE
11. AS-7, M4R: Is this a levee? Is veg removal required within only 8’ of the foundation of the wall?	Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis. This analysis will be performed during the next phase of work. A levee is an earthen embankment, floodwall, or structure along a water course whose purpose is flood risk reduction or water conveyance. In the case of a floodwall, the root-free zone is the greater of either eight (8) feet from toe of the floodwall foundation or fifteen (15) feet from face of floodwall. If there is a drainage system at the toe, then the eight (8) feet is measured from the outside of the drainage system. All vegetation growing over the floodwall’s foundation heel/toe as well as the eight (8) feet root-free zone must be removed.
12. AS-7, M4L: Is seepage a problem for certification?	Further analysis is required to make that determination. Provided that the wall and channel bottom have been designed to accommodate this condition and that existing and anticipated future groundwater conditions are within the anticipated ranges utilized in design, certification may proceed.
13. AS-7, M8L: What is considered the top of the levee? Is there a floodwall?	Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis. This analysis will be performed during the next phase of work.
14. AS-6, M13L: Does not appear to be a levee.	Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis. This analysis will be performed during the next phase of work.
15. AS-6, M23R: Does not appear to be a levee.	Determination of the levee situation on certain lengths of the levee system will require a hydraulic analysis. This analysis will be performed during the next phase of work.

FILE: 8212100132-001 EROSION REPAIR PLOT DATE 2/4/2009



NOTES:

1. REMOVE ALL DISTURBED MATERIAL AND BENCH VERTICALLY INTO COMPETENT MATERIAL.
2. RESTORE TO ORIGINAL GRADE BY PLACEMENT OF APPROVED EXCAVATED SOIL OR IMPORTED SOIL WITH EQUIVALENT OR LOWER PERMEABILITY.
3. PLACE MATERIAL IN HORIZONTAL LIFTS (12 INCH MAXIMUM THICKNESS), MOISTURE CONDITIONED TO AT LEAST OPTIMUM MOISTURE CONTENT AND COMPACTED TO AT LEAST 90 PERCENT OF MAXIMUM DRY DENSITY PER ASTM D1557.
4. COMPACTION TESTING SHOULD BE PERFORMED PER ASTM D1556 OR D2922 , A MINIMUM OF 1 TEST PER 3 CU. YD. OF BACKFILL.

TYPICAL EROSION OR SURFICIAL SLOPE INSTABILITY REPAIR

LEVEE CERTIFICATION PROJECT
VENTURA COUNTY, CALIFORNIA

AMEC Earth & Environmental
1290 N. HANCOCK STREET, SUITE 102
ANAHEIM, CA 92807-1924
www.amec.com/earthandenvironmental

amec

DWN BY: JBD	DATE: February 2009	PROJECT NO: 8212100132
CHK'D BY: DRB	SCALE: Not To Scale	FIGURE No. FIGURE 1

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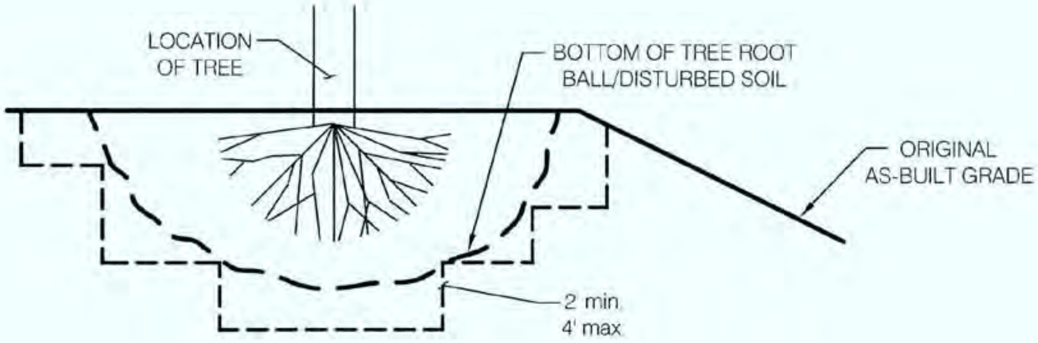
FILE 8212100132-001_EROSION REPAIR PLOT DATE 2/4/2009



NOTES:

1. REMOVE ALL DISTURBED MATERIAL AND BENCH VERTICALLY INTO COMPETENT MATERIAL.
2. RESTORE TO ORIGINAL GRADE BY PLACEMENT OF APPROVED EXCAVATED SOIL OR IMPORTED SOIL WITH EQUIVALENT OR LOWER PERMEABILITY.
3. PLACE MATERIAL IN HORIZONTAL LIFTS (12 INCH MAXIMUM THICKNESS), MOISTURE CONDITIONED TO AT LEAST OPTIMUM MOISTURE CONTENT AND COMPACTED TO AT LEAST 90 PERCENT OF MAXIMUM DRY DENSITY PER ASTM D1557.
4. COMPACTION TESTING SHOULD BE PERFORMED PER ASTM D1556 OR D2922, A MINIMUM OF 1 TEST PER 3 CU. YD. OF BACKFILL.

TYPICAL VEGETATION REMOVAL REPAIR

LEVEE CERTIFICATION PROJECT
VENTURA COUNTY, CALIFORNIA

AMEC Earth & Environmental
1290 N. HANCOCK STREET, SUITE 102
ANAHEIM, CA 92807-1924
www.amec.com/earthandenvironmental

amec

DWN BY: JBD	DATE: February 2009	PROJECT NO: 8212100132
CHK'D BY: DRB	SCALE: Not To Scale	FIGURE No. FIGURE 2

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SECTION 41: PAVEMENT SUBSEALING AND JACKING

41-1 PAVEMENT SUBSEALING

41-1.01 DESCRIPTION

- This work shall consist of filling voids beneath existing portland cement concrete pavement, at the locations shown on the plans, by drilling holes through the existing pavement, injecting grout through the holes and filling the drilled holes with mortar or concrete.

41-1.02 MATERIALS

- Grout for filling the voids beneath the existing pavement shall be composed of portland cement, fly ash and water. Portland cement and fly ash shall be proportioned by weight at the rate of one part portland cement to 2.4 to 2.7 parts fly ash. Water shall be added in an amount to provide a grout efflux time of 10 to 16 seconds as determined by California Test 541, Part D.
- Portland cement for the grout shall be Type II Modified conforming to the provisions in Section 90-2.01, "Cement."
- Fly ash shall conform to the requirements in ASTM Designation: C 618 for either Class C or Class F fly ash, except that the loss on ignition shall not exceed 4 percent. The brand of fly ash used in the work shall conform to the provisions for approval of admixture brands in Section 90-4.03, "Admixture Approval."
- When fly ash, cement, or fly ash and cement are delivered in packages, each package shall be marked plainly with the class, type, name and brand of producer, and the weight of material contained therein. Similar information shall be provided in the shipping invoices accompanying the shipment of packaged or bulk fly ash and cement.
- Chemical admixtures and calcium chloride conforming to the provisions in Section 90-4, "Admixtures," may be used in the grout mixture, subject to the Engineer's written approval.
- In advance of grouting operations, the Contractor shall submit a proposal for the materials to be used in the work accompanied with independent laboratory test data that indicates the initial set time and the one-day, 3-day, and 7-day compressive strengths of the grout at 10-second, 12-second and 14-second efflux times using specimen molds and curing conditions specified in ASTM Designation: C 109.
- Grout having a 7-day compressive strength of less than 750 psi at a 12-second efflux time as determined by the independent laboratory tests will not be acceptable.
- No change in the grout materials shall be made unless a resubmittal of the above information and requirements is furnished to the Engineer.
- Mortar for filling the holes in the concrete pavement shall be composed of one part portland cement to 3 parts fine aggregate, by volume, and only enough water to permit placing and packing of the mortar in the holes. A commercial quality premixed rapid set mortar or concrete may be used to fill the holes.

41-1.03 CONSTRUCTION

- Holes shall be drilled through the pavement and underlying base to a depth of 15 inches to 18 inches below the pavement surface. The holes shall be drilled to the diameter necessary to accommodate the equipment used for injecting the grout. Care shall be taken to protect the pavement surrounding each hole from damage.
- The location of the holes shall conform to the configuration shown on the plans unless otherwise directed or permitted by the Engineer. Before beginning grouting operations, and continuing thereafter to the end of each run or work shift, the holes in at least 2 consecutive slabs requiring subsealing shall be drilled ahead of the grouting operations.
- Open drilled holes shall not remain ungrouted for more than 2 working days.
- The side of the injection hole shall be washed with a minimum water gage pressure of 40 psi just prior to grout injection. The washing device shall be constructed such that a minimum of 4 jets shall direct water horizontally at the slab-base interface.
- The grout plant shall consist of a positive displacement cement injection pump and a high-speed colloidal mixer. The colloidal mixer shall operate between a minimum speed of 800 RPM and a maximum speed of 2,000 RPM. The injection pump shall be capable of sustaining a gage pressure of 150 psi when pumping a grout mixed to a 12-second flow time. A pressure gage shall be located immediately adjacent to the grout hose supply valve and shall be positioned so it can be easily monitored by the Engineer.
- Dry cement and fly ash shall be accurately measured by weight, if in bulk, or shall be packaged in containers of uniform weight.
- Water shall be introduced into the mixing process through a meter or scale.
- Grout not used in the work within one hour after mixing shall be disposed of as directed by the Engineer.
- Grout shall be pressure injected through the holes until all voids under the pavement slab are filled. No portion of the slab shall be moved or raised more than 0.050-inch as a result of pressure grouting. The Engineer will furnish and utilize suitable devices to monitor slab movement during pressure grouting.
- The injection nozzle shall prevent leakage during injection and shall not protrude below the concrete slab. Grout shall be injected into only one hole at a time on any slab. When grout appears at any longitudinal or transverse joint, crack, or adjacent hole, or when monitoring devices indicate slab movement in excess of 0.050-inch, pressure injection of grout shall cease at that hole.
- In the event that grout flow does not occur after 7 seconds of sustained 150 psi injection pump gage pressure and if there is no indication of slab movement, continued injection at that hole shall cease.
- Immediately after the nozzle is removed, the hole shall be temporarily plugged with a round, tapered wooden plug. The plug shall remain in place until pressure grouting at adjacent holes progresses to the point where grout will not be forced up through previously grouted holes.
- In the event the Engineer determines that continued grouting at a location is no longer advantageous, the Engineer may direct the Contractor to cease subsealing operations at that location.

- Grouting shall not be performed when the atmospheric or subgrade temperature is below 40° F, or during inclement weather. When standing rainwater is present in the holes, grouting shall not be performed unless permitted by the Engineer.
- The Contractor shall take necessary precautions to prevent grout from being injected into any drainage facility or other open structure.
- Cracks in the pavement which occur during the injection of grout will be considered as damage to the pavement due to the Contractor's operations. The damage shall be repaired by the Contractor at the Contractor's expense and as directed by the Engineer.
- Upon completion of the grouting operation, grout shall be removed from the drilled holes to a depth of not less than 4 inches below the pavement surface. The holes shall be cleaned and then filled with mortar or premixed, rapid set concrete and finished flush with the concrete pavement surface.
- At the end of each work shift, the work area shall be left in a clean, swept and neat condition.

41-1.04 MEASUREMENT

- The quantity of drilled holes will be measured as units determined by actual count. Any hole drilled that is not shown on the plans or ordered by the Engineer will not be measured nor paid for.
- The quantities of dry cement and fly ash used in the grout mix will be measured by the ton and will be paid for as grout (subsealing). Quantities of grout not used in the work and grout that is wasted by leaking through to the pavement surface because of not taking preventative measures to avoid wasting of grout, will not be paid for. The quantity of grout wasted or disposed of will be determined by the Engineer. Quantities of grout, cement or fly ash remaining on hand after completion of the work will not be paid for.

41-1.05 PAYMENT

- Items of work, measured as specified in Section 41-1.04, "Measurement," will be paid for at the contract unit price for drill hole (subsealing) and the contract price per ton for grout (subsealing).
- The above prices and payments shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in subsealing existing portland cement concrete pavement as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.
- Full compensation for furnishing and placing mortar or concrete for filling the drilled holes shall be considered as included in the contract unit price paid for drill hole (subsealing) and no additional compensation will be allowed therefor.

41-2 PAVEMENT JACKING

41-2.01 DESCRIPTION

- This work shall consist of raising existing portland cement concrete pavement to grade, at the locations shown on the plans, by drilling holes through the existing pavement, injecting grout through the holes to fill voids beneath the pavement and raise the pavement to grade, and filling the drilled holes with mortar or concrete.

41-2.02 MATERIALS

- The grout for pavement jacking and mortar or concrete for filling the drilled holes shall conform to the provisions for grout and mortar or concrete for pavement subsealing in Section 41-1.02, "Materials," except that the grout for pavement jacking shall contain water in an amount to provide a grout efflux time of 16 seconds to 26 seconds. Additional water may be added to reduce the grout efflux time to not less than 10 seconds to initiate the pressure injection of the grout.

41-2.03 CONSTRUCTION

- Pavement jacking shall conform to the provisions for pavement subsealing in Section 41-1.03, "Construction," except for the following:

> The positive displacement grout injection pump shall be capable of providing a sustained gage pressure of 200 psi. Gage pressures exceeding 200 psi, but not exceeding 600 psi, may be used for brief periods of time to start the movement of the slab.
>
> Slabs shall be raised uniformly to grade. The Contractor shall furnish and utilize stringlines to monitor the movement of the pavement.
>
> The final elevation of the surface of the concrete pavement shall not vary at any point more than 0.01-foot above or below the grade established by the Engineer. If the surface of the pavement at any point is higher than 0.01-foot above the grade established by the Engineer, the surface shall be ground to meet the above specified tolerance; however, the entire slab shall be removed and replaced with new concrete pavement if the surface at any point is higher than 0.10-foot above the grade established by the Engineer. Grinding of the concrete pavement or removal and replacement of the pavement, if necessary, shall conform to the provisions in Section 42-2, "Grinding," except for payment.
>
> Adjacent slabs, not requiring adjustment in grade, shall not be moved. Corrections to grade of adjacent slabs, if necessary, and as determined by the Engineer, shall be made in the same manner that is required for pavement that is raised to grade.

41-2.04 MEASUREMENT

- The quantity of drilled holes will be measured as units determined by actual count. Any hole drilled that is not shown on the plans or ordered by the Engineer will not be measured nor paid for.
- The quantities of dry cement and fly ash used in the grout mix will be measured by the ton and will be paid for as grout (jacking). Quantities of grout not used in the work and grout that is wasted by leaking through to the pavement surface because of not taking preventative measures to avoid wasting of grout, will not be paid for. The quantity of grout wasted or disposed of will be determined by the Engineer. Quantities of grout, cement or fly ash remaining on hand after completion of the work will not be paid for.

APPENDIX A1

VCWPD Field Inspection Log
October 2008

Santa Clara River levee 101 to Saticoy

101 to Saticoy

S.C. River Levee

10·27·08 Date

Levees

For use during all Initial and Continuing Eligibility Inspections of levees

	RATED ITEM	A	M	U	N/A	EVALUATION	LOCATIONS/REMARKS/RECOMMENDATIONS
1	Unwanted Vegetation Growth	X				**A** The levee is free of vegetation (trees, bushes, or undesirable weeds). Except in those cases where a vegetation variance has been granted by the Corps, a 15' zone of woody vegetation, is maintained adjacent to the landward/riverside toe of the FCW for riparian habitat.	
						M Minimal number of trees (2" diameter or smaller) and/or brush present on the levee or within the 15' zone, that will not threaten the integrity of the facility.	
						U Tree, weed, and brush cover exists in the FCW requiring removal to reestablish or ascertain FCW integrity. (NOTE: If significant growth on levees exists, prohibiting the inspection of animal burrows or other inspection items, then the levee inspection should be ended until this item is corrected.)	
2	Depressions/Rutting	X				**A** There are no ruts, pot holes, or other depressions on the levee, except for minor depressions caused by levee settlement. The levee crown, embankments, and access road crowns are well established and drain properly without any ponded water.	
						M Some minor depressions in the levee crown, embankment, or access roads that will not pond water and do not threaten the integrity of the levee.	
						U There are depressions greater than 6 inches deep that will and water, endangering the integrity of the levee.	
3	Erosion/Bank Caving	X				**A** No active erosion or bank caving observed on the landward or on the riverward side of the levee.	
						M There are areas where active erosion is occurring or has occurred on or near the levee embankment, but levee integrity is not threatened.	
						U Erosion or caving is occurring or has occurred that threatens the stability and integrity of the levee. The erosion or caving has progressed into the levee section or into the extended footprint of the levee foundation and has compromised the levee foundation stability.	

Key: **A** = Acceptable; **M** = Minimally Acceptable; Maintenance is required. **U** = Unacceptable. **N/A** Not Applicable. RODI = Requires Operation During Inspection

Levees
For use during all Initial and Continuing Eligibility Inspections of levees

Santa Clara River Levee
101 to Saticoy
Levee

10.27.08
Date

	RATED ITEM	A	M	U	N/A		EVALUATION	LOCATIONS/REMARKS/RECOMMENDATIONS
4	Slope Stability	✓				A	No slides present.	
						M	Minor superficial sliding that with deferred repairs will not pose an immediate threat to FCW integrity.	
						U	Evidence of deep seated sliding that threatens FCW integrity. Repairs are required to reestablish FCW integrity.	
5	Cracking	✓				A	No cracking observed on the levee greater than 6 inches deep.	
						M	Longitudinal and/or transverse cracking greater than 6 inches deep. No evidence of vertical movement along the crack.	
						U	Longitudinal and/or transverse cracking present and exhibits signs of vertical movement.	
6	Animal Control	✓				A	Continuous animals burrow control program in place that includes the elimination of active burrowing and the filling in of existing burrows.	
						M	The existing animal burrow control program needs to be improved. Several animal burrows present which may lead to seepage or slope stability problems, and they require immediate attention.	
						U	Animal burrow control program is not effective or is nonexistent. Significant maintenance is required to fill existing burrows, and the levee will not provide reliable flood protection until this maintenance is complete.	
7	Encroachments	✓				A	No trash, debris, excavations, structures, or other obstructions present within the project easement area. Encroachments which do not diminish proper functioning of the project have been previously approved by the Corps.	
						M	Trash, debris, excavations, structures, or other obstructions present, or inappropriate activities that will inhibit project operations and maintenance or emergency operations. Encroachments have not been approved by the Corps.	
						U	Trash, debris, excavations, structures, or other obstructions present, or inappropriate activities that will inhibit project operations and maintenance or emergency operations.	
8	Riprap Revetments and Banks	✓				A	Existing riprap protection is properly maintained and is undamaged. Riprap clearly visible.	
						M	No riprap displaced or scouring activity that could undercut banks, erode embankments, or restrict desired flow. Unwanted vegetation must be cleared and sprayed with an appropriate herbicide.	
						U	Dense brush, trees, or grasses hide the rock protection, or meandering and/or scour activity is undercutting banks, eroding embankments, or impairing channel flows by causing turbulence or shoaling.	
						N/A	There is no riprap protecting the levee.	

Key: **A** = Acceptable; **M** = Minimally Acceptable; Maintenance is required. **U** = Unacceptable. **N/A** Not Applicable. **RODI** = Requires Operation During Inspection

Levees

For use during all Initial and Continuing Eligibility Inspections of levees

Santa Clara River levee 101 to Saticoy Levee

10·27·08 Date

	RATED ITEM	A	M	U	N/A		EVALUATION	LOCATIONS/REMARKS/RECOMMENDATIONS
9	Closure Structures (Stop-log, Earthen Closures, or Gates) (A or U only)					**A**	Closure structure in good repair. Placing equipment, stop-logs, and other materials are readily available at all times. Components of closure clearly marked and installation instructions/procedures readily available.	
						U	Closure structure in poor condition. Parts missing or corroded. Placing equipment may not be available within normal warning time.	
					X	**N/A**	There are no closure structures along the levee.	
10	Underseepage Relief Wells/Toe Drainage Systems					**A**	Toe drainage systems and pressure relief wells necessary for maintaining FCW stability during flood events functioned properly during the last flood event and no sediment is observed in observed in horizontal system (if applicable). Nothing is observed which would indicate that the system won't function properly during the next flood.	
						M	Toe drainage systems or pressure relief wells are damaged and may become clogged if they are not repaired.	
						U	Toe drainage systems or pressure relief wells necessary for maintaining FCW stability during flood events have fallen into disrepair or have become clogged.	
					X	**N/A**	There are no relief wells/toe drainage systems along the levee.	

Key: **A** = Acceptable; **M** = Minimally Acceptable; Maintenance is required. **U** = Unacceptable. **N/A** Not Applicable. **RODI** = Requires Operation During Inspection

Additional issues noted during the inspection:

Inspector Name: D McCarthy

Signature:

Date:


10/27/2008


10/27/2008


10/27/2008


10/27/2008


10/27/2008


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10/27/2008

10/27/2008

APPENDIX B

Meeting Minutes and Milestones

May 11, 2009
10:00 to 11:00 a.m.
Conference Room 263

Levee Certification Team

Meeting Notes: Action Items and Critical Issues

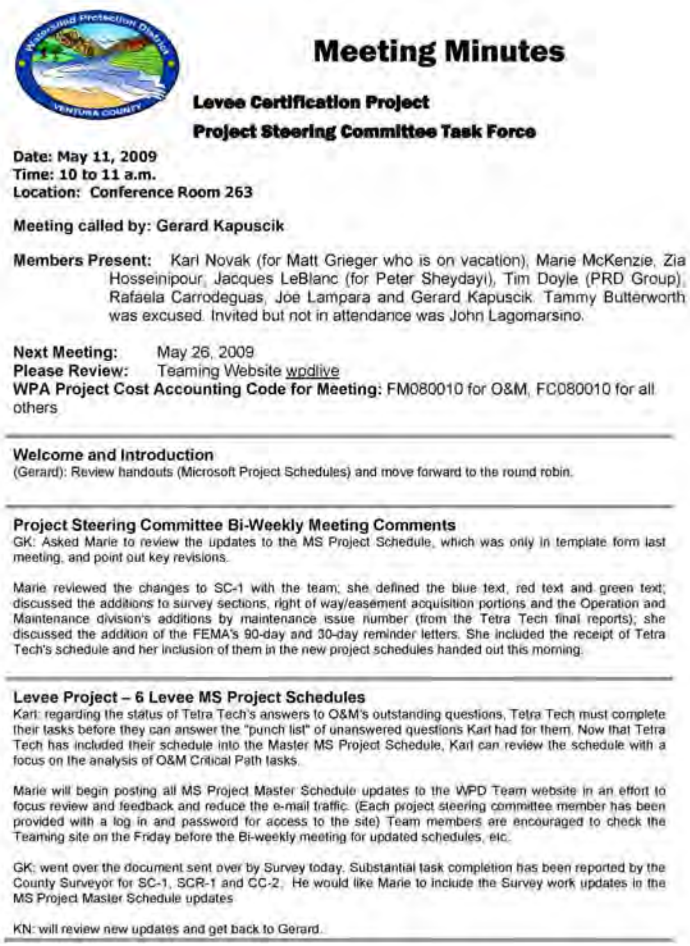
Meeting called by: Gerard Kapuscik
Type of meeting: Project Steering Committee
Facilitator: Gerard Kapuscik
Note taker: Marie McKenzie
Timekeeper: N/A
Attendees:

Watershed Protection District: Gerard Kapuscik, Joe Lampara, Karl Novak, Zia Hosseinipour, Jacques LeBlanc, Rafaela Carrodeguas and Marie McKenzie. PRD Group: Tim Doyle.

Please review: All six Microsoft Project Schedules (exhibits will be provided). Please direct revisions to Marie electronically.

Action Items

- Karl will review the Tetra Tech Schedules provided this morning and determine the critical path analysis.
- Pam is working with Jeff on the best way to approach the CDFG permits.
- Marie will post updated Microsoft Project schedules on the WPD Live Team website the Friday before the Bi-weekly Monday morning meetings. Team members are asked to familiarize themselves with the procedures and the Teaming Website prior to next meeting (May 26, 2009).
- Conference call with Gerard, Karl and Tetra Tech to verify who will be tasked with the flap gate portion of the levee certification process. During this call, the next meeting of the Flap Gate Task Force Committee will be discussed and scheduled.
- Gerard, Marie and Gabe will meet to discuss the procedures for responding to public inquiries.



Meeting Minutes

Levee Certification Project
Project Steering Committee Task Force

Date: May 11, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Karl Novak (for Matt Grieger who is on vacation), Marie McKenzie, Zia Hosseinipour, Jacques LeBlanc (for Peter Sheydayi), Tim Doyle (PRD Group), Rafaela Carrodeguas, Joe Lampara and Gerard Kapuscik. Tammy Butterworth was excused. Invited but not in attendance was John Lagomarsino.

Next Meeting: May 26, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Welcome and Introduction

(Gerard): Review handouts (Microsoft Project Schedules) and move forward to the round robin.

Project Steering Committee Bi-Weekly Meeting Comments

GK: Asked Marie to review the updates to the MS Project Schedule, which was only in template form last meeting, and point out key revisions.

Marie reviewed the changes to SC-1 with the team; she defined the blue text, red text and green text; discussed the additions to survey sections, right of way/easement acquisition portions and the Operation and Maintenance division's additions by maintenance issue number (from the Tetra Tech final reports); she discussed the addition of the FEMA's 90-day and 30-day reminder letters. She included the receipt of Tetra Tech's schedule and her inclusion of them in the new project schedules handed out this morning.

Levee Project – 6 Levee MS Project Schedules

Karl: regarding the status of Tetra Tech's answers to O&M's outstanding questions, Tetra Tech must complete their tasks before they can answer the "punch list" of unanswered questions Karl had for them. Now that Tetra Tech has included their schedule into the Master MS Project Schedule, Karl can review the schedule with a focus on the analysis of O&M Critical Path tasks.

Marie will begin posting all MS Project Master Schedule updates to the WPD Team website in an effort to focus review and feedback and reduce the e-mail traffic. (Each project steering committee member has been provided with a log in and password for access to the site) Team members are encouraged to check the Teaming site on the Friday before the Bi-weekly meeting for updated schedules, etc.

GK: went over the document sent over by Survey today. Substantial task completion has been reported by the County Surveyor for SC-1, SCR-1 and CC-2. He would like Marie to include the Survey work updates in the MS Project Master Schedule updates

KN: will review new updates and get back to Gerard.

Team Member Comments and Contributions – Round Robin

Pam Lindsey:

Regarding CC2, O&M's Zone Three crew members were successful in removing the vegetation, which was impeding the progress of the Survey team.
Bird Surveys: An endangered bird has been located at several sites along the Santa Clara River. If we will be working near these areas in the near future with any sort of equipment, we must alert Pam prior to commencing work. The biologists will let us know if/when nests are located, at this point, there are no nests, only a few birds in the area.

CDFG: To summarize, Pam hopes that CDFG will agree to three streambed agreements (one per watershed), rather than requiring individual permits for each of the six levees. At this point, they would like additional fees paid to their agency for the request for permits Pam previously submitted. Gerard asked what the worst case scenario was (dollar-wise), to which Pam replied $4,000 per levee or $24,000 total. Pam is hoping to pay 50% of that amount, which is $8,000 to $12,000 total.

At this point Pam doesn't need any assistance from the committee. She is collaboratively working with Jeff Humble, CDFG, to find a way to avoid six individual permits. She will alert Gerard if it is necessary to escalate the District's engagement with CDFG.

By the 15th of May, the Corps and LARWQCB permits will go out. The geo-tech work is permitted, but not valid until the CDFG permit has been obtained, The "best case scenario" is that we'll receive a waiver, from the Corps, 60 days from the 15th of May. (Marie is to update the Project Schedules to include this date). The Corp's waiver will "trump" the LARWQCB.

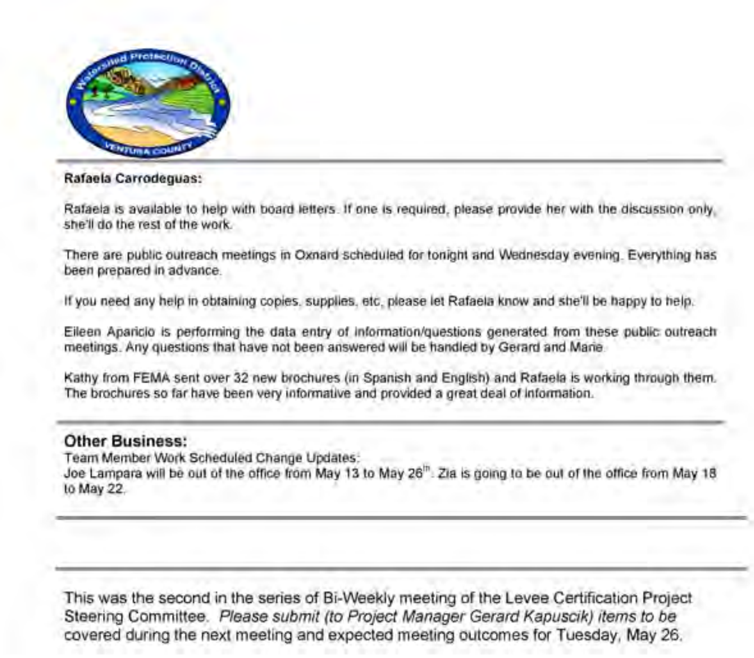
CC-3, since is a Category 3 Levee (i.e. not certifiable by November 30th) is not a part of the permit regime. At this point, any normal maintenance will be covered under existing permits.

Karl Novak:

On Thursday (May 7, 2009) Tetra Tech performed the gradation studies of SCR-1. The rock is very small. Tetra Tech is moving forward with the analysis and will provide us with a "fail/no fail" report by June 19th.

Flap gate plan coordination: Tetra Tech is obtaining the plans from the other municipalities' penetrations, interior drainage, etc. Tim interjected that a representative from PRD Group had been working on obtaining the elevations for the penetrations but after discovering that the hydrology reports would be more informative than the elevations, this project was abandoned. At this point, Design and Construction or the Operations and Maintenance Divisions will handle the construction of any needed flap gates (and/or headwalls). Tetra Tech's task is to determine (through hydrologic analysis & studies) whether flap gates are necessary or not. (Marie is to update the schedules to reflect this). Pam will apply for permits for the flap gate construction as though they all required headwalls, this will give us a larger assumed work area, whether it is needed (the headwall) or not. Design and Construction is primarily working on the Phase 4 levees. Tetra Tech is tasked with the design work on the Phase 3 levees.

Karl would like to know when we'll be scheduling a flap gate meeting to discuss the process. Tetra Tech should be contacted as a part of this discussion.



Rafaela Carrodeguas:

Rafaela is available to help with board letters. If one is required, please provide her with the discussion only, she'll do the rest of the work.

There are public outreach meetings in Oxnard scheduled for tonight and Wednesday evening. Everything has been prepared in advance.

If you need any help in obtaining copies, supplies, etc, please let Rafaela know and she'll be happy to help.

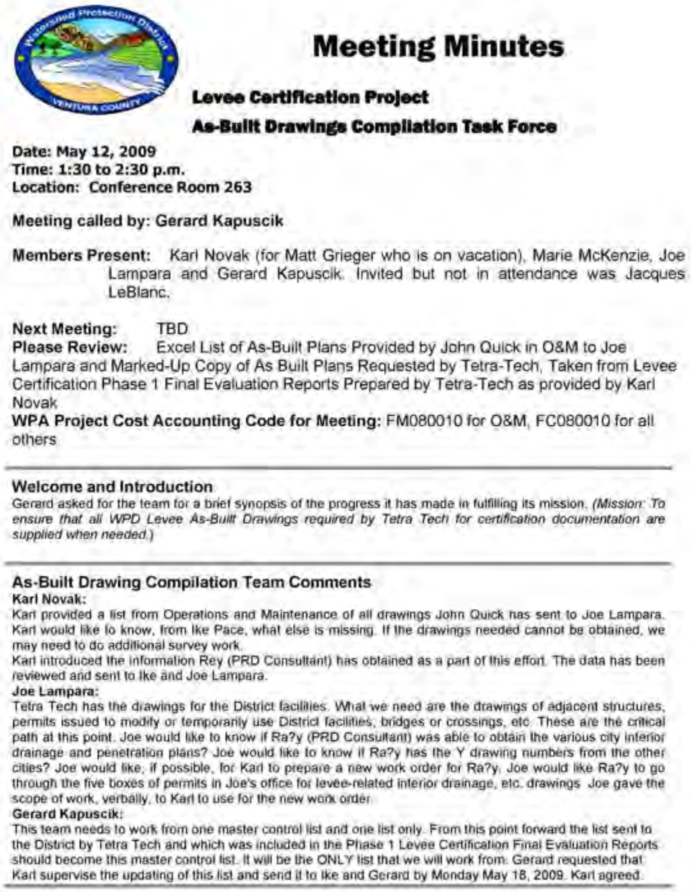
Eileen Aparicio is performing the data entry of information/questions generated from these public outreach meetings. Any questions that have not been answered will be handled by Gerard and Marie.

Kathy from FEMA sent over 32 new brochures (in Spanish and English) and Rafaela is working through them. The brochures so far have been very informative and provided a great deal of information.

Other Business:

Team Member Work Scheduled Change Updates:
Joe Lampara will be out of the office from May 13 to May 26th. Zia is going to be out of the office from May 18 to May 22.

This was the second in the series of Bi-Weekly meeting of the Levee Certification Project Steering Committee. *Please submit (to Project Manager Gerard Kapuscik) items to be covered during the next meeting and expected meeting outcomes for Tuesday, May 26.*



Meeting Minutes

Levee Certification Project

As-Built Drawings Compilation Task Force

Date: May 12, 2009
Time: 1:30 to 2:30 p.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Karl Novak (for Matt Grieger who is on vacation), Marie McKenzie, Joe Lampara and Gerard Kapuscik. Invited but not in attendance was Jacques LeBlanc.

Next Meeting: TBD
Please Review: Excel List of As-Built Plans Provided by John Quick in O&M to Joe Lampara and Marked-Up Copy of As Built Plans Requested by Tetra-Tech, Taken from Levee Certification Phase 1 Final Evaluation Reports Prepared by Tetra-Tech as provided by Karl Novak
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

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Welcome and Introduction

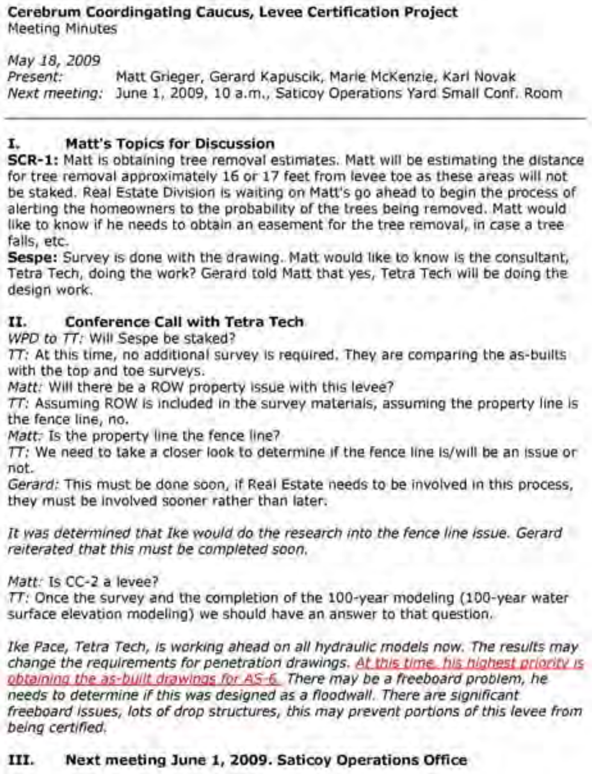
Gerard asked for the team for a brief synopsis of the progress it has made in fulfilling its mission. *(Mission: To ensure that all WPD Levee As-Built Drawings required by Tetra Tech for certification documentation are supplied when needed.)*

As-Built Drawing Compilation Team Comments

Karl Novak:
Karl provided a list from Operations and Maintenance of all drawings John Quick has sent to Joe Lampara. Karl would like to know, from Ike Pace, what else is missing. If the drawings needed cannot be obtained, we may need to do additional survey work.
Karl introduced the information Rey (PRD Consultant) has obtained as a part of this effort. The data has been reviewed and sent to Ike and Joe Lampara.

Joe Lampara:
Tetra Tech has the drawings for the District facilities. What we need are the drawings of adjacent structures, permits issued to modify or temporarily use District facilities, bridges or crossings, etc. These are the critical path at this point. Joe would like to know if Ra?y (PRD Consultant) was able to obtain the various city interior drainage and penetration plans? Joe would like to know if Ra?y has the Y drawing numbers from the other cities? Joe would like, if possible, for Karl to prepare a new work order for Ra?y. Joe would like Ra?y to go through the five boxes of permits in Joe's office for levee-related interior drainage, etc. drawings. Joe gave the scope of work, verbally, to Karl to use for the new work order.

Gerard Kapuscik:
This team needs to work from one master control list and one list only. From this point forward the list sent to the District by Tetra Tech and which was included in the Phase 1 Levee Certification Final Evaluation Reports should become this master control list. It will be the ONLY list that we will work from. Gerard requested that Karl supervise the updating of this list and send it to Ike and Gerard by Monday May 18, 2009. Karl agreed.



Cerebrum Coordingating Caucus, Levee Certification Project
Meeting Minutes

May 18, 2009
Present: Matt Grieger, Gerard Kapuscik, Marie McKenzie, Karl Novak
Next meeting: June 1, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

I. Matt's Topics for Discussion

SCR-1: Matt is obtaining tree removal estimates. Matt will be estimating the distance for tree removal approximately 16 or 17 feet from levee toe as these areas will not be staked. Real Estate Division is waiting on Matt's go ahead to begin the process of alerting the homeowners to the probability of the trees being removed. Matt would like to know if he needs to obtain an easement for the tree removal, in case a tree falls, etc.
Sespe: Survey is done with the drawing. Matt would like to know is the consultant, Tetra Tech, doing the work? Gerard told Matt that yes, Tetra Tech will be doing the design work.

II. Conference Call with Tetra Tech

WPD to TT: Will Sespe be staked?
TT: At this time, no additional survey is required. They are comparing the as-builts with the top and toe surveys.
Matt: Will there be a ROW property issue with this levee?
TT: Assuming ROW is included in the survey materials, assuming the property line is the fence line, no.
Matt: Is the property line the fence line?
TT: We need to take a closer look to determine if the fence line is/will be an issue or not.
Gerard: This must be done soon, if Real Estate needs to be involved in this process, they must be involved sooner rather than later.

It was determined that Ike would do the research into the fence line issue. Gerard reiterated that this must be completed soon.

Matt: Is CC-2 a levee?
TT: Once the survey and the completion of the 100-year modeling (100-year water surface elevation modeling) we should have an answer to that question.

Ike Pace, Tetra Tech, is working ahead on all hydraulic models now. The results may change the requirements for penetration drawings. At this time, his highest priority is obtaining the as-built drawings for AS-6. There may be a freeboard problem, he needs to determine if this was designed as a floodwall. There are significant freeboard issues, lots of drop structures, this may prevent portions of this levee from being certified.

III. Next meeting June 1, 2009. Saticoy Operations Office

Meeting Minutes

Levee Certification Project

Project Steering Committee

Date: May 26, 2009
Time: 10 to 10:30 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Karl Novak, Matt Grieger, Zia Hosseinipour, Peter Sheydayi, Rafaela Carrodeguas, Pam Lindsey, Joe Lampara, Keith Filegar, Marie McKenzie and Gerard Kapuscik. Tammy Butterworth was excused. Invited but not in attendance was John Lagomarsino.

Next Meeting: June 8, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Welcome and Introduction

Gerard welcomed the Project Team members present.

Survey Updates: Matt Grieger

According to Alex Mathews, County Surveyor's Office, the field survey process is going well. Survey expects to provide survey deliverables for the **CC-2** levee during the week of June 1st. **SCR-1:** Penfield and Smith are done with the field work; Jose will be doing the 'in house' work. There is an O&M issue regarding the 200 trees that need to be removed. Estimates (2 of them) put the cost for the removal of those trees at $250,000. Matt is confident there will be no real estate issues, and anticipates beginning the tree removal in 30 days. Pam Lindsey reminded Matt that there is a bird nesting issue and we must be cognizant of that. She must be notified before the work begins.

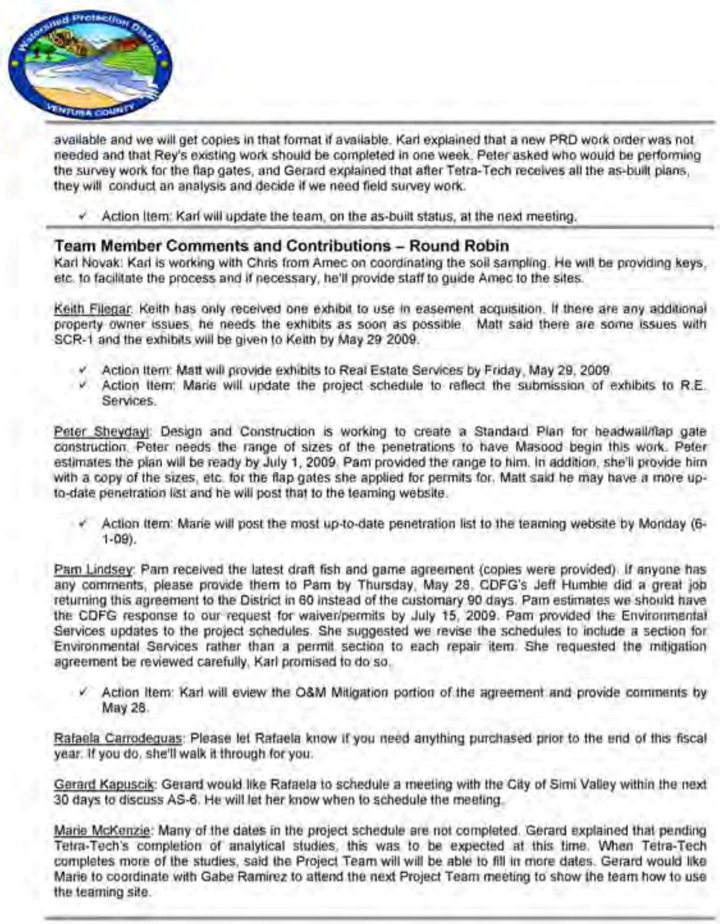
- ✓ Action Item: Matt must Notify Pam Lindsey prior to tree removal. Trees cannot be removed without her approval.
- ✓ Action Item: Matt will check the budget to make sure the $250,000 for tree removal is there.
- ✓ Action Item: Matt will bring written survey status updates prepared by the County Surveyor to this meeting.

SC-1: Matt was concerned that there were staking issues. Gerard updated the team as follows: there are not homeowner issues, or shortness of time issues. The overtopping will not be an issue for certification. It could be a problem later, but not at this time. Gerard will supply the report from Tetra Tech, on this issue, at the next meeting.

- ✓ Action Item: Gerard will supply the Project Team with Tetra-Tech's Report before the June 8th Team m meeting.

As-Built Drawing Compilation Update: Karl Novak

The compilation of the as built drawings for all levees is moving along. It is quite an endeavor as there are approximately 50 penetrations on the AS-6 levee alone. Some cities have electronic versions of the plans available and we will get copies in that format if available. Karl explained that a new PRD work order was not needed and that Rey's existing work should be completed in one week. Peter asked who would be performing the survey work for the flap gates, and Gerard explained that after Tetra-Tech receives all the as-built plans, they will conduct an analysis and decide if we need field survey work.



- ✓ Action Item: Karl will update the team, on the as-built status, at the next meeting.

Team Member Comments and Contributions – Round Robin

Karl Novak: Karl is working with Chris from Amec on coordinating the soil sampling. He will be providing keys, etc. to facilitate the process and if necessary, he'll provide staff to guide Amec to the sites.

Keith Filegar: Keith has only received one exhibit to use in easement acquisition. If there are any additional property owner issues, he needs the exhibits as soon as possible. Matt said there are some issues with SCR-1 and the exhibits will be given to Keith by May 29 2009.

- ✓ Action Item: Matt will provide exhibits to Real Estate Services by Friday, May 29, 2009.
- ✓ Action Item: Marie will update the project schedule to reflect the submission of exhibits to R.E. Services.

Peter Sheydayi: Design and Construction is working to create a Standard Plan for headwall/flap gate construction. Peter needs the range of sizes of the penetrations to have Masood begin this work. Peter estimates the plan will be ready by July 1, 2009. Pam provided the range to him. In addition, she'll provide him with a copy of the sizes, etc. for the flap gates she applied for permits for. Matt said he may have a more up-to-date penetration list and he will post that to the teaming website.

- ✓ Action Item: Marie will post the most up-to-date penetration list to the teaming website by Monday (6-1-09).

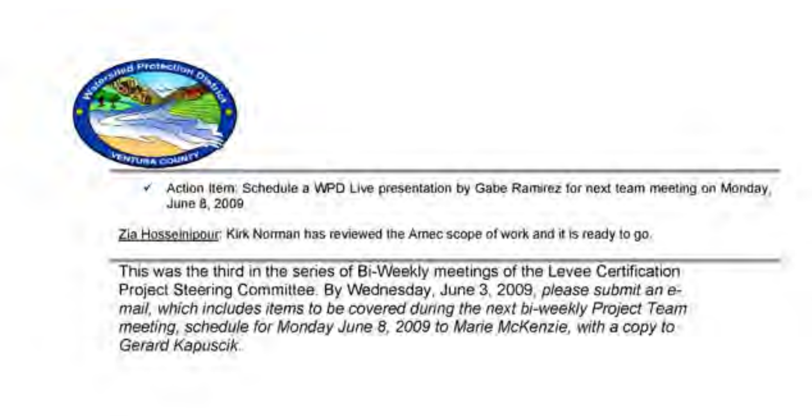
Pam Lindsey: Pam received the latest draft fish and game agreement (copies were provided). If anyone has any comments, please provide them to Pam by Thursday, May 28. CDFG's Jeff Humble did a great job returning this agreement to the District in 60 instead of the customary 90 days. Pam estimates we should have the CDFG response to our request for waiver/permits by July 15, 2009. Pam provided the Environmental Services updates to the project schedules. She suggested we revise the schedules to include a section for Environmental Services rather than a permit section to each repair item. She requested the mitigation agreement be reviewed carefully, Karl promised to do so.

- ✓ Action Item: Karl will eview the O&M Mitigation portion of the agreement and provide comments by May 28.

Rafaela Carrodeguas: Please let Rafaela know if you need anything purchased prior to the end of this fiscal year. If you do, she'll walk it through for you.

Gerard Kapuscik: Gerard would like Rafaela to schedule a meeting with the City of Simi Valley within the next 30 days to discuss AS-6. He will let her know when to schedule the meeting.

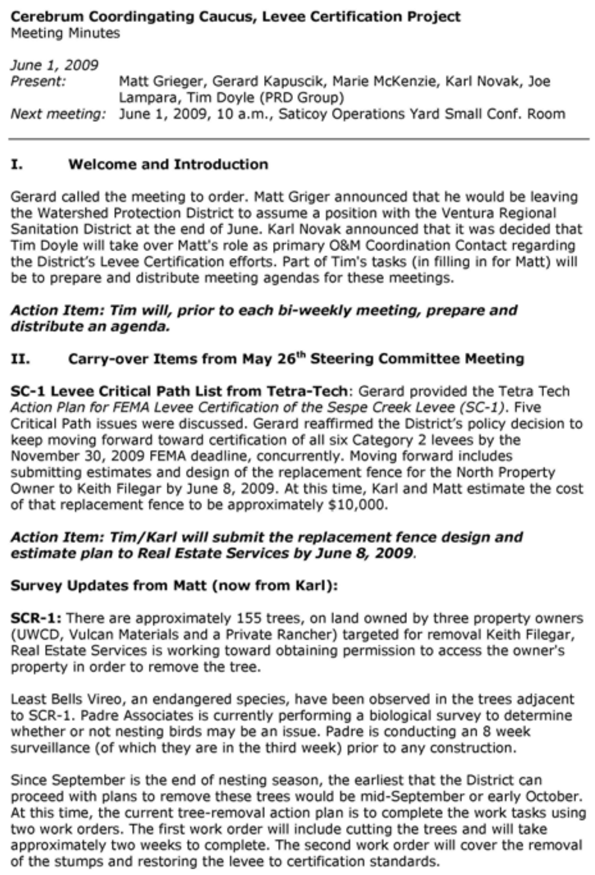
Marie McKenzie: Many of the dates in the project schedule are not completed. Gerard explained that pending Tetra-Tech's completion of analytical studies, this was to be expected at this time. When Tetra-Tech completes more of the studies, said the Project Team will will be able to fill in more dates. Gerard would like Marie to coordinate with Gabe Ramirez to attend the next Project Team meeting to show the team how to use the teaming site.



- ✓ Action Item: Schedule a WPD Live presentation by Gabe Ramirez for next team meeting on Monday, June 8, 2009

Zia Hosseinipour: Kirk Norman has reviewed the Amec scope of work and it is ready to go.

This was the third in the series of Bi-Weekly meetings of the Levee Certification Project Steering Committee. By Wednesday, June 3, 2009, *please submit an e-mail, which includes items to be covered during the next bi-weekly Project Team meeting, schedule for Monday June 8, 2009 to Marie McKenzie, with a copy to Gerard Kapuscik.*



Cerebrum Coordingating Caucus, Levee Certification Project
Meeting Minutes

June 1, 2009
Present: Matt Grieger, Gerard Kapuscik, Marie McKenzie, Karl Novak, Joe Lampara, Tim Doyle (PRD Group)
Next meeting: June 1, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

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I. Welcome and Introduction

Gerard called the meeting to order. Matt Griger announced that he would be leaving the Watershed Protection District to assume a position with the Ventura Regional Sanitation District at the end of June. Karl Novak announced that it was decided that Tim Doyle will take over Matt's role as primary O&M Coordination Contact regarding the District's Levee Certification efforts. Part of Tim's tasks (in filling in for Matt) will be to prepare and distribute meeting agendas for these meetings.

Action Item: Tim will, prior to each bi-weekly meeting, prepare and distribute an agenda.

II. Carry-over Items from May 26th Steering Committee Meeting

SC-1 Levee Critical Path List from Tetra-Tech: Gerard provided the Tetra Tech *Action Plan for FEMA Levee Certification of the Sespe Creek Levee (SC-1)*. Five Critical Path issues were discussed. Gerard reaffirmed the District's policy decision to keep moving forward toward certification of all six Category 2 levees by the November 30, 2009 FEMA deadline, concurrently. Moving forward includes submitting estimates and design of the replacement fence for the North Property Owner to Keith Filegar by June 8, 2009. At this time, Karl and Matt estimate the cost of that replacement fence to be approximately $10,000.

Action Item: Tim/Karl will submit the replacement fence design and estimate plan to Real Estate Services by June 8, 2009.

Survey Updates from Matt (now from Karl):

SCR-1: There are approximately 155 trees, on land owned by three property owners (UWCD, Vulcan Materials and a Private Rancher) targeted for removal Keith Filegar, Real Estate Services is working toward obtaining permission to access the owner's property in order to remove the tree.

Least Bells Vireo, an endangered species, have been observed in the trees adjacent to SCR-1. Padre Associates is currently performing a biological survey to determine whether or not nesting birds may be an issue. Padre is conducting an 8 week surveillance (of which they are in the third week) prior to any construction.

Since September is the end of nesting season, the earliest that the District can proceed with plans to remove these trees would be mid-September or early October. At this time, the current tree-removal action plan is to complete the work tasks using two work orders. The first work order will include cutting the trees and will take approximately two weeks to complete. The second work order will cover the removal of the stumps and restoring the levee to certification standards.

Verification of $250K in O&M Budget for SCR-1 Levee Tree Removal from Matt: Gerard answered the budget question from the last meeting: O&M has $200,000 set aside for work in Zone 2. The additional $100,000 to complete this task may have to come from another source. Matt suggested the use of an existing contract O&M has for tree stump removal in Zone 2.

Action Item: Tim/Karl will identify the funding sources required in the O&M budget to complete the tree-removal project by June 15, 2009.

As-Built Design Plan Compilation Update from Karl: Karl updated the team with the following information: "To date, 95 percent of the as-built drawings identified by Tetra-Tech as required for levee certification work have been identified. We are currently obtaining paper or electronic copies of them from the cities. We should be 98% complete within two weeks (June 15)."

Action Item: Karl will provide the team with a list of as-built documents both those which are outstanding and those he has obtained (June 15).

Any O&M Coordination Issues from Matt or Karl: Matt will be on vacation from June 2, 2009 and returning June 9, 2009. Karl & Matt had questions regarding the procedure for stump removal and the drums Amec has stored at the Moorpark Operations Yard. A phone call was placed to Tetra Tech at the end of the meeting to review and discuss these issues.

III. Conference Call to Tetra Tech

With regard to the specs for stump/root removal: the Phase 1 evaluation reports ALL include comprehensive specifications, instructions and descriptive drawings regarding vegetation removal, compaction, soils, etc.

Karl asked Ike if Amec, Tetra-Tech's Geotechnical Sub-Contractor, would be trenching the levees as a part of their investigative work. Ike answered no, they are only drilling. In addition Amec will back-fill, etc. all in accordance with the subsurface exploration plan filed with the District.

Tim asked Ike about the plans for SC-1, Ike explained that Tetra Tech will be conducting the interior drainage study. Tetra Tech plans on reviewing the existing plans from the developer. Once they are able to, they'll re-issue them and O&M will be responsible for developing the paperwork in support of a maintenance construction contract.

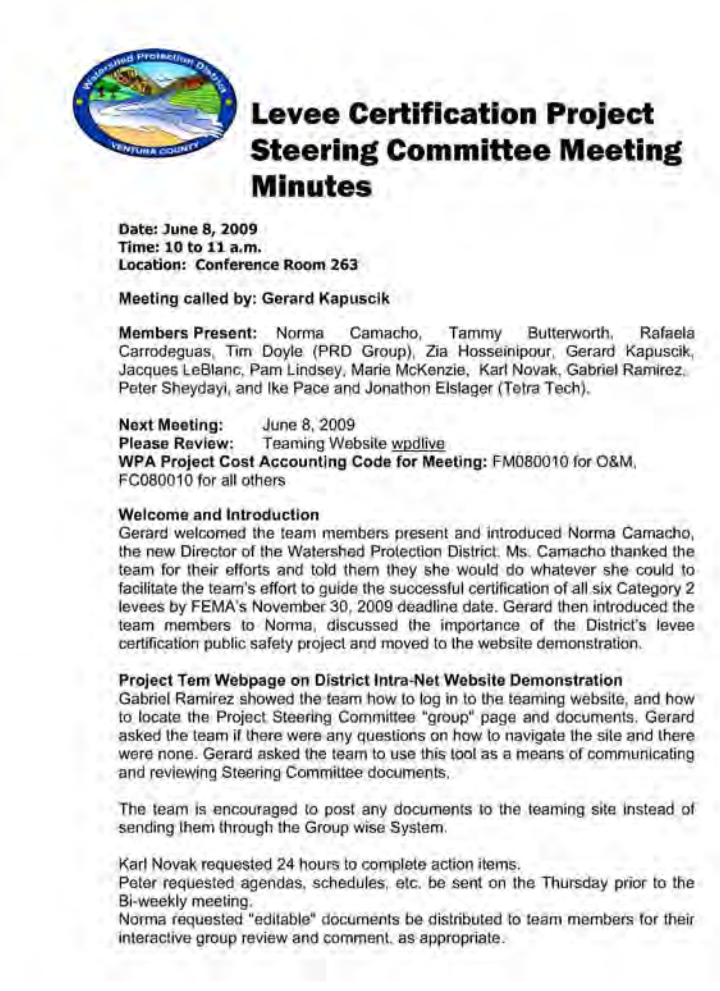
Ike estimates the cost of maintenance construction work at $175,000. Because of the dollar amount, O&M will have to go to the Board of Supervisors to award the contract. The "paperwork" part of this contract should be started, that way when the plans are ready, everything will be in place to move forward with the quote process. Gerard will be responsible for determining who will conduct the review of the soils report for this project.

Action Item: Gerard will obtain the soil report (previously submitted by Griffin Homes for an encroachment permit) and determine who will review it.

Action Item: Karl/Tim will begin the process of preparing the maintenance construction contract paperwork for this task so that we will not lose any time. Karl/Tim will provide a contract development milestone update report at the June 15th meeting.

IV. Next meeting June 15, 2009. Saticoy Operations Office

Please submit agenda items to Tim Doyle by no later than 5:00 p.m. Thursday, June 11, 2009.



Levee Certification Project Steering Committee Meeting Minutes

Date: June 8, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Norma Camacho, Tammy Butterworth, Rafaela Carrodeguas, Tim Doyle (PRD Group), Zia Hosseinipour, Gerard Kapuscik, Jacques LeBlanc, Pam Lindsey, Marie McKenzie, Karl Novak, Gabriel Ramirez, Peter Sheydayi, and Ike Pace and Jonathon Elslager (Tetra Tech).

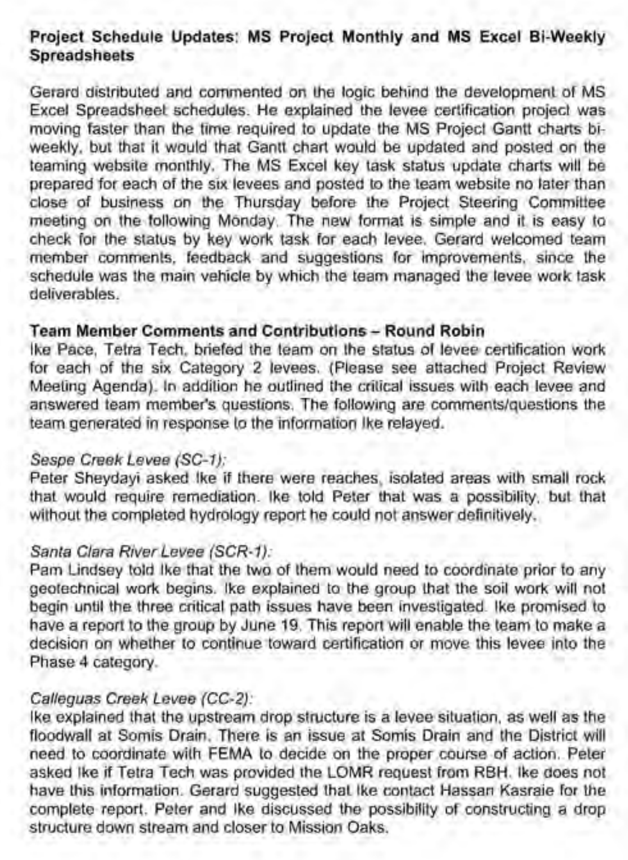
Next Meeting: June 8, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Welcome and Introduction
Gerard welcomed the team members present and introduced Norma Camacho, the new Director of the Watershed Protection District. Ms. Camacho thanked the team for their efforts and told them they she would do whatever she could to facilitate the team's effort to guide the successful certification of all six Category 2 levees by FEMA's November 30, 2009 deadline date. Gerard then introduced the team members to Norma, discussed the importance of the District's levee certification public safety project and moved to the website demonstration.

Project Tem Webpage on District Intra-Net Website Demonstration
Gabriel Ramirez showed the team how to log in to the teaming website, and how to locate the Project Steering Committee "group" page and documents. Gerard asked the team if there were any questions on how to navigate the site and there were none. Gerard asked the team to use this tool as a means of communicating and reviewing Steering Committee documents.

The team is encouraged to post any documents to the teaming site instead of sending them through the Group wise System.

Karl Novak requested 24 hours to complete action items.
Peter requested agendas, schedules, etc. be sent on the Thursday prior to the Bi-weekly meeting.
Norma requested "editable" documents be distributed to team members for their interactive group review and comment, as appropriate.



Project Schedule Updates: MS Project Monthly and MS Excel Bi-Weekly Spreadsheets

Gerard distributed and commented on the logic behind the development of MS Excel Spreadsheet schedules. He explained the levee certification project was moving faster than the time required to update the MS Project Gantt charts bi-weekly, but that it would that Gantt chart would be updated and posted on the teaming website monthly. The MS Excel key task status update charts will be prepared for each of the six levees and posted to the team website no later than close of business on the Thursday before the Project Steering Committee meeting on the following Monday. The new format is simple and it is easy to check for the status by key work task for each levee. Gerard welcomed team member comments, feedback and suggestions for improvements, since the schedule was the main vehicle by which the team managed the levee work task deliverables.

Team Member Comments and Contributions – Round Robin
Ike Pace, Tetra Tech, briefed the team on the status of levee certification work for each of the six Category 2 levees. (Please see attached Project Review Meeting Agenda). In addition he outlined the critical issues with each levee and answered team member's questions. The following are comments/questions the team generated in response to the information Ike relayed.

Sespe Creek Levee (SC-1):
Peter Sheydayi asked Ike if there were reaches, isolated areas with small rock that would require remediation. Ike told Peter that was a possibility, but that without the completed hydrology report he could not answer definitively.

Santa Clara River Levee (SCR-1):
Pam Lindsey told Ike that the two of them would need to coordinate prior to any geotechnical work begins. Ike explained to the group that the soil work will not begin until the three critical path issues have been investigated. Ike promised to have a report to the group by June 19. This report will enable the team to make a decision on whether to continue toward certification or move this levee into the Phase 4 category.

Calleguas Creek Levee (CC-2):
Ike explained that the upstream drop structure is a levee situation, as well as the floodwall at Somis Drain. There is an issue at Somis Drain and the District will need to coordinate with FEMA to decide on the proper course of action. Peter asked Ike if Tetra Tech was provided the LOMR request from RBH. Ike does not have this information. Gerard suggested that Ike contact Hassan Kasraie for the complete report. Peter and Ike discussed the possibility of constructing a drop structure down stream and closer to Mission Oaks.

Peter explained that at one time there was a plan to construct this drop structure. Ike said that he would investigate the possibility; at this point, it appeared to Tetra Tech that the "fix" would be to move the drop structure up toward Adolfo Road. There were, in Ike's opinion, three major issues: FEMA's input, the Districts decision based on FEMA's input and then to schedule the geotechnical work based on the District's decisions.

Arroyo Santa Rosa (ASR-2):
It appears as though there is a significant freeboard deficiency and that this levee may require channelization.

Arroyo Simi Levee (AS-6):
Portions of this levee will be de-listed, the parts that do not protect any insured property. The following scope of work on this levee will be reduced: subsurface exploration and interior drainage. Karl Novak asked for specific information on what will be removed from the scope so that he can cease any O&M work on the de-listed portions of this levee.

Arroyo Simi Floodwall (AS-7):
Ike proposed de-listing portions of this levee. Peter and Ike discussed designing and building "taller" walls, or an off-set wall in the right-of-way. Ike promised to provide a package (regarding all design critical path issues) to Peter, Jacques, Pam, Karl and Gerard.

Peter suggested the team should begin forming working task groups to tackle the resolution of levee-specific issues.

Survey Update from Karl Novak
Karl discussed a deed issue with CC-2. Exhibits Karl has reviewed show that there are portions of property that should have been turned over to WPD, but are still legally listed to another owner. Karl will work on getting legal descriptions to Jose (Eng. Services) and Keith Filegar (Real Estate).

Gerard requested Karl to move forward with this project, recognizing that its quick resolution is not as necessary, since it will not impact the certification schedule. At the Somis Drain portion of this levee there are approximately 45 trees within 15 feet of the levee and outside of the District's easement. Karl will wait on the floodwall resolution prior to going forward with the tree removal. Karl will be prepared to remove the trees, but he will not remove them until he receives direction from Gerard.

Karl informed the group the John Lagomarsino would no longer be attending the Project Steering Committee meetings due to other responsibilities. Both Karl and Tim Doyle will be the representatives from O&M on the Project Steering Committee.

Cerebrum Coordingating Caucus, Levee Certification Project
Meeting Minutes

June 15, 2009
Present: Gerard Kapuscik, Marie McKenzie, Karl Novak, Joe Lampara, Tim Doyle (PRD Group)
Next meeting: June29, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

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I. Agenda Review and Changes

There we no changes to the published agenda. Joe Lampara requested his WPD Live password and log-in be resent.

Action Item: Marie sent Joe his password and log-in ID. ***Completed today.***

II. Carry-over Items from June 1st CCC Meeting

Survey updates from Tim:
Tim passed out Survey's report from June 8, 2009 and advised the team that so far, everything appears to be going smoothly. . There will be actually less work than originally planned and budgeted, especially regarding Phase IV (Staking) of the Survey Work Order. Survey teams will not perform staking unless specifically requested by the District At this time; we have requested Somis Drain and Sespe Creek to be staked.

Action Item: Marie will send the final survey work order to Tim so that he can verify sufficient budget capacity $'s are there for Phase IV work. ***Completed today.***

Gerard will send PDF copies of Tetra Tech's Draft revised action plans for the AS-6, AS-7 and CC-2 to Keith Filegar, Marie McKenzie, Tim Doyle, Joe Lampara and Karl Novak by the end of this week (Friday, June 19th)

Action Item: Gerard will send draft levee plans to aforementioned team members by Friday, June 19th.

Somis Creek tree removal issue (65 trees):
Tim summarized the preparatory planning work undertaken by the O&M Division to date. Gerard indicated that prior to moving forward with authorizing the removal of these trees, Tim and the O&M Division review Tetra-Tech's revised action plan for the CC-2 levee, and await the completion of FEMA's review and recommendations regarding the de-listing of portions of this levee.

Action Item: Gerard will coordinate resolution of these matters with Ike and Kathy Schaefer, Engineer, Region IX, FEMA, and once we reach concurrence with FEMA, he will send Karl and Tim notification regarding the extent and timing of the removal of all, some or none of the trees.

Verification of funds in O&M Budget for work: Gerard handed out an email dated June 14, 2009, summarizing the YTD performance of Levee Budget during the Fiscal Year ending June 30, 2009. As detailed in the e-mail, Gerard projects at YE expenditure of approximately $3.8 Million out of a $4.3 Million budget target, or 88% of the annual target.

At this time, we are on track, budget-wise. Gerard requested O&M send him an updated spreadsheet that outlines O&M work completed and work outstanding for prospective FY 09-10 budget planning purposes.

*Action Item: Karl/Tim will provide an updated maintenance repair spreadsheet by no later that the July 6 Project Steering Committee meeting (**Marie, check with Karl/Tim and pin this date down, please**), The spreadsheet should include completed work; dollars (and man power & equipment) spent and work yet to be completed.*

Fence estimate from Real Estate from SC-1 from Mark Yaftali: Mark Yaftali explained the preliminary plan and suggestions for privacy screen and removable fence. Mark estimates the fence will cost $65 per linear foot including installation.

Action Item: Karl will send the exhibits and quotes to Ike Pace for his review. Karl will request Ike determine where the levee begins and ends.

The fence issue brought up a discussion of the nature, extent and scope of the vegetation removal that will be required at the U/S end of SC-1 in order to ensure certification requirements are met by November 30, 2009. Joe Lampara asked who would be removing the vegetation.

Karl replied that O&M would probably hire a contractor to do the work, based on the general vegetation removal plans and specifications provided by Tetra-Tech in the Phase 1 Evaluation Reports. Joe wanted to make sure the vegetation and sprinkler system would be removed prior to the installation of the privacy fence. Gerard requested a copy of the permit be sent to team members.

Action item: Joe Lampara will send out a copy of the permit to plant trees on SC-1. **Completed today.**

Soil report status for SC-1 from Griffin permit from Gerard: Gerard passed out a copy of a June 5th letter the District sent to Bert Rapp, Director of Fillmore Public Works and to Bill Bartels, Acting City of Fillmore Manager. The letter requested that the City provide the District with access to their Tract 5335 Development Files (Griffin Homes), in particular as-built design plans and geotechnical evaluation reports confirming that the Developer's tract improvements approved by the City did not adversely affect the structural integrity of the SC-1 levee. The District requested copies of this information
Gerard will update the team if the District receives a response.

*Action item: Gerard will update team after speaking to City of Fillmore representatives this morning during a tel-con meeting with FEMA. (**Editorial Note:** The District received PDF copies of eight as-built design plan sheets from the City of Fillmore's files today, June 15th. Gerard will forward copies of those design plan sheets to the team members by e-mail, **today.**)*

As-Built Design Plan Compilation Update from Karl: The list of obtained and outstanding as-built plans is not complete. Karl anticipates the list will be completed by the end of the week (June 19th).

Action Item: Karl will provide the team with a list of as-built documents both those which are outstanding and those he has obtained at the June 22 PSC Meeting. He will also update the team on the status of the bridge drawings at Somis Drain. John Quick is in discussions with the City of Camarillo regarding the signed as-built drawings.

Contract paperwork preparation from Tim: Tim confirms everything is set up and O&M is ready to go when they are told to proceed. Gerard reminded Tim to allow sufficient time for maintenance contract bid process, authorization by the Board of Supervisors for contracts exceeding $100,000, and for Rafaela Carrodeguas to review the procurement approval paperwork.

Status of property deed transfer from City of Camarillo to WPD in the vicinity of CC-2 north of Mission Oaks Blvd. from Karl: Karl will send an email to Eng. Services Survey team right away.

Action Item: Karl will email the County Surveyors requesting them to move forward with the deed transfer process.

III. New Business

SC-1 Levee Construction Plans for Repairs of Undercut of Toe by RR Xing from Gerard: Gerard expects to have the designs from Tetra Tech by June 19. Tim asked what the plans involved. Tim said that in discussions he has had with Matt, they think that a tractor can be used to replace the missing dirt on the slope and return the levee to design standards. Gerard said that it is his desire to repair the levee in the most cost-effective, complete and expeditious manner, but there may be a drainage problem (caused by the developer) that the plans must address. Gerard requested that Joe and Tim coordinate with Tetra Tech regarding their final design plans for the construction fix.

Action Item: Tim will send an email to Tetra Tech expressing his concerns and asking his questions regarding the undercut repair. Gerard will also send a generic email, on the subject, to Ike.

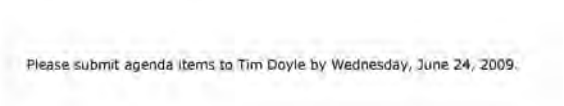
Joe asked if plans and specs were being prepared/considered for the upstream vegetation removal. Joe's review indicates a large portion of the levee will need to be rebuilt after the trees are removed. Karl said that his review leads him to believe there is not a great deal of rebuilding necessary and that it doesn't appear to be a large project. Gerard suggested Tim, Joe and Karl coordinate with Tetra Tech on this issue.

Action Item: Karl, Joe, and Tim will coordinate with Tetra Tech and determine the amount of work necessary to repair the levee after the trees have been removed.

Status of Real Estate submittals from Tim: Tim has all exhibits prepared and is ready to send them as soon as a decision is made to proceed

Update of maintenance activities on levees from Tim: At this time, Tim is waiting on the de-list plan before moving forward on any maintenance/repair issues.

IV. Next meeting June 29, 2009. Saticoy Operations Office



Please submit agenda items to Tim Doyle by Wednesday, June 24, 2009.

Levee Certification Project Steering Committee Meeting Minutes

Date: June 22, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Pam Lindsey, Zia Hossainipour, Tim Doyle (PRD Group), Rafaela Carrodeguas, Marie McKenzie, Joe Lampara and Gerard Kapuscik. Tammy Butterworth was excused. Invited but not in attendance were Peter Sheydayi and Karl Novak.

Next Meeting: July 6, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Environmental Services

Pam updated the Team regarding the current status of the ongoing consultations with the CDFG regarding the development of the Master Streambed Alteration Agreement for the Levee Certification work. Pam distributed copies of the latest version of the streambed agreement, which is very close to being final. Pam requested that Project Team Members review the latest draft of the agreement, and provide her with any comments, concerns or suggested additions by the end of the day since the District wishes to finalize and execute the agreement by no later than this week.

Pam informed the team that she received questions regarding the Casitas Springs (VR-2) levee. Both CDFG and Ojai Valley Land Conservancy (OVLC) have called to ask about the status of vegetation removal requirements for the VR-2 levee. This levee has a lot of mitigation sites, so it would require a lot of work in the vegetation removal category.

Pam explained to the Team that she told CDFG the veg removal at this site, as with many others, would fall under the "umbrella" of the Master Stream Bed Alteration Agreement which the District is currently trying to obtain for maintenance work. Gerard confirmed that the District is pursuing certification of the VR-2 Levee by alternate means (i.e. via a LOMR process), and because of that reason, it was not included in the list of PAL-designated levees which require certification documentation submittals to FEMA by November 30, 2009.

Gerard informed the Team that FEMA has proposed that a consortium of So-Cal local flood control agencies, the USACOE and other interested stakeholders agree to a engage in a cooperative effort whereby this *stakeholder* group develops a "standard of care" definition of the nature, scope and extent of vegetation removal requirements for So-Cal levees.
It is likely that this So-Cal effort will be modeled on a recent effort undertaken concerning levees in the Central Valley which proved highly successful. FEMA will likely request contributions of funds from the stakeholders to finance an experienced, skilled facilitator to help the group reach a *technically-sound, outcomes-based and collaboratively-developed* standard of care for So-Cal levee veg removal.

Status of June 19 Tetra Tech Report for SCR-1 (Fail/No Fail Report)
Gerard announced that Tetra-Tech has advised the District that based on the *preliminary results* of their records search, field investigation, geotechnical, hydraulic and embankment structural analyses, it appears that the SCR-1 Levee cannot be certified for the 1% annual chance flood event (i.e. based on 226,000 cfs flood flow rate in the SC River) by the November 30, 2009 PAL-designation expiration date.

Primary reasons for the apparent failure of the SCR-1 Levee to meet certification requirements include:

- *rock size deficiencies in both the levee revetment and groins,*
- the *channel "thalweg" elevation is below the levee rock-revetment toe-down elevation along the 1969 levee failure location* (in the vicinity of as-built Station 330+00) to the upstream end of the levee system (Sta. 490+00), and
- the *inadequacy of the current configuration of levee protection being demonstrated by past levee failures* (i.e. levee failed in the 1969 floods with a peak discharge of 147,000 cfs, which is only 65% of the new, current 100-year discharge of 226,000 cfs that is required for levee certification under 44 CFR 65.10.

Tetra-Tech's preliminary levee certification evaluation failure results will be *technically critiqued* by District engineering professionals in the Design and Construction and Planning and Regulatory Divisions, and *potentially by professional engineers outside of the District* if deemed necessary by Norma and/or Jeff. However, at this point in time, based on the information in the District's possession, *the probability appears virtually certain that we will not be able to certify the SCR-1 Levee by November 30, 2009 in its current condition.*

Gerard and Ike Pace have developed an action plan reflecting *coordinated consultation* with the USACOE, Supervisor Zaragoza's Office and the City of Oxnard regarding this problem including:

- Taking affirmative steps to ensure that the SCR-1 levee is included in the list of levees that would be eligible to receive Federal assistance during a flood-emergency under the Corps PL84-99 Rehabilitation and Inspection Program (RIP) in the short-term,
- Meetings with the USACOE and Congresswoman Capp's and Gallegly's Office requesting Federal Funding Assistance to bring the SCR-1 levee into certification, in the long-term, and
- Consultation discussions with Supervisor Zaragoza's Office and City of Oxnard as we work together to inform affected property owners and business that will likely be placed in a SFHA flood-plain mapping zone designation triggered by the de-certification of the SCR-1 levee system. Kathy Schaefer from FEMA has advised the District that the *earliest date she plans on issuing REVISED DFIRMs reflecting any decertified-levees would be May of 2010.*

Tim asked Gerard if O&M should move forward with the maintenance work on the SCR1 Levee. Gerard advised Tim to proceed with the steps outlined in the SCR-1 Certification Documentation Action Plan until such time as Norma and Jeff conclude otherwise.

Gerard indicated that he will be meeting with Norma and Jeff later today to discuss this very recent development more fully. He will advise the Group regarding the decisions reached by Norma and Jeff regarding the SCR-1 levee.

O&M Action Item/Updates from June 8th Meeting
Survey Update
Tim reported that survey work for all levees is on track. He expects the Survey team to meet all project deliverable deadlines shown in the Scope of Work documents contained in the Master Work Order. Tetra Tech is working with the Survey team directly regarding increased staking requirements for the SC-1 Levee. The Survey team expects to submit the request for a deed change (regarding CC-2) to Real Estate in one week (June 29).

Action Item Tim: Follow up with Survey. If the deed change is not submitted by Real Estate by June 29, let Gerard know when it will be submitted.

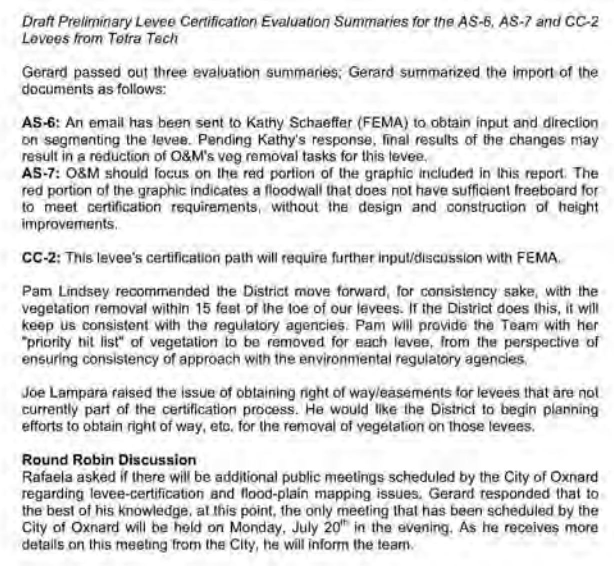
As Built and Penetration List
Tim reported that list is 98% complete. Tim requested direction from Gerard regarding how best to proceed obtaining as-built drawings and interior drainage drawings for levees we may not be certifying at this time.

Gerard directed Tim to contact Ike Pace and discuss the following issues: The estimated date that the as-build and penetration update list will be completed; the current status of the list; priority requests by Tetra-Tech for information that they require during the span of time between today and the time the list will be completed.

Action Item Tim: Contact Ike Pace to review and discuss the progress being made by O&M in updating the as-built plan and levee penetration list, and reach mutual agreement on the next steps.

Real Estate Services
Regarding the fence installation at SC-1, an extension of the length of the fence is required resulting in a design revision. Mark Yaftali, O&M, will revise his design and submit the changes to Ike at Tetra Tech. When the final design is approved by Tetra Tech as meeting the applicable levee certification requirements, the proposal will be submitted to Keith Filegar from Real Estate Services for presentation to the affected property owner.

Joe Lampara brought up an issue. If the fence line is extended, the District must ensure the view from resident (and our access road) driveways are not blocked. The team agreed this was an excellent point and Tim will discuss this issue with Mark before the plans are completed.



Draft Preliminary Levee Certification Evaluation Summaries for the AS-6, AS-7 and CC-2 Levees from Tetra Tech

Gerard passed out three evaluation summaries; Gerard summarized the import of the documents as follows:

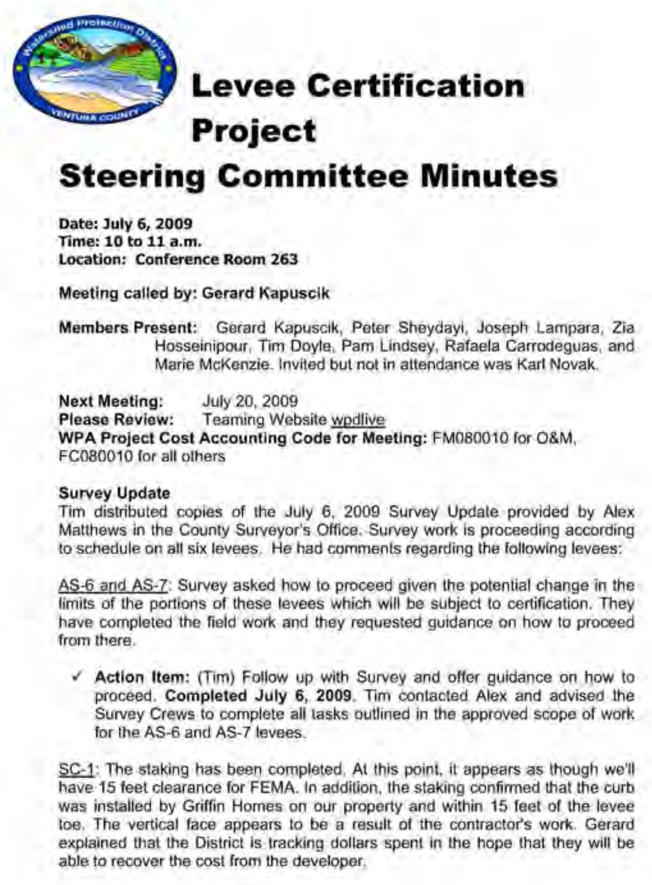
AS-6: An email has been sent to Kathy Schaeffer (FEMA) to obtain input and direction on segmenting the levee. Pending Kathy's response, final results of the changes may result in a reduction of O&M's veg removal tasks for this levee.
AS-7: O&M should focus on the red portion of the graphic included in this report. The red portion of the graphic indicates a floodwall that does not have sufficient freeboard for to meet certification requirements, without the design and construction of height improvements.

CC-2: This levee's certification path will require further input/discussion with FEMA.

Pam Lindsey recommended the District move forward, for consistency sake, with the vegetation removal within 15 feet of the toe of our levees. If the District does this, it will keep us consistent with the regulatory agencies. Pam will provide the Team with her "priority hit list" of vegetation to be removed for each levee, from the perspective of ensuring consistency of approach with the environmental regulatory agencies.

Joe Lampara raised the issue of obtaining right of way/easements for levees that are not currently part of the certification process. He would like the District to begin planning efforts to obtain right of way, etc. for the removal of vegetation on those levees.

Round Robin Discussion
Rafaela asked if there will be additional public meetings scheduled by the City of Oxnard regarding levee-certification and flood-plain mapping issues. Gerard responded that to the best of his knowledge, at this point, the only meeting that has been scheduled by the City of Oxnard will be held on Monday, July 20th in the evening. As he receives more details on this meeting from the City, he will inform the team.



Levee Certification Project

Steering Committee Minutes

Date: July 6, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Gerard Kapuscik, Peter Sheydayi, Joseph Lampara, Zia Hosseinipour, Tim Doyle, Pam Lindsey, Rafaela Carrodeguas, and Marie McKenzie. Invited but not in attendance was Karl Novak.

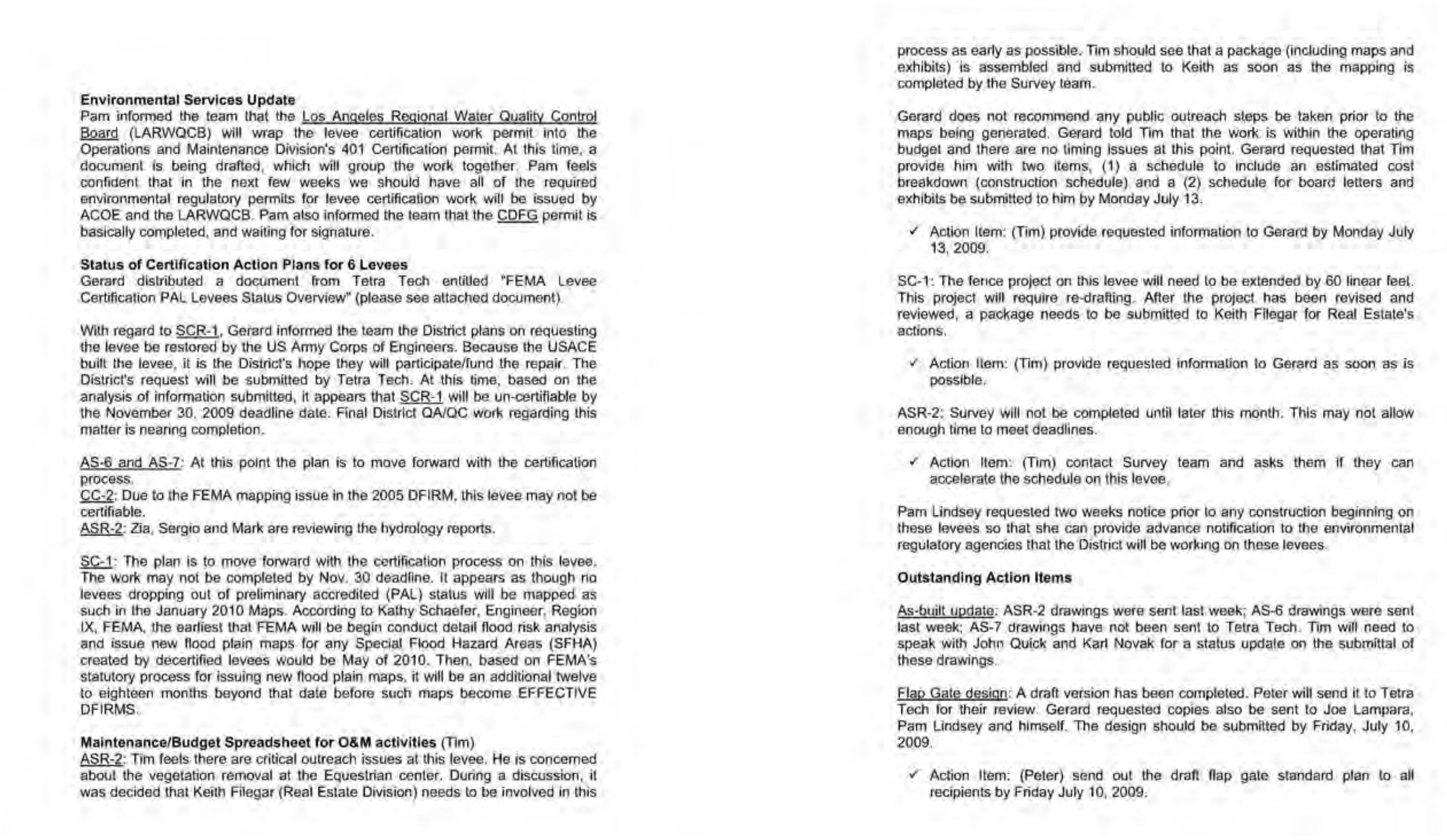
Next Meeting: July 20, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Survey Update
Tim distributed copies of the July 6, 2009 Survey Update provided by Alex Matthews in the County Surveyor's Office. Survey work is proceeding according to schedule on all six levees. He had comments regarding the following levees:

AS-6 and AS-7: Survey asked how to proceed given the potential change in the limits of the portions of these levees which will be subject to certification. They have completed the field work and they requested guidance on how to proceed from there.

- ✓ **Action Item:** (Tim) Follow up with Survey and offer guidance on how to proceed. **Completed July 6, 2009.** Tim contacted Alex and advised the Survey Crews to complete all tasks outlined in the approved scope of work for the AS-6 and AS-7 levees.

SC-1: The staking has been completed. At this point, it appears as though we'll have 15 feet clearance for FEMA. In addition, the staking confirmed that the curb was installed by Griffin Homes on our property and within 15 feet of the levee toe. The vertical face appears to be a result of the contractor's work. Gerard explained that the District is tracking dollars spent in the hope that they will be able to recover the cost from the developer.



Environmental Services Update
Pam informed the team that the Los Angeles Regional Water Quality Control Board (LARWQCB) will wrap the levee certification work permit into the Operations and Maintenance Division's 401 Certification permit. At this time, a document is being drafted, which will group the work together. Pam feels confident that in the next few weeks we should have all of the required environmental regulatory permits for levee certification work will be issued by ACOE and the LARWQCB. Pam also informed the team that the CDFG permit is basically completed, and waiting for signature.

Status of Certification Action Plans for 6 Levees
Gerard distributed a document from Tetra Tech entitled "FEMA Levee Certification PAL Levees Status Overview" (please see attached document).

With regard to SCR-1, Gerard informed the team the District plans on requesting the levee be restored by the US Army Corps of Engineers. Because the USACE built the levee, it is the District's hope they will participate/fund the repair. The District's request will be submitted by Tetra Tech. At this time, based on the analysis of information submitted, it appears that SCR-1 will be un-certifiable by the November 30, 2009 deadline date. Final District QA/QC work regarding this matter is nearing completion.

AS-6 and AS-7: At this point the plan is to move forward with the certification process.
CC-2: Due to the FEMA mapping issue in the 2005 DFIRM, this levee may not be certifiable.
ASR-2: Zia, Sergio and Mark are reviewing the hydrology reports.

SC-1: The plan is to move forward with the certification process on this levee. The work may not be completed by Nov. 30 deadline. It appears as though no levees dropping out of preliminary accredited (PAL) status will be mapped as such in the January 2010 Maps. According to Kathy Schaefer, Engineer, Region IX, FEMA, the earliest that FEMA will be begin conduct detail flood risk analysis and issue new flood plain maps for any Special Flood Hazard Areas (SFHA) created by decertified levees would be May of 2010. Then, based on FEMA's statutory process for issuing new flood plain maps, it will be an additional twelve to eighteen months beyond that date before such maps become EFFECTIVE DFIRMS.

Maintenance/Budget Spreadsheet for O&M activities (Tim)
ASR-2: Tim feels there are critical outreach issues at this levee. He is concerned about the vegetation removal at the Equestrian center. During a discussion, it was decided that Keith Filegar (Real Estate Division) needs to be involved in this process as early as possible. Tim should see that a package (including maps and exhibits) is assembled and submitted to Keith as soon as the mapping is completed by the Survey team.

Gerard does not recommend any public outreach steps be taken prior to the maps being generated. Gerard told Tim that the work is within the operating budget and there are no timing issues at this point. Gerard requested that Tim provide him with two items, (1) a schedule to include an estimated cost breakdown (construction schedule) and a (2) schedule for board letters and exhibits be submitted to him by Monday July 13.

- ✓ Action Item: (Tim) provide requested information to Gerard by Monday July 13, 2009.

SC-1: The fence project on this levee will need to be extended by 60 linear feet. This project will require re-drafting. After the project has been revised and reviewed, a package needs to be submitted to Keith Filegar for Real Estate's actions.

- ✓ Action Item: (Tim) provide requested information to Gerard as soon as is possible.

ASR-2: Survey will not be completed until later this month. This may not allow enough time to meet deadlines.

- ✓ Action Item: (Tim) contact Survey team and asks them if they can accelerate the schedule on this levee.

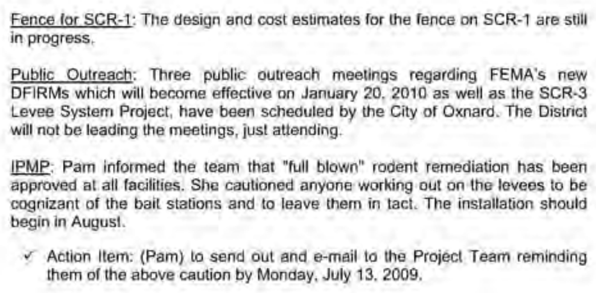
Pam Lindsey requested two weeks notice prior to any construction beginning on these levees so that she can provide advance notification to the environmental regulatory agencies that the District will be working on these levees.

Outstanding Action Items

As-built update: ASR-2 drawings were sent last week; AS-6 drawings were sent last week; AS-7 drawings have not been sent to Tetra Tech. Tim will need to speak with John Quick and Karl Novak for a status update on the submittal of these drawings.

Flap Gate design: A draft version has been completed. Peter will send it to Tetra Tech for their review. Gerard requested copies also be sent to Joe Lampara, Pam Lindsey and himself. The design should be submitted by Friday, July 10, 2009.

- ✓ Action Item: (Peter) send out the draft flap gate standard plan to all recipients by Friday July 10, 2009.

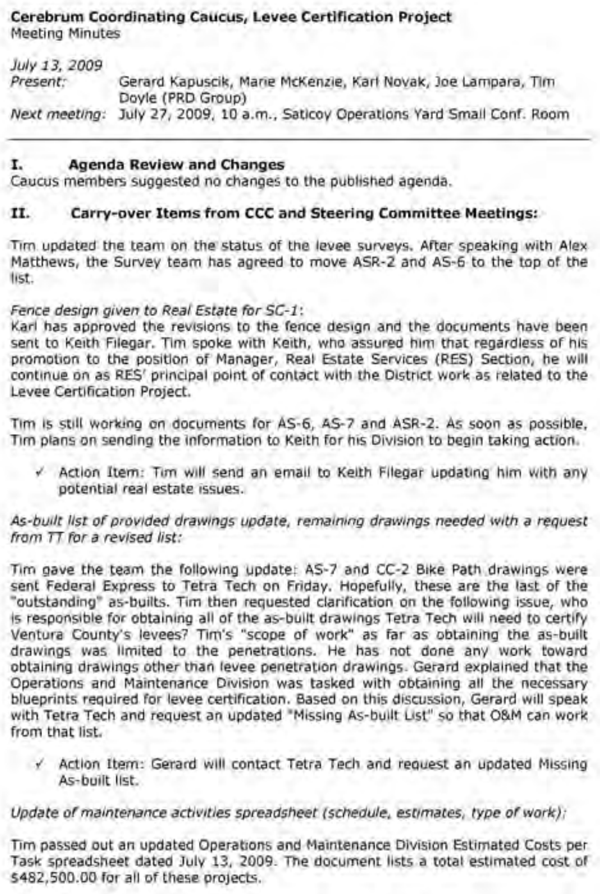


Fence for SCR-1: The design and cost estimates for the fence on SCR-1 are still in progress.

Public Outreach: Three public outreach meetings regarding FEMA's new DFIRMs which will become effective on January 20, 2010 as well as the SCR-3 Levee System Project, have been scheduled by the City of Oxnard. The District will not be leading the meetings, just attending.

IPMP: Pam informed the team that "full blown" rodent remediation has been approved at all facilities. She cautioned anyone working out on the levees to be cognizant of the bait stations and to leave them in tact. The installation should begin in August.

- ✓ Action Item: (Pam) to send out and e-mail to the Project Team reminding them of the above caution by Monday, July 13, 2009.



Cerebrum Coordinating Caucus, Levee Certification Project
Meeting Minutes

July 13, 2009
Present: Gerard Kapuscik, Marie McKenzie, Kari Novak, Joe Lampara, Tim Doyle (PRD Group)
Next meeting: July 27, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

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I. Agenda Review and Changes

Caucus members suggested no changes to the published agenda.

II. Carry-over Items from CCC and Steering Committee Meetings:

Tim updated the team on the status of the levee surveys. After speaking with Alex Matthews, the Survey team has agreed to move ASR-2 and AS-6 to the top of the list.

Fence design given to Real Estate for SC-1:
Kari has approved the revisions to the fence design and the documents have been sent to Keith Filegar. Tim spoke with Keith, who assured him that regardless of his promotion to the position of Manager, Real Estate Services (RES) Section, he will continue on as RES' principal point of contact with the District work as related to the Levee Certification Project.

Tim is still working on documents for AS-6, AS-7 and ASR-2. As soon as possible, Tim plans on sending the information to Keith for his Division to begin taking action.

- ✓ Action Item: Tim will send an email to Keith Filegar updating him with any potential real estate issues.

As-built list of provided drawings update, remaining drawings needed with a request from TT for a revised list:

Tim gave the team the following update: AS-7 and CC-2 Bike Path drawings were sent Federal Express to Tetra Tech on Friday. Hopefully, these are the last of the "outstanding" as-builts. Tim then requested clarification on the following issue, who is responsible for obtaining all of the as-built drawings Tetra Tech will need to certify Ventura County's levees? Tim's "scope of work" as far as obtaining the as-built drawings was limited to the penetrations. He has not done any work toward obtaining drawings other than levee penetration drawings. Gerard explained that the Operations and Maintenance Division was tasked with obtaining all the necessary blueprints required for levee certification. Based on this discussion, Gerard will speak with Tetra Tech and request an updated "Missing As-built List" so that O&M can work from that list.

- ✓ Action Item: Gerard will contact Tetra Tech and request an updated Missing As-built list.

Update of maintenance activities spreadsheet (schedule, estimates, type of work):

Tim passed out an updated Operations and Maintenance Division Estimated Costs per Task spreadsheet dated July 13, 2009. The document lists a total estimated cost of $482,500.00 for all of these projects.

Gerard requested and received a brief description of the quote process for maintenance projects. Gerard also requested verification that the funds O&M planned to spend were available in the 09-10 Fiscal Year (the $482,500.00) Budget.

O&M is proceeding to prepare maintenance construction contract plans and specs for the following three levee certification projects, tentatively titled: **Sespe Creek Levee Toe Undercut Repair 2009, Sespe Creek Levee Repair at Goodenough Rd. 2009** and **Calleguas Creek Levee Tree Removal at Somis Drain 2009.** Gerard stressed the fact that since time was of the essence regarding completion of all three of these contracts before November 1, 2009, at the latest, it was imperative that O&M continue to exercise proactive and affirmative work flow control steps to ensure their timely completion. Gerard asked Tim to notify him immediately, if any critical path elements of these three projects approach a fatal-flaw condition, so that he can provide adaptive Project Management direction, as required.

SC-1 Levee Certification Construction Projects (undercut of levee toe and vegetation removal) critical path schedules/New Business:

The plans and specs are expected from Tetra Tech by August 7, 2009.
The Interior drainage analysis for the levee penetrations (flap gates) are expected to be completed by October 19. This date raised an issue. Having the analysis completed at that time does not allow for much flap gate construction time.

- ✓ Action Item: Gerard will ask Ike if it is necessary for us to wait until all analysis has been completed, or if there is an alternative.

Design and Construction has completed their Standard Plan for Flap Gates. The design was sent out for review and comments will be forthcoming.

- ✓ Action Item: Karl and Joe will review the plan and provide any comments.

III. Round Robin Discussion

Tim raised a question about vegetation on CC-2. Tim noticed considerable vegetation from the drop structure to the Somis Drain confluence within 15 feet of the levee toe. Tim requested clarification, would this vegetation require removal or was it not included in the maintenance items for a reason?

- ✓ Action Item: Tim will send out an email to Ike Pace requesting clarification.

Karl brought distributed a copy of a letter from Southern California Edison dated June 15, 2009 confirming that SCE power poles (i.e. #1564322E and #1561818E) were installed within the footprint of the SCR-1 levee in the vicinity of Central Avenue without prior rights and fall into a franchise position. Accordingly, SCE agrees to removal of those power poles, at their cost, should the District request it. Gerard indicated that Ike had already concluded that event though eventual removal of these power poles was preferable; it was not required as a condition of levee certification. Based on Tim's comments, an in an abundance of preventative caution, Gerard will contact Ike again, and request written confirmation that nothing has changed since Ike first opined that the removal of this SCE power poles was not necessary for levee certification purposes.

- ✓ Action Item: Gerard will email Ike Pace and request an answer to the question: Do either or both of SCE's power poles #1564322E and #1561818E need to be removed prior to November 30, 2009 for levee certification purposes?

Levee Certification Project

Steering Committee Meeting Minutes

Date: July 20, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Zia Hosseinipour, Gerard Kapuscik, Joseph Lampara, Peter Sheydayi, Pam Lindsey, Karl Novak, Tim Doyle, Marie McKenzie and Ike Pace.

Next Meeting: August 3, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Survey Work Update; General Survey Status and ASR-2, AS-6 and CC-2 Specific Survey Work Items/Tim:
ASR-2 and CC-2 surveys have been delivered. Survey completions outstanding and expected within the next two weeks are AS-6 and AS-7. Once the surveys are completed, O&M will request easement acquisition assistance from the Real Estate Services Division. There is a potential problem with AS-6: the apartment complex owner may or may not agree to removal of vegetation in the levee-toe hot zone without mitigation. Ike committed to supplying the District with a technical paper defining the limits of acceptable vegetation within 15 feet of the toe of a levee. ASR-2 only has easement rights, Tim suggested the District obtain a permanent Right of Way. Once the maps are complete the District can work toward obtaining permanent Right of Way. At that time, the legal descriptions will begin.

- ✓ Action Item: Ike will send an email to Tim with the correct language for allowable vegetation in the right of way.

Operation and Maintenance Contract Work – Coordination, Budget & Schedules/Tim:
Tim requested that Ike review the spreadsheet and let him know if any maintenance items are missing. Karl asked Gerard to clarify the project numbers O&M should use for the quotes/bid projects. Gerard confirmed that the following project code numbers should be used depending on the affected zones:

- Zone 1: **P6011007**
- Zone 2: **P6012007**
- Zone 3: **P6015007**

Pam identified approximately 10 items on the list that would require permits.

- ✓ Action Item: Within the next day or two, Ike will review list and let Tim know if any items are missing.

SC-1 Levee Status Update: Draft Design Report, Plans & Specs and Schedule for Toe Drainage Construction Improvements, Vegetation Removal and Privacy Fence Projects: Ike and Tim/Karl
Ike has submitted the first draft of plans and specs. A meeting was scheduled to follow this one to review comments from Mark Yaftali and Bert Rapp. Peter asked why the plan was designed in that manner. Ike explained that he was using a plan already approved by the Army Corps of Engineers and the District and instead of "reinventing the wheel" he was updating that plan. Peter stated that this explanation made sense, but Design and Construction would not have used this method to alleviate the problem. The adjacent affected homeowner has approved of the suggested design for the privacy fence at the north-end of the SC-1 Levee.

As-Builts Drawing Inventory Project: Current Status and Tetra-Tech Priority Work Requirements: Ike and Tim:
Ike informed the team of the following outstanding and high priority drawings:
CC-2: the bridge drawings he received are not signed "as built" drawings
AS-6: we may need 3 or 4 more drawings of the penetrations and storm drains. Ike is waiting on a written reply from FEMA regarding the District's proposed course of action on this levee.
AS-7: Ike suggested the District obtain the missing 3-4 penetrations just in case FEMA requests them. He is still seeking guidance from them on segmenting the levee. At this point, the plan is to certify certain portions of the levee. Peter suggested FEMA visit the site and Gerard agreed that would be a good idea. Zia suggested that if they were unable to visit, perhaps we could take a video of the location for them to view.
Ike explained that their research so far indicates there is a major structural issue with the overhang (as described in the shop drawings Kirk Norman sent him). Ike told the team that the calculations are not meeting the requirements. Ike said that the answer may be to demo the overhang and re-build it in order to meet the freeboard requirement. Gerard asked Ike to run the calcs by Kirk Norman and to send out any preliminary drawings to the Design and Construction Team.
ASR-2: Ike said he still has not received the as built drawings for the puzzle revetment at the toe. In addition, he would like the drawings for the storm drain that has an inlet at the equestrian center and angles out toward the bridge. Gerard stated that it was important for the District to reach out to the affected community soon to ensure the good will we established will remain through the project.

- ✓ Action Item: Ike will discuss other options (instead of demolition and rebuild) with the Tetra Tech structural engineer.
- ✓ Action Item: John Quick must provide the outstanding drawings to Ike as soon as possible.

Real Estate Services Update, Parcel exhibits, Survey Exhibits, and Schedule

This issue was touched on during previous topics. No further discussion was warranted.

Flap Gate and Headwall design Plans, Calculations and Standards Update design update: Peter and Ike
The Flap Gate Standard Plan has been sent out for review and some comments have been returned. Peter and Masood will review and incorporate the comments. Peter anticipates being ready to proceed when needed. He did have one concern, which was that he had to increase the depth of the concrete below the elevation. Peter asked Ike to provide him with guidance as to how deep he should go. Ike responded by saying there are approximately two storm drains at AS-6 that may need flap gates; on AS-7 there is one that may require a flap gate. Ike is still working on the interior drainage analysis, and expects to have it completed by July 31 for (AS-6) and by August 14 for (AS-7) levee. He explained that he may not have to complete the analysis to determine whether a flap gate is necessary or not, he is hoping to provide that answer prior to the analysis completion.

- ✓ Action Item: Ike will provide O&M with the proper depth elevation if flap gates are required.

Status of Discussions with FEMA: Segmentation and Delisting of Portions of AS-6, AS-7 and CC-2 Levees: Gerard
Gerard plans on speaking with Kathy from FEMA at the July 20 Oxnard City meeting. He hopes to get some firm answers regarding the District's questions regarding delisting and segmentation.

Ike informed the team that the FEMA's MAP-IX contractor has verbally acknowledge the map mistake with CC-2. In addition, they told Ike that even if the District can prove the levee's credentials, FEMA will not certify it. Ike is waiting for a reply from Kathy.

- ✓ Action Item: Gerard and Ike will report back to the team after speaking with Kathy from FEMA.

Save Round Items
Pam: Pam suggests the District use the CC-2 bird surveys, which were conducted as part of this effort, and cleanout the vegetation within 15 feet of the toe in order to avoid paying for another bird survey in the future. In addition, Pam is waiting on

responses from some of the Environmental Permitting Agencies. Pam will update the team this week on the status of the permits.

Zia: Zia told the team that a teleconference with Ike and Advance Planning was very productive. Zia feels that all parties are now on the same page with regard to the hydrology results for ASR-2. Joe is putting the results together and he will supply them to Ike.

Karl: Karl asked if any of the power poles needed to be removed to achieve certification. Ike told Karl that the decision was his, but he didn't think any of the power poles would affect certification. Karl said that he was planning on asking SCE to remove the SCE power pole that impinged on the SCR-1 levee face, since SCE responded positively to the previous letter he sent requesting its removal. Karl requested the Ike provide him with an updated justification for requesting the removal of that power pole.

- ✓ Action Item: Ike will send a "white paper" to Karl which outlines the reasons a power pole should be removed from the SCR-1 levee.

Cerebrum Coordinating Caucus, Levee Certification Project
Meeting Minutes

August 10, 2009
Present: Gerard Kapuscik, Marie McKenzie, Roger Boross, John Lagomarsino, Joe Lampara, Tim Doyle (PRD Group)
Next meeting: July 27, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

I. Agenda Review and Changes

There we no changes to the published agenda.

II. Carry-over Items from CCC and Steering Committee Meetings:

Tim updated the team on the status of the levee surveys. After speaking with Alex Matthews, the Survey team has agreed to provide draft topography for AS-6 by Tuesday August 11.

PO Work Status: Tim provided the following updates:

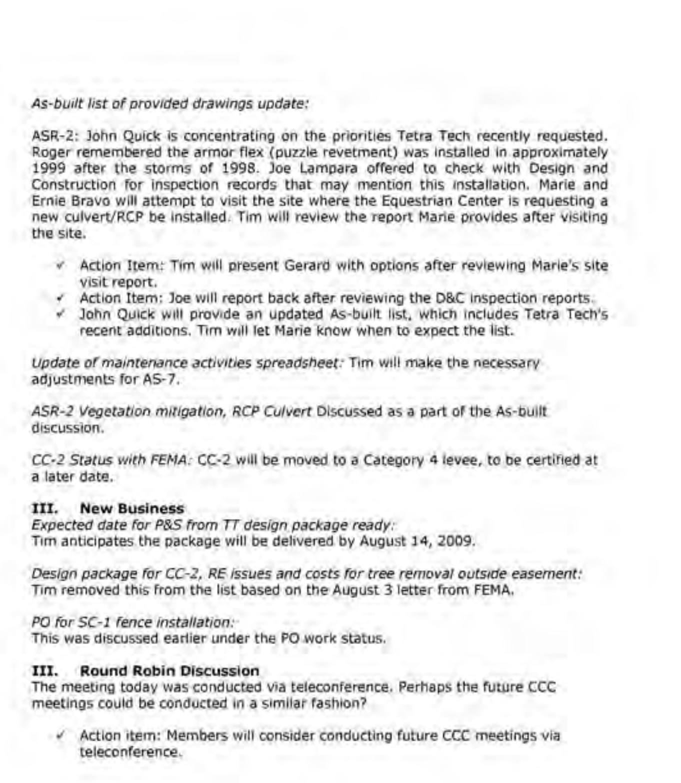
Operations and Maintenance will use two separate blanket Purchase Orders to repair the sink holes at SC-1 and AS-6. They are aware of the environmental restrictions and will contact Pam Lindsey prior to commencement of any repairs.

O&M will use two separate blanket Purchase Orders to remove vegetation at AS-6 and ASR-2 (there is one available for vegetation removal at CC-2 if the vegetation removal is still necessary and authorized). They are aware of the environmental restrictions and will contact Pam Lindsey prior to commencement of any vegetation removal.

O&M will issue a Work Order Contract for SC-1 Privacy Fence installation: Tim provided the following update: O&M will conduct a competitive bid process among 4 contractors with whom they currently have blanket purchase orders. Gerard requested the purchase order be in place by September 18, 2009, in order to ensure there is enough time to complete the project, order materials and meet all levee certification deadlines. The four contractors involved are as follows: Fence Factory, Peterson, CW fence and Golden State. They are aware of the environmental restrictions and will contact Pam Lindsey prior to commencement of any fence installation.

- ✓ Action Item: Tim will ensure the purchase order is in place by 9/18/09.

SC-1 Levee Landward Toe Restoration Design given to Tetra Tech:
The Design and Construction Division will manage this project. The project will go before the Board of Supervisors on September 15. It is expected that the District will request that the Board approve and authorize the Director of Public Works to award a contract to the lowest qualified bidder for this levee restoration construction project.



As-built list of provided drawings update:

ASR-2: John Quick is concentrating on the priorities Tetra Tech recently requested. Roger remembered the armor flex (puzzle revetment) was installed in approximately 1999 after the storms of 1998. Joe Lampara offered to check with Design and Construction for inspection records that may mention this installation. Marie and Ernie Bravo will attempt to visit the site where the Equestrian Center is requesting a new culvert/RCP be installed. Tim will review the report Marie provides after visiting the site.

- ✓ Action Item: Tim will present Gerard with options after reviewing Marie's site visit report.
- ✓ Action Item: Joe will report back after reviewing the D&C inspection reports.
- ✓ John Quick will provide an updated As-built list, which includes Tetra Tech's recent additions. Tim will let Marie know when to expect the list.

Update of maintenance activities spreadsheet: Tim will make the necessary adjustments for AS-7.

ASR-2 Vegetation mitigation, RCP Culvert Discussed as a part of the As-built discussion.

CC-2 Status with FEMA: CC-2 will be moved to a Category 4 levee, to be certified at a later date.

III. New Business

Expected date for P&S from TT design package ready:
Tim anticipates the package will be delivered by August 14, 2009.

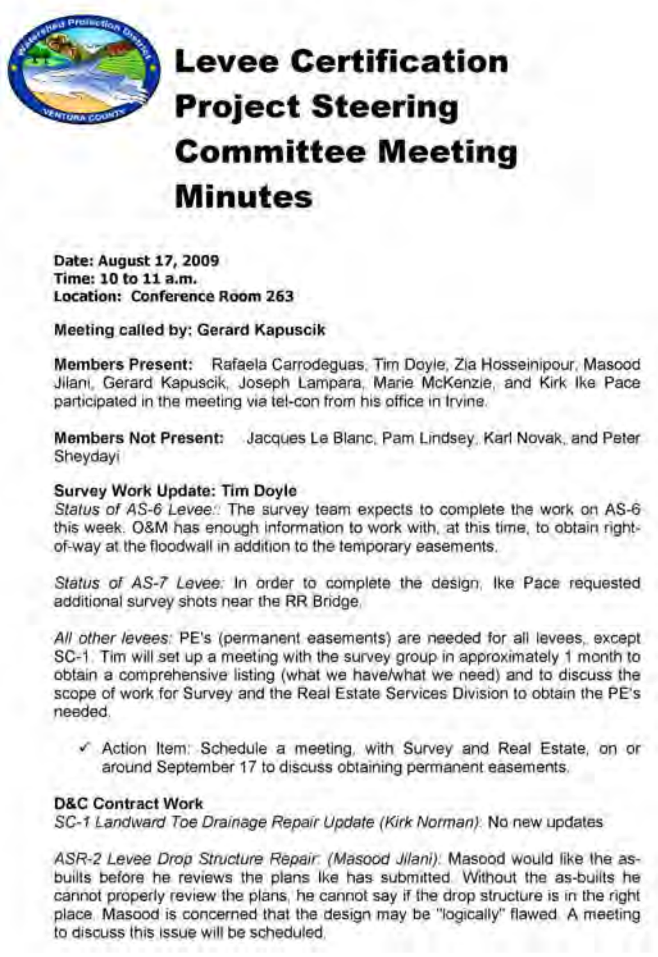
Design package for CC-2, RE issues and costs for tree removal outside easement:
Tim removed this from the list based on the August 3 letter from FEMA.

PO for SC-1 fence installation:
This was discussed earlier under the PO work status.

III. Round Robin Discussion

The meeting today was conducted via teleconference. Perhaps the future CCC meetings could be conducted in a similar fashion?

- ✓ Action item: Members will consider conducting future CCC meetings via teleconference.



Levee Certification Project Steering Committee Meeting Minutes

Date: August 17, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Rafaela Carrodeguas, Tim Doyle, Zia Hosseinipour, Masood Jilani, Gerard Kapuscik, Joseph Lampara, Marie McKenzie, and Kirk Ike Pace participated in the meeting via tel-con from his office in Irvine.

Members Not Present: Jacques Le Blanc, Pam Lindsey, Karl Novak, and Peter Sheydayi

Survey Work Update: Tim Doyle

Status of AS-6 Levee:: The survey team expects to complete the work on AS-6 this week. O&M has enough information to work with, at this time, to obtain right-of-way at the floodwall in addition to the temporary easements.

Status of AS-7 Levee: In order to complete the design, Ike Pace requested additional survey shots near the RR Bridge.

All other levees: PE's (permanent easements) are needed for all levees, except SC-1. Tim will set up a meeting with the survey group in approximately 1 month to obtain a comprehensive listing (what we have/what we need) and to discuss the scope of work for Survey and the Real Estate Services Division to obtain the PE's needed.

- ✓ Action Item: Schedule a meeting, with Survey and Real Estate, on or around September 17 to discuss obtaining permanent easements.

D&C Contract Work

SC-1 Landward Toe Drainage Repair Update (Kirk Norman): No new updates

ASR-2 Levee Drop Structure Repair: (Masood Jilani): Masood would like the as-builts before he reviews the plans Ike has submitted. Without the as-builts he cannot properly review the plans, he cannot say if the drop structure is in the right place. Masood is concerned that the design may be "logically" flawed. A meeting to discuss this issue will be scheduled.

- ✓ Action Item: Masood, Gerard and Ike will meet to discuss reviewing the plans Tetra Tech has submitted.

Ike suggested that when the survey team goes to ASR-2 to measure for the armor flex as-builts, they have a geo-tech engineer out at the same time to monitor the measurements and materials below the armor flex.

- ✓ Action Item: Tim and Larry will meet with Karl to set up the geo-tech and survey work at the ASR-2 Levee.

AS-7 Levee Floodwall Rehabilitation (Jacques LeBlanc): No discussion as Jacques was not present.

O&M Contract Work: Tim Doyle

SC-1 Levee: Tim will review the plans and specs for the vegetation removal project.
ASR-2 RE Status: No TE's yet.
AS-6: The District has no easement here at all. Tim is concerned about the owners of the apartment complex may not agree to the tree removal.

- ✓ Action Item: Tim will email the exhibits of the apartment complex and tree location to Gerard.

AS-Builts
Ike will send an updated list to Tim today. This list will be comprehensive and whatever documents we do not have, we will begin creating.

- ✓ Action Item: Ike will send a comprehensive updated list to Tim.

- ✓ Action Item: From that list, the District will begin creating as-built drawings for any of the levees which we currently do not have.

Board of Supervisors Update Report
90-day Update Report to the Board of Supervisors Regarding the Status of the 6 PALs September 15, 2009: Gerard passed out copies of FEMA's Procedure Memorandum No. 53, Guidance for Notification and Mapping of Expiring Provisionally Accredited Levee Designations, dated April 24, 2009. PM 53 transmits

FEMA's plan for mapping levee-impacted areas after the PAL-designation period expires. PM 53 states that upon determining that a given levee is either accredited or de-accredited, FEMA will initiate a mapping project to revise the levee-impacted areas. PM 53 states that from the start date of the revised mapping process for any levee-impacted areas so affected until the final effective date of the revised flood map, no less than 18 months shall pass to allow for proper outreach and due process. Based on separate but parallel mapping process coordination discussions with Kathy Schaefer, Engineer, Region IX, FEMA, the earliest that such Post-PAL-period expiration levee remapping will begin is July of 2010. And the effective date of such revised maps will be some 18 months later (i.e. January 2012).

Save Round

AS-7 Levee: Ike has identified two flap gates that require repair. The gates need to be either repaired or replaced. Both are on the Left hand side. One is 18" and the other is 48".

- ✓ Action Item: Ike will send the information to Gerard, Tim and Larry for the team to determine which division will handle the repair.

Additional Documents

Gerard handed out a Status Overview Update letter from Tetra Tech. The letter gives the current levee certification project status for all six PAL-designated levees.

Next Meeting: August 31, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Levee Certification Project
Steering Committee Task Force
Meeting Minutes

Date: August 31, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Rafaela Carrodeguas, Gerard Kapuscik, Peter Sheydayi Joseph Lampara, Marie McKenzie, and Tim Doyle. On the phone: Ike Pace.
Members Not Present: Pam Lindsey, Zia Hosseinipour, Karl Novak, Kirk Norman, Masood Jilani and Jacques Le Blanc.

Next Meeting: September 14, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

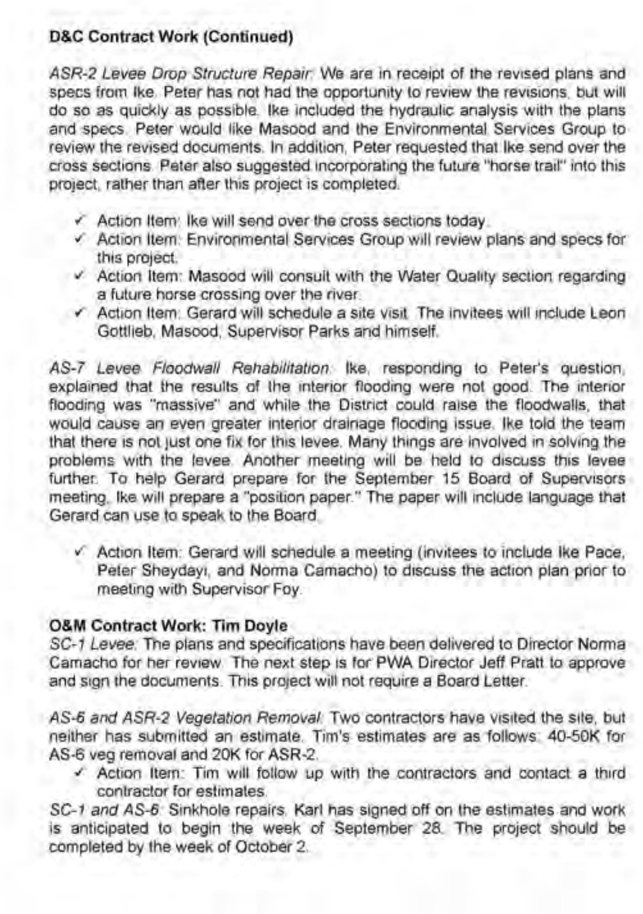
Survey Work Update: Tim Doyle
Status of AS-6: Ike has requested (and a request has been submitted) for additional information at the top of the floodwall. Survey should have this completed by September 1.

Status of ASR-2: Tim will be the lead on the further survey work required to "as build" the armor flex portion of this levee. This process will require a geo-tech person as well as a member of O&M.

AS-7 Bridge: Additional elevation points (piers, RR bridge cords) requested by Ike will be obtained, they are last on the list of priorities.

D&C Contract Work: Peter Sheydayi
SC-1 Landward Toe Drainage Repair: This project is out to bid; the pre-bid meeting is scheduled for September 1, 2009 and there seems to be a lot of contractor interest in the project. The board letter has been submitted. For the most up-to-date information, please check the website at:

http://www.ebidboard.com/public/projects/index.asp?mbrguid=2B485702-FFAE-4327-A8B7-F1C22BE001D2



D&C Contract Work (Continued)

ASR-2 Levee Drop Structure Repair: We are in receipt of the revised plans and specs from Ike. Peter has not had the opportunity to review the revisions, but will do so as quickly as possible. Ike included the hydraulic analysis with the plans and specs. Peter would like Masood and the Environmental Services Group to review the revised documents. In addition, Peter requested that Ike send over the cross sections. Peter also suggested incorporating the future "horse trail" into this project, rather than after this project is completed.

- ✓ Action Item: Ike will send over the cross sections today.
- ✓ Action Item: Environmental Services Group will review plans and specs for this project.
- ✓ Action Item: Masood will consult with the Water Quality section regarding a future horse crossing over the river.
- ✓ Action Item: Gerard will schedule a site visit. The invitees will include Leon Gottlieb, Masood, Supervisor Parks and himself.

AS-7 Levee Floodwall Rehabilitation: Ike, responding to Peter's question, explained that the results of the interior flooding were not good. The interior flooding was "massive" and while the District could raise the floodwalls, that would cause an even greater interior drainage flooding issue. Ike told the team that there is not just one fix for this levee. Many things are involved in solving the problems with the levee. Another meeting will be held to discuss this levee further. To help Gerard prepare for the September 15 Board of Supervisors meeting, Ike will prepare a "position paper." The paper will include language that Gerard can use to speak to the Board.

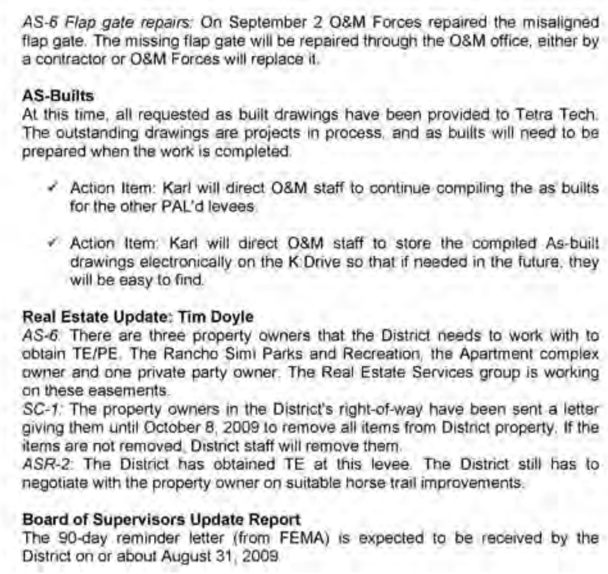
- ✓ Action Item: Gerard will schedule a meeting (invitees to include Ike Pace, Peter Sheydayi, and Norma Camacho) to discuss the action plan prior to meeting with Supervisor Foy.

O&M Contract Work: Tim Doyle
SC-1 Levee: The plans and specifications have been delivered to Director Norma Camacho for her review. The next step is for PWA Director Jeff Pratt to approve and sign the documents. This project will not require a Board Letter.

AS-6 and ASR-2 Vegetation Removal: Two contractors have visited the site, but neither has submitted an estimate. Tim's estimates are as follows: 40-50K for AS-6 veg removal and 20K for ASR-2.

- ✓ Action Item: Tim will follow up with the contractors and contact a third contractor for estimates.

SC-1 and AS-6: Sinkhole repairs. Karl has signed off on the estimates and work is anticipated to begin the week of September 28. The project should be completed by the week of October 2.



AS-6 Flap gate repairs: On September 2 O&M Forces repaired the misaligned flap gate. The missing flap gate will be repaired through the O&M office, either by a contractor or O&M Forces will replace it.

AS-Builts

At this time, all requested as built drawings have been provided to Tetra Tech. The outstanding drawings are projects in process, and as builts will need to be prepared when the work is completed.

- ✓ Action Item: Karl will direct O&M staff to continue compiling the as builts for the other PAL'd levees.
- ✓ Action Item: Karl will direct O&M staff to store the compiled As-built drawings electronically on the K Drive so that if needed in the future, they will be easy to find.

Real Estate Update: Tim Doyle

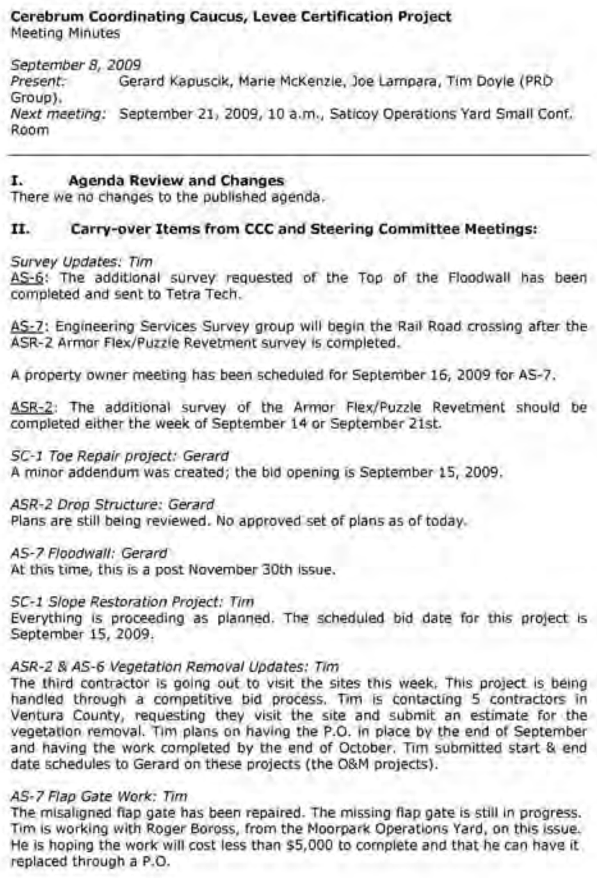
AS-6: There are three property owners that the District needs to work with to obtain TE/PE. The Rancho Simi Parks and Recreation, the Apartment complex owner and one private party owner. The Real Estate Services group is working on these easements.

SC-1: The property owners in the District's right-of-way have been sent a letter giving them until October 8, 2009 to remove all items from District property. If the items are not removed, District staff will remove them.

ASR-2: The District has obtained TE at this levee. The District still has to negotiate with the property owner on suitable horse trail improvements.

Board of Supervisors Update Report

The 90-day reminder letter (from FEMA) is expected to be received by the District on or about August 31, 2009.



Cerebrum Coordinating Caucus, Levee Certification Project
Meeting Minutes

September 8, 2009
Present: Gerard Kapuscik, Marie McKenzie, Joe Lampara, Tim Doyle (PRD Group).
Next meeting: September 21, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

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I. Agenda Review and Changes

There we no changes to the published agenda.

II. Carry-over Items from CCC and Steering Committee Meetings:

Survey Updates: Tim

AS-6: The additional survey requested of the Top of the Floodwall has been completed and sent to Tetra Tech.

AS-7: Engineering Services Survey group will begin the Rail Road crossing after the ASR-2 Armor Flex/Puzzle Revetment survey is completed.

A property owner meeting has been scheduled for September 16, 2009 for AS-7.

ASR-2: The additional survey of the Armor Flex/Puzzle Revetment should be completed either the week of September 14 or September 21st.

SC-1 Toe Repair project: Gerard

A minor addendum was created; the bid opening is September 15, 2009.

ASR-2 Drop Structure: Gerard

Plans are still being reviewed. No approved set of plans as of today.

AS-7 Floodwall: Gerard

At this time, this is a post November 30th issue.

SC-1 Slope Restoration Project: Tim

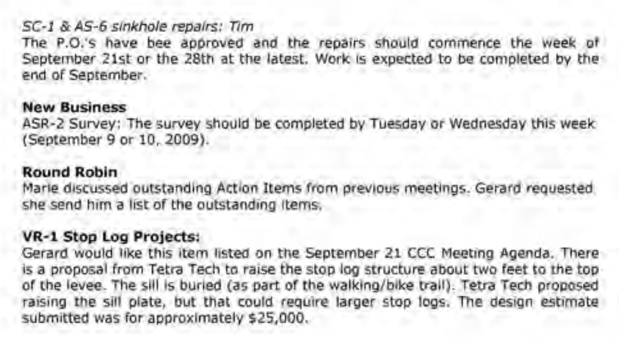
Everything is proceeding as planned. The scheduled bid date for this project is September 15, 2009.

ASR-2 & AS-6 Vegetation Removal Updates: Tim

The third contractor is going out to visit the sites this week. This project is being handled through a competitive bid process. Tim is contacting 5 contractors in Ventura County, requesting they visit the site and submit an estimate for the vegetation removal. Tim plans on having the P.O. in place by the end of September and having the work completed by the end of October. Tim submitted start & end date schedules to Gerard on these projects (the O&M projects).

AS-7 Flap Gate Work: Tim

The misaligned flap gate has been repaired. The missing flap gate is still in progress. Tim is working with Roger Boross, from the Moorpark Operations Yard, on this issue. He is hoping the work will cost less than $5,000 to complete and that he can have it replaced through a P.O.

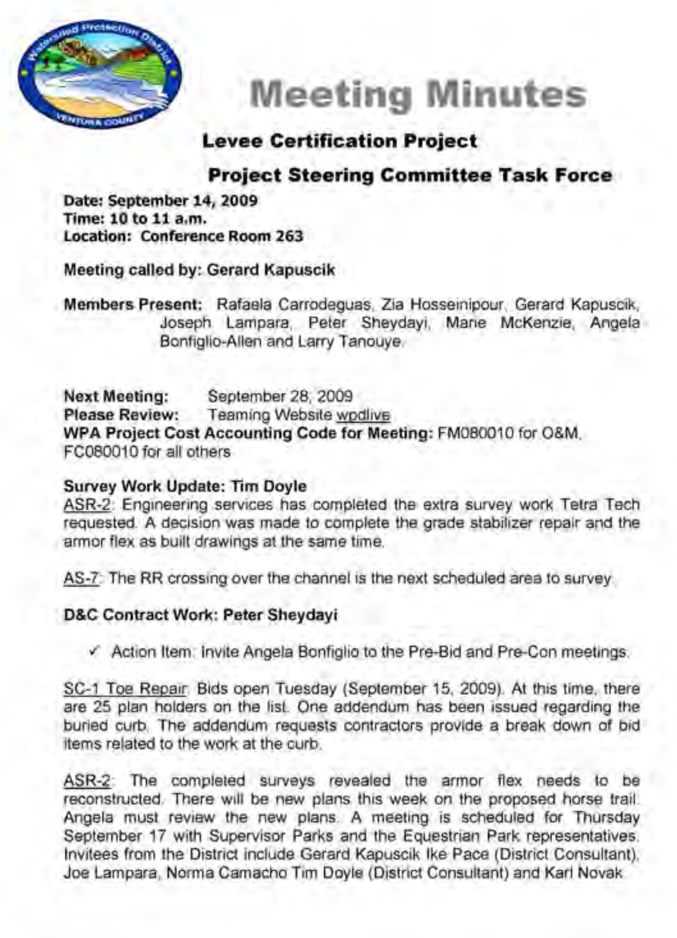


SC-1 & AS-6 sinkhole repairs: Tim
The P.O.'s have bee approved and the repairs should commence the week of September 21st or the 28th at the latest. Work is expected to be completed by the end of September.

New Business
ASR-2 Survey: The survey should be completed by Tuesday or Wednesday this week (September 9 or 10, 2009).

Round Robin
Marie discussed outstanding Action Items from previous meetings. Gerard requested she send him a list of the outstanding items.

VR-1 Stop Log Projects:
Gerard would like this item listed on the September 21 CCC Meeting Agenda. There is a proposal from Tetra Tech to raise the stop log structure about two feet to the top of the levee. The sill is buried (as part of the walking/bike trail). Tetra Tech proposed raising the sill plate, but that could require larger stop logs. The design estimate submitted was for approximately $25,000.



Meeting Minutes

Levee Certification Project

Project Steering Committee Task Force

Date: September 14, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Rafaela Carrodeguas, Zia Hosseinipour, Gerard Kapuscik, Joseph Lampara, Peter Sheydayi, Marie McKenzie, Angela Bonfiglio-Allen and Larry Tanouye.

Next Meeting: September 28, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Survey Work Update: Tim Doyle
ASR-2: Engineering services has completed the extra survey work Tetra Tech requested. A decision was made to complete the grade stabilizer repair and the armor flex as built drawings at the same time.

AS-7: The RR crossing over the channel is the next scheduled area to survey.

D&C Contract Work: Peter Sheydayi

✓ Action Item: Invite Angela Bonfiglio to the Pre-Bid and Pre-Con meetings.

SC-1 Toe Repair: Bids open Tuesday (September 15, 2009). At this time, there are 25 plan holders on the list. One addendum has been issued regarding the buried curb. The addendum requests contractors provide a break down of bid items related to the work at the curb.

ASR-2: The completed surveys revealed the armor flex needs to be reconstructed. There will be new plans this week on the proposed horse trail. Angela must review the new plans. A meeting is scheduled for Thursday September 17 with Supervisor Parks and the Equestrian Park representatives. Invitees from the District include Gerard Kapuscik Ike Pace (District Consultant), Joe Lampara, Norma Camacho Tim Doyle (District Consultant) and Karl Novak.

AS-7: Gerard and Joe Lampara met with the City of Simi Valley last week. The City's position on this levee/floodwall is that the hydrology is too conservative. At this time, there is no floodwall rehab project. Peter told the group that he would like Tetra Tech to conduct a "before and after" study based on the project constructed in the year 2000. Peter feels that the study will help guide the District for the future project.

O&M Contract Work: Tim Doyle
SC-1: Bid opening is tomorrow (September 15, 2009). Seven contractors attended the pre-bid meeting. This job is expected to be completed at the end of October. Peter asked Tim who would be performing the inspections, whether it would be Design and Construction Inspectors or PRD inspectors? Tim agreed to look into that and get back to Peter.

- ✓ Action Item: Tim will tell Peter who is going to be inspecting the work at the SC-1 O&M project
- ✓

AS-6 and AS-7: Tim has contacted five contractors regarding the three sites. The work will be awarded through a competitive bid process. Tim anticipates there will be one week to bid and two weeks to create the Purchase Order. Angela told Tim he should plan on having a biologist on site for documentation purposes.

Tim anticipates the cost of the sinkhole repairs will be approximately $11,000 for both.

AS-7 Flap Gates: One misaligned flap gate has been repaired. The gate missing the cover should be repaired by the end of the month. Tim is coordinating with Roger Boross (O&M Moorpark Yard Supervisor) on this work.

AS-Builts – Discussion
Procedures should be created and followed regarding the proper storage of all District as-built plans. All levee as-built drawings should be located and archived. All levee as built drawings already located should be electronically archived to a shared drive so that all District employees will have access to them.

- ✓ Action Item: The O&M PM will speak with John Quick regarding electronically archiving all obtained as built drawings.

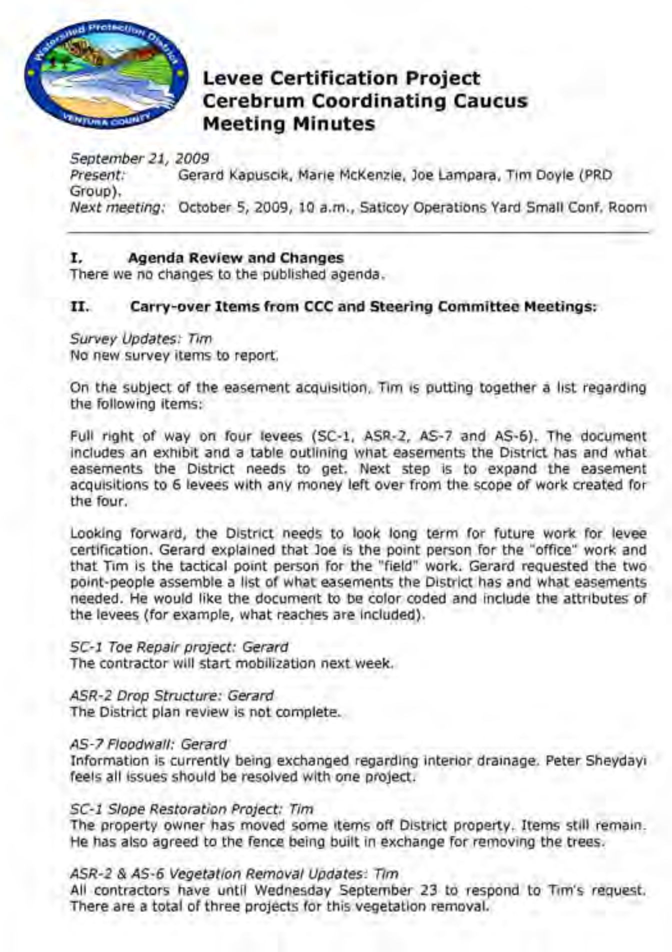
Real Estate: Tim Doyle
AS-6: A property owner is requesting 120 linear feet of fencing as compensation for vegetation removal. Gerard approves the fence installation, once the vegetation has been removed and our Nov. 30 deadline met.

Round Robin: All Team Members

Sespe Toe Repair: Angela told the team the plans for this project do not need to be submitted to the Environmental Permitting Agencies per the O&M Annual Maintenance Permit.

ASR-2: Peter will send the drawings to Angela for her to send out to the environmental agencies.

Board of Supervisors Update Report: September 15, 2009
Gerard will present a 90-Day Status Update Report to the Board of Supervisors during the September 15, 2009 meeting.



Levee Certification Project
Cerebrum Coordinating Caucus
Meeting Minutes

September 21, 2009
Present: Gerard Kapuscik, Marie McKenzie, Joe Lampara, Tim Doyle (PRD Group).
Next meeting: October 5, 2009, 10 a.m., Saticoy Operations Yard Small Conf. Room

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I. Agenda Review and Changes
There we no changes to the published agenda.

II. Carry-over Items from CCC and Steering Committee Meetings:

Survey Updates: Tim
No new survey items to report.

On the subject of the easement acquisition, Tim is putting together a list regarding the following items:

Full right of way on four levees (SC-1, ASR-2, AS-7 and AS-6). The document includes an exhibit and a table outlining what easements the District has and what easements the District needs to get. Next step is to expand the easement acquisitions to 6 levees with any money left over from the scope of work created for the four.

Looking forward, the District needs to look long term for future work for levee certification. Gerard explained that Joe is the point person for the "office" work and that Tim is the tactical point person for the "field" work. Gerard requested the two point-people assemble a list of what easements the District has and what easements needed. He would like the document to be color coded and include the attributes of the levees (for example, what reaches are included).

SC-1 Toe Repair project: Gerard
The contractor will start mobilization next week.

ASR-2 Drop Structure: Gerard
The District plan review is not complete.

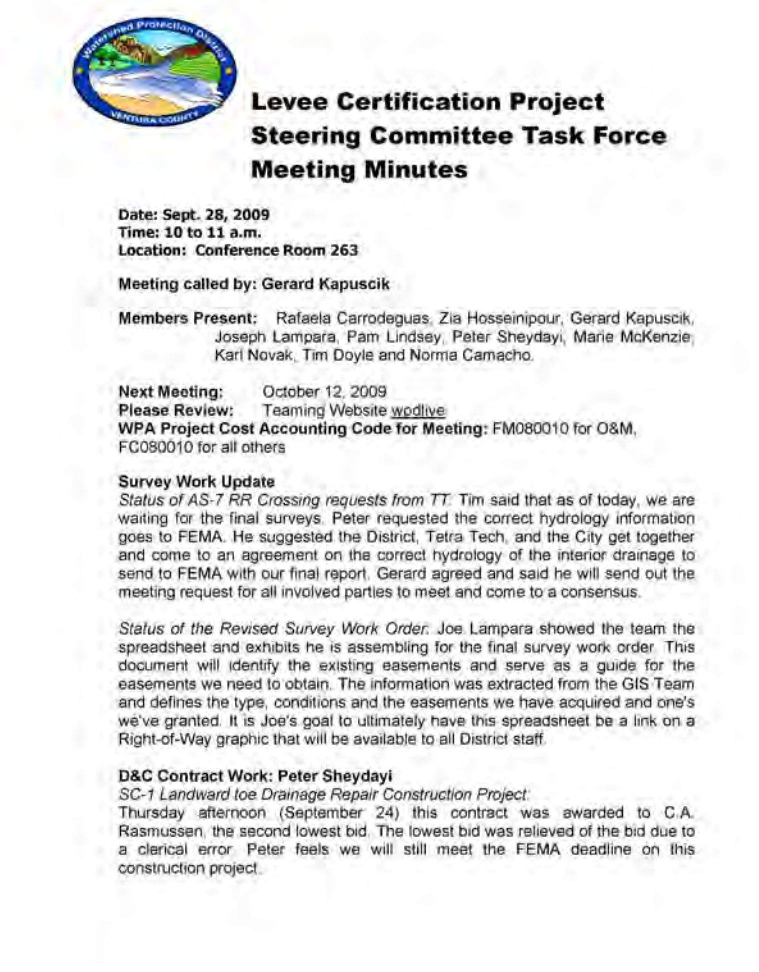
AS-7 Floodwall: Gerard
Information is currently being exchanged regarding interior drainage. Peter Sheydayi feels all issues should be resolved with one project.

SC-1 Slope Restoration Project: Tim
The property owner has moved some items off District property. Items still remain. He has also agreed to the fence being built in exchange for removing the trees.

ASR-2 & AS-6 Vegetation Removal Updates: Tim
All contractors have until Wednesday September 23 to respond to Tim's request. There are a total of three projects for this vegetation removal.

Horse Trail Issue
At this point, "the ball is in Karl's court." A follow up meeting has been scheduled with two representatives from the Equestrian Center, Joe Lampara, Tim Doyle and Karl Novak. Karl is the lead on this issue.

New Business
AS-6: The Pride Street Landowner requested a security fence be installed. A meeting has been scheduled for September 23, 2009 with the fence company, the District and the property owner.



Levee Certification Project
Steering Committee Task Force
Meeting Minutes

Date: Sept. 28, 2009
Time: 10 to 11 a.m.
Location: Conference Room 263

Meeting called by: Gerard Kapuscik

Members Present: Rafaela Carrodeguas, Zia Hosseinipour, Gerard Kapuscik, Joseph Lampara, Pam Lindsey, Peter Sheydayi, Marie McKenzie, Kari Novak, Tim Doyle and Norma Camacho.

Next Meeting: October 12, 2009
Please Review: Teaming Website wpdlive
WPA Project Cost Accounting Code for Meeting: FM080010 for O&M, FC080010 for all others

Survey Work Update

Status of AS-7 RR Crossing requests from TT. Tim said that as of today, we are waiting for the final surveys. Peter requested the correct hydrology information goes to FEMA. He suggested the District, Tetra Tech, and the City get together and come to an agreement on the correct hydrology of the interior drainage to send to FEMA with our final report. Gerard agreed and said he will send out the meeting request for all involved parties to meet and come to a consensus.

Status of the Revised Survey Work Order. Joe Lampara showed the team the spreadsheet and exhibits he is assembling for the final survey work order. This document will identify the existing easements and serve as a guide for the easements we need to obtain. The information was extracted from the GIS Team and defines the type, conditions and the easements we have acquired and one's we've granted. It is Joe's goal to ultimately have this spreadsheet be a link on a Right-of-Way graphic that will be available to all District staff.

D&C Contract Work: Peter Sheydayi

SC-1 Landward toe Drainage Repair Construction Project:
Thursday afternoon (September 24) this contract was awarded to C.A. Rasmussen, the second lowest bid. The lowest bid was relieved of the bid due to a clerical error. Peter feels we will still meet the FEMA deadline on this construction project.

ASR-2 Levee - Drop Structure Repair: Design and Construction will work toward approving the plans and specs. Peter will forward a set to Pam for her review. Peter still has concerns regarding the Equestrian Center Horse Trail.

AS-7 Levee Floodwall Rehabilitation: At this time, there is no project. Joe will send the interior drainage report (conducted by Tetra Tech) to Peter Sheydayi and Kirk Norman. Gerard will circulate a draft meeting agenda prior to the hydrology meeting. Attendees will include Planning and Regulatory, Design and Construction and Tetra Tech.

Peter suggested a pre-winter planning meeting regarding the flood wall. Jacques does not think the walls were built to stand earthquake loads, under those circumstances, raising the walls may not be an option. Peter would like to discuss any pre-winter prep we should consider bearing in mind this is an El Nino year.

- ✓ Action Item: Peter will schedule a pre-winter meeting.
- ✓ Action Item: Gerard will circulate a draft meeting agenda for the AS-7 hydrology meeting.

O&M Contract Work: Tim Doyle
SC-1 Levee Veg Removal/Levee Rehab Project: The project was awarded to Cal Fran and they will begin work next Tuesday.

AS-6, ASR-2 Veg Removal: Two bids were returned, both below the Engineer's Estimate.

SC-1, AS-6 Sinkhole repairs: SC-1 sinkhole repair was completed last week, AS-6 repair will begin today.

AS-7: The cost for replacing the missing flap gate is approximately $3,000. The bid was forwarded to Rafaela for a work order to be created.

As-Builts: Karl Novak
Gerard requested that Karl keep the team updated on the electronic library's progress and the status of obtaining a full set of drawings for all PAL levees.

Real Estate
SC-1 Levee: The property owner accepted the fence. O&M Staff are documenting the debris removal on a weekly basis. Gerard would like a final letter sent indicating our thanks for the efforts and our plan moving forward.

AS-6: The Colony Apartment Owner Meeting resulted in the following: The owner does not want any trees removed. Norma asked Karl to get some correspondence from FEMA regarding the 15 foot vegetation free zone. Once he has this documentation, Norma will present the issue and the owner's response to Supervisor Foy. Norma stated the District must exhaust all possibilities before choosing a final path. Karl should schedule another meeting, if he refuses, we'll speak to Supervisor Foy. After meeting with Foy, we'll take our request for eminent domain to the Board of Supervisors.

In the interim, the Real Estate Services Division should be requested to draft a letter for Eminent Domain and include a timeline for the process.

Round Robin
VR-1 Stop Log Structure: Tetra Tech's proposal to repair included: raising the sill plate and extend the channel.

Peter: After reading the Bureau of Reclamation's report on Matilija Dam, it looks like we don't need the stop logs.

Joe Lampara: Because of Canada de San Joaquin, the stop logs are necessary.

Gerard suggested a separate meeting on whether to repair the stop log structure or not.

- ✓ Action Item: Gerard will schedule a meeting to discuss the repair of the VR-1 stop log structure.

VR-3: What is the status of our contract with Tetra Tech regarding this levee? Pam has notified the Regulatory Agencies that the Live Oaks Diversion Mitigation site will be moved.

- ✓ Action Item: Peter will schedule a meeting to discuss this levee system as a whole, invitees should include: USACE, Tetra Tech, Pam, Joe and Peter.

SC-2: Peter suggested this levee may be fixable within a year. He believes the cost will be shared on a 75/25 percent basis (Federal Govt./WPD).

APPENDIX C

Independent Technical Review (ITR) Documentation

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.

Date: May 22, 2009	**Reviewer:** **Michael E. Zeller**	**Tel:** (520) 623-7980	**Responses to comments by Joe Evelyn on June 8, 2009**	Back Check By: (initials)
Office Tucson SWG	**Type of Document** Levee Cert Report for Hydrology	**Discipline** Civil Engineering/Hydrology		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
GENERAL				
1	Overall	The hydrology method appears to be appropriate for the Santa Clara River	No action required.	MEZ
2	Overall	A comparison was made of statistical results, based upon the gaged data for the Santa Clara River, with computational results obtained from a regression of historic FEMA FIS Hydrologic data at 133 locations throughout Ventura County (see accompanying Excel spreadsheet). The comparison indicates that the hydrologic results of this Levee Certification Report for Hydrology are conservative (safe), when measured against historic FEMA FIS hydrology for Ventura County.	No action required.	MEZ
3	Overall	See accompanying annotated version of the report text with suggested editorial changes.	Editorial changes were carefully reviewed and appropriate changes made to report text.	MEZ
SPECIFIC				
4	Figure 1	Figure 1 is difficult to read and should be replaced with clearer, more distinctly readable copy.	Figure 1 was rescanned from original at higher resolution, and contrast and brightness adjusted to improve readability.	MEZ

Technical Review Comments		**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.	
Date:	**Reviewer:** **Mike Zeller**	**Tel:** (520) 623-7980		Back Check By: (initials)
Office Tucson SWG	**Type of Document** Levee Cert Report for Hydraulics	**Discipline** Hydrology/Hydraulics		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
GENERAL				
1		Editorial comments indentified throughout using track changes.	All the comments within the report were attended and resolved. **Some of the original editorial comments (grammatical or style comments) do not apply any more as the Hydraulics report, Sediment report, and the Memorandum have been merged.**	J.S.
2		If the D50 riprap sizes get in the range of 2 to 3 feet, then some other form of bank protection/groin protection should be considered (like concrete or soil-cement).	Alternatives to current design features may be evaluated if this project goes into the design phase.	J.S.

Technical Review Comments		**Project:** Santa Clara River Levee (SCR-1)		**Location:** Ventura County, CA.	
Date:		**Reviewer:** Mike Zeller	**Tel:** (520) 623-7980		Back Check By: (initials)
Office Tucson SWG		**Type of Document** Levee Cert Report for Hydraulics	**Discipline** Hydrology/Hydraulics		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
3		Considering the two types of regime flow that are possible on the Santa Clara River---Upper (with anti-dunes) and Lower (with dunes)---two distinctly different Manning n-values should be used for the channel when analyzing hydraulics and sediment/scour potential. The current version of the report states that a Manning n-value of 0.035 was adopted for the hydraulic analysis of the Santa Clara River channel. Using this n-value for the flow in the channel will typically produce low Froude numbers and, in turn, lower-regime flow conditions (with dunes). On the other hand, using an n-value of 0.025, which is consistent with the sediment sizes and the unit discharges along the study reach of the Santa Clara River, will produce higher Froude numbers and, in turn, upper-regime flow conditions (with anti-dunes). Accordingly, I strongly recommend that the hydraulic analysis for the Santa Clara River channel be run both ways---using an n-value of 0.035 for WSELs and an n-value of 0.025 for sediment considerations. Doing the latter may also resolve the problems with the Yang Equation not converging; but, at the very least, it might produce more consistent results when comparing General Scour from the model with offline General Scour calculations, especially if the Toffaleti Equation must still be used to route sediments. This is a serious issue. The Santa Clara River has characteristics which suggest the very real possibility that it can flow either under upper-regime or lower-regime conditions; and the difference between the two regimes is significant, particularly when it comes to scour calculations	Not Concur. The Manning's n values were based on the effective FEMA studies and model of the project reach. The varying 'n' values for WSE determination and scour depth calculation would be considered if this study is continued into the design phase.	J.S.
SPECIFIC				
4	XX-3	I believe that perhaps dual Manning n-value HEC-RAS models should have been run for this river system. One model would have higher n-values for lower-regime flow, producing maximum WSELs; and the other model would have minimum n-values for upper regime flow, producing maximum scour depths and riprap sizes.	See the response for Item No.3.	J.S.

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)		**Location:** Ventura County, CA.	
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Office Tucson SWG	**Type of Document** Levee Cert Report for Hydraulics	**Discipline** Hydrology/Hydraulics		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
5	XX-3	Under 'Debris Loading on Bridges' section, it was stated that no debris loading would be applied to the piers because the pier width is more than 6 feet wide. In all cases, regardless of pier width, a min 2.0 ft of added width on each side of the pier for debris loading should be considered. I have seen this loading exceeded many times during floods, even with piers larger than 6 ft in diameter.	Not Concur. The FEMA regulations require the hydraulic studies that are submitted to FEMA to follow the local study criteria and guidelines. For the levee certification project, the USACE's guidelines were selected for the hydraulic evaluation which requires no debris loading for bridge piers with diameters larger than 6 feet. The different debris loading condition may be considered for future design phase.	J.S.
6	XX-7	'Groin Rock Sizing' section. At a groin, the greatest shear stress is located at and near the tip, where significant secondary currents are created due to flow curvature and the resulting "tornado-like" effect of helicoidal flow (which also significantly increases scour at the tip). In effect, it is like flow around a mini abutment. Thus, at the tip of the groin the rock sizes need to be much larger than rock sizes based upon average hydraulic parameters. A good rule-of-thumb is to assume that maximum velocity at and near the tip of the groin, due to flow curvature and secondary currents is 1.7 times the average velocity of the stream. The riprap should then be sized based upon this assumption of increased flow velocity.		

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Office Tucson SWG	**Type of Document** Levee Cert Report for Hydraulics	**Discipline** Hydrology/Hydraulics		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
7	XX-10	‘Field Assessment of Levee Revetment Rock Size’. Further to the issue of inadequate rock sizes for the riprap blanket. It seems to me that with such a large aspect ratio (i.e., Channel Top Width/Hydraulic Depth) on the Santa Clara River (typically, 100, or greater), there is a propensity for the channel to develop an interior sinusoidal low-flow channel that can create high-velocity impingement at the toes of the banks as, over time, the low-flow channel wanders back and forth across the primary channel bed of the Santa Clara River. Thus, in this particular instance, because of the geometric characteristics of the Santa Clara River, **the standard safety factor of 1.3 times the computed scour components (to account for non-uniform flow distribution when computing toe scour) may not be sufficient**. Also, because of the high-velocity impingement associated with a low-flow channel, **the velocity that should be used to compute rock sizes may need to be increased**—thus increasing the median diameter (D50) of rock needed to protect against a 226,000 cfs flood event (which, by the way, is about 80,000 cfs more than the largest flood peak recorded, to date, on the Santa Clara River).		
8	Figure 2	It appears to me that there is a meaningful bend area adjacent to the words “Santa Clara River,” as depicted on Figure 2. The hydraulic/scour calculations accounting for bend components may need to be considered.		

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.	
Date:	**Reviewer:** **Bill Fullerton**	**Tel:** (206) 728-9655	Back Check By: (initials)
Office Seattle SWG	**Type of Document** Levee Cert Report for Hydraulics	**Discipline** Hydrology/Hydraulics	

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
GENERAL				
1		Editorial comments indentified throughout using track changes.	All the comments within the report were attended and resolved. **Some of the original editorial comments (grammatical or style comments) do not apply any more as the Hydraulics report, Sediment report, and the Memorandum (by Ike Pace, June 22, 2009) have been merged.**	J.S.
SPECIFIC				
2		Editorial ‘specific’ comments indentified throughout using ‘comments’. (WTF 2, 3, 7, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18	All the specific comments within the report were attended and resolved.	
3	XX-2	‘Toe of revetment slope’ between Sta.442+95 and 443+00 is very high compared to others. (WTF 1)	The slope was verified based on the as-built plan.	
4	XX-2	‘FIS 100-year Discharge’ section: A little more explanation might be useful here. Did the Corps report say what their 100-year Q was? Can we give a typical range of return periods for the SPF? Can we make a statement about the return period events have increased since the Corps’ SPF was developed in 19XX? (WTF 4)	The detailed information on the discharges was already included in the separate Hydrology Appendix Report. Therefore, the ‘FIS 100-year Discharge’ section of this report was revised to refer to the **Hydrology** Appendix for further information regarding the discharges used in the **Hydraulics** Appendix Report.	J.S.

Technical Review Comments		**Project:** Santa Clara River Levee (SCR-1)		**Location:** Ventura County, CA.	
Date:		**Reviewer:** **Bill Fullerton**	**Tel:** (206) 728-9655		Back Check By: (initials)
Office Seattle SWG		**Type of Document** Levee Cert Report for Hydraulics	**Discipline** Hydrology/Hydraulics		
Item No.	Section/Page	**COMMENTS**		Action Taken:	By:
5	XX-3	‘Debris Loading on Bridges’ section: It seems that it is odd applying this criteria, that a pier just under 6’ wide would have a width of nearly 10 feet with debris, but a pier of 6’ width remains 6’ and a pair of 7’ remains 7’. At least that is how I am interpreting what is written here – That we left the pier widths alone because they were 6’ or wider? (WTF 5)		Not Concur. The FEMA regulations require the hydraulic studies that are submitted to FEMA to follow the local study criteria and guidelines. For the levee certification project, the USACE’s guidelines were selected for the hydraulic evaluation which requires no debris loading for bridge piers with diameters larger than 6 feet. The different debris loading condition may be considered for future design phase.	J.S.
6	XX-7	‘Levee Revetment Analysis’ section: Is the average thickness of 18” the design thickness? As-built thickness? We should specify which one. Did the geotechnical analysis indicate a thickness of what they dug up? If so, we should identify this also. (WTF 10)		It is the thickness specified in the as-built plan. The report was revised to clarify the source.	J.S.
6		The section, ‘Current and as-built streambed thalweg comparison’, may be more suited for the sediment report.		As of now, the hydraulic and sediment reports were revised to be combined into a single report.	J.S.

J.S. – Jung Suh

Technical Review Comments

Project: Santa Clara River Levee (SCR-1)

Location: Ventura County, CA.

Date: 6/23/2009

Reviewer: **Michael E. Zeller**

Tel: (520) 623-7980

Office
Tucson SWG

Type of Document
Levee Cert Report for Sediment

Discipline
Sediment Transport/Scour

Back Check By: (initials)

Item No.	Section/Page	COMMENTS	Action Taken:	By:
GENERAL				
1	overall	See accompanying annotated version of the report text with suggested editorial changes.	Incorporated within the revised text.	
2	13/ General	It occurs to me that since the 1983 SLA Report addressed depletion of sediment from upstream reaches, it would be possible to route a sediment hydrograph through the study reach, using the HEC-RAS sediment-transport model, by appropriately reducing the incoming sediment supply hydrograph by some reasonable factor to replicate the anticipated sediment depletion. If worse comes to worst, you could assume no sediment inflow at the upstream end of the study reach, and then you would have an envelope curve of scour/aggradation for conditions of no sediment inflow and conditions of sediment inflow based upon assuming equilibrium of upstream sediment supply (which is what you have already done with your current modeling).	Sediment modeling was removed for this levee since it failed to meet the appropriate criteria to be certified with FEMA. This may be a technique used for other levees in the future if needed.	
SPECIFIC				
1	4/comparison of Historical Topography	I do not see where consideration for long-term channel degradation has been included in the scour calculations—especially as they relate to computing toedown depths along channel banks and at the groins. Historical data indicates that long-term degradation is present and that it is still progressing.	Long-term degradation was not included for this levee analysis; since it failed to meet the appropriate criteria to be certified with FEMA.	
2	4/comparison of Historical Topography	This relates to my comment in the Hydraulics Report concerning direct flow impingement and increased flow velocities against the banks caused by caused by a “wandering” low-flow channel creating a higher than typical non-uniform flow distribution. This also affects riprap sizes.	It is acknowledged that there is a potential for a higher concentration of flow near the banks and groin. However, since this levee did not pass the lower flow velocities there was no need for further analysis, specific analysis is recommended for future design considerations.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.	
Date: 6/23/2009	**Reviewer:** **Michael E. Zeller**	**Tel:** (520) 623-7980	Back Check By: (initials)
Office Tucson SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour	

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
3	4/comparison of Historical Topography	Based upon some of the low Froude numbers along the Santa Clara River during the 100-year flood, an examination should be made as to whether flow is really in upper regime at all locations. If not, then the formula for dune scour should be used rather than the formula for anti-dune scour, as currently shown. An appropriate formula to use for dune-scour is the following: 1/2ZD = 1/2(0.0655Y1.029), in feet. Note: Lower-regime flow (dunes) occur if Fr ≤ 4.39(R/D50)-0.3.	This has been checked and verified that flow is in upper regime. Additional text has been added to clarify the process for selecting the bed form contribution to total single event scour.	
	4/ EQ	Example: At Sec. 423+57, flow is upper regime and 4.8-ft scour due to anti-dunes occurs. But at Sec. 430+40, immediately upstream, flow is lower regime, and dunes will occur with a scour depth of only 0.6 ft, rather than 2.8 ft predicted for anti-dunes.	Same as above.	
4	4/ Low Flow Incisement	This is correct. It should also be noted that the low-flow thalweg is not to be associated directly with long-term channel degradation, even though long-term channel degradation might be focused over the top of the low-flow thalweg because this is where the ordinary flows are most likely to be located within the channel cross-section.	Low Flow Thalweg was observed to exist and therefore removed from the calculation. Additional text was added for clarification.	
5	8/ local scour	See my comments on the Excel scour-calculation sheet regarding debris loading at these bridge piers. I get 18.62 feet and 16.56 feet of pier scour, respectively, when including consideration for debris.	To be consistent with the hydraulic analysis, the USACE Technical Memorandum No. 4 was referenced as to why debris was not considered for this location.	
6	8-9/Bend Scour	It appears to me that along the north bank, not far downstream of Los Angeles Avenue, there is enough curvature that some bend scour may be present. This possibility should be re-checked to see if the bend angle equals or exceeds 17.8o.	This curvature exists and impacts the North bank of the Santa Clara River. It has been verified that there was no curvature in excess of 17.8-degrees present along the south bank or levied reach.	
7	9/Total Scour	See my comment 5 on the previous page.	See response to comment 5 above.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.
Date: 6/23/2009	**Reviewer:** **Michael E. Zeller**	**Tel:** (520) 623-7980
Office Tucson SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour

Back Check By: (initials)

Item No.	Section/Page	COMMENTS	Action Taken:	By:
8	9/ Sediment Transport Equation	I do not understand what is meant by the statement that: " . . . the HEC-RAS sediment model failed to converge for all the available transport models except the Toffaleti Equation." I have never had a problem with convergence using Yang's Equation. Please explain this statement in greater detail in the text of the report.	Sediment modeling was determined to be not necessary and removed from the appendix for this levee.	
9	10/ Results	When a detailed sediment-routing model is available, the results of the maximum scour that occurs during the passage of the flood hydrograph should be used for the General Scour component when computing total single-event scour potential, rather than the Zeller Equation. This would mean that the General Scour values calculated previously are all too high. However, I have concerns that use of the Toffaleti Equation may actually be under-predicting sediment-transport rates for the Santa Clara River. Additional thought should be given, therefore, as to what values to use for General Scour.	Same as previous.	
10	12/ Vertical Scour	These values for single-event and local pier-scour depths (i.e., 13.1, 12.5, and 10.7) should be re-examined based upon the comments that I have provided herein.	The values for scour was re-examined and revised as noted above.	
11	12/ Vertical Scour	As noted in comment 9, this number (13.1) needs to be re-checked.	See above.	
12	13/ References	Where is the reference for the 1983 SLA Report?	Reference added.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.

Date: 6/25/2009
Reviewer: **Bill Fullerton**
Tel: (206) 728-9655

Office	**Type of Document**	**Discipline**		Back Check By: (initials)
Seattle SWG	Levee Cert Report for Sediment	Sediment Transport/Scour		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
GENERAL				
1	Overall	See accompanying annotated version of the report text with suggested editorial changes.	Incorporated within the revised text.	
SPECIFIC				
1	4/ Comparison of Topographic Data	Please indicate how much degradation, in feet	Refined text from the 6/22/09 memo was incorporated into the report and no longer pertinent.	
2	5/ Comparison of Topographic Data	Please indicate how much degradation, in feet	Same as response to comment 1.	
3	5/ Comparison of Topographic Data	Please indicate how much degradation, in feet	Same as response to comment 1.	
4	5/ Comparison of Topographic Data	Please indicate how much degradation, in feet	Same as response to comment 1.	
5	5/ Comparison of Topographic Data	Please indicate how much degradation, in feet	Same as response to comment 1.	
6	5/ Review of Aerial Photos	Need to fill in the reference that has been left blank	Reference was added.	
7	5/ Review of Aerial Photos	*"During the 1969 flood, confinement of the flood flows by the levee, instead of allowing the flows to expand across the floodplain, may have contributed to the washing out of portion of the Los Angeles Avenue Bridge and other damages cited in the previous section."* I don't know if this is too pertinent and is pointing the finger at the Corps project – Maybe we should take this out? ASK IKE	Refined text from the 6/22/09 memo was incorporated into the report.	
8	6/ Review of Aerial Photos	*"Prior installation of the second groin series downstream of the Los Angeles Avenue, a section of the channel bank has been carved approximately 60 feet inward to the levee."* Is this sentence out of place, Where it is located, it seems we are talking about changes between 2002 and 2005. This should be moved to the portion of the paragraph that is talking about the time period that thee changes occurred and we need to provide a time frame – actual date range over which these changes occurred.	Refined text from the 6/22/09 memo was incorporated into the report	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)		**Location:** Ventura County, CA.	
Date: 6/25/2009	**Reviewer:** **Bill Fullerton**	**Tel:** (206) 728-9655		Back Check By: (initials)
Office Seattle SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
9	6/ Review of Sediment Report	I don't understand this one… "Since 1979"? Are we referring to the SLA report only, then it was between 1979 to 1983 at most, since the report was done in 1983. We need to provide the time frame so people know if we are reporting exactly what was in the SLA report or we are using some of our information to take it forward to the present. Also, I don't see 1979 in the tale, so where is this information coming from for this date. Then it gets more confusing, because the next paragraph describes the period from 1981 to 1983?	Section omitted from the revised report	
10	6/ Table 2 line 1	If I take the SQ Yards and multiple by the length, I get 43,520,000 cubic yards, this is huge. Are we sure that the value is not already cubic yards?	Section omitted from the revised report.	
11	6/ Table 2 line 5	This is even bigger – almost 110 million cubic yards!!!	Same as above	
12	7/ Quantitative Analysis of Scour	Please fill out the proper title and designation for the Hydraulics Appendix/Report	Updated as requested.	
13	7/ Estimate of General Scour	Since this is Zeller's equation, I talked to him about it and if we are doing the modeling, this seems redundant and the model is suppose to be better ---- though I don't trust the small numbers that were produced.	Added informational text describing the limitations of the procedures/removal of the HEC-RAS model.	
14	7/ Estimate of General Scour	*"The computed general scour depth was 3.3 feet based on the maximum flow velocity of 18.75 fps at HEC-RAS Station 423+57."* Why did we choose this section. Is it extreme or representative of reach average conditions? What does Zeller say? Should we use maximum conditions or more representative such as reach average?	Scour table added for clarity under total scour section. Scour was computed for each river station, and the section showing the maximum was used.	
15	7/ Anti-Dune Trough Depth	Did anyone check what the bed forms would actually be? If so, indicate why we are in the anti dune range. I am wondering if we are not in dune conditions when I look at the Froude numbers. Please check Figure 5.22 from the newer version of Simons and Senturk (1992 – Water Resources Pub.)	Checked 2006 ASCE Manual on *Sedimentation Engineering: Theory, Measurements, Modeling, and Practice* – all sections were determined to be upper regime using the Manning's number of 0.035 for the channel. Additional text was added to clarify the section.	
16	7/ Anti-Dune Trough Depth	Dunes can also occur and there are peaks and troughs associated with them also. After you figure out what is the proper bed form, this needs to be re-written.	Further explanation was added to this section.	
17	7/ Anti-Dune Trough Depth	I would reference Simons and Senturk rather than SLA.	SLA reference confirmed with Zeller.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)		**Location:** Ventura County, CA.	
Date: 6/25/2009	**Reviewer:** **Bill Fullerton**	**Tel:** (206) 728-9655		Back Check By: (initials)
Office Seattle SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour		

Item No.	Section/Page	COMMENTS	Action Taken:	By:
18	8/ Anti-Dune Trough Depth	How representative is the maximum velocity. If this is very extreme, then applying it to the entire channel is way conservative. We might want to calculate also based on reach average hydraulics and say the one is the extreme at station 423+57 and the other (reach average) is more representative of the typical estimate of the anti-dune component of scour.	Scour was computed for each river station, and the section showing the maximum was used. This is slightly different then the previous approach.	
19	8/ Low-Flow Channel Incisement	We should not include this. I had a discussion with Zeller since this is his recommendation. First of all, this is based on Southern AZ, so not necessarily applicable to SoCAL. However, the major reason for not including this is that we have a “natural” channel out there which has formed a low flow channel (or several) and has a distinct thalweg. In is not a flat bottom design channel. Since we are making our comparisons of adequacy of levee riprap blanket and groin toedown depths based on transposing the thalweg to the levee, we are already accounting for the “low flow channel incision.	Added explanation and not used.	
20	8/ Low-Flow Channel Incisement	*"However, if a low-flow thalweg is predicted to be present, it should be assumed to be at least two feet deep within regional watercourses, unless field observations indicate otherwise."* Where did this statement come from? This type of broad statement needs to have a reference!	Reference Zeller 1981 was added to the text.	
21	8/ Local Scour	Is this section really applicable? Unless the scour holes from the bridge are large enough the expand over to the levee (laterally and longitudinally), it isn’t influencing the levee. I believe the FDA Highway manuals discuss some assumptions on dimensions for scour holes so they can see when there is influence between piers. Perhaps, this could be used to see if the scour holes influence the levees? Mike Z is the best person I know for bridge scour in these types of rivers – Southwest.	Added text explanation, this is only applicable at and immediately downstream of the bridge. According to Zeller this is applicable approximately within 54-ft of the piers.	
22	8/ Local Scour	We also calculate scour for 101, so it should be mentioned here also and the information on location and piers provided.	101 removed references in the scour portion since it is the downstream limit of the levee.	
23	8/ Local Scour	I believe we did not use debris loading. We should indicate this and cite the CORPS reference that this guidance is from.	Added reference to be consistent with hydraulics.	
24	9/ Total Scour	This is unclear – you need to list out each component and show how it is totaled up.	Added text and table for clarification.	
25	9/ Total Scour	Make proper reference	Added reference.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.	
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Office Seattle SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour	

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
26	9/ Sediment Transport Modeling	If we were serious about modeling sediment transport, we should have calibrated or verified the model. We have cross sections and or topography spanning a long period and we could have run the major floods (we have a hydrologic record from a nearby gage) between these periods to see how well the model reproduced the actual response. This is what Pizzi is doing on the Santa Ana. I know e do not have the time to do this now, but it should be considered in the future both when we budget this type of work and when we actually perform it. If there is not any data to calibrate/verify the model, then some type of sensitivity analysis is recommend (what if we change the sediment supply by 25%, what if we change the bed material distribution, etc….)	Sediment modeling was removed for this levee since it failed to meet the appropriate criteria to be certified with FEMA regardless.	
27	10/ Sediment Gradation	Explain why they were considered inconsistent or unrepresentative?	See response to comment 26 above.	
28	10/ Sediment Transport Equation	Was there any available sediment transport measurements on gages within the Santa Clara River? We need to indicate one way or the other. If there is sediment transport data, then we need to try and use it in the selection of the equation.	See response to comment 26 above.	
29	10/ Sediment Transport Equation	*"HEC-RAS sediment model failed to converge for all the available transport models except the Toffaleti equation (1968)."* I do not understand what is meant by did not converge? In general, I would think that Yang would be a good choice. Did the model run for a while then the hydraulics did not converge because the degradation/aggradation created some crazy channel sections? The Yang equation(s) itself is pretty simple and is explicit, so I don't understand why it wouldn't converge?	See response to comment 26 above.	
30	10/ Boundary Conditions - Sediment Supply	When there is a lot of uncertainty in sediment supply, another modeling technique that is often used to lessen the sensitivity to the assumed sediment supply condition, is to start the modeling a considerable distance U/S of where the area of interest is. Did we start our model upstream of our area of interest, and how far. What was the upstream station of the model and how far is this above the U/S end of the levee. This would be important information to work into this section	See response to comment 26 above.	
31	10/ Boundary Conditions - Sediment Supply	When this option is used, it is generally necessary to start the model at a location we believe is pretty much in a state of sediment balance.	See response to comment 26 above.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)		**Location:** Ventura County, CA.	
Date: 6/25/2009	**Reviewer:** **Bill Fullerton**	**Tel:** (206) 728-9655		Back Check By: (initials)
Office Seattle SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
32	10/ Boundary Conditions - Sediment Supply	What are the other possible trends? This statement leads me to believer, why did we do this in the first place. It implies we have no confidence at all in the results and they are basically just random. There's uncertainty in any sediment modeling results. We should not have chosen a boundary condition that we don't have any faith in. We need to have a better understanding of the boundary/supply condition and its validity and remove this statement. We can add some caveat as to there being uncertainty in the results sediment transport and the associated scour and deposition in natural rivers is extremely complicated and any model is only an approximation. In addition,	See response to comment 26 above.	
33	10/ Base Flood Hydrograph	How did this hydrograph compare in shape – duration to the 1969, which was stated to be the largest flood recorded?	See response to comment 26 above.	
34	11/ Sediment Transport Modeling Results	These values seem very low to me for a river with such high potential for sediment transport.	See response to comment 26 above.	
35	11-12/ Table 3, Column 6	I would get rid of this column – Also "worst" is not a good term!	See response to comment 26 above.	
36	12/ Conclusions & Recommendations	OK – So why is our assumption better. Was SLA basing theirs on continued sand and gravel mining? We can't just make this statement without saying why our assumption is more appropriate for current conditions (if it is. If it not, then we need to redo the analysis with the assumption similar to SLA!!!!	Reworded.	
37	12/ Conclusions & Recommendations	We should not discuss the reasons form other parts of the report here, particularly as the first item under the reasons from this analysis! We can list these as additional reasons, after we have made our conclusions from this report. So we would separate the ones from this report from the ones from the other reports by a sentence or two introducing the ones from other reports/parts of the report.	Revised.	
38	12/ Conclusions & Recommendations	Please take this and make it logical, then I will review.	Revised.	
39	General Figures	It is general practice to have Figure titles below the figure, not above. In contrast, it is appropriate to place Table titles above the table.	Noted.	

Technical Review Comments	**Project:** Santa Clara River Levee (SCR-1)	**Location:** Ventura County, CA.

Date: 6/25/2009	**Reviewer:** **Bill Fullerton**	**Tel:** (206) 728-9655		Back Check By: (initials)
Office Seattle SWG	**Type of Document** Levee Cert Report for Sediment	**Discipline** Sediment Transport/Scour		

Item No.	Section/Page	**COMMENTS**	Action Taken:	By:
40	General Figures	Another general comment on most of these figures, especially amps is that they can all be enlarged some. The text is very small, but we are not using the entire space within the margin. I agree with the overall 1 inch margins, but the we have the lines and another 1/2 to 3/4 inch between that and the figure or the titles! This is making the space for the figures too small.. Also – why do we have the path for the figure – this is meaningless for anyone reading the report and is a distraction. I would get rid of it.	Revised figures.	
41	Figure 5	The line for the aveage curve needs to be even heavier to distinguish it more from the other curves.	Removed.	
42	Figure 7	You have the figure title up here, we don't need a similar title on the graph, delete the title on the graph so the graph can be expanded. This figure is not of much sue, since the changes are so small this is one line. Unless something changes, I would just get rid of this figure.	Removed.	

APPENDIX D

Additional Appendices

D1. Scope of Work
D2. Hydrologic Analysis
D3. Hydraulic Analysis

APPENDIX D1

Scope of Work

county of ventura

PUBLIC WORKS AGENCY
JEFF PRATT
Agency Director

Phillip L. Nelson, Director
Engineering Services

Michael K. Sullivan, County Surveyor
County Surveyor's Office

Raymond Gutierrez Jr., Manager
Development & Inspection Services

May 5, 2009

Tetra Tech, Inc.
1230 Columbia Street, Suite 1000
San Diego, CA 92101

Attn: Bob Hall

Subject: **Notice to Proceed**
Santa Clara River, Hwy 101 to Saticoy
AE No. 09-30; Project No. P6012007

Enclosed is your fully executed copy of the subject contract.

This letter is your Notice to Proceed. Exhibit B indicates the schedule for completion of the work.

Gerald Kapuscik will be the Project Manager and you are advised to contact this person on all matters pertaining to this project.

All billings should be sent : Ventura County Public Works Agency
Engineering Services Division, Attn: Victoria Escoto
800 South Victoria Avenue, L#1670
Ventura CA 93009-1670

All invoices to be paid against this contract must reference the AE number shown above and must be accompanied by a signed copy of one of our **General Claim forms, which I have enclosed**. If your contract is based on hourly rates, personnel time records must be submitted with your claim.

Sincerely,

Phillip L. Nelson
Director Engineering Services

PLN/:vqe
Enclosures

Hall of Administration L # 1670
800 S. Victoria Ave., Ventura, CA 93009 (805) 654-2039 Fax (805) 677-8762 http://publicworks.countyofventura.org/eng_services

EXHIBIT A

SCOPE OF SERVICES

FEMA LEVEE CERTIFICATION
SCR-1
Santa Clara River, Hwy 101 to Saticoy

1. Description of Project

In a nation-wide effort to certify all existing flood control levees, FEMA has identified existing levee facilities within Ventura County. A number of these existing levee facilities have been given a Provisionally Accredited Levee (PAL) status. As part of this effort FEMA has requested the Ventura County Watershed Protection District (Agency) to evaluate the Santa Clara River Levee (SCR-1) and prepare documents for the certification process based on FEMA's regulatory requirements as identified in Title 44 of the Code of Federal Regulations (CFR), Section 65.10 (44 CFR 65.10).

Certification Criteria are as follows:

- Design criteria (freeboard, closures, embankment protection, embankment and foundation stability, settlement, and interior drainage).
- Operation plans and criteria (for closures and interior drainage).
- Maintenance plans and criteria.
- Actual certification requirements (i.e. as-builts, forms, documentation, and data).

As part of the Phase 1 process, an evaluation of the SCR-1 levee system was conducted to recommend a levee categorization.

Levee Categorizations are as follows:

- Category 1 – Levees meet 44 CFR 65.10 requirements and all data or complete documentation is available.
- Category 2 – Levees may meet 44 CFR 65.10 requirements, but additional data or documentation is needed.
- Category 3 – Levees do not currently meet 44 CFR 65.10 requirements.
- Not a Levee – Based on physical conditions, low WSEL, no SFHA, and/or not providing flood protection.

A levee that is assigned a Category 1 or 2 rating will be further evaluated in the Phase 2 or 3 processes, respectively, in order to finalize its certification status. A levee that is assigned a Category 3 rating will require a Pre-Design Study in the Phase 4 process and implementation of the required improvements to achieve certification status.

During Phase 1 work the SCR-1 levee system was determined to be a Category 2 levee which may meet 44 CFR 65.10, but additional data or documentation is needed. The Consultant shall provide the Agency with engineering services to support Phase 3 work of the FEMA Levee Certification Project for the SCR-1 levee system. The Phase 3 work consists of data collection, site investigations, engineering analyses, and preparation of certification documentation as appropriate. This work is described in the scope of work below as Tasks 1 through 13.

As part of the Phase 1 work a field investigation was performed that identified deficiencies in the SCR-1 levee system that will require rehabilitation. As an Option the Agency may elect to contract with the Consultant to provide engineering services for the rehabilitation effort. The engineering services would include: engineering and design, preparation of construction plans, specifications, estimate and engineering during construction and preparation of as-builts, evaluations and inspections as-required to rehabilitate found deficiencies that would prohibit levee certification. This work is described in the scope of work below as OPTION Tasks 14 through 18.

The Consultant may also be requested to perform additional unforeseen services necessary for completion of the project that are not included in and beyond the scope of work. The Consultant shall submit a request to the Agency prior to commencing on any additional services. The additional services may be authorized by the Agency as deemed necessary. Consultant shall not proceed with the requested additional services until authorization from the Agency is received.

The work to complete the tasks in this Phase 3 scope of work shall generally follow the schedule presented in Exhibit B, however several tasks may be required to start simultaneously and shall be authorized at the discretion of the Agency to ensure adequate time is allowed to complete the work. After completion of any task that changes this levee/floodwall from a Category 2 levee system to a Category 3 levee system, the Consultant shall formally notify the Agency in writing. The Agency then, at its sole discretion, will decide whether or not to issue a stop work order on any further Phase 3 work.

In the event of a stop work order, for any reason, the Consultant shall be entitled to payment for services performed up to the date of the stop work notice. This includes full payment on completed tasks and partial payment, dependent on amount of work completed and submitted, on authorized unfinished tasks.

2. Basic Services

The following services will be performed by the Consultant:

Task 1) Project Management, Coordination and Data Collection

I. Consultant shall participate in a kick-off meeting with the Agency.

II. Consultant shall maintain appropriate coordination with the Agency. Consultant shall coordinate and manage milestones, schedule, roles and responsibilities, resource plan, and document control process of the project team. This will include preparing and maintaining a project schedule using Microsoft Project.

III. Consultant shall coordinate with the LA District office, U.S. Army Corps of Engineers (USACE) to ensure USACE design guidelines are known and followed for Category 2 levees constructed by the USACE.

IV. Consultant shall collect all remaining available documentation and data for the levee system. Efforts shall include:

   a. Researching FEMA archives and databases for previous Certification Documents, CLOMR/LOMR case files, Flood Insurance Studies, etc.

b. Researching the files and archives of other Federal Agencies, including the USACE and the National Resources Conservation Service, as well as Agency files and archives for planning and design studies, site data, etc.

Task 2) Site Investigations

Consultant shall complete all necessary site investigations to include but not limited to; subsurface explorations and geotechnical testing, materials testing and analysis, collect all soil data necessary to supplement any provided by the Agency, topographic data if needed, and any other investigation required to ensure that the necessary information and data is available to determine whether or not the levees meet FEMA certification criteria.

I. Subsurface Soil Exploration:

Prior to the start of this task, Consultant shall prepare a work plan for geotechnical exploration that includes a sketch of bore hole locations, depth of each bore hole, soil sampling intervals along the bore hole, sample custody protocols, and the soil testing methods that follow the standard geotechnical procedures (i.e. ASTM). Consultant shall meet with the Agency to go over the work plan prior to the start of this task.

Exploratory methods are to include hollow stem auger borings utilizing a high torque truck mounted drill rig and test pits. The test pit explorations for the SCR-1 levee system will utilize a backhoe to verify the existence and condition of buried levee revetment and possibly the condition of the embankment itself. If revetment or embankment material is encountered, controlled backfill utilizing a compaction wheel and water supply will be needed.

Consultant shall perform 26 subsurface borings and 26 test pits along the levee system to support the geotechnical assessment required for certification. Consultant shall assume the following:

- Applicable permits from Fish & Wildlife, Corps of Engineers, and Regional Water Quality Control Board will be provided by the Agency at no cost to Consultant.
- Consultant shall provide all necessary information necessary for application of encroachment, access and traffic control permits. Agency shall provide these permits at no cost to the Consultant.
- Consultant shall obtain well/boring installation and closure permits
- Adequate topographic mapping will be provided prior to marking field locations,
- Full vehicular access to both ends and top of levee along the entire length of the levee,
- Consultant shall notify Underground Service Alert prior to excavating exploratory borings. Where necessary, Consultant shall provide a specialty utility locator. Agency will be responsible for identifying location of buried utilities that are owned and operated by the Agency,

- Staging area for equipment storage and potable water source will be provided by the Agency,
- Cuttings and mud drummed can be stored on site prior to disposal,
- Disposal manifests are to be signed by an Agency representative (owner/operator of levees where waste is generated),
- Disposal of non-hazardous drilling material to be performed by Consultant. Removal of hazardous material, if any, is not included in this scope of work,
- Cold patching will be performed for all borings drilled through asphalt,
- Excavation equipment and labor for test pits to be provided by the Agency.

II. Laboratory Testing:

Consultant shall perform laboratory testing of the samples collected during the subsurface exploration. Laboratory testing will include in-situ moisture and density, grain size distribution, shear strength and hydraulic conductivity.

III. Topographic Mapping Coordination:

The Agency has updated 2005 LIDAR data in NAVD88 datum that is appropriate for certification. Consultant shall assume that the Agency will provide the 2005 LIDAR data in NAVD88 datum. In addition, the Agency will provide pertinent cross section survey information along the levee/floodwall at 100-ft intervals (min) and as described in Task 7.

Consultant shall provide coordination with the Agency's survey department for this task. Consultant shall utilize the provided survey information in the appropriate analyses to assure the most current improvements to ground elevations are considered.

Task 3) Engineering Analyses

Consultant shall perform engineering analyses or review existing analyses including; Geotechnical Assessment (slope or embankment stability, seepage, settlement), Hydrologic Analysis, Hydraulic Analysis, Scour/Aggradation Analysis, Structural Evaluation, System Evaluation and Floodplain Delineation, necessary to determine if the Category 2 levee meets the certification criteria in 44 CFR 65.10.

I. Geotechnical Assessment:

Once subsurface conditions are evaluated and laboratory testing is completed, the Consultant shall perform a geotechnical analysis. Analyses will include seepage analysis, slope stability analysis, and a brief discussion of seismic considerations. Where sustained water flow levels indicate that embankment or foundation seepage could be problematic, seepage analysis will be performed using SEEPW, a finite-element software program that can perform transient seepage modeling. Based on discussion with the Corps, steady-state analysis will not be required due to the rapid hydraulic loading anticipated on the levees.

Slope stability of levee embankments will be performed utilizing SLOPEW, a computer program that can perform a variety of limit equilibrium stability analysis methods (Bishops, Janbu, Morgenstern-Price, etc.) under both static and pseudo-static loading conditions. Slope stability will be evaluated in accordance with the methodology outlined in USACE Manual EM 1110-2-1913.

All geotechnical analyses required by Section 65.10 of the NFIP regulations (and identified in FEMA MT-2 forms) will be performed.

Consultant shall prepare a geotechnical report which documents all subsurface exploration, laboratory testing results and the geotechnical assessment consistent with levee certification requirements.

II. Hydrologic Analysis:

The discharge frequency values presented in the December 2006 Ventura County Watershed Protection District report (VCWPD) titled “Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line” are directly usable for Santa Clara River and Sespe Creek levee certification purposes. This report was developed through a collaborative effort among hydrologic engineering staff at VCWPD, Corps of Engineers (Los Angeles District), and Los Angeles County Department of Public Works. The study results are current in that flow data through water year 2005 was used in the hydrologic analysis, and there have been no flood events in the interim that are large enough to significantly alter the discharge frequency values in the report. Water Resource Council Bulletin #17B discharge frequency procedures were applied as prescribed by FEMA guidelines as the basis for the hydrologic analysis.

Consultant shall extract and prepare hydrologic documentation required for levee certification and develop hydrographs to support the levee/embankment seepage analysis. Baseflood hydrographs would be generated using a “balanced hydrograph” approach in which the baseflood hydrograph would be consistent with respect to volume duration frequency relationships for the Santa Clara River levee. A pattern hydrograph based on either a hypothetical flood event such as Standard Project Flood or a large historical flood event would be used to shape the baseflood hydrographs.

III. Hydraulic Analysis:

The current FEMA FIS hydraulic model for the Santa Clara River is available. The current FEMA FIS hydraulic model will be used as the basis for the hydraulic model to develop the freeboard analysis.

Consultant shall determine whether the levee system can be segmented along its length in accordance with FEMA guidance and requirements. If the levee or any portion can be segmented and categorized as a channel rather than a levee the Consultant shall prepare documentation to pursue identification of the appropriate segments as a channel and de-listing as a levee with FEMA. Consultant shall meet with the Agency to go over the results of this task prior to proceeding.

IV. Scour/Aggradation Analysis:

Consultant shall perform additional sedimentation and scour analyses to support the freeboard, embankment protection and embankment stability analyses. The sediment transport functions within HEC-RAS will be used to determine short-term aggradation or degradation associated with specific storm events. Long-term sediment transport will be determined based on historical data which will include information shown on the as-builts and any other readily available historical topographic data or previous study reports. It is assumed that the sediment gradation information is available and sediment sampling and laboratory analyses will not be required. Consultant shall meet with the Agency to go over the results of this task prior to proceeding.

V. Structural Evaluation:

Consultant shall perform a structural evaluation. The structural evaluation will be done by reviewing available information, which will include a review of Period or Annual Inspection Reports. A site visit to visually assess the structural elements will be conducted. The evaluation will include a review of the most recent corrugated metal pipe (CMP) condition assessments, if any exist. It is assumed that the video taping of the CMP will not be required by the USACE-LA District. A detailed analysis of CMP will be performed in accordance with current Corps guidance.

The evaluation will also include the evaluation of the structural integrity of reinforced concrete structures including stop logs and storm drain outlets and masonry walls as appropriate. No material testing will be performed as part of this task.

VI. System Evaluation:

Consultant shall perform a system evaluation. The system evaluation will consist of determining whether the individual components adequately pass their individual certification requirements and ensuring that possible interaction among the components will not result in failure.

It is assumed that the Failure Mode Analysis (FMA) is not required for the levee certification and is not included in this scope of work.

Consultant shall perform a qualitative evaluation of the system only. In-depth evaluation using mathematic and/or computer models will not be performed.

The system shall have an emergency response plan supported by a flood warning system. Consultant will review the existing Emergency Response Plan with the Agency and update the plan as necessary. The preparation of a new emergency response plan, if needed, is not included in this scope of work.

VII. Floodplain Delineation:

Based on the output from the hydraulic analysis the Consultant shall delineate the 100-year and 500-year floodplains.

Task 4) Re-evaluate Category 2 Levee

Consultant shall re-evaluate the Category 2 levee based on the additional information and data obtained and the results of the engineering analyses performed and re-categorize each Category 2 levee as either a Category 1 levee, for which all data and information is now available and the levee meets 44 CFR 65.10 criteria, or as a Category 3 levee which does not meet the criteria of 44 CFR 65.10. Consultant shall meet with the Agency to go over the results of this task prior to proceeding.

Task 5) Collect, Organize and Assemble Data

Consultant shall collect, organize and assemble in the proper format all existing data and documents required by FEMA for certification.

Consultant shall assume that a current emergency response plan is in effect and available for inclusion to the certification package. The Consultant shall assume that current emergency response plan documents will be provided for updating.

Task 6) Review, Evaluate and Modify O&M Manual

Consultant shall review, evaluate and update as required the existing Operations and Maintenance Plan and Manual to ensure it meets FEMA requirements related to the levee certification process.

Task 7) Perform Interior Drainage

Consultant shall perform an interior drainage analysis, identifying the sources and magnitude of interior flooding. This interior drainage analysis must be based on the joint probability of interior and exterior flooding and must include delineation of areas landward of the levee where interior runoff may pond. Consultant shall utilize the guidance and criteria contained in the USACE publication EM 1110-2-1413, Engineering and Design – Hydrologic Analysis of Interior Drainage Areas.

The Agency shall provide the Consultant with copies of master plan of drainage and all storm drain as-builts that are available for use in this analysis for each storm drain penetration. If no as-builts are available the Agency will provide survey documentation of the storm drain's outlet, inlets, inverts and manhole elevations upstream of each penetration until the ground elevation at the inlets/manholes is 2' above the top of levee/floodwall or the u/s limit of the storm drain system.

Based on the field investigation and review of the as-built plans, there are 8 storm drain penetrations through the levee. All storm drains have flap gates with the exception of two locations at Side Drain 1A and a 12" metal pipe private drain (possibly abandoned).

Task 8) Prepare Levee Certification Report

Consultant shall prepare a Levee Certification Report (LCR) to document and describe the basis for the certification determination of the levee system under evaluation. The LCR shall contain full documentation of data, information, assumptions, and explanation sufficiently clear so that an individual not familiar with the project could review the LCR and understand how the levee certification (certified or not certified) was made. Consultant shall meet with the Agency to present and discuss results of this task.

Task 9) Conduct Independent Technical Review

Consultant shall conduct an Independent Technical Review (ITR) of the LCR by a qualified team not involved in the day-to-day production of the LCR for the purpose of confirming the proper application of established criteria, policies, and professional practices, in addition to ensuring that appropriate methods of analyses were performed and documentation is sufficient to support the final determination. A copy of the ITR documentation shall be included in the final LCR.

Task 10) Complete FEMA Forms

Consultant shall complete all necessary forms and documents required by FEMA including MT-2 Form 3, "Riverine Structures Form", Attachment M, and if required MT-2 Form 2, "Riverine Hydrology & Hydraulics Form". The forms will be included as part of the Levee Certification Report.

Task 11) Certification

All data prepared by the consultant to certify that a given levee system complies with the requirements set forth in 44 CFR 65.10, to include all forms, transmittals, analysis, documents, etc. required by FEMA for certification of a levee, shall be certified by being stamped and signed by a Registered Professional Engineer prior to being submitted to the Agency.

Task 12) Submit Deliverables

Consultant shall submit the signed and stamped documents, forms, backup data and engineering analysis as noted below in Section 3 Deliverables, to the Agency for submission to FEMA.

Task 13) Submit Backup Data

Consultant shall submit to the Agency all other items specified in Section 3 Deliverables.

Task 14) OPTION - Conceptual Remediation Plan

Not Applicable.

Task 15) OPTION - Engineering and Design

Not Applicable.

Task 16) OPTION - Plans, Specifications and Estimate

Not Applicable.

Task 17) OPTION - Preliminary Evaluation of Revetment Protection

Consultant shall log 3 test pits excavated within the riverward side slope of the levee. The test pits will be excavated to evaluate the extent and quality of the existing rock revetment material. Field assessment of the rock material will be performed in order to estimate the size range of the rip rap material. Laboratory testing will be performed to evaluate durability and abrasion resistance. The Agency will provide all equipment and manpower to excavate the test pits as well as to replace the rock revetment after it has been assessed.

Task 18) OPTION - Field Observation of Levee Maintenance and Repairs

The Consultant shall perform up to 4 site visits in order to observe levee maintenance and/or repair procedures that are necessary as part of the levee certification process. The observations will be performed in order to verify that the repairs are being completed in accordance with the appropriate specifications and details. Quality control testing will be performed by the Agency in order to confirm that minimum project standards (soil gradation, moisture conditioning, and relative compaction) are being met. The Consultant shall coordinate with the Agency in order to optimize the effectiveness of each site visit. It will be the responsibility of the Agency to give adequate notice to the Consultant prior to initiating any maintenance or repair work.

3. Deliverables

For each levee system the consultant shall submit the following to the Agency:

I. Five hard copies and one electronic copy of all the data and information obtained from the site investigations and material testing noted in the scope of work above.

II. Five hard copies and one electronic copy of the engineering analyses performed in the assessment of Category 2 levees.

III. Five hard copies and one electronic copy of the preliminary report providing the results of the site investigations, material testing and engineering analysis and the Consultant's rational for the re-categorization of the Category 2 levee as either Category 1 or Category 3.

IV. For levee re-categorized as Category 1 levee provide:

  a. Five hard copies and one electronic copy of the Consultants Draft Levee Certification Report.

  b. Five hard copies, signed and stamped by a Registered Professional Engineer, and one electronic copy, with an electronic signature and stamp, of the Consultants final certification report, including all of the backup information, documents and forms and engineering analysis as required by FEMA for levee certification.

  c. Five additional hard copies and one electronic copy of the interior drainage analysis for Agency records.

EXHIBIT B

TIME SCHEDULE

FEMA LEVEE CERTIFICATION
SCR-1
Santa Clara River, Hwy 101 to Saticoy

Consultant shall complete the Phase 3 work for the project within the time limits indicated in the table below. The following schedule assumes a project Notice to Proceed of April 27, 2009, with final drafts of all deliverables submitted to the Agency by no later than November 20, 2009.

Task Description	Due Dates
Kick-off Meeting	04/30/09
OPTION – Preliminary Evaluation of Revetment Protection	05/29/09
OPTION – Field Observation of Levee Maintenance and Repairs	On-Going
OPTION – Conceptual Remediation Plan	N/A
Review Meeting	N/A
OPTION – Engineering and Design	N/A
Review Meeting	N/A
OPTION – Plans, Specifications and Estimate	N/A
Review Meeting	N/A
Hydrologic Analysis	05/29/09
Hydraulic Analysis	06/26/09
Review Meeting	06/30/09
Scour/Aggradation Analysis	08/28/09
Review Meeting	09/01/09
Perform Interior Drainage	09/11/09
Exploration Meeting	05/26/09
Subsurface Soil Exploration	06/19/09
Laboratory Testing	07/17/09
Geotechnical Assessment	09/04/09
Structural Evaluation	09/04/09
System Evaluation	09/11/09
Floodplain Delineation	09/18/09
Re-Evaluate Category 2 Levee	09/25/09
Review Meeting	09/29/09
Review, Evaluate and Modify O&M Manual	10/09/09
Prepare Levee Certification Report	10/23/09
Review Meeting	10/27/09
Complete FEMA Forms	10/30/09
Conduct Independent Technical Review	11/06/09
Submit Deliverables	11/20/09
Submit Backup Data	12/18/09

Should the Consultant be delayed because of acts or omissions of the Agency, this shall be documented by the Consultant and submitted weekly to Agency for approval of delays. Schedule is contingent on Agency review times to be within 7 calendar days.

APPENDIX D2

Hydrologic Analysis

Santa Clara River Levee
County of Ventura, California

FEMA ID No.: 18
County System No.: SCR-1
Flood Source: Santa Clara River
Communities: City of Oxnard

Hydrologic Analysis

November 2009

TETRA TECH, INC.
17770 Cartwright Road, Suite 500
Irvine, California 92614

Introduction

This hydrologic report was prepared in support of FEMA recertification studies for the Santa Clara River Levee project which provides flood protection to the City of Oxnard and the Oxnard floodplain, in Ventura County, California (see inset map in figure 1). Discharge frequency determinations including the FEMA baseflood (one-percent annual exceedance probability flood event) were based on methodology prescribed in FEMA regulations (44 CFR 65.10) as well as "Appendix C: Guidance for Riverine Flooding Analyses and Mapping of FEMA's Guidelines and Specifications for Flood Hazard Mapping Partners," dated February 2002 (http://www.fema.gov/pdf/fhm/frm_gsac02.pdf). This guidance describes the scope and methodologies acceptable for hydrologic analyses that support FEMA flood hazard mapping. Paragraph C.1.1 of these guidelines states: "*Where appropriate, the Mapping Partner that is performing the hydrologic analysis shall use all available flood flow-frequency information and shall not duplicate previous work by Federal, State, or local agencies, or work performed as part of a new or revised Flood Insurance Study (FIS) for FEMA. Where such data are not available, where conditions have changed invalidating the published information, or where the methodologies or data used in the previous FIS(s) are not appropriate, a new hydrologic analysis will be required.*"

The paragraph C.1.1 guidelines are pertinent to this study because the adopted discharge frequency relationship, including the baseflood peak discharge value, is taken directly from a prior hydrologic study performed by the Ventura County Watershed Protection District (VCWPD) in 2006. A brief summary of the hydrologic methods and discharge frequency values adopted in the 2006 VCWPD study are presented in the current report. Attachments are also provided that present the 2006 VCWPD hydrologic report in full, along with the detailed computer output files used in deriving volume-duration frequency relationships and the derivation of a baseflood hydrograph for the Santa Clara River Levee.

Project Description

The Santa Clara River Levee is a 4.72-mile-long project designed and constructed by the U.S. Army Corps of Engineers (Corps), Los Angeles District, and has been in operation since its completion in April 1961 (Figures 2 & 3). The project was authorized by the 1948 Flood Control Act as an improvement under the general plan for flood control recommended for approval in the Chief of Engineers report dated 6 August 1946, and published as part of House Document 443, Eightieth Congress, first session. The project consists of a stone-revetted single levee along the east bank of the Santa Clara River from the west end of South Mountain to the bridge on U.S. Highway 101; a series of groins; side drainage structures; and weighted-stone toe protection (see Figure 1 for levee plan detail). Ventura County Watershed Protection District, the project owner and operator, has designated the Santa Clara River Levee project as (SCR-1).

The Santa Clara River Levee was designed to control the Corps' Standard Project Flood discharge of 225,000 cubic feet per second (cfs) emanating from the 1600 square mile Santa Clara River watershed. The levee height varies from about 4 feet to 13 feet. The compacted fill embankment has a top width of 18 feet, and the levee embankment slopes are no steeper than 1V:2H on both landside and riverside faces. Riprap stone revetment 1.5 - 2.0 feet thick extends below the adjacent streambed, and was concreted in the vicinity of highway bridges. Rock groins were constructed to divert flows away from the levee toe. In addition, a weighted-stone toe section along the levee was designed to protect the revetment from undermining.

The Santa Clara River levee is identified as Levee ID 18 by the Federal Emergency Management Agency (FEMA), and as Levee System SCR-1 by the County of Ventura.

Physiographic Characteristics of Santa Clara River Levee Drainage Area

The Santa Clara River drains a 1600 square mile watershed, and empties into the Pacific Ocean near Ventura, California, about 60 miles west-northwest of Los Angeles. About 90 percent of the drainage is mountainous with steep rocky ridges and numerous canyons. The remaining 10 percent consists of narrow alluvial valleys and a coastal plain. Approximately 95 percent of the watershed lies north of the river. The river rises in the San Gabriel Mountains and flows about 84 miles to its mouth near Ventura. The maximum elevation in the basin is 8,826 feet at Mount Pinos, located in the Tehachapi Mountains near the western end of the northern boundary. The average slope of the river in the mountains is 160 feet per mile, and decreases to 15 feet per mile near the coast. The vegetal cover increases in density from the comparatively arid eastern part of the basin to the more humid western part. Mean annual precipitation for the basin ranges from 16 inches near the coast to about 36 inches for the Topatopa Mountains, and about 25 inches for the San Gabriel Mountains.

Chaparral and sagebrush are the principal types of native vegetation in the mountains and foothills. Coniferous trees grow in scattered areas of the higher mountains, and sycamore and cottonwood trees along most of the tributary streams. Brush fires periodically denude large areas within the watershed. The alluvial valleys are characterized by extensive agricultural use and urbanization. The Santa Clara River basin is underlain by an impervious basement complex of pre-Jurassic schist, quartzite, slate, limestone, and granite. Alluvial deposits cover the floors of the larger valleys to a maximum depth of several hundred feet.

Previous Hydrology Reports

The following reports were reviewed to obtain hydrologic information pertaining to the levee:

1. *"Santa Clara River 2006 Hydrology Update, Phase I, from Ocean to County Line,"* Ventura County Watershed Protection District report, December 2006.
2. *"Design Memorandum No. 1, Hydrology for the Santa Clara River Levee, Ventura County, California,"* U.S. Army Corps of Engineers, Los Angeles District, October 1958.
3. *"Design Memorandum No. 2, General Design for the Santa Clara River Levee, Ventura County, California,"* U.S. Army Corps of Engineers, Los Angeles District, November 1958.

Table 1 summarizes the peak streamflows from the three publications referenced above for the 10-year, 50-year, 100-year, SPF and 500-year flood events.

Table 1 - Summary of Discharge Frequency and Design Flood Values (cfs) from Previous Reports

Location	Drainage Area (sq. mi.)	Q_{10}	Q_{50}	Q_{100}	SPF	Q_{500}
Design Memorandum No. 1, Hydrology for Santa Clara River Levee, USACE, October 1958						
At Santa Clara River Levee	1600	N/A	N/A	N/A	225,000	N/A
December 2006 VCWPD Hydrology Update, Phase I Report						
At USGS Santa Clara River at Montalvo Stream Gage[1]	1594	72,800	172,000	226,000	N/A	373,000
Santa Clara River Levee [1]	1600	72,800	172,000	226,000	N/A	373,000

1. Computed Probability Discharges.

The Corps of Engineers reports of October and November 1958 provide the basis of design including hydrology for the Santa Clara River Levee project. As part of a coordinated watershed planning and management effort, the December 2006 Ventura County Watershed Protection District (VCWPD) report, which updated an earlier 1994 report, was reviewed by HDR Engineering Inc.; the Los Angeles District of the Corps of Engineers; and the Los Angeles County Department of Public Works. Comments received from the various agencies were addressed in finalizing the 2006 report. A copy of this report is attached as an attachment, as it contains the detailed flow frequency analysis adopted in this study.

U.S.G.S. Stream Gages

The U.S. Geological Survey (USGS) streamgage on the Santa Clara River at Montalvo, CA (#11114000) near the mouth of the Santa Clara River measures runoff from 1594 square miles. The period of record used in the VCWPD report spanned 68 years (1932 to 2005). Table 1 of the 2006 VCWPD report provides a list of the annual peak discharges for the period of record through 2005.

Santa Clara River Discharge Frequency Analysis

The discharge frequency values presented in the December 2006 Ventura County Watershed Protection District report (VCWPD) entitled “Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line” are directly applicable for Santa Clara River levee certification purposes. This report was developed through a collaborative effort among hydrologic engineering staff at VCWPD, the Corps of Engineers (Los Angeles District), and the Los Angeles County Department of Public Works. The study results are current in that flow data through water year 2005 were used in the hydrologic analysis, and there have been no flood events in the interim that are large enough to significantly alter the discharge frequency values in the report. Water Resource Council Bulletin #17B—“Guidelines for Determining Flood Flow Frequency (1982)”—procedures were applied as prescribed by FEMA guidelines as the basis for the hydrologic analysis. Section III (Frequency Analysis) in the 2006 VCWPD report presents the details of the discharge frequency analysis for the Santa Clara River. The gage station skew of -0.515 was weighted with a generalized skew of -0.3 to produce the weighted skew of -0.5 for use in the Log Pearson Type III analysis. Flood Frequency Analysis (HEC-FFA) computer runs for the statistical analysis of the Santa Clara River at Monvalvo gage record are presented in Appendix 2 of the VCWPD report.

Adopted discharge frequency values for the Santa Clara River at Montalvo streamgage and for the Santa Clara River (SCR-1) levee certification are shown in table 2 below. The Montalvo streamgage measures discharge from 1594 square miles of the 1600 square mile drainage area upstream of the Santa Clara River Levee hence it is directly applicable for the discharge frequency relationship at the levee. The discharge frequency values were taken directly from Table 3 of the VCWPD report: "Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line." Figure 2 of the VCWPD report presents a graphical representation of the frequency curves at key locations on the Santa Clara River.

Table 2 - Adopted Discharge Frequency Values for Santa Clara River Levee (cfs)

Location	**Return Period (year)**							
	2-yr	**5-yr**	**10-yr**	**20-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
Montalvo	12,800	41,900	72,800	111,000	172,000	226,000	286,000	373,000

Volume-Duration Frequency Analysis

Geotechnical evaluation of levee stability considering seepage requires an estimate of the likely duration of various river stages associated with a baseflood event. Therefore a volume-duration frequency analysis for durations ranging from 1 day to 120 days has been performed using the mean daily flow record at the Santa Clara River at Montalvo streamgage. Daily flow values from the USGS Water Resources website for the period 1927 to 2004 were downloaded into the Hydrologic Engineering Center Statistical Software Package (HEC-SSP), and a graphical analysis of the data was performed to estimate volume frequency relationships. Weibull plotting positions were used in the graphs of annual maximum average flow for each duration (1-day, 2-day, etc). A graph presenting the volume-duration frequency relations is provided in Figure 4. The following table summarizes the results of the analysis.

Table 3 - Baseflood Volume-Duration Analysis Results

Flow Duration (days)	**Average Maximum Discharge (cfs)**
1	94,700
2	59,300
3	46,300
5	32,400
7	26,000
10	19,800
15	13,800
30	8,700
60	7,200
90	5,000
120	3,800

For short duration (less than 3 days) seepage analysis, a baseflood hydrograph was generated using a "balanced hydrograph" approach in which a baseflood hydrograph is constructed to be consistent with respect to volume-duration frequency relationships for the Santa Clara River at

Montalvo streamgage record. A pattern hydrograph based on the Corps' standard project flood hydrograph for Sespe Creek (Figure 5) was used to shape the baseflood hydrograph. Figure 6 presents the baseflood hydrograph recommended for geotechnical evaluations of levee stability considering seepage. The detailed derivation of the volume-duration-frequency relationship and the baseflood hydrograph are provided in Attachments B, C, and D in the form of an HEC-SSP output summary, volume-frequency spreadsheet, and HEC-1 balanced hydrograph output file, respectively.

References

The following reports contain hydrologic information pertaining to the Santa Clara River Levee, or were used to as references for the discharge frequency analyses performed:

Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line, Ventura County Watershed Protection District report, December 2006.

Detailed Project Report for Flood Control and Environmental Assessment, Main Report and Appendixes, Sespe Creek at Fillmore, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, March 1980.

Guidelines for Determining Flood Flow Frequency, Bulletin 17B, Interagency Committee on Water Data, March 1982.

HEC-1 Flood Hydrograph Package Users Manual, U.S. Army Corps of Engineers, Hydrologic Engineering Center, June 1998.

HEC-SSP Statistical Software Package Users Manual, U.S. Army Corps of Engineers, Hydrologic Engineering Center, August 2008.

Design Memorandum No. 1, Hydrology for the Santa Clara River Levee, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, October 1958.

Design Memorandum No. 2, General Design for the Santa Clara River Levee, Ventura County, California, U.S. Army Corps of Engineers, Los Angeles District, November 1958.

Attachments

A. *Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line,* Ventura County Watershed Protection District Report, December 2006.

B. HEC-SSP Volume-Duration Frequency Analysis for Sespe and Santa Clara River Levees Output File.

C. Volume-Duration Frequency Analysis and Base Flood Determination Spreadsheet.

D. HEC-1 Balanced Hydrograph Output File for Santa Clara River Levee.

Figure 1 - Santa Clara River Levee Vicinity Map

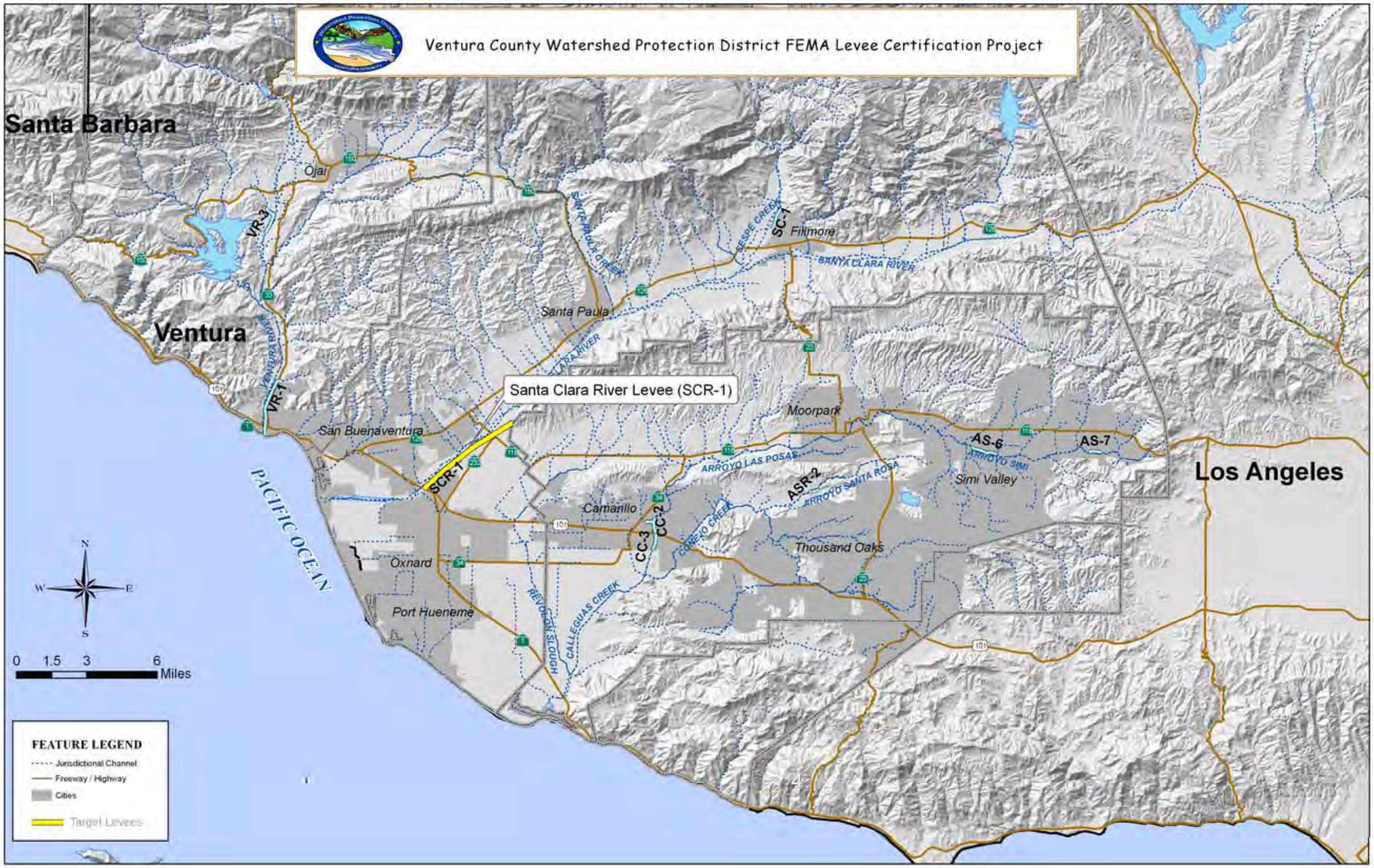


Figure 2 -Aerial Photo of Santa Clara River Levee Area, California

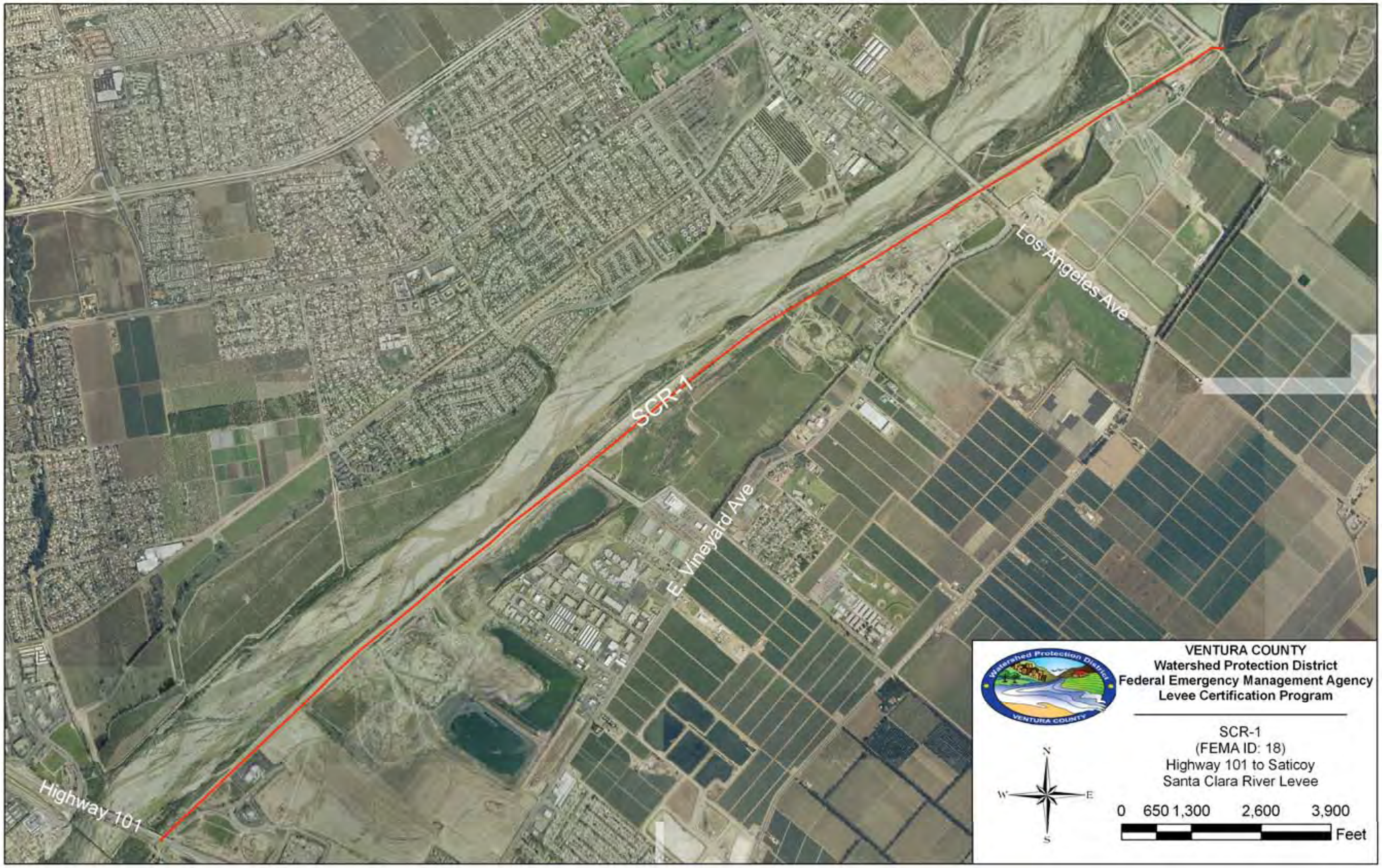


Figure 3 - Santa Clara River Levee Plan View

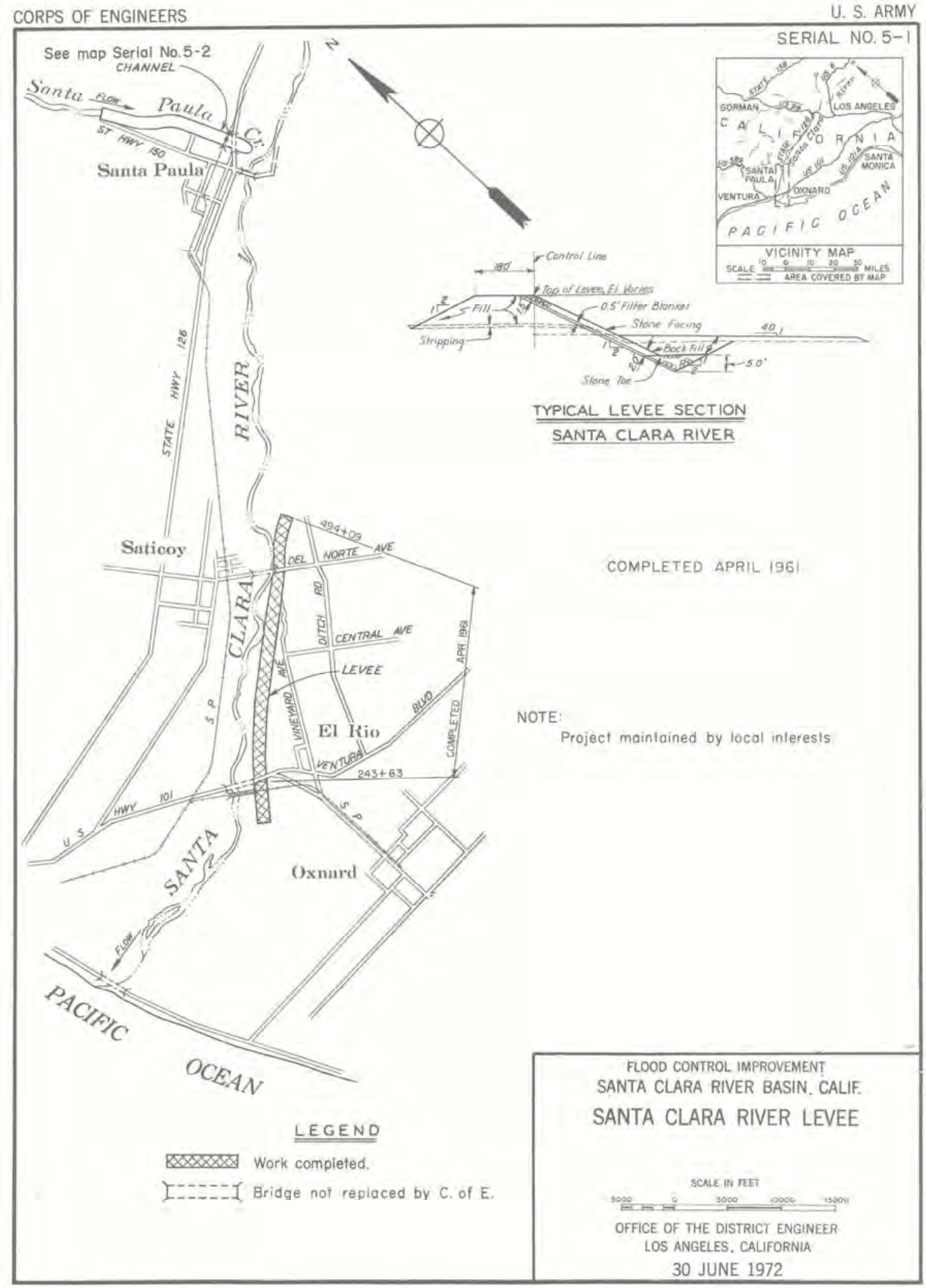


Figure 4 - Volume-Duration-Frequency Curves for Santa Clara River at Montalvo, California Streamgage Record

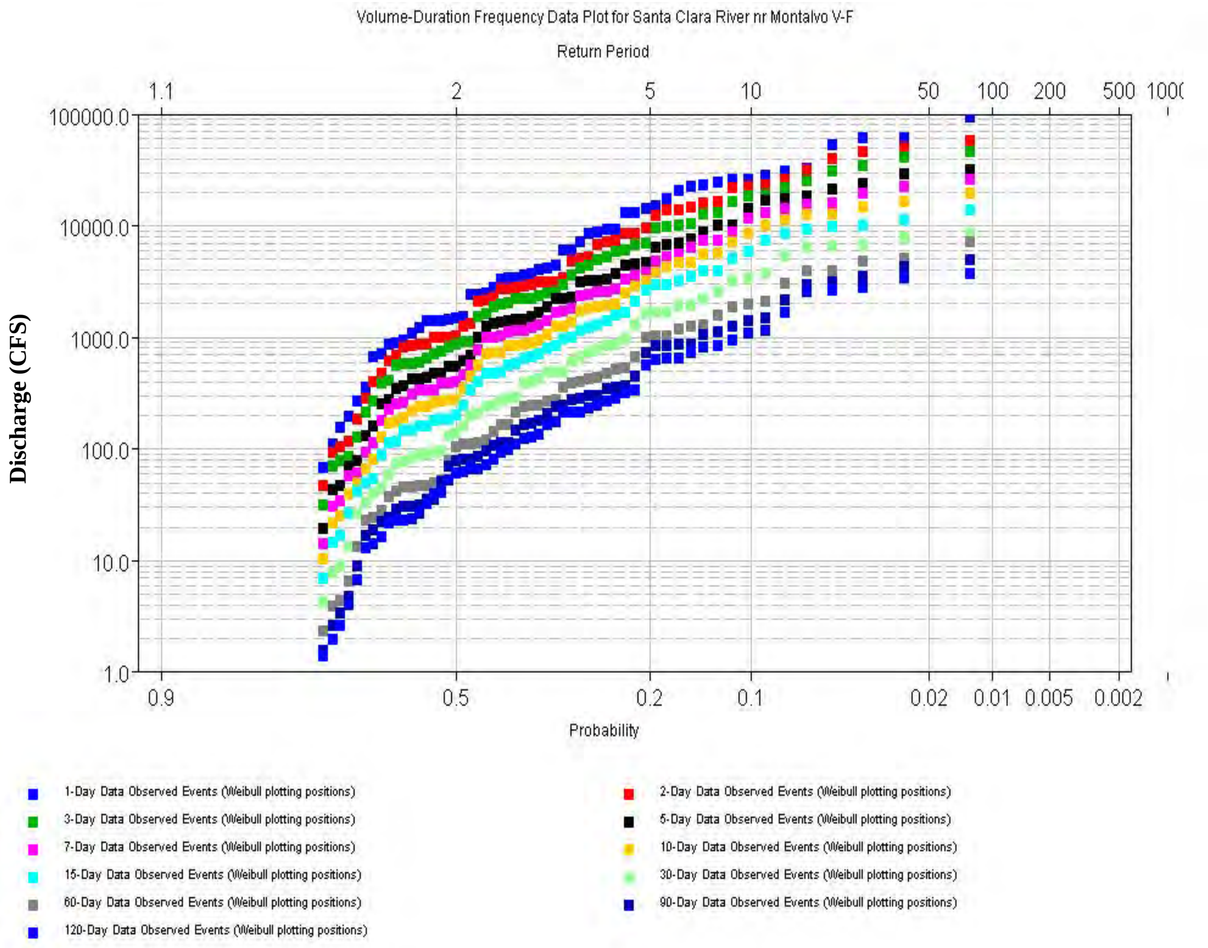


Figure 5 - Sespe Creek Levee Standard Project Flood Hydrograph

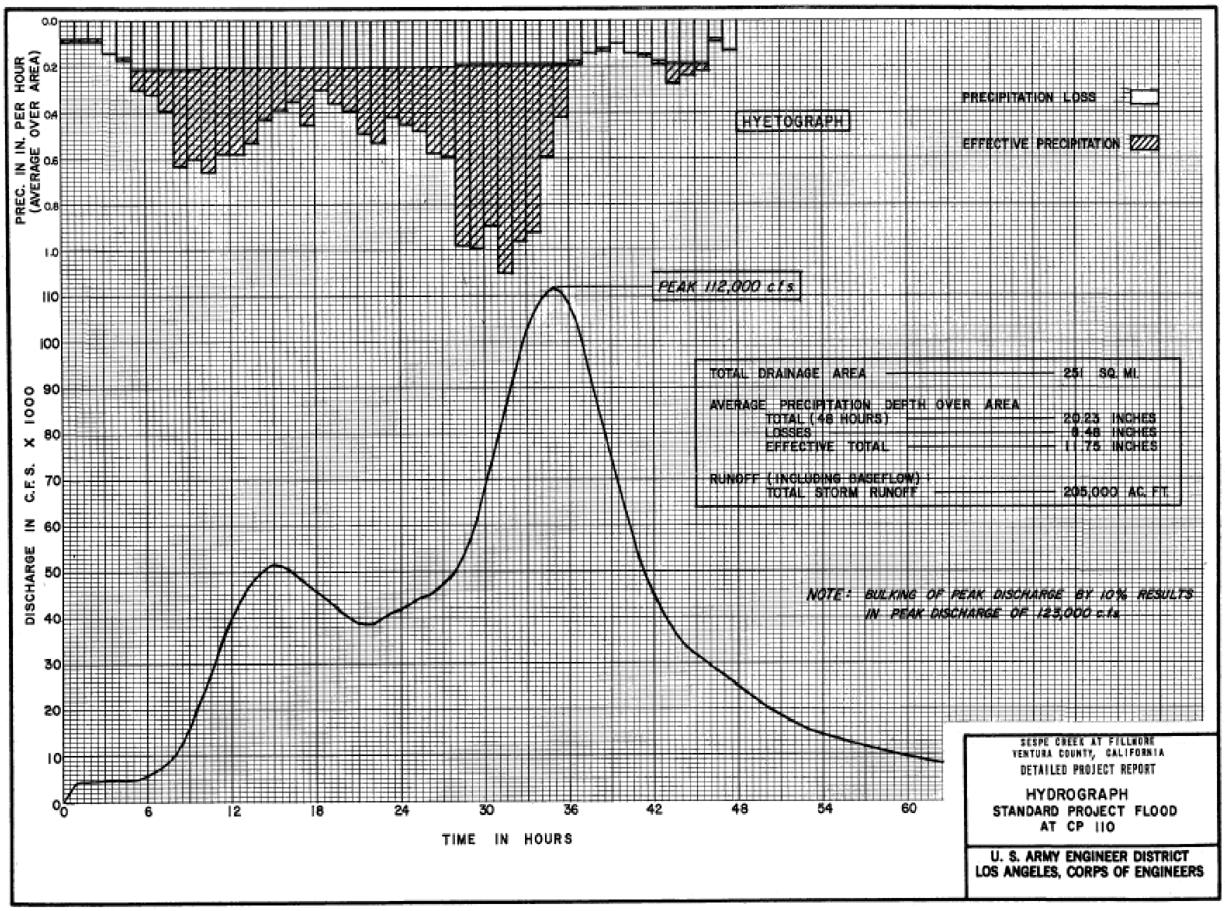
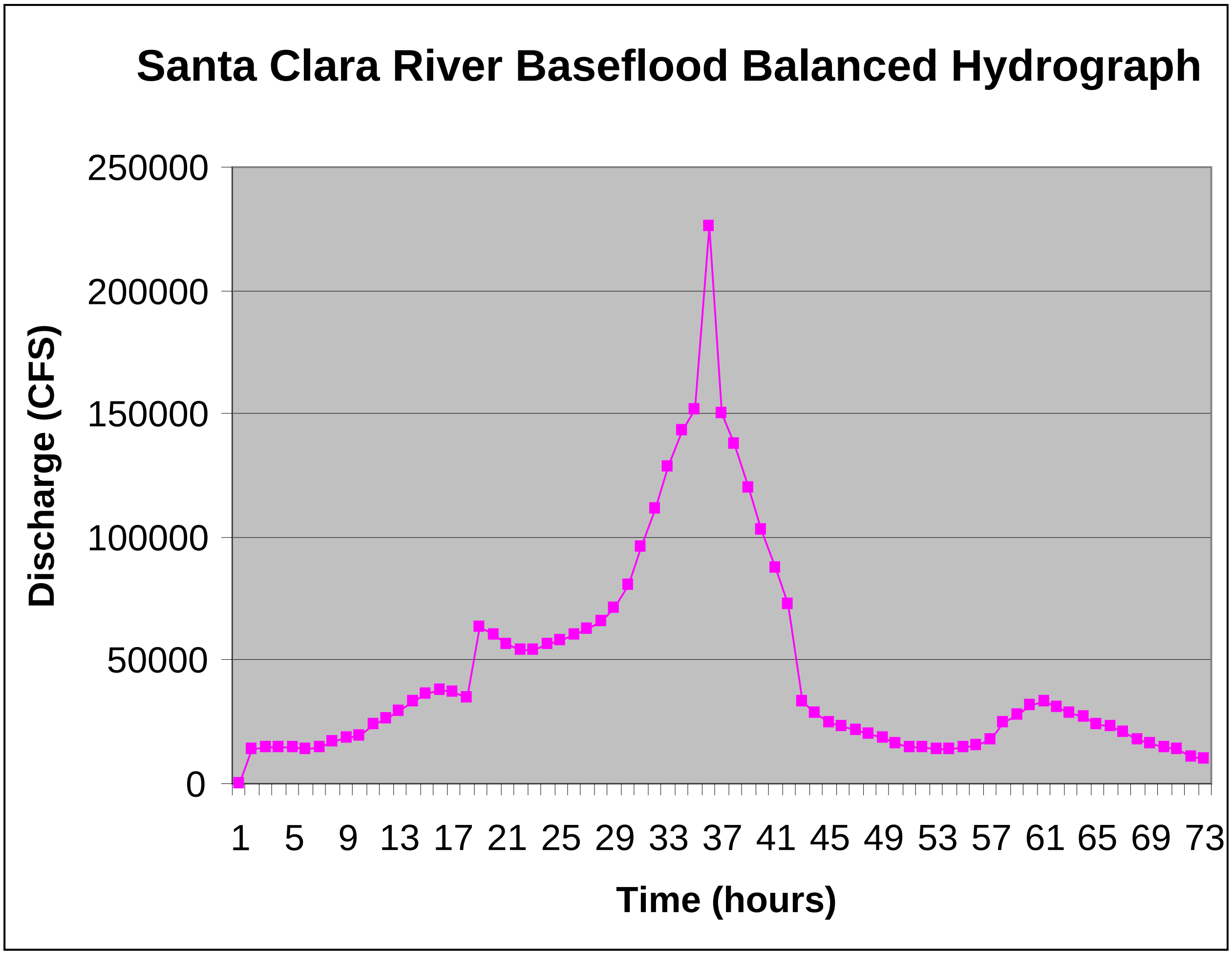


PLATE B-12

Figure 6 - Santa Clara River Baseflood Hydrograph



Attachment A

Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line, **Ventura County Watershed Protection District, December 2006.**

(Included in the Attached CD)

Attachment B

HEC-SSP Volume-Duration Frequency Analysis for Sespe and Santa Clara River Levees Output File

```
--------------------------
Volume-Duration Analysis
19 Mar 2009 11:36 AM
--------------------------
--- Input Data ---
Analysis Name: Santa Clara River nr Montalvo V-F
Description: Santa Clara River near Montalvo, CA USGS gage 11114000 V-F
Data Set Name: Santa Clara Riv nr Montalvo Daily POR
DSS File Name: F:\Tetra_Tech_Inc\Ventura County Levee
Cert\SCR\Santa_Clara_River\Santa_Clara_River.dss
DSS Pathname: /SANTA CLARA RIVER/MONTALVO CA/FLOW//1DAY/USGS/
Project Path: F:\Tetra_Tech_Inc\Ventura County Levee Cert\SCR\Santa_Clara_River
Report File Name: F:\Tetra_Tech_Inc\Ventura County Levee
Cert\SCR\Santa_Clara_River\VolumeFrequencyAnalysisResults\Santa_Clara_River_nr_Montalvo_V-F
\Santa_Clara_River_nr_Montalvo_V-F.rpt
Result File Name: F:\Tetra_Tech_Inc\Ventura County Levee
Cert\SCR\Santa_Clara_River\VolumeFrequencyAnalysisResults\Santa_Clara_River_nr_Montalvo_V-F
\Santa_Clara_River_nr_Montalvo_V-F.xml
Analyze Maximums
Analysis Year: Water Year
Record Start Date: 01 Oct 1927
Record End Date: 30 Sep 2004
User-Specified Durations
Duration: 1 day
Duration: 2 days
Duration: 3 days
Duration: 5 days
Duration: 7 days
Duration: 10 days
Duration: 15 days
Duration: 30 days
Duration: 60 days
Duration: 90 days
Duration: 120 days
Plotting Position Type: Weibull
Probability Distribution Type: None
Use Log Transform
User-Specified Frequencies
Frequency: 0.2
Frequency: 0.5
Frequency: 1.0
Frequency: 2.0
Frequency: 5.0
Frequency: 10.0
Frequency: 20.0
Frequency: 50.0
Frequency: 80.0
Frequency: 90.0
Frequency: 95.0
Frequency: 99.0
Display ordinate values using 0 digits in fraction part of value
--- End of Input Data ---
====================================================================
Statistical Analysis of 1-day Maximum values
====================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (1-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|------------------------------|-------------------------------|
| Mean 3.6068 | Historic Events 0 |
```

```
| Standard Dev 0.7405 | High Outliers 0 |
| Station Skew -0.3362 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|------------------------------|-------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 33.51
Based on statistics after 0 zero events and 21 missing events were
deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 488,036.09
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (1-day Max)
------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|-------------------------|--------------------------------------|
| 04 Feb 1928 1,460 | 1 1969 92,300 1.28 |
| 05 Apr 1929 888 | 2 1978 60,700 2.56 |
| 15 Mar 1930 1,080 | 3 1998 60,000 3.85 |
| 05 Feb 1931 2,490 | 4 1983 52,800 5.13 |
| 09 Feb 1932 20,300 | 5 1962 32,000 6.41 |
| 30 Sep 1933 --- | 6 1993 30,200 7.69 |
| 30 Sep 1934 --- | 7 1992 28,400 8.97 |
| 30 Sep 1935 --- | 8 1980 26,000 10.26 |
| 30 Sep 1936 --- | 9 1973 25,800 11.54 |
| 30 Sep 1937 --- | 10 1958 24,300 12.82 |
| 30 Sep 1938 --- | 11 2001 23,000 14.10 |
| 30 Sep 1939 --- | 12 1966 22,400 15.38 |
| 30 Sep 1940 --- | 13 1932 20,300 16.67 |
| 30 Sep 1941 --- | 14 1986 17,300 17.95 |
| 30 Sep 1942 --- | 15 1952 15,000 19.23 |
| 30 Sep 1943 --- | 16 1971 14,300 20.51 |
| 30 Sep 1944 --- | 17 1991 13,000 21.79 |
| 30 Sep 1945 --- | 18 1967 13,000 23.08 |
| 30 Sep 1946 --- | 19 1996 9,330 24.36 |
| 30 Sep 1947 --- | 20 2004 9,160 25.64 |
| 30 Sep 1948 --- | 21 1974 8,700 26.92 |
| 30 Sep 1949 --- | 22 1979 8,430 28.21 |
| 06 Feb 1950 859 | 23 1975 7,110 29.49 |
| 30 Sep 1951 --- | 24 1997 6,000 30.77 |
| 16 Jan 1952 15,000 | 25 1970 5,930 32.05 |
| 21 Dec 1952 350 | 26 2000 4,340 33.33 |
| 14 Feb 1954 1,200 | 27 1959 4,190 34.62 |
| 01 May 1955 270 | 28 1982 4,060 35.90 |
| 26 Jan 1956 3,390 | 29 1972 3,700 37.18 |
| 13 Jan 1957 1,450 | 30 2003 3,550 38.46 |
| 03 Apr 1958 24,300 | 31 1988 3,400 39.74 |
| 16 Feb 1959 4,190 | 32 1956 3,390 41.03 |
| 02 Feb 1960 67 | 33 1984 3,310 42.31 |
| 07 Nov 1960 154 | 34 1976 2,800 43.59 |
| 10 Feb 1962 32,000 | 35 1931 2,490 44.87 |
| 10 Feb 1963 2,420 | 36 1963 2,420 46.15 |
| 01 Apr 1964 936 | 37 1981 2,380 47.44 |
| 10 Apr 1965 1,390 | 38 1968 1,500 48.72 |
| 29 Dec 1965 22,400 | 39 1928 1,460 50.00 |
| 06 Dec 1966 13,000 | 40 1957 1,450 51.28 |
| 21 Nov 1967 1,500 | 41 1985 1,400 52.56 |
```

```
| 25 Feb 1969 92,300 | 42 1977 1,390 53.85 |
| 01 Mar 1970 5,930 | 43 1965 1,390 55.13 |
| 29 Nov 1970 14,300 | 44 1954 1,200 56.41 |
| 27 Dec 1971 3,700 | 45 1930 1,080 57.69 |
| 11 Feb 1973 25,800 | 46 1964 936 58.97 |
| 07 Jan 1974 8,700 | 47 1929 888 60.26 |
| 08 Mar 1975 7,110 | 48 1950 859 61.54 |
| 09 Feb 1976 2,800 | 49 1990 700 62.82 |
| 03 Jan 1977 1,390 | 50 1999 668 64.10 |
| 04 Mar 1978 60,700 | 51 1953 350 65.38 |
| 27 Mar 1979 8,430 | 52 1955 270 66.67 |
| 16 Feb 1980 26,000 | 53 1987 194 67.95 |
| 01 Mar 1981 2,380 | 54 1961 154 69.23 |
| 01 Apr 1982 4,060 | 55 2002 111 70.51 |
| 01 Mar 1983 52,800 | 56 1960 67 71.79 |
| 25 Dec 1983 3,310 | 57 1995 --- 73.08 |
| 20 Dec 1984 1,400 | 58 1994 --- 74.36 |
| 15 Feb 1986 17,300 | 59 1989 --- 75.64 |
| 06 Mar 1987 194 | 60 1951 --- 76.92 |
| 29 Feb 1988 3,400 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 17 Feb 1990 700 | 63 1947 --- 80.77 |
| 19 Mar 1991 13,000 | 64 1946 --- 82.05 |
| 12 Feb 1992 28,400 | 65 1945 --- 83.33 |
| 19 Feb 1993 30,200 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 20 Feb 1996 9,330 | 69 1941 --- 88.46 |
| 22 Dec 1996 6,000 | 70 1940 --- 89.74 |
| 23 Feb 1998 60,000 | 71 1939 --- 91.03 |
| 12 Apr 1999 668 | 72 1938 --- 92.31 |
| 21 Feb 2000 4,340 | 73 1937 --- 93.59 |
| 05 Mar 2001 23,000 | 74 1936 --- 94.87 |
| 24 Nov 2001 111 | 75 1935 --- 96.15 |
| 12 Feb 2003 3,550 | 76 1934 --- 97.44 |
| 26 Feb 2004 9,160 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.087
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (1-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.6068 | Historic Events 0 |
| Standard Dev 0.7405 | High Outliers 0 |
| Station Skew -0.3362 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
====================================================================
Statistical Analysis of 2-day Maximum values
====================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (2-day Max)
----------------------------------------------------------------
```

```
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.4746 | Historic Events 0 |
| Standard Dev 0.7501 | High Outliers 0 |
| Station Skew -0.3449 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 23.23
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 382,982.17
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (2-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|-------------------------|------------------------------------|
| 05 Feb 1928 1,235 | 1 1969 57,900 1.28 |
| 05 Apr 1929 689 | 2 1983 49,500 2.56 |
| 16 Mar 1930 985 | 3 1978 45,500 3.85 |
| 05 Feb 1931 2,075 | 4 1998 40,000 5.13 |
| 10 Feb 1932 13,570 | 5 1962 31,600 6.41 |
| 30 Sep 1933 --- | 6 1993 25,600 7.69 |
| 30 Sep 1934 --- | 7 1992 22,700 8.97 |
| 30 Sep 1935 --- | 8 2001 22,600 10.26 |
| 30 Sep 1936 --- | 9 1980 21,550 11.54 |
| 30 Sep 1937 --- | 10 1973 16,105 12.82 |
| 30 Sep 1938 --- | 11 1958 15,830 14.10 |
| 30 Sep 1939 --- | 12 1952 14,350 15.38 |
| 30 Sep 1940 --- | 13 1966 13,700 16.67 |
| 30 Sep 1941 --- | 14 1932 13,570 17.95 |
| 30 Sep 1942 --- | 15 1986 12,350 19.23 |
| 30 Sep 1943 --- | 16 1967 9,380 20.51 |
| 30 Sep 1944 --- | 17 1971 8,480 21.79 |
| 30 Sep 1945 --- | 18 1991 8,445 23.08 |
| 30 Sep 1946 --- | 19 1979 7,310 24.36 |
| 30 Sep 1947 --- | 20 1996 7,205 25.64 |
| 30 Sep 1948 --- | 21 1974 6,795 26.92 |
| 30 Sep 1949 --- | 22 1975 5,235 28.21 |
| 07 Feb 1950 840 | 23 2004 5,022 29.49 |
| 30 Sep 1951 --- | 24 1970 4,810 30.77 |
| 16 Jan 1952 14,350 | 25 1997 3,360 32.05 |
| 02 Dec 1952 282 | 26 1959 3,135 33.33 |
| 14 Feb 1954 1,000 | 27 2003 3,125 34.62 |
| 02 May 1955 185 | 28 1988 3,105 35.90 |
| 27 Jan 1956 2,865 | 29 2000 2,960 37.18 |
| 14 Jan 1957 866 | 30 1956 2,865 38.46 |
| 04 Apr 1958 15,830 | 31 1972 2,795 39.74 |
| 17 Feb 1959 3,135 | 32 1982 2,705 41.03 |
| 02 Feb 1960 46 | 33 1976 2,700 42.31 |
| 08 Nov 1960 92 | 34 1984 2,265 43.59 |
| 11 Feb 1962 31,600 | 35 1981 2,150 44.87 |
| 11 Feb 1963 1,334 | 36 1931 2,075 46.15 |
| 02 Apr 1964 616 | 37 1963 1,334 47.44 |
| 10 Apr 1965 1,018 | 38 1928 1,235 48.72 |
```

```
| 30 Dec 1965 13,700 | 39 1965 1,018 50.00 |
| 07 Dec 1966 9,380 | 40 1968 1,000 51.28 |
| 22 Nov 1967 1,000 | 41 1954 1,000 52.56 |
| 25 Feb 1969 57,900 | 42 1930 985 53.85 |
| 02 Mar 1970 4,810 | 43 1957 866 55.13 |
| 30 Nov 1970 8,480 | 44 1985 856 56.41 |
| 27 Dec 1971 2,795 | 45 1950 840 57.69 |
| 11 Feb 1973 16,105 | 46 1977 814 58.97 |
| 08 Jan 1974 6,795 | 47 1929 689 60.26 |
| 08 Mar 1975 5,235 | 48 1964 616 61.54 |
| 10 Feb 1976 2,700 | 49 1999 466 62.82 |
| 03 Jan 1977 814 | 50 1990 400 64.10 |
| 05 Mar 1978 45,500 | 51 1953 282 65.38 |
| 28 Mar 1979 7,310 | 52 1955 185 66.67 |
| 17 Feb 1980 21,550 | 53 1987 116 67.95 |
| 02 Mar 1981 2,150 | 54 2002 104 69.23 |
| 02 Apr 1982 2,705 | 55 1961 92 70.51 |
| 02 Mar 1983 49,500 | 56 1960 46 71.79 |
| 26 Dec 1983 2,265 | 57 1995 --- 73.08 |
| 20 Dec 1984 856 | 58 1994 --- 74.36 |
| 15 Feb 1986 12,350 | 59 1989 --- 75.64 |
| 07 Mar 1987 116 | 60 1951 --- 76.92 |
| 01 Mar 1988 3,105 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 400 | 63 1947 --- 80.77 |
| 20 Mar 1991 8,445 | 64 1946 --- 82.05 |
| 13 Feb 1992 22,700 | 65 1945 --- 83.33 |
| 20 Feb 1993 25,600 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 21 Feb 1996 7,205 | 69 1941 --- 88.46 |
| 26 Jan 1997 3,360 | 70 1940 --- 89.74 |
| 24 Feb 1998 40,000 | 71 1939 --- 91.03 |
| 12 Apr 1999 466 | 72 1938 --- 92.31 |
| 22 Feb 2000 2,960 | 73 1937 --- 93.59 |
| 06 Mar 2001 22,600 | 74 1936 --- 94.87 |
| 25 Nov 2001 104 | 75 1935 --- 96.15 |
| 13 Feb 2003 3,125 | 76 1934 --- 97.44 |
| 26 Feb 2004 5,022 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.088
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (2-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.4746 | Historic Events 0 |
| Standard Dev 0.7501 | High Outliers 0 |
| Station Skew -0.3449 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
====================================================================
Statistical Analysis of 3-day Maximum values
====================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
```

```
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (3-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.3552 | Historic Events 0 |
| Standard Dev 0.7612 | High Outliers 0 |
| Station Skew -0.3525 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
---------------------
<< Low Outlier Test >>
---------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 16.42
Based on statistics after 0 zero events and 21 missing events were deleted.
----------------------
<< High Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 312,591.02
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (3-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 06 Feb 1928 910 | 1 1969 45,233 1.28 |
| 06 Apr 1929 567 | 2 1983 40,700 2.56 |
| 17 Mar 1930 862 | 3 1978 34,333 3.85 |
| 06 Feb 1931 1,524 | 4 1998 30,667 5.13 |
| 10 Feb 1932 10,363 | 5 1962 24,833 6.41 |
| 30 Sep 1933 --- | 6 1993 21,533 7.69 |
| 30 Sep 1934 --- | 7 1992 18,733 8.97 |
| 30 Sep 1935 --- | 8 1980 18,500 10.26 |
| 30 Sep 1936 --- | 9 2001 16,103 11.54 |
| 30 Sep 1937 --- | 10 1958 12,907 12.82 |
| 30 Sep 1938 --- | 11 1973 12,603 14.10 |
| 30 Sep 1939 --- | 12 1932 10,363 15.38 |
| 30 Sep 1940 --- | 13 1952 10,100 16.67 |
| 30 Sep 1941 --- | 14 1986 9,637 17.95 |
| 30 Sep 1942 --- | 15 1966 9,530 19.23 |
| 30 Sep 1943 --- | 16 1967 7,003 20.51 |
| 30 Sep 1944 --- | 17 1991 6,717 21.79 |
| 30 Sep 1945 --- | 18 1979 5,967 23.08 |
| 30 Sep 1946 --- | 19 1971 5,842 24.36 |
| 30 Sep 1947 --- | 20 1996 5,125 25.64 |
| 30 Sep 1948 --- | 21 1974 4,930 26.92 |
| 30 Sep 1949 --- | 22 1975 4,360 28.21 |
| 08 Feb 1950 648 | 23 1970 4,117 29.49 |
| 30 Sep 1951 --- | 24 2004 3,594 30.77 |
| 17 Jan 1952 10,100 | 25 2000 2,977 32.05 |
| 03 Dec 1952 213 | 26 1997 2,526 33.33 |
| 15 Feb 1954 743 | 27 1972 2,487 34.62 |
| 02 May 1955 128 | 28 1988 2,366 35.90 |
| 28 Jan 1956 2,175 | 29 2003 2,224 37.18 |
| 15 Jan 1957 578 | 30 1959 2,206 38.46 |
| 03 Apr 1958 12,907 | 31 1956 2,175 39.74 |
| 18 Feb 1959 2,206 | 32 1982 2,037 41.03 |
| 03 Feb 1960 32 | 33 1976 1,968 42.31 |
| 08 Nov 1960 70 | 34 1984 1,877 43.59 |
| 12 Feb 1962 24,833 | 35 1981 1,620 44.87 |
```

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| 11 Feb 1963 906 | 36 1931 1,524 46.15 |
| 02 Apr 1964 413 | 37 1928 910 47.44 |
| 10 Apr 1965 699 | 38 1963 906 48.72 |
| 24 Nov 1965 9,530 | 39 1930 862 50.00 |
| 07 Dec 1966 7,003 | 40 1968 800 51.28 |
| 22 Nov 1967 800 | 41 1954 743 52.56 |
| 26 Feb 1969 45,233 | 42 1965 699 53.85 |
| 02 Mar 1970 4,117 | 43 1950 648 55.13 |
| 01 Dec 1970 5,842 | 44 1985 601 56.41 |
| 27 Dec 1971 2,487 | 45 1957 578 57.69 |
| 12 Feb 1973 12,603 | 46 1977 575 58.97 |
| 09 Jan 1974 4,930 | 47 1929 567 60.26 |
| 08 Mar 1975 4,360 | 48 1964 413 61.54 |
| 11 Feb 1976 1,968 | 49 1999 390 62.82 |
| 04 Jan 1977 575 | 50 1990 267 64.10 |
| 06 Mar 1978 34,333 | 51 1953 213 65.38 |
| 29 Mar 1979 5,967 | 52 1955 128 66.67 |
| 18 Feb 1980 18,500 | 53 2002 85 67.95 |
| 03 Mar 1981 1,620 | 54 1987 77 69.23 |
| 03 Apr 1982 2,037 | 55 1961 70 70.51 |
| 03 Mar 1983 40,700 | 56 1960 32 71.79 |
| 27 Dec 1983 1,877 | 57 1995 --- 73.08 |
| 21 Dec 1984 601 | 58 1994 --- 74.36 |
| 16 Feb 1986 9,637 | 59 1989 --- 75.64 |
| 07 Mar 1987 77 | 60 1951 --- 76.92 |
| 02 Mar 1988 2,366 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 267 | 63 1947 --- 80.77 |
| 20 Mar 1991 6,717 | 64 1946 --- 82.05 |
| 13 Feb 1992 18,733 | 65 1945 --- 83.33 |
| 21 Feb 1993 21,533 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 22 Feb 1996 5,125 | 69 1941 --- 88.46 |
| 27 Jan 1997 2,526 | 70 1940 --- 89.74 |
| 24 Feb 1998 30,667 | 71 1939 --- 91.03 |
| 13 Apr 1999 390 | 72 1938 --- 92.31 |
| 23 Feb 2000 2,977 | 73 1937 --- 93.59 |
| 07 Mar 2001 16,103 | 74 1936 --- 94.87 |
| 26 Nov 2001 85 | 75 1935 --- 96.15 |
| 14 Feb 2003 2,224 | 76 1934 --- 97.44 |
| 27 Feb 2004 3,594 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.088
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (3-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.3552 | Historic Events 0 |
| Standard Dev 0.7612 | High Outliers 0 |
| Station Skew -0.3525 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
==================================================================
Statistical Analysis of 5-day Maximum values
==================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
```

```
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (5-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.1928 | Historic Events 0 |
| Standard Dev 0.7785 | High Outliers 0 |
| Station Skew -0.3620 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
---------------------
<< Low Outlier Test >>
---------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 10.1
Based on statistics after 0 zero events and 21 missing events were deleted.
----------------------
<< High Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 240,555.29
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (5-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 08 Feb 1928 603 | 1 1969 31,640 1.28 |
| 08 Apr 1929 415 | 2 1983 28,520 2.56 |
| 19 Mar 1930 679 | 3 1978 23,946 3.85 |
| 08 Feb 1931 1,005 | 4 1998 21,200 5.13 |
| 12 Feb 1932 6,892 | 5 1993 18,380 6.41 |
| 30 Sep 1933 --- | 6 1962 17,052 7.69 |
| 30 Sep 1934 --- | 7 1980 16,820 8.97 |
| 30 Sep 1935 --- | 8 1992 13,980 10.26 |
| 30 Sep 1936 --- | 9 2001 9,961 11.54 |
| 30 Sep 1937 --- | 10 1958 9,928 12.82 |
| 30 Sep 1938 --- | 11 1973 8,722 14.10 |
| 30 Sep 1939 --- | 12 1952 7,614 15.38 |
| 30 Sep 1940 --- | 13 1932 6,892 16.67 |
| 30 Sep 1941 --- | 14 1986 6,690 17.95 |
| 30 Sep 1942 --- | 15 1966 6,438 19.23 |
| 30 Sep 1943 --- | 16 1967 4,686 20.51 |
| 30 Sep 1944 --- | 17 1979 4,540 21.79 |
| 30 Sep 1945 --- | 18 1991 4,416 23.08 |
| 30 Sep 1946 --- | 19 1971 3,686 24.36 |
| 30 Sep 1947 --- | 20 1975 3,296 25.64 |
| 30 Sep 1948 --- | 21 1996 3,235 26.92 |
| 30 Sep 1949 --- | 22 1974 3,168 28.21 |
| 10 Feb 1950 438 | 23 1970 3,068 29.49 |
| 30 Sep 1951 --- | 24 1972 2,280 30.77 |
| 19 Jan 1952 7,614 | 25 2004 2,233 32.05 |
| 05 Dec 1952 130 | 26 2000 2,214 33.33 |
| 16 Feb 1954 469 | 27 1997 1,848 34.62 |
| 03 May 1955 79 | 28 1988 1,663 35.90 |
| 29 Jan 1956 1,427 | 29 1981 1,518 37.18 |
| 17 Jan 1957 348 | 30 1982 1,433 38.46 |
| 05 Apr 1958 9,928 | 31 1956 1,427 39.74 |
| 20 Feb 1959 1,327 | 32 1984 1,382 41.03 |
```

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| 05 Feb 1960 19 | 33 2003 1,374 42.31 |
| 09 Nov 1960 43 | 34 1959 1,327 43.59 |
| 13 Feb 1962 17,052 | 35 1976 1,243 44.87 |
| 13 Feb 1963 547 | 36 1931 1,005 46.15 |
| 04 Apr 1964 249 | 37 1930 679 47.44 |
| 12 Apr 1965 427 | 38 1928 603 48.72 |
| 26 Nov 1965 6,438 | 39 1968 550 50.00 |
| 07 Dec 1966 4,686 | 40 1963 547 51.28 |
| 23 Nov 1967 550 | 41 1954 469 52.56 |
| 28 Feb 1969 31,640 | 42 1977 468 53.85 |
| 04 Mar 1970 3,068 | 43 1950 438 55.13 |
| 03 Dec 1970 3,686 | 44 1965 427 56.41 |
| 28 Dec 1971 2,280 | 45 1929 415 57.69 |
| 14 Feb 1973 8,722 | 46 1985 363 58.97 |
| 11 Jan 1974 3,168 | 47 1957 348 60.26 |
| 10 Mar 1975 3,296 | 48 1999 276 61.54 |
| 12 Feb 1976 1,243 | 49 1964 249 62.82 |
| 07 Jan 1977 468 | 50 1990 160 64.10 |
| 05 Mar 1978 23,946 | 51 1953 130 65.38 |
| 31 Mar 1979 4,540 | 52 1955 79 66.67 |
| 20 Feb 1980 16,820 | 53 2002 69 67.95 |
| 05 Mar 1981 1,518 | 54 1987 46 69.23 |
| 05 Apr 1982 1,433 | 55 1961 43 70.51 |
| 05 Mar 1983 28,520 | 56 1960 19 71.79 |
| 29 Dec 1983 1,382 | 57 1995 --- 73.08 |
| 23 Dec 1984 363 | 58 1994 --- 74.36 |
| 17 Feb 1986 6,690 | 59 1989 --- 75.64 |
| 07 Mar 1987 46 | 60 1951 --- 76.92 |
| 03 Mar 1988 1,663 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 160 | 63 1947 --- 80.77 |
| 22 Mar 1991 4,416 | 64 1946 --- 82.05 |
| 15 Feb 1992 13,980 | 65 1945 --- 83.33 |
| 23 Feb 1993 18,380 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 23 Feb 1996 3,235 | 69 1941 --- 88.46 |
| 27 Jan 1997 1,848 | 70 1940 --- 89.74 |
| 26 Feb 1998 21,200 | 71 1939 --- 91.03 |
| 15 Apr 1999 276 | 72 1938 --- 92.31 |
| 25 Feb 2000 2,214 | 73 1937 --- 93.59 |
| 08 Mar 2001 9,961 | 74 1936 --- 94.87 |
| 28 Nov 2001 69 | 75 1935 --- 96.15 |
| 16 Feb 2003 1,374 | 76 1934 --- 97.44 |
| 27 Feb 2004 2,233 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.089
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (5-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.1928 | Historic Events 0 |
| Standard Dev 0.7785 | High Outliers 0 |
| Station Skew -0.3620 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
====================================================================
Statistical Analysis of 7-day Maximum values
====================================================================
```

```
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (7-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.0795 | Historic Events 0 |
| Standard Dev 0.7898 | High Outliers 0 |
| Station Skew -0.3574 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 7.23
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 199,369.88
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (7-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 10 Feb 1928 462 | 1 1969 25,383 1.28 |
| 10 Apr 1929 333 | 2 1983 22,037 2.56 |
| 21 Mar 1930 556 | 3 1978 19,427 3.85 |
| 10 Feb 1931 758 | 4 1998 15,871 5.13 |
| 14 Feb 1932 5,150 | 5 1993 15,363 6.41 |
| 30 Sep 1933 --- | 6 1980 14,234 7.69 |
| 30 Sep 1934 --- | 7 1962 13,020 8.97 |
| 30 Sep 1935 --- | 8 1992 11,576 10.26 |
| 30 Sep 1936 --- | 9 1958 8,777 11.54 |
| 30 Sep 1937 --- | 10 2001 7,253 12.82 |
| 30 Sep 1938 --- | 11 1973 7,229 14.10 |
| 30 Sep 1939 --- | 12 1952 6,347 15.38 |
| 30 Sep 1940 --- | 13 1986 5,489 16.67 |
| 30 Sep 1941 --- | 14 1932 5,150 17.95 |
| 30 Sep 1942 --- | 15 1966 4,764 19.23 |
| 30 Sep 1943 --- | 16 1979 3,821 20.51 |
| 30 Sep 1944 --- | 17 1967 3,560 21.79 |
| 30 Sep 1945 --- | 18 1991 3,321 23.08 |
| 30 Sep 1946 --- | 19 1971 2,704 24.36 |
| 30 Sep 1947 --- | 20 1970 2,565 25.64 |
| 30 Sep 1948 --- | 21 1975 2,535 26.92 |
| 30 Sep 1949 --- | 22 1974 2,413 28.21 |
| 12 Feb 1950 337 | 23 1996 2,366 29.49 |
| 30 Sep 1951 --- | 24 1972 1,790 30.77 |
| 19 Jan 1952 6,347 | 25 2004 1,727 32.05 |
| 07 Dec 1952 94 | 26 2000 1,657 33.33 |
| 18 Feb 1954 337 | 27 1997 1,378 34.62 |
| 03 May 1955 56 | 28 1981 1,264 35.90 |
| 30 Jan 1956 1,022 | 29 1988 1,198 37.18 |
```

```
| 19 Jan 1957 249 | 30 1959 1,143 38.46 |
| 07 Apr 1958 8,777 | 31 1982 1,132 39.74 |
| 17 Feb 1959 1,143 | 32 1984 1,124 41.03 |
| 07 Feb 1960 14 | 33 1956 1,022 42.31 |
| 11 Nov 1960 30 | 34 1976 993 43.59 |
| 15 Feb 1962 13,020 | 35 2003 986 44.87 |
| 15 Feb 1963 392 | 36 1931 758 46.15 |
| 03 Apr 1964 178 | 37 1930 556 47.44 |
| 12 Apr 1965 305 | 38 1928 462 48.72 |
| 28 Nov 1965 4,764 | 39 1968 395 50.00 |
| 09 Dec 1966 3,560 | 40 1963 392 51.28 |
| 25 Nov 1967 395 | 41 1977 383 52.56 |
| 01 Mar 1969 25,383 | 42 1950 337 53.85 |
| 06 Mar 1970 2,565 | 43 1954 337 55.13 |
| 05 Dec 1970 2,704 | 44 1929 333 56.41 |
| 30 Dec 1971 1,790 | 45 1965 305 57.69 |
| 13 Feb 1973 7,229 | 46 1985 260 58.97 |
| 13 Jan 1974 2,413 | 47 1957 249 60.26 |
| 12 Mar 1975 2,535 | 48 1999 223 61.54 |
| 15 Feb 1976 993 | 49 1964 178 62.82 |
| 08 Jan 1977 383 | 50 1990 114 64.10 |
| 07 Mar 1978 19,427 | 51 1953 94 65.38 |
| 02 Apr 1979 3,821 | 52 2002 61 66.67 |
| 22 Feb 1980 14,234 | 53 1955 56 67.95 |
| 07 Mar 1981 1,264 | 54 1987 34 69.23 |
| 07 Apr 1982 1,132 | 55 1961 30 70.51 |
| 05 Mar 1983 22,037 | 56 1960 14 71.79 |
| 31 Dec 1983 1,124 | 57 1995 --- 73.08 |
| 25 Dec 1984 260 | 58 1994 --- 74.36 |
| 19 Feb 1986 5,489 | 59 1989 --- 75.64 |
| 12 Mar 1987 34 | 60 1951 --- 76.92 |
| 05 Mar 1988 1,198 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 114 | 63 1947 --- 80.77 |
| 24 Mar 1991 3,321 | 64 1946 --- 82.05 |
| 16 Feb 1992 11,576 | 65 1945 --- 83.33 |
| 24 Feb 1993 15,363 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 25 Feb 1996 2,366 | 69 1941 --- 88.46 |
| 28 Jan 1997 1,378 | 70 1940 --- 89.74 |
| 28 Feb 1998 15,871 | 71 1939 --- 91.03 |
| 14 Apr 1999 223 | 72 1938 --- 92.31 |
| 27 Feb 2000 1,657 | 73 1937 --- 93.59 |
| 10 Mar 2001 7,253 | 74 1936 --- 94.87 |
| 30 Nov 2001 61 | 75 1935 --- 96.15 |
| 18 Feb 2003 986 | 76 1934 --- 97.44 |
| 28 Feb 2004 1,727 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.089
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (7-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 3.0795 | Historic Events 0 |
| Standard Dev 0.7898 | High Outliers 0 |
| Station Skew -0.3574 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
```

```
====================================================================
Statistical Analysis of 10-day Maximum values
====================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (10-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.9529 | Historic Events 0 |
| Standard Dev 0.8012 | High Outliers 0 |
| Station Skew -0.3441 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 5.02
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 160,324.96
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (10-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 13 Feb 1928 344 | 1 1969 19,298 1.28 |
| 13 Apr 1929 262 | 2 1983 16,096 2.56 |
| 24 Mar 1930 445 | 3 1978 14,412 3.85 |
| 13 Feb 1931 556 | 4 1993 12,629 5.13 |
| 10 Feb 1932 3,847 | 5 1998 12,560 6.41 |
| 30 Sep 1933 --- | 6 1980 11,386 7.69 |
| 30 Sep 1934 --- | 7 1962 9,888 8.97 |
| 30 Sep 1935 --- | 8 1992 8,427 10.26 |
| 30 Sep 1936 --- | 9 1958 7,084 11.54 |
| 30 Sep 1937 --- | 10 1973 5,693 12.82 |
| 30 Sep 1938 --- | 11 2001 5,489 14.10 |
| 30 Sep 1939 --- | 12 1952 4,697 15.38 |
| 30 Sep 1940 --- | 13 1966 4,615 16.67 |
| 30 Sep 1941 --- | 14 1986 4,270 17.95 |
| 30 Sep 1942 --- | 15 1932 3,847 19.23 |
| 30 Sep 1943 --- | 16 1979 3,206 20.51 |
| 30 Sep 1944 --- | 17 1991 2,887 21.79 |
| 30 Sep 1945 --- | 18 1967 2,506 23.08 |
| 30 Sep 1946 --- | 19 1970 1,990 24.36 |
| 30 Sep 1947 --- | 20 1971 1,916 25.64 |
| 30 Sep 1948 --- | 21 1974 1,844 26.92 |
| 30 Sep 1949 --- | 22 1975 1,792 28.21 |
| 15 Feb 1950 237 | 23 1996 1,682 29.49 |
| 30 Sep 1951 --- | 24 1972 1,342 30.77 |
| 21 Jan 1952 4,697 | 25 2000 1,258 32.05 |
| 10 Dec 1952 66 | 26 2004 1,232 33.33 |
```

```
| 19 Feb 1954 236 | 27 1997 1,042 34.62 |
| 03 May 1955 40 | 28 1981 947 35.90 |
| 30 Jan 1956 715 | 29 1984 896 37.18 |
| 20 Jan 1957 174 | 30 1982 859 38.46 |
| 10 Apr 1958 7,084 | 31 1988 839 39.74 |
| 20 Feb 1959 837 | 32 1959 837 41.03 |
| 10 Feb 1960 10 | 33 1976 725 42.31 |
| 13 Nov 1960 21 | 34 1956 715 43.59 |
| 17 Feb 1962 9,888 | 35 2003 702 44.87 |
| 18 Feb 1963 274 | 36 1931 556 46.15 |
| 03 Apr 1964 125 | 37 1930 445 47.44 |
| 11 Apr 1965 218 | 38 1928 344 48.72 |
| 26 Nov 1965 4,615 | 39 1968 278 50.00 |
| 12 Dec 1966 2,506 | 40 1963 274 51.28 |
| 28 Nov 1967 278 | 41 1977 268 52.56 |
| 04 Mar 1969 19,298 | 42 1929 262 53.85 |
| 09 Mar 1970 1,990 | 43 1950 237 55.13 |
| 07 Dec 1970 1,916 | 44 1954 236 56.41 |
| 01 Jan 1972 1,342 | 45 1965 218 57.69 |
| 15 Feb 1973 5,693 | 46 1985 190 58.97 |
| 16 Jan 1974 1,844 | 47 1957 174 60.26 |
| 15 Mar 1975 1,792 | 48 1999 170 61.54 |
| 16 Feb 1976 725 | 49 1964 125 62.82 |
| 11 Jan 1977 268 | 50 1990 80 64.10 |
| 10 Mar 1978 14,412 | 51 1953 66 65.38 |
| 05 Apr 1979 3,206 | 52 2002 49 66.67 |
| 25 Feb 1980 11,386 | 53 1955 40 67.95 |
| 09 Mar 1981 947 | 54 1987 25 69.23 |
| 08 Apr 1982 859 | 55 1961 21 70.51 |
| 08 Mar 1983 16,096 | 56 1960 10 71.79 |
| 03 Jan 1984 896 | 57 1995 --- 73.08 |
| 20 Dec 1984 190 | 58 1994 --- 74.36 |
| 22 Feb 1986 4,270 | 59 1989 --- 75.64 |
| 14 Mar 1987 25 | 60 1951 --- 76.92 |
| 06 Mar 1988 839 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 80 | 63 1947 --- 80.77 |
| 27 Mar 1991 2,887 | 64 1946 --- 82.05 |
| 19 Feb 1992 8,427 | 65 1945 --- 83.33 |
| 27 Feb 1993 12,629 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 28 Feb 1996 1,682 | 69 1941 --- 88.46 |
| 01 Feb 1997 1,042 | 70 1940 --- 89.74 |
| 26 Feb 1998 12,560 | 71 1939 --- 91.03 |
| 16 Apr 1999 170 | 72 1938 --- 92.31 |
| 29 Feb 2000 1,258 | 73 1937 --- 93.59 |
| 07 Mar 2001 5,489 | 74 1936 --- 94.87 |
| 30 Nov 2001 49 | 75 1935 --- 96.15 |
| 24 Mar 2003 702 | 76 1934 --- 97.44 |
| 02 Mar 2004 1,232 | 77 1933 --- 98.72 |
|---------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.088
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (10-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.9529 | Historic Events 0 |
| Standard Dev 0.8012 | High Outliers 0 |
| Station Skew -0.3441 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
```

```
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
====================================================================
Statistical Analysis of 15-day Maximum values
====================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (15-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.8034 | Historic Events 0 |
| Standard Dev 0.8075 | High Outliers 0 |
| Station Skew -0.3465 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 3.42
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 118,371.42
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (15-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 18 Feb 1928 242 | 1 1969 13,701 1.28 |
| 18 Apr 1929 198 | 2 1983 11,187 2.56 |
| 28 Mar 1930 339 | 3 1978 10,062 3.85 |
| 18 Feb 1931 399 | 4 1993 9,683 5.13 |
| 15 Feb 1932 2,935 | 5 1998 9,180 6.41 |
| 30 Sep 1933 --- | 6 1980 8,339 7.69 |
| 30 Sep 1934 --- | 7 1962 7,327 8.97 |
| 30 Sep 1935 --- | 8 1992 5,770 10.26 |
| 30 Sep 1936 --- | 9 1958 5,083 11.54 |
| 30 Sep 1937 --- | 10 1973 3,957 12.82 |
| 30 Sep 1938 --- | 11 2001 3,873 14.10 |
| 30 Sep 1939 --- | 12 1952 3,469 15.38 |
| 30 Sep 1940 --- | 13 1966 3,206 16.67 |
| 30 Sep 1941 --- | 14 1986 2,965 17.95 |
| 30 Sep 1942 --- | 15 1932 2,935 19.23 |
| 30 Sep 1943 --- | 16 1979 2,640 20.51 |
| 30 Sep 1944 --- | 17 1991 2,080 21.79 |
| 30 Sep 1945 --- | 18 1967 1,671 23.08 |
| 30 Sep 1946 --- | 19 1974 1,579 24.36 |
| 30 Sep 1947 --- | 20 1970 1,398 25.64 |
| 30 Sep 1948 --- | 21 1971 1,278 26.92 |
| 30 Sep 1949 --- | 22 1975 1,195 28.21 |
| 15 Feb 1950 158 | 23 1996 1,149 29.49 |
```

```
| 30 Sep 1951 --- | 24 2000 987 30.77 |
| 27 Jan 1952 3,469 | 25 1972 958 32.05 |
| 04 Jan 1953 49 | 26 2004 824 33.33 |
| 20 Feb 1954 158 | 27 1997 781 34.62 |
| 03 May 1955 26 | 28 1982 708 35.90 |
| 30 Jan 1956 477 | 29 1984 660 37.18 |
| 20 Jan 1957 116 | 30 1981 647 38.46 |
| 15 Apr 1958 5,083 | 31 1959 578 39.74 |
| 25 Feb 1959 578 | 32 1988 559 41.03 |
| 12 Feb 1960 7 | 33 1976 483 42.31 |
| 13 Nov 1960 14 | 34 1956 477 43.59 |
| 22 Feb 1962 7,327 | 35 2003 477 44.87 |
| 23 Feb 1963 183 | 36 1931 399 46.15 |
| 03 Apr 1964 87 | 37 1930 339 47.44 |
| 13 Apr 1965 147 | 38 1928 242 48.72 |
| 30 Nov 1965 3,206 | 39 1929 198 50.00 |
| 12 Dec 1966 1,671 | 40 1968 186 51.28 |
| 03 Dec 1967 186 | 41 1963 183 52.56 |
| 09 Mar 1969 13,701 | 42 1977 179 53.85 |
| 14 Mar 1970 1,398 | 43 1954 158 55.13 |
| 12 Dec 1970 1,278 | 44 1950 158 56.41 |
| 06 Jan 1972 958 | 45 1985 148 57.69 |
| 20 Feb 1973 3,957 | 46 1965 147 58.97 |
| 21 Jan 1974 1,579 | 47 1957 116 60.26 |
| 20 Mar 1975 1,195 | 48 1999 114 61.54 |
| 21 Feb 1976 483 | 49 1964 87 62.82 |
| 16 Jan 1977 179 | 50 1990 53 64.10 |
| 14 Mar 1978 10,062 | 51 1953 49 65.38 |
| 10 Apr 1979 2,640 | 52 2002 42 66.67 |
| 28 Feb 1980 8,339 | 53 1955 26 67.95 |
| 14 Mar 1981 647 | 54 1987 17 69.23 |
| 13 Apr 1982 708 | 55 1961 14 70.51 |
| 13 Mar 1983 11,187 | 56 1960 7 71.79 |
| 07 Jan 1984 660 | 57 1995 --- 73.08 |
| 21 Dec 1984 148 | 58 1994 --- 74.36 |
| 27 Feb 1986 2,965 | 59 1989 --- 75.64 |
| 14 Mar 1987 17 | 60 1951 --- 76.92 |
| 06 Mar 1988 559 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 53 | 63 1947 --- 80.77 |
| 01 Apr 1991 2,080 | 64 1946 --- 82.05 |
| 21 Feb 1992 5,770 | 65 1945 --- 83.33 |
| 04 Mar 1993 9,683 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 04 Mar 1996 1,149 | 69 1941 --- 88.46 |
| 06 Feb 1997 781 | 70 1940 --- 89.74 |
| 28 Feb 1998 9,180 | 71 1939 --- 91.03 |
| 16 Apr 1999 114 | 72 1938 --- 92.31 |
| 06 Mar 2000 987 | 73 1937 --- 93.59 |
| 11 Mar 2001 3,873 | 74 1936 --- 94.87 |
| 30 Nov 2001 42 | 75 1935 --- 96.15 |
| 28 Mar 2003 477 | 76 1934 --- 97.44 |
| 05 Mar 2004 824 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.088
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (15-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|-------------------------------|
| Mean 2.8034 | Historic Events 0 |
| Standard Dev 0.8075 | High Outliers 0 |
```

```
| Station Skew -0.3465 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|-------------------------------|
Warning: No ordinates specified for graphical frequency curve
==================================================================
Statistical Analysis of 30-day Maximum values
==================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (30-day Max)
--------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|-------------------------------|
| Mean 2.5702 | Historic Events 0 |
| Standard Dev 0.8192 | High Outliers 0 |
| Station Skew -0.2947 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|-------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 1.85
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 74,625.23
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (30-day Max)
------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 04 Mar 1928 139 | 1 1978 8,516 1.28 |
| 08 Apr 1929 159 | 2 1969 7,800 2.56 |
| 03 Apr 1930 203 | 3 1998 6,779 3.85 |
| 25 Feb 1931 201 | 4 1983 6,447 5.13 |
| 29 Feb 1932 1,646 | 5 1993 6,421 6.41 |
| 30 Sep 1933 --- | 6 1980 5,391 7.69 |
| 30 Sep 1934 --- | 7 1962 3,740 8.97 |
| 30 Sep 1935 --- | 8 1958 3,424 10.26 |
| 30 Sep 1936 --- | 9 1992 3,165 11.54 |
| 30 Sep 1937 --- | 10 1973 2,558 12.82 |
| 30 Sep 1938 --- | 11 2001 2,223 14.10 |
| 30 Sep 1939 --- | 12 1952 1,911 15.38 |
| 30 Sep 1940 --- | 13 1986 1,901 16.67 |
| 30 Sep 1941 --- | 14 1979 1,659 17.95 |
| 30 Sep 1942 --- | 15 1932 1,646 19.23 |
| 30 Sep 1943 --- | 16 1966 1,604 20.51 |
| 30 Sep 1944 --- | 17 1991 1,274 21.79 |
| 30 Sep 1945 --- | 18 1971 972 23.08 |
| 30 Sep 1946 --- | 19 1974 864 24.36 |
| 30 Sep 1947 --- | 20 1967 835 25.64 |
```

```
| 30 Sep 1948 --- | 21 1970 766 26.92 |
| 30 Sep 1949 --- | 22 1996 726 28.21 |
| 10 Feb 1950 84 | 23 2000 662 29.49 |
| 30 Sep 1951 --- | 24 1975 612 30.77 |
| 10 Feb 1952 1,911 | 25 1972 491 32.05 |
| 30 Dec 1952 39 | 26 1997 480 33.33 |
| 17 Feb 1954 130 | 27 1982 480 34.62 |
| 03 May 1955 13 | 28 2004 418 35.90 |
| 30 Jan 1956 238 | 29 1981 403 37.18 |
| 20 Jan 1957 58 | 30 1984 382 38.46 |
| 13 Apr 1958 3,424 | 31 1959 289 39.74 |
| 12 Mar 1959 289 | 32 1988 280 41.03 |
| 08 Feb 1960 4 | 33 1976 265 42.31 |
| 02 Dec 1960 8 | 34 2003 246 43.59 |
| 09 Mar 1962 3,740 | 35 1956 238 44.87 |
| 10 Mar 1963 92 | 36 1930 203 46.15 |
| 03 Apr 1964 45 | 37 1931 201 47.44 |
| 13 Apr 1965 73 | 38 1929 159 48.72 |
| 14 Dec 1965 1,604 | 39 1928 139 50.00 |
| 12 Dec 1966 835 | 40 1954 130 51.28 |
| 18 Dec 1967 95 | 41 1968 95 52.56 |
| 07 Mar 1969 7,800 | 42 1963 92 53.85 |
| 11 Mar 1970 766 | 43 1977 90 55.13 |
| 27 Dec 1970 972 | 44 1999 88 56.41 |
| 20 Jan 1972 491 | 45 1950 84 57.69 |
| 07 Mar 1973 2,558 | 46 1985 75 58.97 |
| 02 Feb 1974 864 | 47 1965 73 60.26 |
| 11 Mar 1975 612 | 48 1957 58 61.54 |
| 16 Feb 1976 265 | 49 1964 45 62.82 |
| 31 Jan 1977 90 | 50 1953 39 64.10 |
| 10 Mar 1978 8,516 | 51 2002 33 65.38 |
| 25 Apr 1979 1,659 | 52 1990 27 66.67 |
| 15 Mar 1980 5,391 | 53 1955 13 67.95 |
| 29 Mar 1981 403 | 54 1987 9 69.23 |
| 12 Apr 1982 480 | 55 1961 8 70.51 |
| 28 Mar 1983 6,447 | 56 1960 4 71.79 |
| 22 Jan 1984 382 | 57 1995 --- 73.08 |
| 02 Jan 1985 75 | 58 1994 --- 74.36 |
| 14 Mar 1986 1,901 | 59 1989 --- 75.64 |
| 28 Mar 1987 9 | 60 1951 --- 76.92 |
| 06 Mar 1988 280 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 27 | 63 1947 --- 80.77 |
| 29 Mar 1991 1,274 | 64 1946 --- 82.05 |
| 07 Mar 1992 3,165 | 65 1945 --- 83.33 |
| 09 Mar 1993 6,421 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 19 Mar 1996 726 | 69 1941 --- 88.46 |
| 13 Feb 1997 480 | 70 1940 --- 89.74 |
| 03 Mar 1998 6,779 | 71 1939 --- 91.03 |
| 14 Apr 1999 88 | 72 1938 --- 92.31 |
| 12 Mar 2000 662 | 73 1937 --- 93.59 |
| 13 Mar 2001 2,223 | 74 1936 --- 94.87 |
| 30 Nov 2001 33 | 75 1935 --- 96.15 |
| 26 Mar 2003 246 | 76 1934 --- 97.44 |
| 02 Mar 2004 418 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.085
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (30-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
```

```
|------------------------------|------------------------------|
| Mean 2.5702 | Historic Events 0 |
| Standard Dev 0.8192 | High Outliers 0 |
| Station Skew -0.2947 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|------------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
==================================================================
Statistical Analysis of 60-day Maximum values
==================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (60-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|------------------------------|------------------------------|
| Mean 2.3428 | Historic Events 0 |
| Standard Dev 0.8385 | High Outliers 0 |
| Station Skew -0.3025 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|------------------------------|------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 0.97
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 50,108.34
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (60-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 03 Apr 1928 113 | 1 1969 7,086 1.28 |
| 15 Apr 1929 109 | 2 1993 5,067 2.56 |
| 23 Apr 1930 104 | 3 1978 4,837 3.85 |
| 25 Feb 1931 110 | 4 1998 3,932 5.13 |
| 22 Feb 1932 1,005 | 5 1983 3,857 6.41 |
| 30 Sep 1933 --- | 6 1980 3,020 7.69 |
| 30 Sep 1934 --- | 7 1992 2,060 8.97 |
| 30 Sep 1935 --- | 8 1958 1,941 10.26 |
| 30 Sep 1936 --- | 9 1962 1,874 11.54 |
| 30 Sep 1937 --- | 10 1973 1,571 12.82 |
| 30 Sep 1938 --- | 11 1966 1,291 14.10 |
| 30 Sep 1939 --- | 12 1986 1,260 15.38 |
| 30 Sep 1940 --- | 13 2001 1,183 16.67 |
| 30 Sep 1941 --- | 14 1952 1,032 17.95 |
| 30 Sep 1942 --- | 15 1979 1,014 19.23 |
| 30 Sep 1943 --- | 16 1932 1,005 20.51 |
| 30 Sep 1944 --- | 17 1991 669 21.79 |
```

```
| 30 Sep 1945 --- | 18 1971 521 23.08 |
| 30 Sep 1946 --- | 19 1967 520 24.36 |
| 30 Sep 1947 --- | 20 1974 465 25.64 |
| 30 Sep 1948 --- | 21 1996 436 26.92 |
| 30 Sep 1949 --- | 22 1970 422 28.21 |
| 15 Feb 1950 46 | 23 1997 395 29.49 |
| 30 Sep 1951 --- | 24 2000 388 30.77 |
| 11 Mar 1952 1,032 | 25 1975 349 32.05 |
| 23 Jan 1953 28 | 26 1984 276 33.33 |
| 25 Mar 1954 79 | 27 1982 264 34.62 |
| 03 May 1955 7 | 28 1972 246 35.90 |
| 30 Jan 1956 119 | 29 1981 244 37.18 |
| 05 Mar 1957 47 | 30 2003 238 38.46 |
| 19 Apr 1958 1,941 | 31 2004 210 39.74 |
| 06 Mar 1959 162 | 32 1988 163 41.03 |
| 09 Mar 1960 2 | 33 1959 162 42.31 |
| 02 Dec 1960 4 | 34 1976 141 43.59 |
| 07 Apr 1962 1,874 | 35 1956 119 44.87 |
| 09 Apr 1963 52 | 36 1928 113 46.15 |
| 08 Apr 1964 23 | 37 1931 110 47.44 |
| 13 Apr 1965 37 | 38 1929 109 48.72 |
| 14 Jan 1966 1,291 | 39 1930 104 50.00 |
| 30 Jan 1967 520 | 40 1954 79 51.28 |
| 17 Jan 1968 49 | 41 1963 52 52.56 |
| 19 Mar 1969 7,086 | 42 1968 49 53.85 |
| 09 Apr 1970 422 | 43 1999 47 55.13 |
| 26 Jan 1971 521 | 44 1957 47 56.41 |
| 18 Feb 1972 246 | 45 1950 46 57.69 |
| 16 Mar 1973 1,571 | 46 1977 45 58.97 |
| 04 Mar 1974 465 | 47 1985 41 60.26 |
| 03 Apr 1975 349 | 48 1965 37 61.54 |
| 15 Feb 1976 141 | 49 1953 28 62.82 |
| 02 Mar 1977 45 | 50 2002 24 64.10 |
| 09 Apr 1978 4,837 | 51 1964 23 65.38 |
| 14 Apr 1979 1,014 | 52 1990 13 66.67 |
| 28 Mar 1980 3,020 | 53 1955 7 67.95 |
| 28 Mar 1981 244 | 54 1987 4 69.23 |
| 30 Apr 1982 264 | 55 1961 4 70.51 |
| 23 Mar 1983 3,857 | 56 1960 2 71.79 |
| 22 Jan 1984 276 | 57 1995 --- 73.08 |
| 16 Jan 1985 41 | 58 1994 --- 74.36 |
| 30 Mar 1986 1,260 | 59 1989 --- 75.64 |
| 28 Mar 1987 4 | 60 1951 --- 76.92 |
| 06 Mar 1988 163 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 13 | 63 1947 --- 80.77 |
| 15 Apr 1991 669 | 64 1946 --- 82.05 |
| 09 Apr 1992 2,060 | 65 1945 --- 83.33 |
| 07 Mar 1993 5,067 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 30 Mar 1996 436 | 69 1941 --- 88.46 |
| 07 Feb 1997 395 | 70 1940 --- 89.74 |
| 02 Apr 1998 3,932 | 71 1939 --- 91.03 |
| 08 May 1999 47 | 72 1938 --- 92.31 |
| 19 Apr 2000 388 | 73 1937 --- 93.59 |
| 11 Apr 2001 1,183 | 74 1936 --- 94.87 |
| 12 Dec 2001 24 | 75 1935 --- 96.15 |
| 08 Apr 2003 238 | 76 1934 --- 97.44 |
| 23 Mar 2004 210 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.085
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (60-day Max)
```

```
---------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.3428 | Historic Events 0 |
| Standard Dev 0.8385 | High Outliers 0 |
| Station Skew -0.3025 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
===================================================================
Statistical Analysis of 90-day Maximum values
===================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (90-day Max)
---------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.2066 | Historic Events 0 |
| Standard Dev 0.8438 | High Outliers 0 |
| Station Skew -0.3106 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
----------------------
<< Low Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 0.68
Based on statistics after 0 zero events and 21 missing events were deleted.
-----------------------
<< High Outlier Test >>
-----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 37,884.66
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (90-day Max)
-------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 18 Apr 1928 81 | 1 1969 4,948 1.28 |
| 15 Apr 1929 114 | 2 1993 4,291 2.56 |
| 09 Apr 1930 85 | 3 1978 3,527 3.85 |
| 01 May 1931 77 | 4 1998 3,146 5.13 |
| 20 Mar 1932 724 | 5 1983 2,957 6.41 |
| 30 Sep 1933 --- | 6 1980 2,161 7.69 |
| 30 Sep 1934 --- | 7 1958 1,481 8.97 |
| 30 Sep 1935 --- | 8 1992 1,393 10.26 |
| 30 Sep 1936 --- | 9 1962 1,250 11.54 |
| 30 Sep 1937 --- | 10 1973 1,116 12.82 |
| 30 Sep 1938 --- | 11 1952 1,042 14.10 |
| 30 Sep 1939 --- | 12 1986 864 15.38 |
| 30 Sep 1940 --- | 13 1966 863 16.67 |
| 30 Sep 1941 --- | 14 1979 845 17.95 |
```

```
| 30 Sep 1942 --- | 15 2001 824 19.23 |
| 30 Sep 1943 --- | 16 1932 724 20.51 |
| 30 Sep 1944 --- | 17 1991 446 21.79 |
| 30 Sep 1945 --- | 18 1967 367 23.08 |
| 30 Sep 1946 --- | 19 1971 358 24.36 |
| 30 Sep 1947 --- | 20 1974 348 25.64 |
| 30 Sep 1948 --- | 21 1996 302 26.92 |
| 30 Sep 1949 --- | 22 1997 300 28.21 |
| 15 Feb 1950 31 | 23 1970 283 29.49 |
| 30 Sep 1951 --- | 24 2000 277 30.77 |
| 10 Apr 1952 1,042 | 25 1975 241 32.05 |
| 04 Feb 1953 19 | 26 2003 234 33.33 |
| 11 Apr 1954 69 | 27 1984 207 34.62 |
| 03 May 1955 5 | 28 1982 178 35.90 |
| 30 Jan 1956 79 | 29 1981 166 37.18 |
| 06 Mar 1957 31 | 30 1972 165 38.46 |
| 03 May 1958 1,481 | 31 2004 148 39.74 |
| 05 Apr 1959 108 | 32 1929 114 41.03 |
| 31 Mar 1960 2 | 33 1988 113 42.31 |
| 29 Dec 1960 3 | 34 1959 108 43.59 |
| 19 Apr 1962 1,250 | 35 1976 94 44.87 |
| 30 Apr 1963 35 | 36 1930 85 46.15 |
| 08 Apr 1964 22 | 37 1928 81 47.44 |
| 13 Apr 1965 24 | 38 1956 79 48.72 |
| 07 Feb 1966 863 | 39 1931 77 50.00 |
| 30 Jan 1967 367 | 40 1954 69 51.28 |
| 16 Feb 1968 35 | 41 1999 50 52.56 |
| 18 Apr 1969 4,948 | 42 1963 35 53.85 |
| 02 May 1970 283 | 43 1968 35 55.13 |
| 25 Feb 1971 358 | 44 1957 31 56.41 |
| 18 Mar 1972 165 | 45 1950 31 57.69 |
| 15 Apr 1973 1,116 | 46 1977 30 58.97 |
| 03 Apr 1974 348 | 47 1985 29 60.26 |
| 03 May 1975 241 | 48 1965 24 61.54 |
| 16 Mar 1976 94 | 49 1964 22 62.82 |
| 30 Mar 1977 30 | 50 1953 19 64.10 |
| 14 Apr 1978 3,527 | 51 2002 16 65.38 |
| 14 Apr 1979 845 | 52 1990 9 66.67 |
| 07 Apr 1980 2,161 | 53 1955 5 67.95 |
| 27 Apr 1981 166 | 54 1987 3 69.23 |
| 19 Apr 1982 178 | 55 1961 3 70.51 |
| 22 Apr 1983 2,957 | 56 1960 2 71.79 |
| 28 Jan 1984 207 | 57 1995 --- 73.08 |
| 13 Feb 1985 29 | 58 1994 --- 74.36 |
| 18 Apr 1986 864 | 59 1989 --- 75.64 |
| 28 Mar 1987 3 | 60 1951 --- 76.92 |
| 06 Mar 1988 113 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 9 | 63 1947 --- 80.77 |
| 15 Apr 1991 446 | 64 1946 --- 82.05 |
| 04 May 1992 1,393 | 65 1945 --- 83.33 |
| 06 Apr 1993 4,291 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 06 Apr 1996 302 | 69 1941 --- 88.46 |
| 19 Feb 1997 300 | 70 1940 --- 89.74 |
| 02 May 1998 3,146 | 71 1939 --- 91.03 |
| 24 Apr 1999 50 | 72 1938 --- 92.31 |
| 10 May 2000 277 | 73 1937 --- 93.59 |
| 10 Apr 2001 824 | 74 1936 --- 94.87 |
| 30 Dec 2001 16 | 75 1935 --- 96.15 |
| 12 May 2003 234 | 76 1934 --- 97.44 |
| 23 Mar 2004 148 | 77 1933 --- 98.72 |
|--------------------------|-------------------------------------|
<< Skew Weighting >>
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.086
Mean-square error of regional skew is undefined.
```

```
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (90-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.2066 | Historic Events 0 |
| Standard Dev 0.8438 | High Outliers 0 |
| Station Skew -0.3106 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
Warning: No ordinates specified for graphical frequency curve
====================================================================
Statistical Analysis of 120-day Maximum values
====================================================================
--- Preliminary Results ---
Note: Adopted skew equals station skew and preliminary
frequency statistics are for the conditional frequency curve
because of zero or missing events.
Warning: Number of zero/missing values and low outliers
is greater than 25% of the systematic record.
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (120-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|-----------------------------|------------------------------|
| Mean 2.1047 | Historic Events 0 |
| Standard Dev 0.8386 | High Outliers 0 |
| Station Skew -0.3035 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|-----------------------------|------------------------------|
--- End of Preliminary Results ---
---------------------
<< Low Outlier Test >>
---------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 low outlier(s) identified below test value of 0.56
Based on statistics after 0 zero events and 21 missing events were deleted.
----------------------
<< High Outlier Test >>
----------------------
Based on 56 events, 10 percent outlier test value K(N) = 2.811
0 high outlier(s) identified above test value of 28,980.06
--- Final Results ---
<< Plotting Positions >>
Santa Clara Riv nr Montalvo Daily POR (120-day Max)
--------------------------------------------------------------------
| Events Analyzed | Ordered Events |
| FLOW | Water FLOW Weibull |
| Day Mon Year CFS | Rank Year CFS Plot Pos |
|--------------------------|-------------------------------------|
| 23 Apr 1928 66 | 1 1969 3,726 1.28 |
| 11 Apr 1929 99 | 2 1993 3,354 2.56 |
| 09 May 1930 65 | 3 1978 2,804 3.85 |
| 01 May 1931 63 | 4 1998 2,627 5.13 |
| 18 Apr 1932 553 | 5 1983 2,526 6.41 |
| 30 Sep 1933 --- | 6 1980 1,673 7.69 |
| 30 Sep 1934 --- | 7 1958 1,129 8.97 |
| 30 Sep 1935 --- | 8 1992 1,065 10.26 |
| 30 Sep 1936 --- | 9 1962 942 11.54 |
| 30 Sep 1937 --- | 10 1973 837 12.82 |
| 30 Sep 1938 --- | 11 1952 804 14.10 |
```

```
| 30 Sep 1939 --- | 12 1979 728 15.38 |
| 30 Sep 1940 --- | 13 1986 648 16.67 |
| 30 Sep 1941 --- | 14 1966 647 17.95 |
| 30 Sep 1942 --- | 15 2001 631 19.23 |
| 30 Sep 1943 --- | 16 1932 553 20.51 |
| 30 Sep 1944 --- | 17 1991 334 21.79 |
| 30 Sep 1945 --- | 18 1967 317 23.08 |
| 30 Sep 1946 --- | 19 1971 278 24.36 |
| 30 Sep 1947 --- | 20 1974 263 25.64 |
| 30 Sep 1948 --- | 21 1997 247 26.92 |
| 30 Sep 1949 --- | 22 1996 232 28.21 |
| 15 Feb 1950 23 | 23 1975 214 29.49 |
| 30 Sep 1951 --- | 24 1970 212 30.77 |
| 28 Apr 1952 804 | 25 2000 210 32.05 |
| 04 Feb 1953 14 | 26 2003 176 33.33 |
| 11 Apr 1954 52 | 27 1984 164 34.62 |
| 03 May 1955 4 | 28 1982 134 35.90 |
| 30 Jan 1956 60 | 29 1981 127 37.18 |
| 06 Mar 1957 24 | 30 1972 124 38.46 |
| 14 Apr 1958 1,129 | 31 2004 111 39.74 |
| 04 May 1959 81 | 32 1929 99 41.03 |
| 30 Apr 1960 1 | 33 1988 93 42.31 |
| 28 Jan 1961 2 | 34 1959 81 43.59 |
| 31 Mar 1962 942 | 35 1976 71 44.87 |
| 06 Jun 1963 26 | 36 1928 66 46.15 |
| 22 Apr 1964 16 | 37 1930 65 47.44 |
| 13 Apr 1965 32 | 38 1931 63 48.72 |
| 07 Feb 1966 647 | 39 1956 60 50.00 |
| 01 Apr 1967 317 | 40 1954 52 51.28 |
| 17 Mar 1968 40 | 41 1968 40 52.56 |
| 18 May 1969 3,726 | 42 1999 39 53.85 |
| 04 Jun 1970 212 | 43 1965 32 55.13 |
| 27 Mar 1971 278 | 44 1963 26 56.41 |
| 11 Apr 1972 124 | 45 1957 24 57.69 |
| 15 May 1973 837 | 46 1950 23 58.97 |
| 16 Mar 1974 263 | 47 1977 23 60.26 |
| 01 Apr 1975 214 | 48 1985 21 61.54 |
| 15 Apr 1976 71 | 49 1964 16 62.82 |
| 30 Mar 1977 23 | 50 1953 14 64.10 |
| 26 Apr 1978 2,804 | 51 2002 13 65.38 |
| 04 May 1979 728 | 52 1990 7 66.67 |
| 07 May 1980 1,673 | 53 1955 4 67.95 |
| 27 May 1981 127 | 54 1987 3 69.23 |
| 19 May 1982 134 | 55 1961 2 70.51 |
| 21 May 1983 2,526 | 56 1960 1 71.79 |
| 28 Jan 1984 164 | 57 1995 --- 73.08 |
| 13 Feb 1985 21 | 58 1994 --- 74.36 |
| 18 Apr 1986 648 | 59 1989 --- 75.64 |
| 12 Mar 1987 3 | 60 1951 --- 76.92 |
| 24 Apr 1988 93 | 61 1949 --- 78.21 |
| 30 Sep 1989 --- | 62 1948 --- 79.49 |
| 18 Feb 1990 7 | 63 1947 --- 80.77 |
| 15 Apr 1991 334 | 64 1946 --- 82.05 |
| 25 Apr 1992 1,065 | 65 1945 --- 83.33 |
| 27 Apr 1993 3,354 | 66 1944 --- 84.62 |
| 30 Sep 1994 --- | 67 1943 --- 85.90 |
| 30 Sep 1995 --- | 68 1942 --- 87.18 |
| 03 May 1996 232 | 69 1941 --- 88.46 |
| 26 Feb 1997 247 | 70 1940 --- 89.74 |
| 01 Jun 1998 2,627 | 71 1939 --- 91.03 |
| 16 Apr 1999 39 | 72 1938 --- 92.31 |
| 08 Jun 2000 210 | 73 1937 --- 93.59 |
| 09 May 2001 631 | 74 1936 --- 94.87 |
| 29 Jan 2002 13 | 75 1935 --- 96.15 |
| 05 Jun 2003 176 | 76 1934 --- 97.44 |
| 05 Mar 2004 111 | 77 1933 --- 98.72 |
|----------------------------|--------------------------------------|
<< Skew Weighting >>
```

```
---------------------------------------------------------------
Based on 77 events, mean-square error of station skew = 0.085
Mean-square error of regional skew is undefined.
---------------------------------------------------------------
<< Conditional Statistics >>
Santa Clara Riv nr Montalvo Daily POR (120-day Max)
----------------------------------------------------------------
| Log Transform: | |
| FLOW, CFS | Number of Events |
|------------------------------|-------------------------------|
| Mean 2.1047 | Historic Events 0 |
| Standard Dev 0.8386 | High Outliers 0 |
| Station Skew -0.3035 | Low Outliers 0 |
| Regional Skew --- | Zero Events 0 |
| Weighted Skew --- | Missing Events 21 |
| Adopted Skew --- | Systematic Events 77 |
|------------------------------|-------------------------------|
Warning: No ordinates specified for graphical frequency curve
```

Attachment C

Volume-Duration Frequency Analysis
and
Base Flood Determination Spreadsheet

Ventura County Levee Certification Baseflood Hydrographs **28-Mar-09 Joe Evelyn**

Baseflood (100-year) hydrographs of 72- hour duration were derived for the Santa Clara River Levee near Montalvo, and for the Sespe Creek near Fillmore, CA levee. For longer durations (>3 days) volume-duration frequency values are provided in the "Baseflood Results" and "VC V-F" worksheet tabs.

The Santa Clara River Levee baseflood hydrograph was derived from volume-frequency relationships at the Santa Clara River at Montalvo, CA USGS streamgage (1594 square miles) transposed to the Santa Clara River Levee location (1600 square miles). The baseflood hydrograph was developed as a balanced hydrograph (for all durations in the hydrograph the average discharge has a 1-percent annual exceedance probability) patterned after the Corps of Engineers Sespe Creek Standard Project Flood hydrograph. Reference- “Detailed Project Report for Flood Control and Environmental Assessment, Main Report and Appendixes, Sespe Creek at Fillmore, Ventura County, California”, U.S. Army Corps of Engineers, Los Angeles District, March 1980.

The Sespe Creek Levee baseflood hydrograph (for all durations in the hydrograph the average discharge has a 1-percent annual exceedance probability) was derived from the volume-frequency relationship at the Sespe Creek near Fillmore USGS streamgage record. The baseflood hydrograph was initially developed as a balanced hydrograph patterned after the Corps of Engineers Sespe Creek Levee Standard Project Flood hydrograph. However in order to smooth hydrograph shape around the peak discharge, the 1-day and 2-day average discharges were increased while the 3-day average discharge was not altered. The modification produces a more realistic hydrograph shape that is also more conservative from the standpoint of evaluating levee stability with respect to seepage analysis.

The Corps of Engineers Flood Hydrograph Package (HEC-1) software was used to generate the balanced hydrographs for each levee. The balanced hydrograph feature of HEC1 was to used to distribute the volume-duration 100-year discharge values (peak, 1-day, 2-day, & 3-day discharges) into a hydrograph having the general shape of a 3-day duration standard project flood hydrograph.

It should be noted that there is no unique 100-year flood hydrograph for a given location. Observed flood hydrograph shapes are a function of the magnitude and distribution of storm precipitation in conjunction with the physical and hydrologic characteristics of a watershed. However a balanced hydrograph closely matches the average discharge over the various durations (instantaneous peak to in this case 3-days) and so is a reasonable characterization of a specific return period (in this case 100-year) flood hydrograph.

Ventura County Levee Certification Joe Evelyn 28-Mar-09

Baseflood (100-year) hydrographs for each Ventura County levee.
For durations longer than 3-days (72 hours) see the adjacent volume-duration frequency table or "Vol-Freq Results" worksheet.

For additional baseflood derivation details see subsequent worksheets.

Baseflood Hydrograph Discharge (cubic feet per second)

Time (hours)	Santa Clara River Levee	Sespe Creek Levee
0	0	0
1	13911	9371
2	14955	10074
3	14649	11011
4	14960	11245
5	13764	10330
6	14471	10817
7	16863	12935
8	18764	15175
9	19704	15934
10	24182	19524
11	26462	21577
12	29265	24285
13	33655	27928
14	36362	30174
15	37606	31206
16	36947	30660
17	35118	29142
18	63418	34547
19	60212	32801
20	56728	30903
21	53940	29384
22	53940	29384
23	56310	30675
24	58122	31662
25	60630	33029
26	62721	34168
27	65788	35838
28	70945	38647
29	80841	44038
30	96172	52390
31	111504	60742

Average Discharge for Duration of the 100-year flood in CFS

Duration in Days	Santa Clara River Levee	Sespe Creek Levee
1	94700	40000
2	59300	35700
3	46300	28400
5	32400	20100
7	26000	14700
10	19800	11000
15	13800	8520
30	8700	4800
60	7200	3820
90	5000	2790
120	3800	2150

32	128230	69854
33	143562	78206
34	151925	82761
35	226000	135000
36	150531	82002
37	137987	75169
38	119867	65298
39	103141	56187
40	87810	47835
41	72478	39482
42	32923	27320
43	28533	23678
44	25095	20824
45	23266	19306
46	21510	17849
47	19900	16514
48	18217	15117
49	16462	13660
50	14925	12385
51	15022	11171
52	13797	10260
53	13860	10322
54	14332	10718
55	15278	11134
56	17566	12142
57	24381	16853
58	27779	19233
59	31680	21718
60	33040	22256
61	30953	20851
62	28866	19445
63	26779	18039
64	24345	16399
65	23302	15697
66	20867	14057
67	18085	12182
68	16346	11011
69	14955	10074
70	13564	9137
71	10781	7263
72	10086	6794

Ventura County Levee Certification Joe Evelyn 28-Mar-09

The first table below presents a summary of the 100-year flood volume-duration relationships for the Santa Clara River and Sespe Creek levees based on the volume-frequency relations developed for associated streamgages (Santa Clara River at Montalvo, CA and Sespe Creek near Fillmore, CA, respectively).

Average Discharge for Duration of the 100-year flood in CFS

Duration in Days	Santa Clara River	Sespe Creek
1	94700	40000
2	59300	35700
3	46300	28400
5	32400	20100
7	26000	14700
10	19800	11000
15	13800	8520
30	8700	4800
60	7200	3820
90	5000	2790
120	3800	2150
Baseflood peak discharge (cfs)	226,000	135,000
Pattern Hydrograph Peak Discharge	112,000	112,000
Ratio of 100-year Qpeak to Corps Design Flood peak discharge	2.0179	1.2054

Average Discharge for Duration of the 100-year flood in CFS **times** Duration in hours for HEC1 input to produce balanced hydrograph

Duration in Days	Santa Clara River	Sespe Creek		Hours
1	2272800	960000		24
2	2846400	1713600		48
3	3333600	2044800		72

Ventura County Levees Joe Evelyn 28-Mar-09

Streamgages used to derive volume-frequency relationships at the levees

Levee Name	Levee Drainage Area (sq. mi.)	Streamgage Name	USGS Gage Number	Gage Drainage Area (sq. mi.)	Baseflood Peak Discharge (CFS)	Daily Flow Systematic POR (yrs)	Levee Design Discharge (CFS)
Sespe Creek (VCWPD-SC-1)	261.1	Sespe Creek near Fillmore, CA	11113000	251	135,000	98	123,000
Santa Clara River (VCWPD-SCR-1)	1600	Santa Clara River at Montalvo, CA	11114000	1594	226,000	77	225,000

Sespe Creek Levee Baseflood Derivation 28-Mar-09

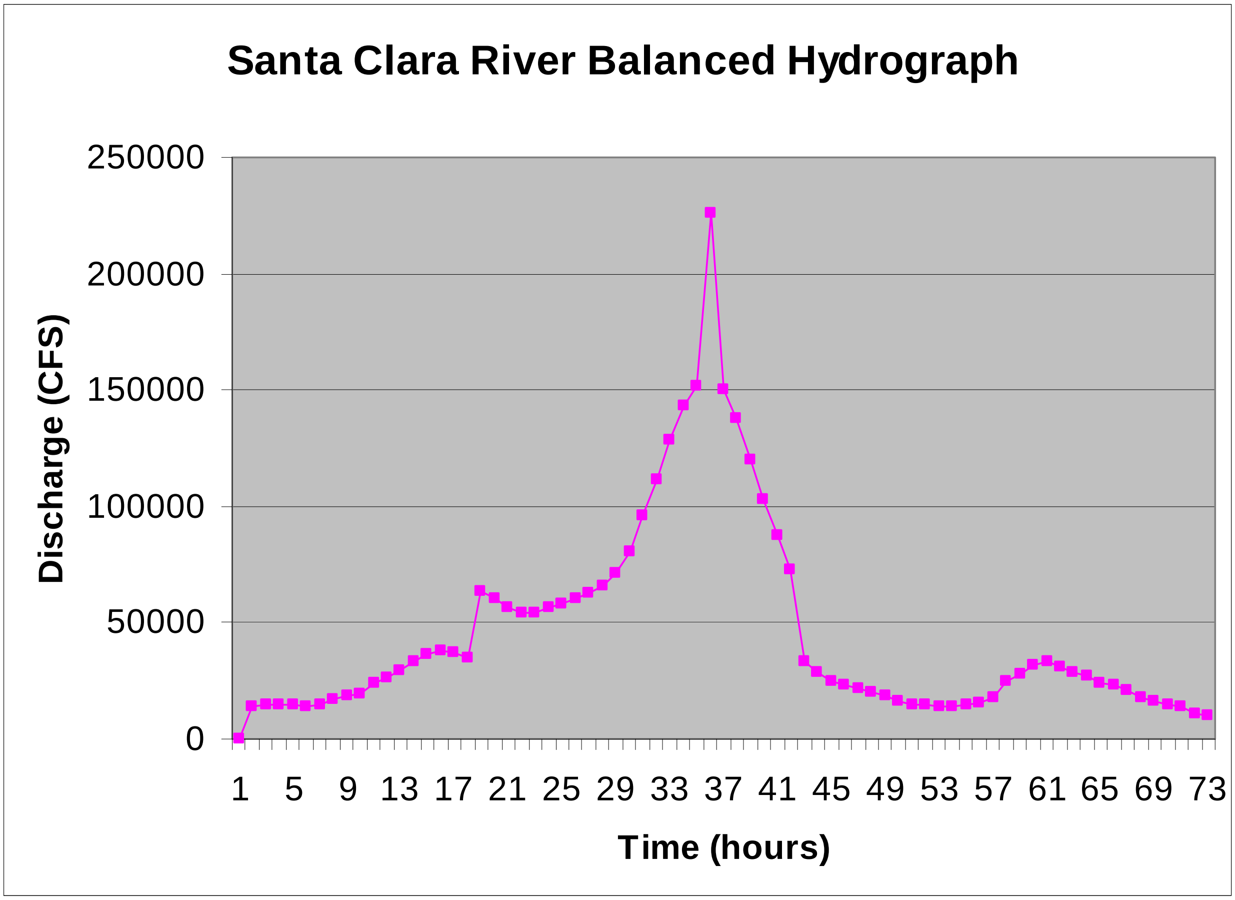
Pattern Hydrograph Values from the Standard Project Flood for Sespe Creek Levee read from the March 1980 Corps of Engineers Detailed Project report plate B-12

Ratio of Sespe Creek 100-year Qpeak to Sespe Creek SPF Qpeak (without bulked flow adjustment) = 135,000/112,000 CFS or 1.2054

Note: Volume-Duration Frequency Data Plot below is HEC-SSP Output Analysis of Sespe Creek near Fillmore, CA Streamgage Record

Time (hrs)	Sespe Creek Levee Balanced Baseflood Hydrograph in CFS	ADOPTED-Modified Sespe Creek Baseflood Hydrograph in CFS
0	0	0
1	8537	9371
2	9178	10074
3	10031	11011
4	10245	11245
5	10458	10330
6	12166	10817
7	16007	12935
8	18603	15175
9	22824	15934
10	31313	19524
11	42142	21577
12	52054	24285
13	57168	27928
14	54354	30174
15	45992	31206
16	45187	30660
17	42950	29142
18	33311	34547
19	31627	32801
20	29797	30903
21	28332	29384
22	23181	29384
23	24199	30675
24	24978	31662
25	22483	33029
26	23258	34168
27	22436	35838
28	23887	38647
29	27219	44038
30	32381	52390
31	37543	60742
32	43175	69854
33	48337	78206
34	51152	82761

35	135000	135000
36	50814	82002
37	48775	75169
38	48149	65298
39	50637	56187
40	43110	47835
41	35583	39482
42	37636	27320
43	32617	23678
44	28687	20824
45	26596	19306
46	30053	17849
47	27804	16514
48	25453	15117
49	26655	13660
50	24167	12385
51	23702	11171
52	22050	10260
53	19962	10322
54	18657	10718
55	17614	11134
56	19391	12142
57	23034	16853
58	23478	19233
59	21770	21718
60	20276	22256
61	18995	20851
62	17715	19445
63	16434	18039
64	14940	16399
65	14300	15697
66	12806	14057
67	11098	12182
68	10031	11011
69	9178	10074
70	8324	9137
71	6616	7263
72	6190	6794
73	2243	2243


Santa Clara River Balanced Hydrograph
Discharge (CFS)
250000
200000
150000
100000
50000
0
1
5
9
13
17
21
25
29
33
37
41
45
49
53
57
61
65
69
73
Time (hours)

Attachment D

HEC-1 Balanced Hydrograph Output File
for
Santa Clara River Levee

```
1*****************************************                                                   ***************************************
 *                                       *                                                   *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                   *    U.S. ARMY CORPS OF ENGINEERS     *
 *               JUN   1998              *                                                   *    HYDROLOGIC ENGINEERING CENTER    *
 *            VERSION 4.1                *                                                   *          609 SECOND STREET          *
 *                                       *                                                   *       DAVIS, CALIFORNIA 95616       *
 *  RUN DATE   26MAR09  TIME  22:15:44   *                                                   *           (916) 756-1104            *
 *                                       *                                                   *                                     *
 *****************************************                                                   ***************************************




                                                 X     X  XXXXXXX   XXXXX           X
                                                 X     X  X        X     X         XX
                                                 X     X  X        X                X
                                                 XXXXXXX  XXXX     X        XXXXX   X
                                                 X     X  X        X                X
                                                 X     X  X        X     X          X
                                                 X     X  XXXXXXX   XXXXX          XXX




            THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

            THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
            THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
            NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
            DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL   LOSS RATE:GREEN AND AMPT INFILTRATION
            KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM


1                                                       HEC-1 INPUT                                                     PAGE  1

           LINE           ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

              1           ID          VENTURA COUNTY LEVEE CERTIFICATION
              2           ID          SANTA CLARA RIVER LEVEE AT MONTALVO, CA
              3           ID          MARCH 26, 2009 JOSEPH EVELYN
              4           ID          100-YEAR BALANCED HYDROGRAPH USING CORPS' SESPE CREEK LEVEE
              5           ID           72-HOUR SPF HYDROGRAPH (W/O BULKING FACTOR) AS A PATTERN HYDROGRAPH
              6           ID       EB      EB      EB      EB      EB      EB      EB      EB      EB      E
              7           IT      60 26MAR09    0000      73
              8           IO       1
              9           BA    1600          2.0179
                          *  Using Sespe Creek Levee 72-hour SPF Hydrograph as Pattern Hydrograph
             10           QI    4000    4300    4700    4800    4900    5700    7500   10200   16000   24000
             11           QI   32300   40000   46000   49700   51400   50500   48000   45500   43200   40700
             12           QI   38700   38700   40400   41700   43500   45000   47200   50900   58000   69000
```

```
             13          QI   80000   92000  103000  109000  112000  108000   99000   86000   74000   63000
             14          QI   52000   45000   39000   34300   31800   29400   27200   24900   22500   20400
             15          QI   18400   16900   15300   14300   13500   12700   11800   11000   10200    9500
             16          QI    8900    8300    7700    7000    6700    6000    5200    4700    4300    3900
             17          QI    3100    2900    2700
                          *  SANTA CLARA RIVER Levee Volume-Freq Values (Peak, 24-hr, 48-hr, 72-hr)
             18          HB       1  226000      24 2272800      48 2846400      72 3333600
             19          ZZ
1*****************************************                                                   ***************************************
 *                                       *                                                   *                                     *
 *   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *                                                   *    U.S. ARMY CORPS OF ENGINEERS     *
 *               JUN   1998              *                                                   *    HYDROLOGIC ENGINEERING CENTER    *
 *            VERSION 4.1                *                                                   *          609 SECOND STREET          *
 *                                       *                                                   *       DAVIS, CALIFORNIA 95616       *
 *  RUN DATE   26MAR09  TIME  22:15:44   *                                                   *           (916) 756-1104            *
 *                                       *                                                   *                                     *
 *****************************************                                                   ***************************************




                                   VENTURA COUNTY LEVEE CERTIFICATION
                                   SANTA CLARA RIVER LEVEE AT MONTALVO, CA
                                   MARCH 26, 2009    JOSEPH EVELYN
                                   100-YEAR BALANCED HYDROGRAPH USING CORPS' SESPE CREEK LEVEE
                                    72-HOUR SPF HYDROGRAPH (W/O BULKING FACTOR) AS A PATTERN HYDROGRAPH
                                EB      EB      EB      EB      EB      EB      EB      EB      EB      E

    8 IO          OUTPUT CONTROL VARIABLES
                        IPRNT           1  PRINT CONTROL
                        IPLOT           0  PLOT CONTROL
                        QSCAL          0.  HYDROGRAPH PLOT SCALE

      IT          HYDROGRAPH TIME DATA
                         NMIN          60  MINUTES IN COMPUTATION INTERVAL
                        IDATE     26MAR 9  STARTING DATE
                        ITIME        0000  STARTING TIME
                           NQ          73  NUMBER OF HYDROGRAPH ORDINATES
                       NDDATE     29MAR 9  ENDING DATE
                       NDTIME        0000  ENDING TIME
                       ICENT           19  CENTURY MARK

                    COMPUTATION INTERVAL    1.00 HOURS
                         TOTAL TIME BASE   72.00 HOURS

           ENGLISH UNITS
                DRAINAGE AREA          SQUARE MILES
                PRECIPITATION DEPTH    INCHES
                LENGTH, ELEVATION      FEET
                FLOW                   CUBIC FEET PER SECOND
```

```
               STORAGE VOLUME        ACRE-FEET
               SURFACE AREA          ACRES
               TEMPERATURE           DEGREES FAHRENHEIT
         BALANCE RESULTS          226000.         2272800.         2860054.         3320930.              0.

 *****************************************************************************************************************************

                                                             HYDROGRAPH AT STATION

 *****************************************************************************************************************************
                                              *                                *                                *
    DA MON HRMN  ORD       FLOW    *  DA MON HRMN  ORD       FLOW    *  DA MON HRMN  ORD       FLOW    *  DA MON HRMN  ORD       FLOW
                                              *                                *                                *
    26 MAR 0000    1    13911.     *  26 MAR 1900   20    56728.     *  27 MAR 1400   39   103141.     *  28 MAR 0900   58    27779.
    26 MAR 0100    2    14955.     *  26 MAR 2000   21    53940.     *  27 MAR 1500   40    87810.     *  28 MAR 1000   59    31680.
    26 MAR 0200    3    14649.     *  26 MAR 2100   22    53940.     *  27 MAR 1600   41    72478.     *  28 MAR 1100   60    33040.
    26 MAR 0300    4    14960.     *  26 MAR 2200   23    56310.     *  27 MAR 1700   42    32923.     *  28 MAR 1200   61    30953.
    26 MAR 0400    5    13764.     *  26 MAR 2300   24    58122.     *  27 MAR 1800   43    28533.     *  28 MAR 1300   62    28866.
    26 MAR 0500    6    14471.     *  27 MAR 0000   25    60630.     *  27 MAR 1900   44    25095.     *  28 MAR 1400   63    26779.
    26 MAR 0600    7    16863.     *  27 MAR 0100   26    62721.     *  27 MAR 2000   45    23266.     *  28 MAR 1500   64    24345.
    26 MAR 0700    8    18764.     *  27 MAR 0200   27    65788.     *  27 MAR 2100   46    21510.     *  28 MAR 1600   65    23302.
    26 MAR 0800    9    19704.     *  27 MAR 0300   28    70945.     *  27 MAR 2200   47    19900.     *  28 MAR 1700   66    20867.
    26 MAR 0900   10    24182.     *  27 MAR 0400   29    80841.     *  27 MAR 2300   48    18217.     *  28 MAR 1800   67    18085.
    26 MAR 1000   11    26462.     *  27 MAR 0500   30    96172.     *  28 MAR 0000   49    16462.     *  28 MAR 1900   68    16346.
    26 MAR 1100   12    29265.     *  27 MAR 0600   31   111504.     *  28 MAR 0100   50    14925.     *  28 MAR 2000   69    14955.
    26 MAR 1200   13    33655.     *  27 MAR 0700   32   128230.     *  28 MAR 0200   51    15022.     *  28 MAR 2100   70    13564.
    26 MAR 1300   14    36362.     *  27 MAR 0800   33   143562.     *  28 MAR 0300   52    13797.     *  28 MAR 2200   71    10781.
    26 MAR 1400   15    37606.     *  27 MAR 0900   34   151925.     *  28 MAR 0400   53    13860.     *  28 MAR 2300   72    10086.
    26 MAR 1500   16    36947.     *  27 MAR 1000   35   226000.     *  28 MAR 0500   54    14332.     *  29 MAR 0000   73     3657.
    26 MAR 1600   17    35118.     *  27 MAR 1100   36   150531.     *  28 MAR 0600   55    15278.     *
    26 MAR 1700   18    63418.     *  27 MAR 1200   37   137987.     *  28 MAR 0700   56    17566.     *
    26 MAR 1800   19    60212.     *  27 MAR 1300   38   119867.     *  28 MAR 0800   57    24381.     *
                                              *                                *                                *
 *****************************************************************************************************************************

   PEAK FLOW      TIME                                 MAXIMUM AVERAGE FLOW
                                                6-HR        24-HR        72-HR      72.00-HR

+    (CFS)        (HR)
                                      (CFS)
+   226000.      34.00                        155675.       94065.       46053.        46053.
                                   (INCHES)      .000         .000         .000          .000
                                    (AC-FT)    77194.      186575.      274033.       274033.

                                    CUMULATIVE AREA =      .00 SQ MI

1
                                                                          RUNOFF SUMMARY
                                                                  FLOW IN CUBIC FEET PER SECOND
                                                               TIME IN HOURS,  AREA IN SQUARE MILES

                                                   PEAK    TIME OF     AVERAGE FLOW FOR MAXIMUM PERIOD      BASIN     MAXIMUM     TIME OF
```

```
          OPERATION       STATION       FLOW      PEAK                                                   AREA       STAGE      MAX STAGE
+                                                             6-HOUR     24-HOUR     72-HOUR

          HYDROGRAPH AT
+                                     226000.   34.00      155675.      94065.      46053.          .00


 *** NORMAL END OF HEC-1 ***
```

APPENDIX D3

Hydraulic Analysis

Santa Clara River Levee
County of Ventura, California

FEMA ID No.: 18
County System No.: SCR-1
Flood Source: Santa Clara River
Communities: City of Oxnard

Hydraulic Analysis

November 2009

TETRA TECH, INC.
17770 Cartwright Road, Suite 500
Irvine, California 92614

Introduction

The Santa Clara River Levee is identified as Levee ID #18 by the Federal Emergency Management Agency (FEMA) and as Levee System SCR-1 by the County of Ventura (Figure 1). The SCR-1 Levee is a 4.72-mile long system designed and constructed by the U.S. Army Corps of Engineers (Corps), Los Angeles District, and has been in operation since its completion in April 1961. The levee is located along the southeast bank of the Santa Clara River between Highway (Hwy) 101 and Saticoy in the City of Oxnard, Ventura County, California as shown on Figure 2. The levee system was constructed to protect existing residential, commercial, industrial, and agricultural property in low lying areas within the base flood floodplain of the Santa Clara River Watershed.

The SCR-1 Levee is currently undergoing extensive hydraulic, engineering and geotechnical analysis in order to document local compliance by the Ventura County Watershed Protection District (VCWPD) with FEMA National Flood Insurance Program (NFIP) Levee Certification requirements. The VCWPD has contracted with Tetra Tech to conduct the necessary analyses required to determine if the SCR-1 Levee is certifiable under FEMA's regulatory requirements as identified in Title 44 of the Code of Federal Regulations (CFR), Section 65.10 (44 CFR 65.10).

Levee Description

The SCR-1 Levee was originally designed to control the Corps' Standard Project Flood discharge of 225,000 cubic feet per second (cfs) from the 1,600-square mile Santa Clara River watershed. The levee height varies from approximately 4 feet to 13 feet. The compacted fill embankment has a top width of 18 feet, and the levee embankment slopes are 2H to 1V on both the landward side and riverward side. The riverward side of the embankment has rock revetment 1.5-2 feet thick and was concreted in the vicinity of highway bridges. The rock revetment extends from the top of the embankment to varying depths. The lowest depth of the rock revetment is referred herein as toe-down.

The reasoning for the varying rock revetment depths is described in the Corps 1958 General Design Memorandum (GDM) titled *"Santa Clara River Levee, Design Memorandum No.2 (General Design)"* (Corps, 1958) which documented the differences between the project-document plan and the recommended plan. A board of consultants provided recommendations on the configuration of the rock revetment. Excerpts from the GDM are included herein: *"The board of consultants recommend that (a) instead of a levee with a deep toe-down (the toe-down would extend 12 feet below the streambed), where a 200-foot berm of undisturbed granular streambed material exists between the levee and the main-stream channel, the depth of the toe-down to be extended only 5 feet below the top elevation of this undisturbed material or (b) in the absence of this undisturbed material and at locations subject to direct attack by streamflow, groins extending 150 feet into the stream and spaced 225 feet – with slight deflection in the downstream direction – be built."*

The toe-down varies from 5 to 10 feet below the river streambed from Hwy 101 to a distance of approximately 8,500 linear feet upstream, at which point the toe-down changes significantly from approximately 5 feet below the streambed to approximately 10 feet above the streambed.

The toe-down depth changes from approximately 10 feet above the streambed from 8,500 linear feet upstream of Hwy 101, to approximately 5 feet above the streambed at Hwy 118, to approximately 18 feet above the streambed at the upstream end of the levee. As described above rock groins were constructed to divert flows away from the levee rock revetment. In addition a weighted stone toe section along the levee toe-down was designed to launch into the river to protect the rock revetment from undermining.

The summary of the SCR-1 levee attributes based on the as-built plans is presented in Table 1.

Channel Description

The streambed of the Santa Clara River is approximately 900 feet wide at the upstream end of the levee (near Unified Water Conservation District Canal). The streambed subsequently widens to a width of approximately 1,600 feet, and then narrows down to approximately 700 feet in width at the Los Angeles Avenue (Hwy 118) Bridge. The streambed slope along this reach is approximately 0.0029 feet/foot. The streambed between Hwy 118 and Hwy 101 has the same geometric shape as the reach upstream of Hwy 118. The widths of the streambed are approximately 500 feet and 1,300 feet for the narrowest and widest sections, respectively. The streambed is approximately 700 feet wide at Hwy 101. The streambed slope for this reach is approximately 0.0025 feet/foot. The streambed is formed in alluvial material comprised of sand, gravel, and cobbles. Vegetation is growing approximately 100 feet away from the levee toe on the channel overbank areas, except in the vicinity of Hwy 101 where vegetation is located approximately 40 feet away from the levee toe on the riverward side.

Mapping

The topographic information of the project area was provided by the VCWPD in the 2005 County LIDAR (Light Detection and Ranging) format. In 2009, a cross sectional survey along the SCR-1 Levee at 100-foot interval was provided from Ventura County to supplement the 2005 LIDAR information. The horizontal control is based on North American Datum (NAD) 1983, while the vertical control is based on North American Vertical Datum (NAVD) 1988.

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
Upstream End of SCR-1 Levee System										
491+75	480+00		0.00546	2:1	7.50	N/A[5]	22.80	2:1	0.00251	A
480+00	480+00	Side Drain			7.48		19.33			A
480+00	476+00		0.00546	2:1	7.48		19.33	2:1	0.00251	A
476+00	470+00		0.00300	2:1	5.61	N/A	18.15	2:1	0.00251	A
470+00	470+00	Groin	Length = 150'		4.27		17.86			A
470+00	467+75		0.00300	2:1	4.27	N/A	17.86	2:1	0.00251	A
467+75	467+75	Groin	Length = 150'		3.77		17.75			A
467+75	467+00		0.00300	2:1	3.77	N/A	17.75	2:1	0.00251	A
467+00	466+00		0.00451	2:1	3.60	N/A	17.71	2:1	0.00251	A
466+00	465+85		0.00451	2:1	7.45	N/A	17.51	2:1	0.00251	A
465+85	465+50		0.00451	2:1	7.44	N/A	17.48	2:1	0.00251	A
465+50	465+50	Groin	Length = 150'		7.41		17.41			A
465+50	465+10		0.00451	2:1	7.41	N/A	17.41	2:1	0.00251	A
465+10	464+00		0.00451	2:1	7.37	N/A	17.33	2:1	0.00251	A
464+00	463+25		0.00451	2:1	7.28	N/A	17.11	2:1	0.00251	A
463+25	463+25	Groin	Length = 150'		7.21		16.96			A
463+25	461+15		0.00451	2:1	7.21	N/A	16.96	2:1	0.00251	A
461+15	461+00		0.00451	2:1	7.03	N/A	16.54	2:1	0.00251	A
461+00	461+00	Groin	Length = 150'		7.02		16.51			A
461+00	458+75		0.00451	2:1	7.02	N/A	16.51	2:1	0.00251	A
458+75	458+75	Groin	Length = 150'		6.83		16.06			A
458+75	457+90		0.00233	2:1	6.83	N/A	16.06	2:1	0.00251	A
457+90	456+50		0.00233	2:1	6.76	N/A	15.90	2:1	0.00251	A
456+50	456+50	Groin	Length = 150'		6.94		15.92			A
456+50	456+00		0.00233	2:1	6.94	N/A	15.92	2:1	0.00251	A
456+00	455+55		0.00233	2:1	7.01	N/A	15.93	2:1	0.00251	A
455+55	455+50		0.00233		7.07		15.94		0.00251	A

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
455+50	454+25		0.00233	2:1	7.07	N/A	16.04	2:1	0.00984	A
454+25	454+25	Groin	Length = 150'		7.24		16.98			A
454+25	452+00		0.00233	2:1	7.24	N/A	16.98	2:1	0.00984	A
452+00	452+00	Groin	Length = 150'		7.53		18.67			A
452+00	449+75		0.00233	2:1	7.53	N/A	18.67	2:1	0.00984	A
449+75	449+75	Groin	Length = 150'		7.83		20.36			A
449+75	447+50		0.00233	2:1	7.83	N/A	20.36	2:1	0.00984	A
447+50	447+50	Groin	Length = 150'		8.13		22.05			A
447+50	445+25		0.00233	2:1	8.13	N/A	22.05	2:1	0.00984	A
445+25	445+25	Groin	Length = 150'		8.43		23.74			A
445+25	445+00		0.00233	2:1	8.43	N/A	23.74	2:1	0.00984	A
445+00	443+80		0.00000	2:1	8.46	N/A	23.93	2:1	0.00984	A
443+80	443+80	Ramp No. 3			8.90		25.11			A
443+80	443+20		0.00000	2:1	8.90	N/A	25.11	2:1	0.00984	A
443+20	443+20	Ramp No. 2			9.12		25.70			A
443+20	443+00		0.00000	2:1	9.12	N/A	25.70	2:1	0.00984	A
443+00	443+00	Groin	Length = 150'		9.19		25.90			A
443+00	442+95		0.00000	2:1	9.19	N/A	25.90	2:1	0.70000	A
442+95	442+00		0.00000	2:1	9.21	N/A	29.40	2:1	0.00412	A
442+00	442+00	Side Drain No. 2			9.56		29.79			B
442+00	441+50		0.00000	2:1	9.56	N/A	29.79	2:1	0.00412	A
441+50	440+41		0.00000	2:1	9.56	N/A	29.79	2:1	0.00412	Concreted
440+41	440+41	Los Angeles Avenue (Hwy 118) Bridge								Concreted
440+41	439+80		0.01646	2:1	10.14	N/A	30.45	2:1	0.00412	Concreted
439+80	438+70		0.00136	2:1	8.86	N/A	29.20	2:1	0.00412	Concreted
438+70	438+49		0.00136	2:1	9.11	N/A	29.50	2:1	0.00412	A
438+49	438+49	Ramp No. 4			9.16		29.56			A
438+49	438+30		0.00136	2:1	9.16	N/A	29.56	2:1	0.00412	A

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
438+30	437+60		0.00136	2:1	9.21	N/A	29.61	2:1	0.00412	A
437+60	436+80		0.00136	2:1	9.37	N/A	29.81	2:1	0.00412	A
436+80	436+80	Groin	Length = 180'		9.55		30.03			A
436+80	434+00		0.00136	2:1	9.55	N/A	30.03	2:1	0.00412	A
434+00	433+80		0.00136	2:1	10.19	N/A	30.61	2:1	0.00114	A
433+80	433+80	Groin	Length = 180'		10.24		30.61			A
433+80	433+12		0.00136	2:1	10.24	N/A	30.61	2:1	0.00114	A
433+12	430+80		0.00157	2:1	10.40	N/A	30.60	2:1	0.00114	A
430+80	430+80	Groin	Length = 180'		10.63		30.51			A
430+80	427+80		0.00157	2:1	10.63	N/A	30.51	2:1	0.00118	A
427+80	427+80	Groin	Length = 180'		10.93		30.39			A
427+80	426+10		0.00157	2:1	10.93	N/A	30.39	2:1	0.00118	A
426+10	424+80		0.00231	2:1	11.10	N/A	30.33	2:1	0.00118	A
424+80	424+80	Groin	Length = 180'		11.13		30.18			B
424+80	422+55		0.00231	2:1	11.13	N/A	30.18	2:1	0.00118	B
422+55	422+55	Commercial Drain			11.19		29.93			B
422+55	421+80		0.00231	2:1	11.19	N/A	29.93	2:1	0.00118	B
421+80	421+80	Groin	Length = 180'							B
421+80	420+65		0.00231	2:1	11.21	N/A	29.84	2:1	0.00118	B
420+65	420+20		0.00231	2:1	11.24	N/A	29.71	2:1	0.00118	B
420+20	420+20	Ramp			11.25		29.66			B
420+20	419+50		0.00231	2:1	11.25	N/A	29.66	2:1	0.00118	B
419+50	417+85		0.00231	2:1	11.27	N/A	29.58	2:1	0.00118	B
417+85	417+25		0.00231	2:1	11.31	N/A	29.40	2:1	0.00118	B
417+25	417+00		0.00231	2:1	11.32	N/A	29.33	2:1	0.00118	B
417+00	416+38		0.00400	2:1	11.33	N/A	29.30	2:1	0.00118	B
416+38	415+75		0.00400	2:1	11.24	N/A	29.13	2:1	0.00118	B
415+75	413+95		0.00400	2:1	11.15	N/A	28.95	2:1	0.00118	B

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
413+95	413+95	Ramp No.7			10.89		28.44			B
413+95	413+00		0.00400	2:1	10.89	N/A	28.44	2:1	0.00118	B
413+00	410+60		0.00400	2:1	10.76	N/A	28.17	2:1	0.00118	B
410+60	410+60	Side Drain No.3			10.41		27.50			B
410+60	408+80		0.00400	2:1	10.41	N/A	27.50	2:1	0.00118	B
408+80	408+10		0.00400	2:1	10.15	N/A	26.99	2:1	0.00118	B
408+10	399+90		0.00400	2:1	10.05	N/A	26.79	2:1	0.00118	B
399+90	398+00		0.00400	2:1	8.87	N/A	24.46	2:1	0.00364	B
398+00	398+00	County Ramp			8.60		24.39			B
398+00	397+00		0.00400	2:1	8.60	N/A	24.39	2:1	0.00364	B
397+00	395+05		0.00221	2:1	8.45	N/A	24.36	2:1	0.00364	B
395+05	393+90		0.00221	2:1	8.52	N/A	24.63	2:1	0.00364	B
393+90	391+75		0.00221	2:1	8.56	N/A	24.80	2:1	0.00364	B
391+75	391+75	Groin	Length = 150'		8.64		25.11			B
391+75	389+50		0.00221	2:1	8.64	N/A	25.14	2:1	0.00000	A
389+50	389+50	Groin	Length = 150'		10.11		24.64			A
389+50	387+25		0.00221	2:1	10.11	N/A	24.64	2:1	0.00000	A
387+25	387+25	Groin	Length = 150'		11.58		24.15			A
387+25	386+60		0.00221	2:1	11.58	N/A	24.15	2:1	0.00000	A
386+60	385+77		0.00164	2:1	12.00	N/A	24.00	2:1	0.00000	A
385+77	385+77	Commercial Drain			12.00		23.86			B
385+77	385+00		0.00164	2:1	12.00	N/A	23.86	2:1	0.00000	A
385+00	385+00	Groin	Length = 150'		12.00		23.74			A
385+00	382+75		0.00164	2:1	12.00	N/A	23.74	2:1	0.00000	A
382+75	382+75	Groin	Length = 150'		12.00		23.37			A
382+75	381+55		0.00164	2:1	12.00	N/A	23.37	2:1	0.00000	A
381+55	380+95		0.00164	2:1	12.00	N/A	23.17	2:1	0.00000	A
380+95	380+50		0.00164	2:1	12.00	N/A	23.07	2:1	0.00000	A

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
380+50	380+50	Groin	Length = 150'		12.00		23.00			A
380+50	379+65		0.00164	2:1	12.00	N/A	23.00	2:1	0.00000	A
379+65	379+10		0.00164	2:1	12.00	N/A	22.86	2:1	0.00000	A
379+10	378+25		0.00164	2:1	12.00	N/A	22.77	2:1	0.00000	A
378+25	378+25	Groin	Length = 150'		12.00		22.63			A
378+25	376+83		0.00164	2:1	12.00	N/A	22.63	2:1	0.00000	A
376+83	376+00		0.00131	2:1	12.00	N/A	22.40	2:1	0.00000	A
376+00	376+00	Groin	Length = 150'		12.00		22.29			A
376+00	373+75		0.00131	2:1	12.00	N/A	22.29	2:1	0.00000	A
373+75	373+75	Groin	Length = 150'		12.00		22.00			A
373+75	373+00		0.00131	2:1	12.00	N/A	22.00	2:1	0.00000	A
373+00	371+50		0.00233	2:1	12.00	N/A	21.90	2:1	0.00000	A
371+50	371+50	Groin	Length = 150'		12.22		21.55			A
371+50	369+25		0.00233	2:1	12.22	N/A	21.55	2:1	0.00000	A
369+25	369+25	Groin	Length = 150'		12.54		21.03			A
369+25	369+00		0.00233	2:1	12.54	N/A	21.03	2:1	0.00000	A
369+00	367+00		0.00233	2:1	12.58	N/A	20.97	2:1	0.00321	A
367+00	367+00	Groin	Length = 150'		12.87		21.14			A
367+00	364+75		0.00629	2:1	12.87	N/A	21.14	2:1	0.00321	A
364+75	364+75	Groin	Length = 150'		12.31		20.45			A
364+75	362+50		0.00629	2:1	12.31	N/A	20.45	2:1	0.00321	A
362+50	362+50	Groin	Length = 150'		11.74		19.76			A
362+50	360+25		0.00629	2:1	11.74	N/A	19.76	2:1	0.00321	A
360+25	360+25	Groin	Length = 150'		11.18		19.06			A
360+25	358+00		0.00629	2:1	11.18	N/A	19.06	2:1	0.00321	A
358+00	358+00	Groin	Length = 150'		10.61		18.37			A
358+00	357+30		0.00629	2:1	10.61	N/A	18.37	2:1	0.00321	A
357+30	355+80		0.00629	2:1	10.44	N/A	18.16	2:1	0.00321	A

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
355+80	355+75		0.00440	2:1	10.35	N/A	17.98	2:1	0.00321	A
355+75	355+75	Groin	Length = 150'		10.34		17.97			A
355+75	355+00		0.00440	2:1	10.34	N/A	17.97	2:1	0.00321	A
355+00	353+70		0.00440	2:1	10.30	N/A	17.88	2:1	0.00321	A
353+70	353+50		0.00440	2:1	10.22	N/A	17.73	2:1	0.00321	A
353+50	353+50	Groin	Length = 150'		10.20		17.70			A
353+50	352+80		0.00440	2:1	10.20	N/A	17.70	2:1	0.00321	A
352+80	351+25		0.00440	2:1	10.16	N/A	17.62	2:1	0.00321	A
351+25	351+25	Groin	Length = 150'		10.07		17.44			A
351+25	350+00		0.00440	2:1	10.07	N/A	17.44	2:1	0.00321	A
350+00	349+00		0.00440	2:1	9.99	N/A	17.29	2:1	0.00321	A
349+00	349+00	Groin	Length = 150'		9.86		17.17			A
349+00	347+30		0.00440	2:1	9.86	N/A	17.17	2:1	0.00321	A
347+30	346+75		0.00368	2:1	9.65	N/A	16.97	2:1	0.00321	A
346+75	346+75	Groin	Length = 150'		9.63		16.94			A
346+75	344+50		0.00368	2:1	9.63	N/A	16.94	2:1	0.00321	A
344+50	344+50	Groin	Length = 150'		9.51		16.83			A
344+50	342+25		0.00368	2:1	9.51	N/A	16.83	2:1	0.00321	A
342+25	342+25	Groin	Length = 150'		9.39		16.73			A
342+25	340+00		0.00368	2:1	9.39	N/A	16.73	2:1	0.00321	A
340+00	340+00	Groin	Length = 150'		9.28		16.62			A
340+00	337+75		0.00368	2:1	9.28	N/A	16.62	2:1	0.00321	A
337+75	337+75	Groin	Length = 150'		9.16		16.52			A
337+75	335+50		0.00368	2:1	9.16	N/A	16.52	2:1	0.00321	A
335+50	335+50	Groin	Length = 150'		9.04		16.41			A
335+50	334+80		0.00368	2:1	9.04	N/A	16.41	2:1	0.00321	A
334+80	333+25		0.00429	2:1	9.01	N/A	16.38	2:1	0.00321	A
333+25	333+25	Groin	Length = 150'		8.83		16.21			A

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
333+25	332+00		0.00429	2:1	8.83	N/A	16.21	2:1	0.00321	A
332+00	330+00		0.00438	2:1	8.69	N/A	16.08	2:1	0.00321	C
330+00	330+00	Groin	Length = 180'		8.45		15.84			C
330+00	327+00		0.00438	2:1	8.45	N/A	15.84	2:1	0.00321	C
327+00	327+00	Groin	Length = 180'		8.08		15.49			C
327+00	324+00		0.00438	2:1	8.08	N/A	15.49	2:1	0.00321	C
324+00	324+00	Groin	Length = 180'		7.72		15.14			C
324+00	322+40		0.00438	2:1	7.72	N/A	15.14	2:1	0.00321	C
322+40	321+00		0.00319	2:1	7.53	N/A	14.96	2:1	0.00321	C
321+00	321+00	Groin	Length = 180'		7.52		14.96			C
321+00	318+00		0.00319	2:1	7.52	N/A	14.96	2:1	0.00321	C
318+00	318+00	Groin	Length = 180'		7.52		14.97			C
318+00	316+80		0.00319	2:1	7.52	N/A	14.97	2:1	0.00321	C
316+80	316+80	Side Drain No.6			7.51		14.97			C
315+80	315+80	Ramp No. 9			7.51		14.97			C
315+80	315+50		0.00319	2:1	7.51	N/A	14.97	2:1	0.00321	C
315+50	315+50	Ramp No.8			7.51	N/A	14.97	2:1	0.00321	C
315+50	315+00		0.00319	2:1	7.51	N/A	14.97	2:1	0.00321	C
315+00	315+00	Groin	Length = 180'		7.51		14.97			C
315+50	313+00		0.00319	2:1	7.51	N/A	14.97	2:1	0.00321	C
313+00	312+50		0.00232	2:1	7.50	N/A	15.00	2:1	0.33000	C
312+50	312+00		0.00232	2:1	7.56	N/A	31.38	2:1	0.00000	C
312+00	312+00	Groin	Length = 180'		7.62		31.27			C
312+00	310+00		0.00232	2:1	7.62	N/A	31.27	2:1	0.00000	B
310+00	309+00		0.00232	2:1	7.86	N/A	30.80	2:1	0.00000	B
309+00	309+00	Groin	Length = 180'		7.61		30.20			B
309+00	307+40		0.00400	2:1	7.61	N/A	30.20	2:1	0.00000	B
307+40	306+00		0.00400	2:1	7.53	N/A	29.56	2:1	0.00000	B

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
306+00	306+00	Groin	Length = 180'		7.47		29.00			B
306+00	303+00		0.00400	2:1	7.47	N/A	29.00	2:1	0.00000	B
303+00	303+00	Groin	Length = 180'		7.33		27.80			B
303+00	300+00		0.00400	2:1	7.33	N/A	27.80	2:1	0.00000	B
300+00	300+00	Groin	Length = 180'		7.18		26.60			B
300+00	297+50		0.00400	2:1	7.18	N/A	26.60	2:1	0.00000	B
297+50	297+00		0.00400	2:1	7.07	N/A	25.60	2:1	0.00000	B
297+00	297+00	Groin	Length = 180'		7.84		26.20			B
297+00	294+00		0.00248	2:1	7.84	N/A	26.20	2:1	0.00000	B
294+00	294+00	Groin	Length = 180'		8.16		25.46			B
294+00	291+00		0.00248	2:1	8.16	N/A	25.46	2:1	0.00000	B
291+00	291+00	Groin	Length = 180'		8.03		24.71			B
291+00	288+00		0.00248	2:1	8.03	N/A	24.71	2:1	0.00000	B
288+00	288+00	Groin	Length = 180'		7.91		23.97			B
288+00	285+00		0.00248	2:1	7.91	N/A	23.97	2:1	0.00000	B
285+00	285+00	Groin	Length = 180'		7.79		23.22			B
285+00	282+50		0.00248	2:1	7.79	N/A	23.22	2:1	0.00000	B
282+50	282+00		0.00248	2:1	7.69	N/A	22.60	2:1	0.00000	B
282+00	282+00	Groin	Length = 180'		7.69		22.50			B
282+00	280+00		0.00166	2:1	7.69	N/A	22.50	2:1	0.00000	B
280+00	279+00		0.00166	2:1	7.77	N/A	22.17	2:1	0.00400	B
279+00	279+00	Groin	Length = 180'		7.81		22.40			B
279+00	276+00		0.00166	2:1	7.81	N/A	22.40	2:1	0.00400	B
276+00	276+00	Groin	Length = 180'		7.93		23.10			B
276+00	273+00		0.00166	2:1	7.93	N/A	23.10	2:1	0.00400	B
273+00	273+00	Groin	Length = 180'		8.06		23.81			B
273+00	270+00		0.00166	2:1	8.06	N/A	23.81	2:1	0.00400	B
270+00	270+00	Groin	Length = 180'		8.18		24.51			B

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]
270+00	267+40		0.00166	2:1	8.18	N/A	24.51	2:1	0.00400	B
267+40	267+00		0.00360	2:1	8.21	N/A	25.04	2:1	0.00400	B
267+00	267+00	Groin	Length = 180'		8.15		25.06			B
267+00	266+00		0.00360	2:1	8.15	N/A	25.06	2:1	0.00400	B
266+00	264+00		0.00360	2:1	8.00	N/A	25.10	2:1	0.00400	B
264+00	264+00	Groin	Length = 180'		8.01		25.18			B
264+00	261+00		0.00360	2:1	8.01	N/A	25.18	2:1	0.00400	B
261+00	261+00	Groin	Length = 180'		8.02		25.30			B
261+00	259+90		0.00360	2:1	8.02	N/A	25.30	2:1	0.00400	B
259+90	258+00		0.00150	2:1	8.03	N/A	25.30	2:1	0.00195	B
258+00	258+00	Groin	Length = 180'		8.43		25.39			B
258+00	255+00		0.00150	2:1	8.43	N/A	25.39	2:1	0.00195	B
255+00	255+00	Groin	Length = 180'		9.08		25.52			B
255+00	252+30		0.00150	2:1	9.08	N/A	25.52	2:1	0.00195	B
252+30	252+00		0.00525	2:1	10.00	N/A	26.00	2:1	0.00314	B
252+00	252+00	Groin	Length = 180'		9.96		25.94			B
252+00	249+00		0.00525	2:1	9.96	N/A	25.94	2:1	0.00314	B
249+00	249+00	Groin	Length = 180'		9.96		25.94			B
249+00	246+20		0.00000	2:1	8.11	N/A	23.84	2:1	0.00314	B
246+20	246+20	Side Drain No. 5					24.72			B
246+20	246+00		0.00000	2:1	9.22	N/A	24.72	2:1	0.00314	B
246+00	246+00	Groin	Length = 180'		9.96		24.78			B
246+00	244+34		0.00000	2:1	9.30	N/A	24.78	2:1	0.00314	B
244+34	244+34	Center Line of Highway 101 Bridge								B
Downstream End of SCR-1 Levee System (Highway 101)										

1. Levee revetment consists of facing stone with 18” thick at top and 24” thick at toe. Upstream and downstream sections of Los Angeles Avenue and Highway 101 Bridges are concreted.
2. Height and Depth corresponding to the upstream station.
3. Toe-down depth is measured from top of levee elevation to rock revetment toe-down elevation.

Table 1 – Levee Attributes Summary

As-built Station		Levee					Revetment[1]			
					Height					
U/S	D/S	Feature	Top of Levee Slope (ft/ft)	Landward Sideslope (H):(V)	Riverward[2] (ft)	Landward (ft)	Toe-down Depth[2,3] (ft)	Sideslope (H):(V)	Toe of Revetment Slope (ft/ft)	Type of Weighted Stone Toe[4]

4. Weighted Stone Toe: Type A is an up-side-down triangle (base width of 0 ft and top width of 10 feet); Type B is a trapezoid (base width of 10 ft and top width of 30 feet); Type C is a parallelogram (base width of 20 ft and top width of 20 feet). The height of the weighted stone toe is 5 ft and the sideslope is 2H: 1V.
5. N/A – Data not available.

Levee As-built Plans

The Corps 1961 as-built plans titled *"Santa Clara River Levee Plans for Construction of Levee and Appurtenances, Santa Clara River Basin, California"* (Corps, 1961) and 1971 as-built plans titled *"Santa Clara River Levee, Levee and Channel restoration Project, Santa Clara River Basin, California"* (Corps, 1971) and the County of Ventura 1985 as-built plans titled *"Santa Clara River Groin Repair, County of Ventura"* (VCWPD, 1985) were used in comparing the levee as designed with the existing levee geometry based on the current topographic data.

The effort represented in the 1971 as-built plans was designed and constructed in response to damages caused by the 1969 floods (see following section – Levee Damage and Maintenance). The original design contained 40 groins with lengths of 150 feet to which the 1971 design added 35 groins with lengths of 180 feet. The effort represented by the 1985 as-built plans was designed and constructed to restore 5 groins damaged by an earlier flood, possibly the 1983 flood.

The elevations shown on the as-built plans were in National Geodetic Vertical Datum (NGVD) 1929 and have been converted to the NAVD 1988 system. For conversion to current topographic data; the average elevation of NAVD 1988 datum is approximately 2.45 feet higher than the NGVD 1929 datum in the vicinity of the SCR-1 levee. Table 2 lists the top of levee elevation profiles of as-built plans and 2009 survey data. In general, the current top of levee elevations are lower than the elevations shown on the as-built plans, except in two locations. In the locations where the current levee elevations are lower than the as-built plans, the largest differences are approximately 0.94 and 0.97 feet at HEC-RAS Stations 407+99 and 394+24 and are approximately 4,300 feet and at approximately 5,600 feet downstream of Hwy 118, respectively.

Table 2 –Top of Levee Elevation Comparison

HEC-RAS Station	Approximate As-Built Station	Top of Levee Elevation (feet)		Difference in Elevation (feet)
		As-Built	2009 Survey Data	
Upstream End of SCR-1 Levee				
493+87	490+10	157.85	157.27	-0.58
488+43	478+17	151.33	150.90	-0.43
484+19	473+97	149.54	148.95	-0.59
478+00	467+06	147.47	147.08	-0.39
471+90	461+03	144.76	143.98	-0.78
465+70	454+85	142.64	141.93	-0.71
459+47	448+50	141.16	140.62	-0.54
452+95	442+61	140.35	139.66	-0.69
Los Angeles Avenue (Hwy 118) Bridge				
448+78	439+05	138.75	138.29	-0.46
443+00	432+54	137.86	137.13	-0.73
437+29	425+54	136.72	136.70	-0.02
430+40	418+18	135.02	134.10	-0.92
423+57	411+25	132.45	132.02	-0.43
418+40	406+35	130.49	130.01	-0.48
413+20	401+21	128.43	127.99	-0.44

Table 2 –Top of Levee Elevation Comparison

HEC-RAS Station	Approximate As-Built Station	Top of Levee Elevation (feet)		Difference in Elevation (feet)
		As-Built	2009 Survey Data	
407+99	396+05	126.54	125.60	**-0.94**
401+00	389+07	125.00	124.20	-0.80
394+24	382+68	123.81	122.84	**-0.97**
387+00	376+30	122.78	121.97	-0.81
379+60	370+05	121.66	121.00	-0.66
374+50	364+88	119.62	119.10	-0.52
369+50	359+66	116.33	115.40	-0.93
364+41	354+55	113.64	113.10	-0.54
359+30	349+78	111.54	111.10	-0.44
354+30	344+65	109.47	109.25	-0.22
349+28	339+67	107.64	107.72	0.08
342+20	332+51	104.85	106.12	1.27
335+26	326+85	102.39	103.11	0.72
330+00	321+22	100.07	100.55	0.48
324+80	315+88	98.37	98.18	-0.19
319+62	311+05	97.00	96.85	-0.15
314+50	306+28	95.70	95.60	-0.10
309+00	301+20	93.67	93.55	-0.12
303+52	295+85	91.77	91.75	-0.02
296+50	290+05	90.32	89.95	-0.37
289+32	283+15	88.61	87.90	-0.71
282+20	276+20	87.41	87.00	-0.41
275+00	269+31	86.27	85.50	-0.77
269+30	263+52	84.55	84.14	-0.41
263+56	257+75	83.02	82.19	-0.83
257+50	252+35	82.46	82.39	-0.07
251+32	247+05	79.70	79.27	-0.43
Downstream End of SCR-1 Levee/Highway 101 Bridge				

Levee Damage and Maintenance

Several severe storms prior to the completion of the SCR-1 levee had been documented in the Corps 1968 report titled *“Flood Plain Information, Santa Clara River (Saticoy to Pacific Ocean), Ventura County, California”* (Corps, 1968). The February/March 1938 flood damaged the Hwy 118 Bridge (Los Angeles Avenue). The January 1943 flood caused severe damage to agriculture land and crops and bridges. The January 1952 flood was severe enough to cause damage to the properties along the river. No details of flood damages for the above mentioned floods were documented. The estimated peak discharges were 95,000 cfs, 72,000 cfs and 45,000 cfs for 1938, 1943, and 1952 floods, respectively. These values were obtained from Table 1 of the Ventura County Hydrology report titled *“Santa Clara River 2006 Hydrology Update, Phase I – From Ocean to County Line”* (VCWPD, 2006).

The floods of January and February 1969 were the most damaging floods of record along the Santa Clara River in Ventura County. The following are excerpted from the Corps report titled

"Floods in Southern California during January and February, 1969" (Corps, 1969) pertaining to the reach from Hwy 118 to Hwy 101:

"The only significant damage that occurred in this reach during the January flood was damage to the revetment of an existing levee constructed by the Corps of Engineers.

February floodflows washed out about 500 feet of State Route 118 bridge, damaged agricultural property and utilities, and severely damaged flood-control improvements constructed by the Corps of Engineers. … The flood eroded the south bank near the existing Corps levee, damaging some groins; then deflected, ricocheted from the State Route 118 bridge, and returned to the south bank - where the floodflows cut in close to the Corps levee, bounced off to the north bank, and carved a long arch.. The floodflows then deflected to the south bank where they undercut the toe protection on the Corps levee, causing the failure of about 2,000 feet of levee and eroding the ground behind the levee for a distance of about 100 feet."

The estimated peak discharge of the 1969 flood is 165,000 cfs before the gage data adjustment shown in 'Table 1' of the above mentioned 2006 Ventura County Hydrology report. In addition, peak discharges greater than 45,000 cfs since 1938 are listed in Table 3 (below). Of the 12 flows of 45,000 cfs or greater, the 165,000 cfs in 1969 was the largest that has occurred in the 70 year period since 1938.

Table 3 – Annual Peak Discharges [1]

Year	Montalvo [2]
1938	95,000
1943	72,000
1952	45,000
1958	50,000
1969	147,000[3]
1973	58,200
1978	102,200
1980	81,400
1983	100,000
1992	104,000
1998	84,000
2005	136,000

1. Discharge in cfs.
2. Montalvo gage data adjusted through 1993.
3. Actual estimate discharge before gage data adjustment is 165,000 cfs.

The original construction, completed in 1961 contained 40 groins. After the 1969 flood damage, the Corps repaired 7 of the original 40 groins (station 330+00 to station 344+50), restored 2,100 linear feet of levee embankment with deeper rock revetment (station 311+00 to station 332+00), and added 35 additional groins (station 246+00 to station 330+00 and station 421+80 to station 436+80), which were completed in 1971. A total of 75 groins are now in place along the study reach of the SCR from station 246+00 to station 470+00. In December 1985, Ventura County restored 5 groins (between as-built Station 316+45 and Station 356+45, see Figure 3) in the vicinity of the 1969 levee failure location. The damage to the 5 groins was likely due to the low flow channel encroaching and washing out the top portion of the groin tips. No County maintenance records were available to determine when the damage happened. The damages may have been due to the 1983 flood with a peak discharge of 100,000 cfs.

Computer Model Development

Steady-state water surface profiles were computed using the HEC-River Analysis System (HEC-RAS) program version 4.0 (March 2008), developed by the Corps for open channel reaches. The primary basis for the HEC-RAS model input data was the preliminary 2008 FEMA Santa Clara River Flood Insurance Study (FIS) provided by the VCWPD. The FIS HEC-RAS model begins from the Pacific Ocean (RS 20+33) and extends approximately 39.5 miles upstream (northeast) (RS 2100+36). As the application for the preliminary FIS is still being processed by FEMA, it was decided that Tetra Tech would incorporate the FIS review comments by the VCWPD (VCWPD, 2008) into the Levee Certification Study model in order to meet the November 2009 study deadline. Tetra Tech's responses to the comments are included in Attachment A. The main review comments by the County considered for this study were:

- 100-year flow discharge
- Correct "With Levee" condition model
- Debris loading on bridge piers
- Bridge modeling approach for low flow condition
- Split flow condition
- Ineffective flow areas
- Additional cross sections

A discussion of the actions taken for the review comments are included in Attachment A and are discussed throughout this report.

With Levee Model

There exist many sections of non-engineering earthen embankment from the Pacific Ocean to Hwy 101. The "With Levee" condition of the FIS HEC-RAS model assumed these non-engineering earthen embankments would not fail during the flood. This assumption provides a conservative water surface profile from the Pacific Ocean to Highway 101 because no overflow from the channel was allowed during the flood simulation. Therefore, this model was adopted and modified for the SCR-1 Levee Certification hydraulic analysis.

Cross Sections

The FIS HEC-RAS model originally included a total of twenty (20) cross sections along Santa Clara River within the limits of the SCR-1 Levee. For the Levee Certification Study model, twenty-two (22) new cross sections were added to the FIS HEC-RAS model in order to reduce the distances between the original cross sections which were as much as 2,470 feet apart from each other. For the additional cross sections, an existing condition 3D surface was created in Digital Terrain Model (DTM) format based on the County-provided 2005 Bare Earth LIDAR data. Then, the cross sections were cut along the project reach using Microstation InRoad software such that two consecutive original cross sections were not more than 500 feet apart from each other. The locations of the HEC-RAS cross sections (original FIS cross sections and additional cross sections) are shown on Figure 3. The top of levee elevations from 2009 cross sectional survey data were used to verify those from 2005 LIDAR data.

FIS 100-year Discharge

Per the recommendation of the VCWPD's review comments of the preliminary FIS study, the updated FIS 100-year discharge of 226,000 cfs was used for the study instead of the 231,576 cfs, which was the original discharge used for the preliminary FIS study model. (See Attachment A for further discussion.) The 100-year peak discharge of 226,000 cfs was also verified by Tetra Tech through a separate hydrologic evaluation (See Hydrology Appendix D2).

Manning's N-values

Based on the 2008 FIS HEC-RAS model, a Manning's roughness coefficient of 0.035 was used for the active streambed while coefficients ranging from 0.016 to 0.120 were used to represent the overbank areas for the SCR-1 levee reach. The roughness coefficients were also verified during the field inspection in 2008 and using aerial photography.

Debris Loading on Bridges

Bridge piers and culverts have been shown to trap significant amounts of debris during flood flows. "*The Hydrology and Hydraulics Policy Memorandum No. 4*" (Corps, 2004), prepared by the Corps Los Angeles District, was used to establish the debris loadings for the Hwy 101 and Los Angeles Avenue bridge piers. For bridge piers larger than 6-feet in diameter, the memorandum recommends assuming no debris loading on the piers. There are 13 piers at the Highway 101 Bridge. Nine (9) of the 13 piers are 7 feet wide, while the remaining 4 piers are 6 feet wide. There are 14 piers at the Los Angeles Avenue Bridge with a width of 6 feet. The Standard Pacific Railroad (SPRR) Bridge is located approximately 600 feet downstream of the Hwy 101 Bridge and has piers with an average width of 11 feet. Therefore, no debris loadings on the bridge piers were included for the SPRR, Hwy 101, and Los Angeles Avenue Bridges.

Flow Regime

Subcritical flow conditions were selected in the Levee Certification HEC-RAS hydraulic model to analyze the flow characteristics of the Santa Clara River. As flows accelerate to supercritical conditions (i.e., Froude number greater than 1.0), more sediment is entrained that transfers more momentum from the flow core to the boundary. Where flows achieve supercritical flow conditions, the increased sediment movement may excite a mild or minor hydraulic jump to revert the flow to subcritical conditions (i.e., Froude number less than 1.0). A good rule of thumb for soft-bottomed channels and alluvial fan hydraulics is that the Froude number should not exceed 1.0 (Grant, 1997). The subcritical flow regime is also used in the levee revetment rock analysis and scour analysis.

Downstream Reach Boundary Conditions

Critical flow depth was used in the FIS HEC-RAS model as the downstream boundary condition at the Pacific Ocean outlet. The Pacific Ocean is approximately 4.5 miles downstream of the SCR-1 levee; therefore, the influence of the ocean tide is negligible. The same boundary conditions were adopted in the Levee Certification HEC-RAS model.

Levee Analyses

Several analyses have been performed to determine if the SCR-1 Levee is certifiable under FEMA's regulatory requirements as identified in 44 CFR 65.10. These analyses include; a freeboard evaluation, a review of historical aerial photographs, levee revetment toe-down depth evaluation, groin rock size evaluation, rock revetment size evaluation, weighted stone toe evaluation, and scour analysis.

Freeboard Evaluation

FEMA certification requires the height of a levee to include an additional height (freeboard) above the water surface elevation of the 100-year flood event (one percent chance exceedance flood or base flood). The required freeboard is 3 feet according to 44 CFR 65.10 criteria. An additional one foot of freeboard is required for 100 feet upstream/downstream of structures (such as bridges) and 0.5 feet at the upstream end of a levee.

For the SCR-1 Levee, water surface profiles were computed using the Levee Certification HEC-RAS model, described above. Table 4 shows computed channel hydraulics of the 100-year peak discharge based on the subcritical flow regime analysis. Figure 4 depicts the profiles of the top of levee, channel thalweg, and computed 100-year flood water surface along the levee. HEC-RAS computer printouts are presented in Attachment B.

Table 4 – Computed 100-year Channel Hydraulics of SCR-1 Levee

HEC-RAS River Station	Q (cfs)	Channel Thalweg Elevation (ft)	Water Surface Elevation (ft)	Average Channel Velocity (fps)	Top Width (ft)	Hydraulic Depth (ft)	Froude Number
Upstream End of SCR-1 Levee							
493+87	226,000	117.04	134.75	11.72	2261.40	11.78	0.60
488+43	226,000	114.36	133.39	10.89	1937.30	11.54	0.56
484+19	226,000	112.99	132.73	9.62	2650.30	11.84	0.49
478+00	226,000	112.26	131.68	9.24	2371.27	12.84	0.45
471+90	226,000	111.04	131.16	7.43	2361.10	14.14	0.35
465+70	226,000	108.28	130.62	7.50	2108.56	16.61	0.32
459+47	226,000	106.25	129.55	9.49	1831.61	18.28	0.39
452+95	226,000	105.30	128.87	9.27	1780.48	18.17	0.38
Los Angeles Avenue (Hwy 118) Bridge							
448+78	226,000	103.47	126.78	12.04	1370.22	18.00	0.50
443+00	226,000	102.11	125.39	12.43	1149.42	15.82	0.55
437+29	226,000	101.21	123.22	14.02	1034.49	18.45	0.58

Table 4 – Computed 100-year Channel Hydraulics of SCR-1 Levee

HEC-RAS River Station	Q (cfs)	Channel Thalweg Elevation (ft)	Water Surface Elevation (ft)	Average Channel Velocity (fps)	Top Width (ft)	Hydraulic Depth (ft)	Froude Number
430+40	226,000	98.74	121.27	14.35	916.95	17.18	0.61
423+57	226,000	97.54	116.38	18.75	783.55	15.73	0.83
418+40	226,000	96.42	114.29	17.63	864.90	14.82	0.81
413+20	226,000	94.45	112.06	16.62	1067.96	12.73	0.82
407+99	226,000	93.96	111.00	13.45	1282.16	13.13	0.65
401+00	226,000	92.22	109.85	10.87	1630.43	12.75	0.54
394+24	226,000	91.24	108.64	10.34	1781.70	12.39	0.49
387+00	226,000	88.84	107.71	9.25	1712.10	14.26	0.43
379+60	226,000	87.88	106.78	9.14	1817.60	13.78	0.41
374+50	226,000	86.90	106.23	8.84	1812.37	14.11	0.41
369+50	226,000	85.75	105.31	9.73	1658.45	14.00	0.46
364+41	226,000	84.68	103.83	11.38	1448.31	13.93	0.51
359+30	226,000	83.51	102.23	12.34	1487.62	12.32	0.62
354+30	226,000	82.31	100.72	12.58	1550.74	11.58	0.65
349+28	226,000	81.43	99.46	11.52	1638.54	12.92	0.56
342+20	226,000	80.59	97.44	11.43	1654.78	11.95	0.58
335+26	226,000	78.60	95.15	11.00	1801.75	11.51	0.57
330+00	226,000	76.72	92.93	11.44	2007.03	9.84	0.64
324+80	226,000	75.21	91.21	11.25	2119.46	9.48	0.64
319+62	226,000	73.41	89.79	10.53	2365.28	10.29	0.58
314+50	226,000	72.89	88.70	9.38	2567.01	9.39	0.54
309+00	226,000	71.63	87.49	8.92	2640.42	9.60	0.51
303+52	226,000	70.44	86.27	8.76	2714.27	9.88	0.49
296+50	226,000	68.95	84.61	8.92	2772.04	9.14	0.52
289+32	226,000	67.13	83.22	8.30	2924.98	9.67	0.47
282+20	226,000	66.10	81.91	8.04	2744.40	10.24	0.44
275+00	226,000	63.38	79.84	10.21	1915.96	12.35	0.51
269+30	226,000	60.92	78.90	9.32	1969.21	12.32	0.47
263+56	226,000	58.29	78.19	8.45	2152.79	13.08	0.41
257+50	226,000	55.48	77.52	8.19	2081.71	14.10	0.38
251+32	226,000	53.37	76.33	9.45	1895.79	14.71	0.43
Downstream End of SCR-1 Levee/Highway 101 Bridge							

Based on the top of levee elevations presented in Table 2 and water surface elevations calculated in Table 4, the available freeboard at each cross section was determined and summarized in Table 5. The top of levee elevations based on the VCWPD's 2009 survey instead of those from the as-built plans were used for the analysis.

Table 5 – SCR-1 Levee Freeboard Analysis

HEC-RAS River Station	Channel Thalweg Elevation (ft)	Water Surface Elevation (ft)	Top of Levee Elevation (ft)	Freeboard (ft)	
				Actual	Required by FEMA
Upstream End of SCR-1 Levee					
493+87	117.04	134.75	157.27	22.52	3.50

Table 5 – SCR-1 Levee Freeboard Analysis

HEC-RAS River Station	Channel Thalweg Elevation (ft)	Water Surface Elevation (ft)	Top of Levee Elevation (ft)	Freeboard (ft)	
				Actual	Required by FEMA
488+43	114.36	133.39	150.90	17.51	3.00
484+19	112.99	132.73	148.95	16.22	3.00
478+00	112.26	131.68	147.08	15.40	3.00
471+90	111.04	131.16	143.98	12.82	3.00
465+70	108.28	130.62	141.93	11.31	3.00
459+47	106.25	129.55	140.62	11.07	3.00
452+95	105.30	128.87	139.66	10.79	4.00
Los Angeles Avenue (Hwy 118) Bridge					
448+78	103.47	126.78	138.29	11.51	4.00
443+00	102.11	125.39	137.13	11.74	3.00
437+29	101.21	123.22	136.70	13.48	3.00
430+40	98.74	121.27	134.10	12.83	3.00
423+57	97.54	116.38	132.02	15.64	3.00
418+40	96.42	114.29	130.01	15.72	3.00
413+20	94.45	112.06	127.99	15.93	3.00
407+99	93.96	111.00	125.60	14.60	3.00
401+00	92.22	109.85	124.20	14.35	3.00
394+24	91.24	108.64	122.84	14.20	3.00
387+00	88.84	107.71	121.97	14.26	3.00
379+60	87.88	106.78	121.00	14.22	3.00
374+50	86.90	106.23	119.10	12.87	3.00
369+50	85.75	105.31	115.40	10.09	3.00
364+41	84.68	103.83	113.10	9.27	3.00
359+30	83.51	102.23	111.10	8.87	3.00
354+30	82.31	100.72	109.25	8.53	3.00
349+28	81.43	99.46	107.72	8.26	3.00
342+20	80.59	97.44	106.12	8.68	3.00
335+26	78.60	95.15	103.11	7.96	3.00
330+00	76.72	92.93	100.55	7.62	3.00
324+80	75.21	91.21	98.18	6.97	3.00
319+62	73.41	89.79	96.85	7.06	3.00
314+50	72.89	88.70	95.60	6.90	3.00
309+00	71.63	87.49	93.55	6.06	3.00
303+52	70.44	86.27	91.75	5.48	3.00
296+50	68.95	84.61	89.95	5.34	3.00
289+32	67.13	83.22	87.90	4.68	3.00
282+20	66.10	81.91	87.00	5.09	3.00
275+00	63.38	79.84	85.50	5.66	3.00
269+30	60.92	78.90	84.14	5.24	3.00
263+56	58.29	78.19	82.19	4.00	3.00
257+50	55.48	77.52	82.39	4.87	3.00
251+32	53.37	76.33	79.27	2.94	4.00
Downstream End of SCR-1 Levee/Highway 101 Bridge					

Based on Table 5, the computed water surface elevations with respect to the top of levee elevations indicate the top of levee is a minimum of 2.94 feet higher than the 100-year flood event. The levee meets the FEMA freeboard criteria except in the vicinity of the Hwy 101 Bridge. In the area within 100 feet of the upstream side of the bridge, the required freeboard is 4 feet; however, the actual calculated freeboard is only 2.94 feet and is therefore deficient in this reach.

Review of Aerial Photos

Historical aerial photos of 1927, 1942, 1956, 1967, 1975, 1978, 1986, 1989 and 2002 were obtained from the U.S. Geological Survey (USGS) and Earth Data Analysis Center. The left and right channel banks were identified and superimposed onto 2005 aerial photography as shown on Figure 5. The channel limits of pre-levee project, post-levee project to pre-1969 flood, and post-1969 flood are depicted on Figure 5. Prior to the construction of the levee in 1961, upstream of Hwy 118 the floodplain limits were wider than the post-levee conditions. Confinement of the flood flows by the levee, instead of allowing the flows to expand across the floodplain, in the 1969 flood may have contributed to the damage of the Hwy 118 Bridge and other damages cited in the previous section. High flows and velocities of the 1969 flood cut into the north bank and widened the channel downstream of Hwy 118. After the 1969 flood the entire channel reach migrated southeastward toward the levee. Since the 1969 floods the channel has migrated laterally approximately 160 feet and exposed several groins in the vicinity from Hwy 101 to approximately 3,000 feet upstream of Hwy 101.

Several locations show lateral channel movement between the years 2002 and 2005. These may be due to the 2005 flood with a peak discharge of 136,000 cfs. One location upstream of Hwy 118, a 300-foot lateral cut has been carved into the channel bank for a distance of approximately 1,000 feet. At approximately 1,500 feet upstream of Hwy 118, a section of the channel bank has been carved approximately 60 feet towards the levee.

The evaluation of historical aerial photos indicates lateral migration of the main channel has occurred both as a long term trend and also during single large flood events. Based on this evaluation, lateral migration for flood events smaller than the 100-year flow of 226,000 cfs have been significant enough to cause major damage to the levee that jeopardizes its ability to provide 100-year flood protection.

Levee Revetment Toe-down Depth Evaluation

The levee protection of the SCR-1 Levee includes a rock revetment with an average thickness of approximately 18 inches, which extends from the top of embankment to varying depths, based on the as-built plans. A review of the bed thalweg profiles was conducted to determine if there is adequate toe-down to prevent undermining of the levee protection. The adequacy of levee toe-down was initially assessed based on whether the channel thalweg is below the toe-down depth of the levee rock revetment and the burial depth of the groins. The groins are intended to protect the levee by preventing the migrating channel thalweg from directly impinging against the toe of the toe of the rock revetment. Therefore, the stability of the groins is key to protecting the levee. A comparison of the current thalweg elevations versus the 1971 as-built elevations was made to determine if the channel thalweg has exhibited a trend toward aggradation or degradation. This determination was made to assess whether a continuation of historic elevation change trends will increase or decrease the potential for failure of the rock revetment by undermining.

Current versus As-Built Streambed (Thalweg) Comparison

An initial assessment of whether the Santa Clara River is aggrading or degrading was performed by comparing the 1971 as-built thalweg elevation and the current thalweg elevation based on 2005 LIDAR information. The historical streambed profiles presented in Attachment C show the current thalweg of the Santa Clara River is approximately 6 feet lower than the 1971 as-built thalweg elevation in the upstream vicinity of Hwy 101 and then matching approximately 2,500 linear feet upstream. The middle reach along the SCR-1 Levee has experienced either aggradation or degradation ranging from only 1 to 2 feet. In the upstream reach from approximately 3,000 linear feet downstream of Hwy 118 to the upstream side of Hwy 118 the current thalweg of the Santa Clara River is approximately 2 to 5 feet lower than the 1971 as-built thalweg elevation. The Streambed Profiles provided in Attachment C also indicates the current channel thalweg and portions of the 1971 as-built channel thalweg are lower than the groin toe elevation from Station 360+00 and upstream toward the end of the levee system.

The changes of the thalweg elevation have occurred locally not uniformly throughout the entire channel section and the wide bank to bank distance results in insignificant variations of the computed water profiles with similar discharges. The overall reach just upstream of the Hwy 101 Bridge actually indicates aggradation has occurred, possible by the constriction at the bridge crossing. Channel thalweg trends between 1949 and 2005, shown from the Stillwater Science report (2007) titled "*Assessment of Geomorphic Processes for the Santa Clara River Watershed*" also reflects this aggradation.

Levee Revetment Toe-down Depths

The streambed profiles, included in Attachment C, indicate that the channel thalweg is lower than the toe-down of the rock revetment starting at station 335+00 and continuing upstream through the Highway 118 Bridge (approximately station 441+00). For this portion of the levee, it is critical that the groins are adequate to prevent potential lateral migration of the thalweg from contacting the levee. If the thalweg were to impinge upon the levee, failure of the levee by erosion would be likely since the rock revetment would be undermined. However, reviewing the as-built toe-down of the riverward tips of the groin, indicates that between station 360+00 and 392+00, the burial depth of the groin tips is above the current thalweg location. Therefore, migration of the channel thalweg would result in undermining of these groins and would potentially lead to failure of the levee by erosion. In addition, there are no groins installed between stations 392+00 to 421+00.

Based on review of the rock revetment toe-downs (designed to prevent erosion of the levee material) and rock groins (designed to prevent migration of the thalweg to the toe of the levee), determination has been made that there is insufficient burial depth of both features to prevent the erosion of the levee in event the channel thalweg should migrate toward the levee. This condition exists from stations 360+00 to 421+00. The current position of the thalweg in the downstream portion of the study area as well as review of the historic behavior of the channel indicate that the channel thalweg is active and can migrate sufficiently to threaten these areas of inadequate levee protection. Therefore, the levee is considered deficient because of lack of adequate toe-down for erosion protection. It should be noted, that this conclusion was reached without considering the potential for scour at the tips of the groins or the toe of the levee. Scour would further increase the thalweg depth and may result in additional locations to be considered deficient. Scour is evaluated in a later section.

Groin Rock Sizing

The importance of groins, as stated in a previous section, is to deflect the main flows and erosive forces of the river away from the levee embankment. Evaluation of the adequacy of the rock size used to construct the groins was assessed for the levee reach from Station 360+00 to Hwy 101 (Station 249+37). The as-built groin rock size was compared with the computed required groin rock size based on the river hydraulics. The as-built gradation specification of groin and toe stone is presented in Table 6.

Table 6 – As-built Groin and Toe Stone Gradation Specification

Weight (lbs)	Percent of Total by Weight (%)
1,000 to 400	30
400 to 100	40
100 to 10	20
10 or less	10

Channel hydraulics can vary locally in the proximity of the groins, therefore as an initial test, the average channel hydraulics at HEC-RAS station 354+30 (approximate as-built station 344+65) was used in estimating the required groin rock size. The average channel hydraulic parameters included a flow velocity of 12.88 fps and depth of 11.33 feet. The methods used for sizing rock erosion protection presented in EM 1110-2-1601 (Corps, 1994) were assumed for an initial sizing of the rock required for the groins. These methods are utilized as a comparison and may not be appropriate for design. Future design efforts should consider a more detailed analysis to account for hydraulic variations in the proximity of the groins. The Channel Protection Design (CHANLPRO) computer program, based on EM 1110-2-1601 and developed by the Corps Waterway Experiment Station in 1998, was used to compute the minimum groin rock size (see Table 7). Comparison of computed rock size versus the as-built rock size indicates that the as-built groin rock does not meet the current design criteria, and the groin rocks are predicted to be unable to withstand the average channel hydraulics during a 100-year flood event without accounting for anticipated hydraulic variations in the proximity of the groins (Figure 6). For example, comparing the required median rock size from the analysis indicates the need for a D_{50} in the range of 270 to 400 lbs. In contrast, the as-built rock gradation indicates a D_{50} of 30 to 200 pounds.

The results of this evaluation are consistent with the observed damage to the groins from the 1969 and early 1980s flood events where river flows came into direct contact with them. The rock groins were likely damaged due to the rock being too small to resist the hydraulics. It is also possible that the rock groins could have been undermined during the peak flows. During peak flows direct attack from a migrating thalweg can exhibit velocities greater then the channel average further exacerbating the failure potential.

Table 7 – Required Groin Rock Gradations

By Weight (lbs)					
W_{100}		W_{50}		W_{15}	
Max	Min	Max	Min	Max	Min
1,350	540	400	270	200	80
By Size (in)					
D_{100}		D_{50}		D_{15}	
Max	Min	Max	Min	Max	Min
27.0	19.9	18.0	15.8	14.3	10.7

Levee Revetment Rock Size Analysis

On May 6, 2009, Tetra Tech, and their geotechnical sub-consultant AMEC, conducted field reconnaissance and geotechnical investigation along the SCR-1 Levee. Three test pits were excavated (Figure 7) after initial field observations indicated the possibility of poor rock revetment gradation. The subsurface conditions encountered in the test pits generally consisted of 2 to 3 feet of rock revetment material overlying fill material which composed the levee embankment. The thickness of the rock revetment material was as much as 4 feet in limited areas. However, the rock revetment materials were generally composed of eight inch or smaller sized stone, with some material as much as 24 inch diameter, infilled with silty sand. Rock revetment material was predominantly comprised of sandstone with lesser amounts of basalt, and rhyolite. The underlying levee fill material generally consisted of silty sand, silty sand with gravel, and coarse sand with gravel. The estimated gradation of the three test pits are listed in Table 8. The detailed analysis is presented in Attachment D.

Table 8 – Test Pit Revetment Rock Gradation

	Rock Weight (lbs)				
	490	260	40	5.5	1.5
Test Pit	Percent Lighter by Weight				
#1	100.0	85.7	68.7	40.5	3.1
#2	100.0	70.6	35.9	13.2	4.1
#3	100.0	49.9	35.1	24.6	1.4

Two representative HEC-RAS sections were selected for rock revetment size analysis. HEC-RAS Station 354+30 and Station 407+99 were selected based on regions of the high channel flow velocities and for location with respect to the test pits. The average channel hydraulics near the levee toe were computed by HEC-RAS and utilized to determine the required levee rock revetment size. Figures 8 and 9 show velocity distributions of these representative sections were prepared for the 100-year flood event. From the HEC-RAS velocity distributions average flow velocities acting on the levee rock revetment were computed to be 10.29 fps and 12.17 fps and the average hydraulic flow depths were estimated to be 11.40 feet and 11.64 feet for Stations 354+30 and 407+99, respectively. The CHANLPRO computer program was used to determine the required levee revetment rock size as summarized in Table 9. The resulting required diameter ranges of D_{50} are between 10.5 and 12 inches and 14 and 16 inches computed by the CHANLPRO program for Stations 354+30 and 407+99, respectively.

The estimated gradation of the rock revetment observed in the field was plotted alongside the gradation calculated by the CHANLPRO program for the two sections (HEC-RAS Station 354+30 and Station 407+99). Station 354+30 is closest to Test Pits #1 and #2. In general the large revetment rock, D_{60} and higher, sampled in the field at Test Pits #1 and #2, is heavier than the computed rock weights for the hydraulic conditions at Station 354+30. For rock sizes from less than the D_{60} to about the D_{50} Test Pit #1 is slightly larger than the lower bound of the calculated rock size envelope. For the D_{50} to the D_{40} Test Pit #1 material is slightly smaller than the lower bound of the calculated required rock size. For sizes below the D_{40}, Test Pit # 1 is about 50% smaller than the rock required by the lower bound. In contrast, Test Pit #2 sizes remain larger than the upper bound of the required rock size from the D_{100} down to about the D_{20}, where it is equal to the upper bound. The gradation of Test Pit #2 is heavier than the required computed rock size however it is poorly distributed and does not fit within the computed gradation envelope as shown in Figure 10.

Table 9 – Computed Revetment Rock Gradations

By Weight (lbs)

HEC-RAS Station	W_{100}		W_{50}		W_{15}	
	Max	Min	Max	Min	Max	Min
354+30	400	160	120	80	60	20
407+99	950	380	280	190	140	60

By Size (in)

HEC-RAS Station	D_{100}		D_{50}		D_{15}	
	Max	Min	Max	Min	Max	Min
354+30	18.0	13.3	12.0	10.5	9.5	7.1
407+99	24.0	17.7	16.0	14.0	12.7	9.5

The hydraulics and the associated required rock revetment sizes near Test Pit #3 are best represented by those calculated for Station 407+99. The gradation of Test Pit #3 is heavier than the required computed rock size however it is poorly distributed and does not fit within the computed gradation envelope as shown on Figure 11.

The extent of the levee that would have rock revetment similar to Test Pit #1, based on a visual assessment, is approximately 9,000 linear feet from as-built Sta. 262+00 to Sta. 350+00 (near Central Ave Drain) and approximately 7,000 linear feet from Sta. 420+00 to Sta. 490+90 (upstream terminus). Based on the visual assessment the remainder of the levee would have rock revetment similar to Test Pits #2 and #3. Additionally the poor gradation distribution of the field observed rocks from all the test pits may result in the rock being unable to interlock properly. For the reasons stated above the current SCR-1 Levee rock revetment is deemed inadequate to provide 100-year flood protection.

Weighted Stone Toe

In addition to the SCR-1 Levee rock revetment and groins, weighted stone toe protection was placed along the levee toe during construction. The levee revetment stone toe has a dual purpose; 1) to anchor the entire levee length of rock revetment from vertical movement, and 2) to act as launching stone to protect the levee from undermining in the event of scour. Procedures for sizing launching stone toe volumes are presented in EM 1110-2-1601 (Corps, 1994). The launch slope for a non-cohesive soil material is assumed to be 2H: 1V, the thickness after launching is equal to 1.5 times the thickness of the levee rock revetment. Using these assumptions the volume of stone toe required is equal to 3.35 times the thickness of the levee rock revetment times the estimated historic degradation depth (or depth to the measure channel thalweg from the levee toe-down). Table 10 summarizes the stone toe volume analysis for the reach where current channel thalweg elevation is lower than the groin toe elevation.

Table 10 – Stone Toe Volume Analysis

As-Built Station		Historic Degradation Depth[1] (ft)	Type[2] of Weighted Stone Toe	Required Volume[3] (ft^3/ft)	Available Volume[4] (ft^3/ft)	Deficiency (Yes/No)
Upstream	Downstream					
491+75	470+00	18.18	A	121.78	27.64	Yes
470+00	455+00	18.18	A	121.78	27.64	Yes
455+00	443+00	13.77	A	92.29	27.64	Yes
443+00	442+50	9.37	A	62.80	27.64	Yes
442+50	434+00	6.02	A	40.33	27.64	Yes
434+00	425+00	8.89	A	59.57	27.64	Yes
425+00	399+90	8.89	B	59.57	77.64	No
399+90	391+75	8.89	B	59.57	77.64	No
391+75	369+00	13.04	A	87.40	27.64	Yes
369+00	345+00	13.04	A	87.40	27.64	Yes
345+00	335+50	11.00	A	73.71	27.64	Yes

1. Estimated between levee toe-down elevation and current channel thalweg elevation.
2. Stone toe: Type A is an up-side-down triangle (base width of 0 ft and top width of 10 feet); Type B is a trapezoid (base width of 10 ft and top width of 30 feet. The height of the toe stone is 5 ft and the side slope is 2H: 1V.
3. Volume required covering the historic degradation depth with a thickness of 1.5 times the revetment thickness.
4. Available volume based on as-built plan typical section drawings.

The analysis results in Table 10 estimate that the as-built weighted stone toe volume is insufficient, from as-built Sta. 335+50 to Sta. 391+75 and from Sta. 425+00 to Sta. 490+90 to be able to protect the current channel thalweg if it migrated towards the levee, neglecting the influence of scour or future channel degradation.

Scour Analysis

Single-Event scour is normally computed as the sum of general scour, bed-form depth, low-flow incisement, local scour, and bend scour. The following paragraphs describe the estimation of each single-event scour component. (Note that Long-Term scour [i.e., degradation] is typically computed separately and was not included in this assessment.) In general, the calculation of the individual scour components are based on the hydraulic results presented in Table 4.

Estimate of General Scour

The general scour estimated by the procedure in this section is localized and is a temporary form of channel bed degradation that typically occurs during a single flood event. The equation is intended to provide an upper limit on this potential form of scour. It does not represent degradation that can occur over the long term as a result of a continued sediment deficit, such as would occur downstream of a dam. A single-event 100-year flood general scour assessment estimate of general scour was performed using the following equation from Zeller (1981):

$$Z_{gs} = Y_{max}\left[\frac{0.0685V_m^{\ 0.8}}{Y_h^{\ 0.4}S_e^{\ 0.3}} - 1\right]$$

Where:

Z_{gs} = *General scour depth, in feet;*
V_m = *Mean Velocity of flow, in feet per second;*
Y_{max} = *Maximum depth of flow, in feet;*
Y_h = *Hydraulic depth of channel, in feet; and,*
S_e = *Bed slope or Energy slope, in feet per foot.*

When general scour is computed to be negative, it should be assumed that the general scour component is equal to zero.

Bed Form Depth

For the purposes of evaluating an upper envelope for temporary scour that can occur during the passage of flood flows, differentials in streambed gradient associated with channel bed formations is considered. Bed forms are a second type of scour that can occur in sand-bed channels during a flood event. For purposes of evaluating the maximum streambed changes during the passage of a single event, two main bed forms, dunes or anti-dunes, are considered. In general, dunes typically form in lower regime flow (highly subcritical) and anti-dunes develop when flows are upper regime (at or near critical). Essential to properly characterizing the single event scour, a determination was made of the flow regime, either upper or lower. The distinction between flow regimes was made using the applicable charts found in the “Manual on Sedimentation Engineering” (ASCE, 2006).

It is customary to consider the bed form scour component in upper regime flow as one-half of the anti-dune height, from crest to trough. Based on this relationship, an equation was developed (Simons, Li & Associates, 1982). This relationship is:

$$Z_a = \frac{1}{2}(0.14)\frac{2\pi V_m^{\ 2}}{g} = 0.0137V_m^{\ 2}\text{, Upper Regime Flow}$$

Similarly for lower regime flow, one-half of the dune height, from crest to trough, is typically used as the bed form scour component. Again this relationship is visibly present in the equation below (developed by Julien & Klassen, 1995):

$$Z_d = \frac{1}{2}(2.5Y)\left(\frac{D_{50}}{Y}\right)^{0.3} = 1.25Y^{0.7}D_{50}{}^{0.3}$$, Lower Regime Flow

For this reach it was determined from the channel hydraulics that, for the purposes of this investigation, the entire reach can be considered to be in upper regime flow conditions.

Low-Flow Channel Incisement

Low-flow channel incisement is the formation of a low flow channel within the main channel in which low discharges are carried. There is no known methodology for predicting low-flow channel depth. Based on guidance as presented by Zeller (1981), if a low-flow thalweg is predicted to be present, it should be assumed to be at least two feet deep within regional watercourses, unless field observations indicate otherwise.

Local Scour

Local scour is observed whenever an abrupt change in the direction of flow occurs. Abrupt changes in flow direction can be caused by obstructions to flow, such as bridge piers or abrupt constrictions at bridge abutments, and drop structures. For this case two bridges are located within the study reach. Local scour for the HWY 101 bridge was not considered since it is located on the downstream side of the subject reach and not considered to impact the SCR-1 levee. However, the Hwy 118 Bridge is located approximately 5,000 feet from the upstream end of the SCR-1 levee system and consists of 14 circular-shaped piers, each with a diameter of 6 feet. Due to the proximity of the Hwy 118 Bridge to the SCR-1 levee system, local scour due to the presence of bridge piers was considered for this analysis. In accordance with *"The Hydrology and Hydraulics Policy Memorandum No. 4"* (Corps, 2004), prepared by the Corps Los Angeles District, bridge piers larger than 6-feet in diameter, no debris loading is recommended.

The depth of scour at bridge piers is highly dependent upon the shape of the pier. A square-nosed pier causes the deepest scour and is computed from (Richardson et. al., 1975):

$$Z_{lsp} = 2.2Y\left(\frac{b_p}{Y}\right)^{0.65} F_u^{0.43}$$

Where:

Z_{lsp} = *Local scour depth due to pier, in feet;*
Y = *Flow depth, in feet;*
b_p = *Pier width normal to flow direction; in feet; and,*
F_u = *Upstream Froude number.*

Bend Scour

Bend scour normally occurs along the outside of bends, and is caused by spiral, transverse currents which form within the flow as the water moves through the bend. Presently, there is no single procedure which will consistently and accurately predict bend scour over a wide range of hydraulic conditions. However, a relationship was developed by Zeller (1981) for estimating bend scour in sand-bed channels based upon the assumption of the maintenance of constant stream power within the channel bend. This relationship is as follows:

$$\mathrm{Z_{bs}} = \frac{0.0685 Y_{\max} V_m^{\,0.8}}{Y_h^{\,0.4} S_e^{\,0.3}} \left[2.1 \left(\frac{\sin^2(\alpha/2)}{\cos\alpha} \right)^{0.2} - 1 \right]$$

Where:

Z_{bs} = *Bend-scour component of total scour depth, in feet;*
V_m = *Maximum velocity of flow immediately upstream of bend, in feet per second;*
Y_{max} = *Maximum depth of flow immediately upstream of bend, in feet;*
Y_h = *Maximum Hydraulic depth of flow immediately upstream of bend, in feet; and,*
S_e = *Maximum Energy slope immediately upstream of bend (or bed slope for uniform-flow conditions), in feet per foot.*
α = *Angle formed by the projection of the channel centerline from the point of curvature to a point which meets a line tangent to the outer bank of the channel, in degrees.*

The bend scour should be assumed to be zero for bends with deflection angles up to 17.8°. The SCR-1 levee along the Santa Clara River is fairly straight and is flowing between banks during a 100-year flood, therefore, the single 100-year flood event bend scour depth is assumed to be zero (0) feet. It should be noted points of flow impingement that can cause very large scour as the channel thalweg migrates within the larger main channel. This type of behavior was documented during the 1969 flood and was previously described in this report under the section "Levee Damage and Maintenance."

Total Scour

Total scour may be computed as the sum of general scour, bed form (anti-dune trough) depth, low-flow incisement, local scour, and bend scour. Table 11 below shows the maximum total scour as computed for the SCR-1 levied reach.

Table 11 – Total Single Event Scour Summary

Santa Clara River (River Sta.)	General Scour Depth Zgs (ft)	Bed Form Trough Depth Zbf(ft)	Low-Flow Thalweg Depth, Zlft (ft)	Bend Scour Depth Zbs (ft)	Sum of Components ∑Zi	Total Scour Depth Zt = 1.3∑Zi (ft)
423+57	3.3	4.8	2.00	0.00	10.1	13.1

The total computed maximum potential scour, was computed at River Station 423+57, and considers all components, except local scour and is estimated to be 10.1 feet. Multiplying by a safety factor of 1.3 increases the total potential scour depth to 13.1 feet for a single 100-year flood event. At and immediately downstream of the Hwy 118 Bridge, an additional local scour (pier scour) depth of 18.3 feet should be included.

These scour estimates are typically used in the initial design of flood control facilities like the SCR-1 Levee. As stated in the above 'Levee Description' section, the SCR-1 Levee was originally to be designed with 12-feet of rock revetment toe-down below the streambed which is very close to what has been computed here. As documented in the GDM and reflected on the as-built plans, the rock revetment toe-down depths were changed significantly during the design process with the addition of rock groins. As shown on the plan and profile exhibit in Attachment C, the current rock revetment toe-down only provides 5 to10 feet of scour protection from Hwy 101 to as-built Sta. 335+50 and provides no scour protection from Sta. 335+50 to the upstream terminus of the levee at Sta. 490+93. In addition, the rock groins have been buried to a depth of 10 to 15 feet below the streambed from Hwy 101 to Sta. 330+00, then the rock groins lose burial depth gradually from 5-feet at Sta. 332+50 to 0-feet at Sta. 358+00. Upstream of Sta. 358+00 to Sta. 470+00 the rock groins would be undermined if the channel thalweg migrated towards the levee.

Conclusions

Based on the analyses performed in pursuit of compliance with FEMA's regulatory requirements of 44 CFR 65.10, the SCR-1 Levee cannot be certified for the 100-year flood event due to the following reasons:

1. In the area within 100 feet upstream of the Hwy 101 Bridge, the required freeboard is 4 feet; however, the actual calculated freeboard is only 2.94 feet and is therefore deficient in this reach.
2. Based on historical aerial photos and lateral migration evaluation, the Santa Clara River has the potential to erode the river bank and expose the rock revetment and groins during a single large flood event.
3. Current channel thalweg elevation is below the levee rock revetment toe-down elevation along the levee from the 1969 levee failure location (in the vicinity of as-built Station 330+00) to the upstream end of the levee system (Sta. 490+90).
4. Current channel thalweg elevations are lower than the groin toe elevations from Station 360+00 to the upstream end of the levee system (Sta. 490+90).
5. Comparison of computed groin rock size versus the as-built groin rock size indicates the as-built groin rock does not meet the current design criteria for rock sufficiently sized to withstand the predicted hydraulic forces during a 100-year event. The results of this evaluation are consistent with the observed damage to the groins from the 1969 and early 1980s flood events where river flows came into direct contact with the groins and caused portions of the groins to fail.
6. Three test pits were dug to test the rock revetment along the levee sides slopes. Hydraulic calculations were also performed to identify the gradation of the rock required to protect the side slopes in these locations during the 100-year event. The results indicated that the lower portion of the rock gradation, D_{40} and finer, at Test Pit #1 is smaller than the lower bound of the required rock size. The extent of the levee that would have rock revetment similar to the undersized rock from Test Pit #1, based on a visual assessment, is approximately 9,000 linear feet from as-built Sta. 262+00 to Sta. 350+00 (near Central Ave Drain) and approximately 7,000 linear feet from Sta. 420+00

to Sta. 490+90 (upstream terminus). Based on the visual assessment the remainder of the levee would have rock revetment similar to Test Pits #2 and #3 which have poorly distributed gradations. Additionally the poor gradation distribution of the field observed rocks from all the test pits may result in the rock being unable to interlock properly.

7. The as-built weighted stone toe volume is insufficient by a factor of 3, from as-built Sta. 335+50 to Sta. 391+75, to be able to protect the current scour depth if the channel thalweg migrated towards the levee.
8. The rock groins were intended to prevent the channel from migrating against the levee side slopes. As a result of the groin placement, and the design intent of preventing the channel thalweg from contacting the levee slope, the levee slope protection toe-down was not designed for the condition of the channel thalweg impinging on the levee toe. However, the rock groins are not adequate to prevent the migration of the channel for two reasons:
    a. The rock groins are undersized to withstand the hydraulic forces of the 100-year flood event.
    b. The rock groins for much of their length are not buried sufficiently to prevent failure due to undermining.
9. Since the rock groins are insufficient to prevent migration of the channel thalweg against the levee side slope, the levee to remain stable must resist the hydraulic forces and scour that would occur with the thalweg against the toe of the levee. However, the levee protection is not adequate to resist the resulting forces and scour for several reasons:
    a. The estimated maximum potential total scour depth of 13.1 feet below the existing channel thalweg during a 100-year flood would undercut the entire levee rock revetment toe-down.
    b. The additional volume of material placed as the weighted stone toe is insufficient to launch and protect the levee against the current scour depth from the toe-down.
    c. Based on three test pits, the size of the riprap blanket on the levee side slope is suspect in terms of its size at some locations and in terms of the quality of the gradation at others.
10. The inadequacy of the current configuration of levee protection has been demonstrated by past failures of the system. The levee failed in the 1969 floods with a peak discharge of 165,000 cfs, which is only 73% of the 100-year discharge of 226,000 cfs that is required for certification.

References

ASCE, 2006, *Sedimentation Engineering: Theory, Measurements, Modeling, and Practice,* Hardcover, 424 pages.

County of Ventura, 2008. *Review of 2008 FEMA Santa Clara River Flood Insurance Study for City of Fillmore.* Ventura County Watershed Protection District, California.

County of Ventura, 1985, *Santa Clara River Groin Repair*, Public Works Agency, Ventura County Flood Control District.

County of Ventura, December 2006, *Santa Clara River 2006 Hydrology Update, Phase I, From Ocean to County Line*, Ventura County Watershed Protection District.

County of Ventura, December 2008, *Review of 2008 FEMA Santa Clara River Flood Insurance Study for City of Oxnard*, prepared by RBF Consulting and Kasraie Consulting for Ventura County Watershed Protection District.

Gordon E. Grant, February 1977, *Critical Flow Constrains Flow Hydraulics in Mobile-bed Streams: a New Hypothesis*, Water Resources Research, Vol. 33, No. 2, Pages 349-358.

Julien, P. Y., and Klaassen, G. J. (1995) *Sand-dune geometry of large rivers during floods.* J. Hydraul. Eng., 121 (9), 657–663.

Simons, Li and Associates, Inc., Sept. 30, 1983, *Hydraulic, Erosion and Sedimentation Study of the Santa Clara River,* Ventura, California.

U.S. Army Corps of Engineers, 1958, *Santa Clara River Basin, California: Santa Clara River Levee, Design Memorandum No. 2 (General Design),* Los Angeles District, California.

U.S. Army Corps of Engineers, 1961, *Santa Clara River Levee, Plans for Construction of Levee and Appurtenances,* Los Angeles District, California.

U.S. Army Corps of Engineers, June 1968, *Flood Plain Information, Santa Clara River (Saticoy to Pacific Ocean)*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1969, *Floods in Southern California during January and February, 1969*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1971, *Santa Clara River Levee, Levee and Channel Restoration Project*, Los Angeles District, California.

U.S. Army Corps of Engineers, 1994, *Engineering and Design - Hydraulic Design of Flood Control Channels, Engineering Manual 1110-2-1601*, Department of the Army, Washington D.C., 183 p.

U.S. Army Corps of Engineers, 1998, *User's Manual for CHANLPRO*, PC Program for Channel Protection Design, Waterways Experiment Station, Vicksburg, MS.

U.S. Army Corps of Engineers, August 2005, *Hydrology and Hydraulics Policy Memorandum No. 4, Debris Loading on Bridges and Culverts,* Los Angeles District, California.

U.S. Army Corps of Engineers, March 2008, *HEC-RAS River Analysis System*. Hydrologic Engineering Center. Davis, California.

Zeller, M. E., 1981, *Scour Depth Formula for Estimation of Toe Protection Against General Scou*r, Pima County Department of Transportation and Flood Control District, Tucson, Arizona.

Attachments

Attachment A.	County's Review Comments on the Preliminary FIS Study and Tetra Tech's Response
Attachment B.	HEC-RAS Results
Attachment C.	Plan and Profile Exhibit
Attachment D.	Geotechnical Investigation Report by AMEC (including Test Pit Data)

Figure 1 – Santa Clara River Levee (SCR-1) Vicinity Map

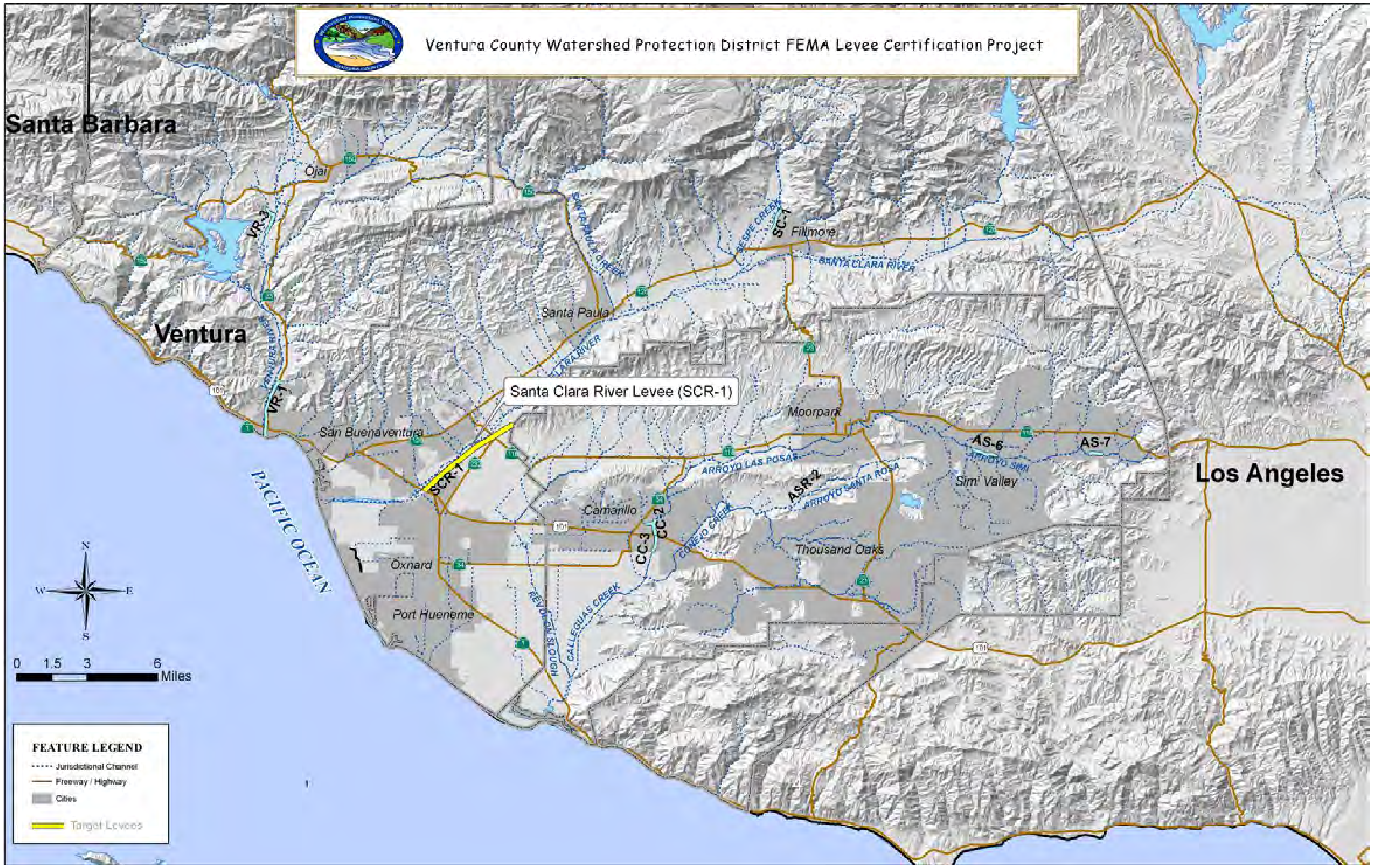


Figure 2 – Santa Clara River Levee (SCR-1) Location Map

Figure 3 – Location Map of HEC-RAS Cross Sections

Figure 4 – Computed 100-year Water Surface Profile along SCR-1 Levee

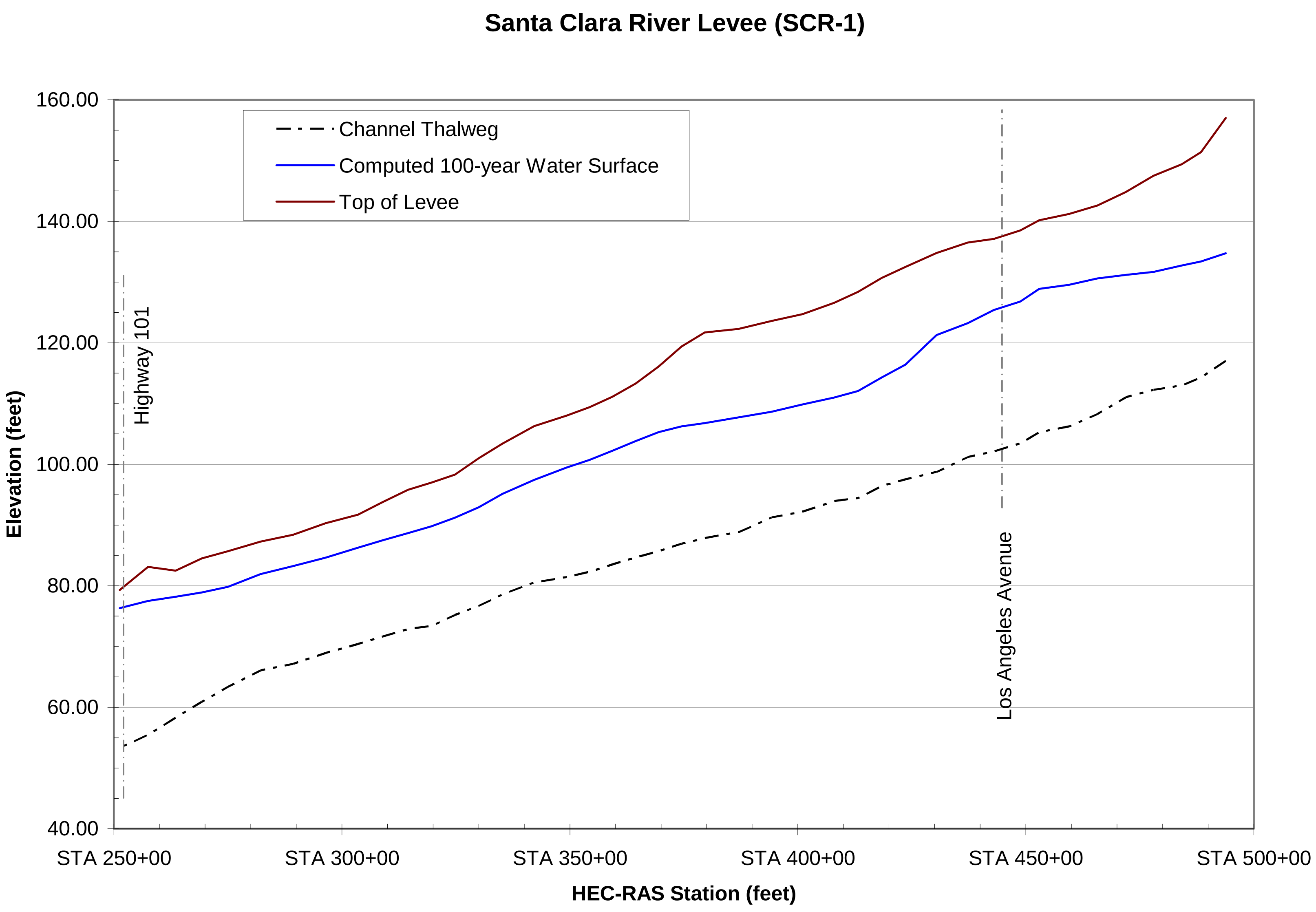


Figure 5 – Historical Lateral Migration of Santa Clara River, based on Aerial Photos

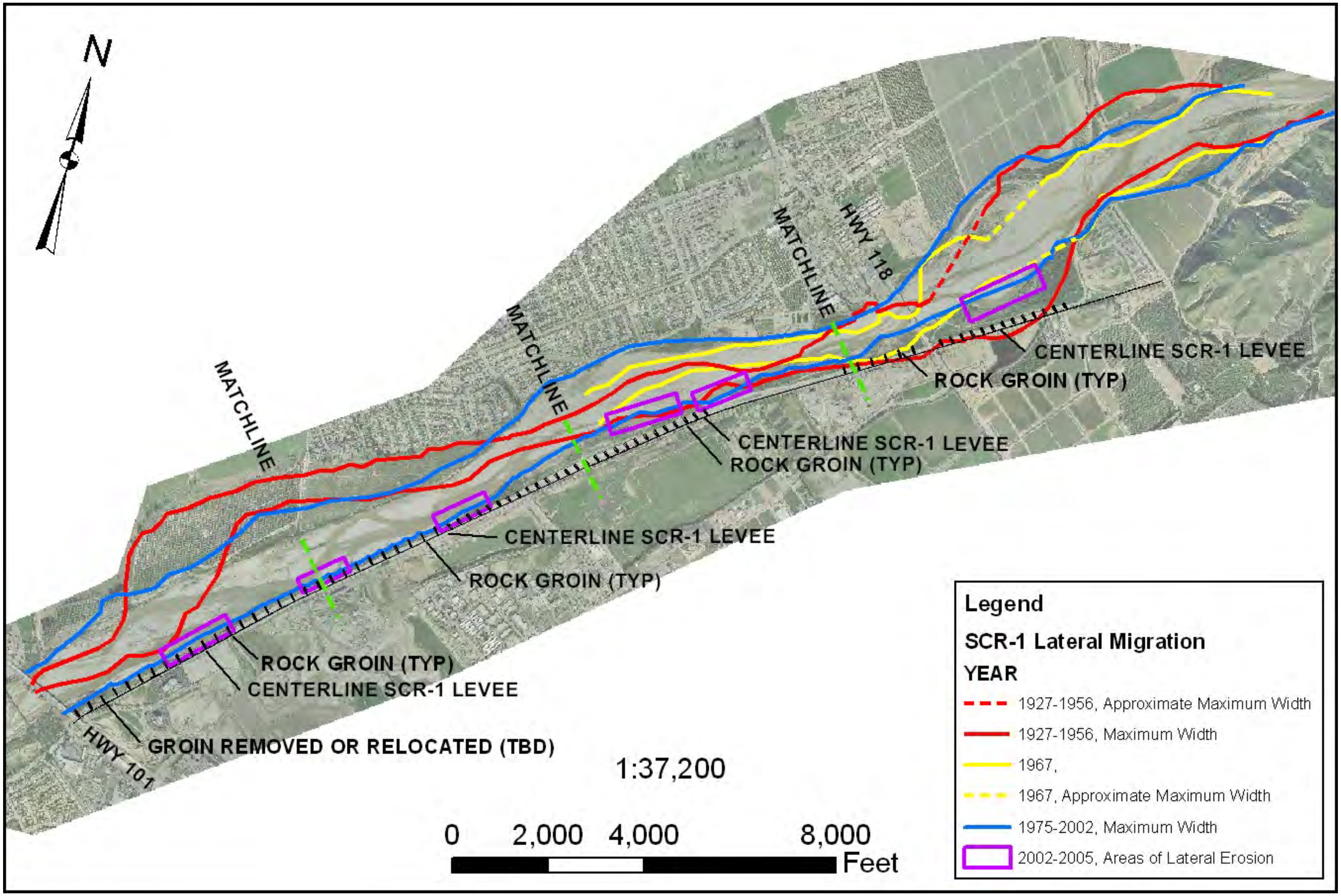


Figure 6 – Santa Clara River Levee (SCR-1) Groin Stone Gradation Comparison

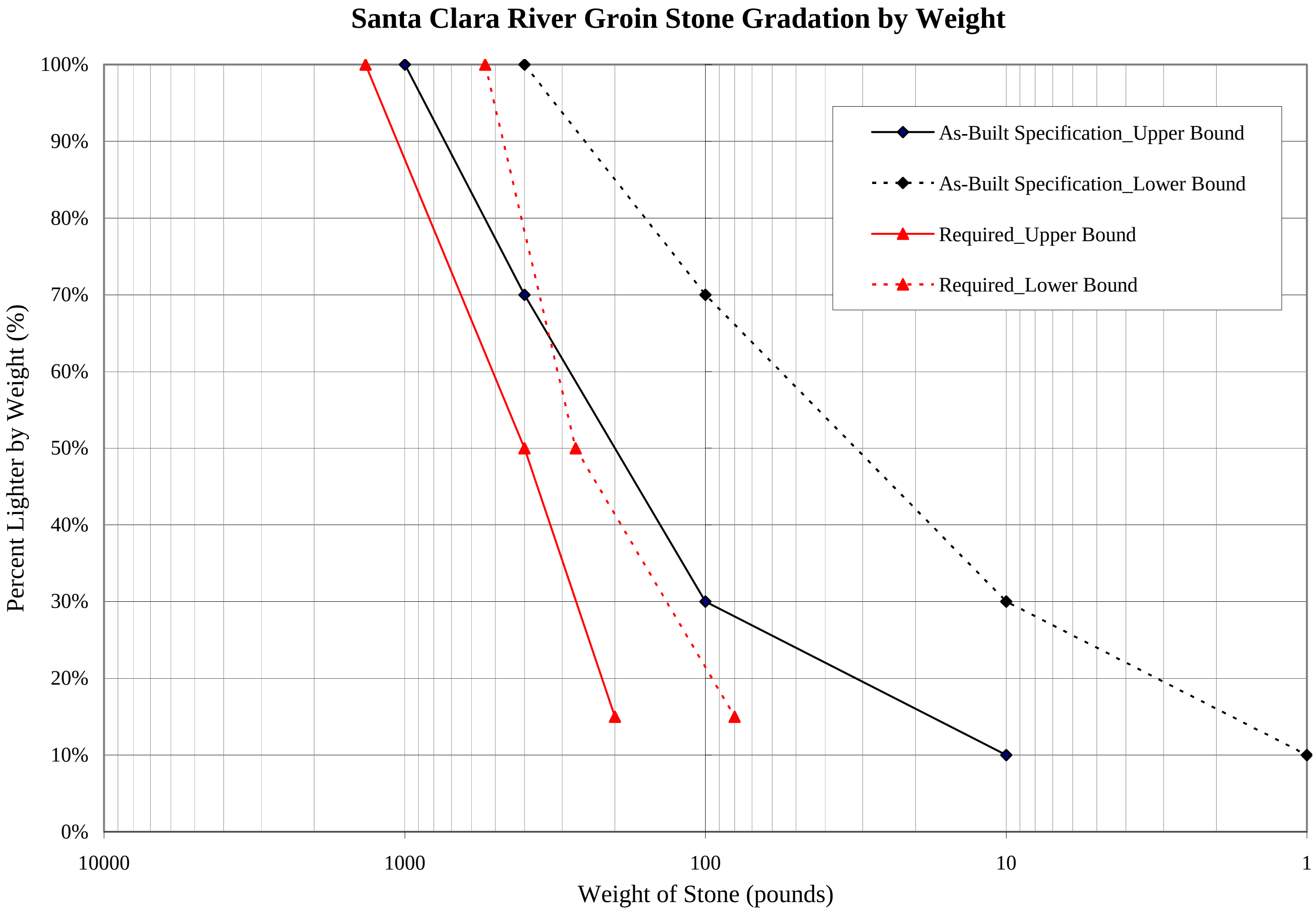


Figure 7 – Test Pit Location Map for Levee Rock Revetment Analysis

Figure 8 – Velocity Distribution of HEC-RAS Station 354+30

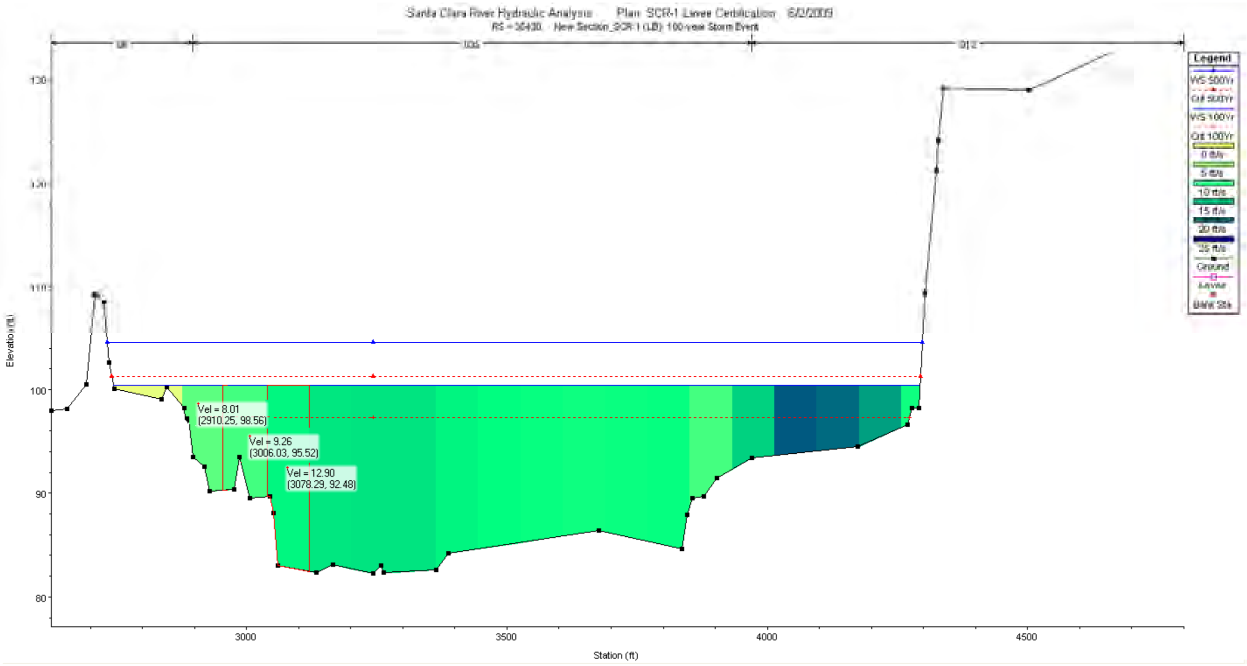


Figure 9 – Velocity Distribution of HEC-RAS Station 407+99

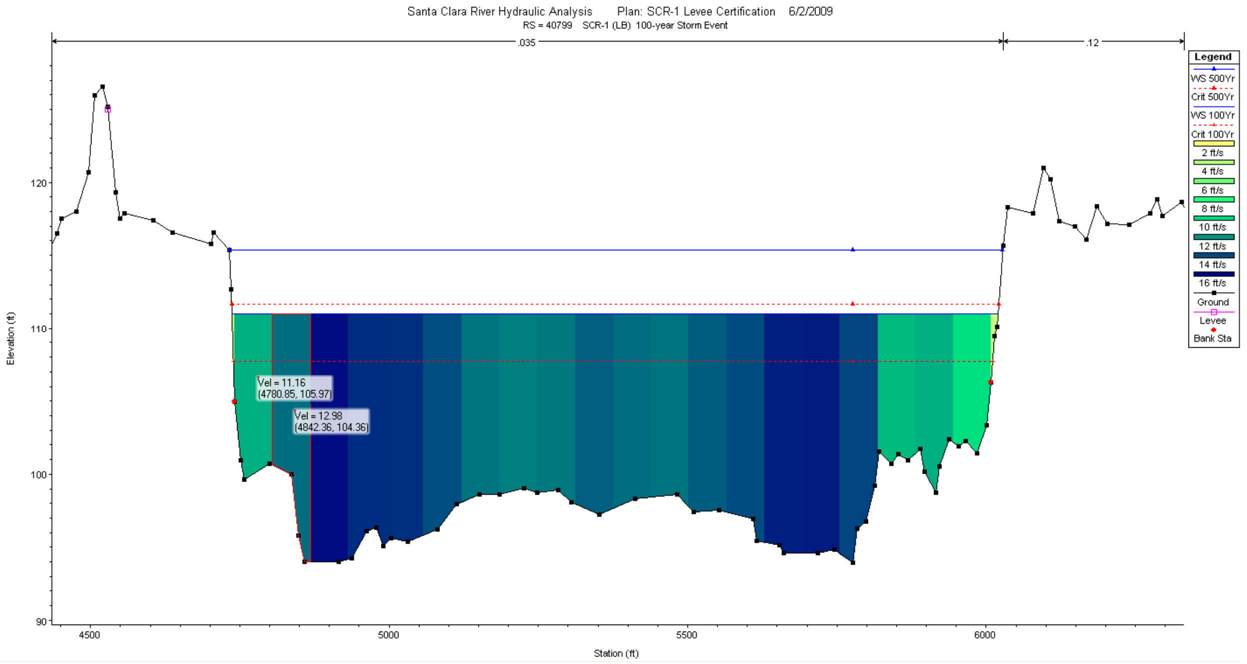


Figure 10 –Rock Revetment Gradation near Test Pits # 1 & 2

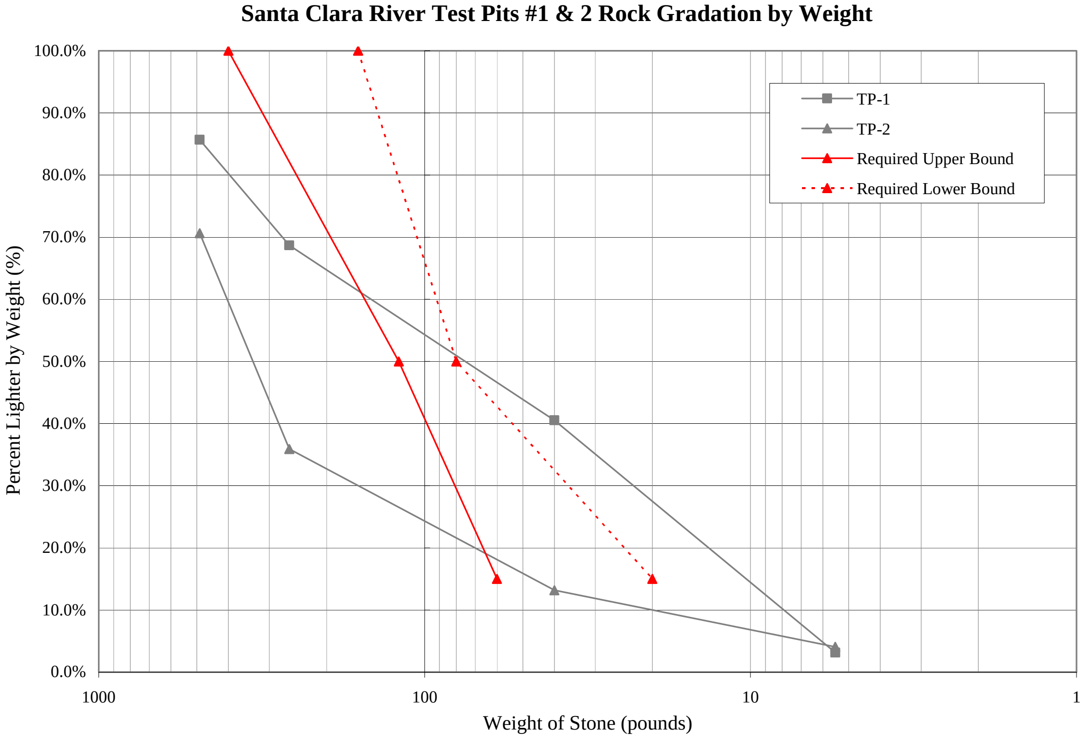


Figure 11 – Rock Revetment Gradation near Test Pit # 3

Attachment A

County's Review Comments on the Preliminary FIS Study
and
Tetra Tech's Response

2008 FEMA Santa Clara River FIS Review Comments by the Ventura County and Responses by Tetra Tech

Introduction

The Ventura County (County) has reviewed the Technical Support Data Notebook (TSDN) for Santa Clara River associated with the preliminary 2008 Santa Clara River Flood Insurance Study (FIS). Then, the review comments were submitted to FEMA for consideration during the approval process of the FIS. After consulting the County, Tetra Tech, which is currently conducting the Levee Certification Study for the Santa Clara Rive Levee (SCR-1), decided to incorporate the review comments into the levee certification Study model in order to meet the November 2009 PAL deadline.

The County's review comments are shown below in *Black*, while the Tetra Tech's responses are shown within parenthesis and in *Blue*. The heading number of each paragraph corresponds to the number in the County's report. Only the review comments that concerned the hydraulic modeling approaches of SCR-1 levee were discussed below. Also, the discussion of how these were incorporated into the Levee Certification Study is included in the Hydraulics Report.

2.1.1 Santa Clara River

A. **Hydrology.** The basis for the peak flow hydrology for the Santa Clara River is the VCWPD's December 2006 Flood Flow Frequency (FFF) analysis. This technique is a FEMA-approved standard procedure for gauged watersheds, and because the streamgage record naturally includes debris and sediment (bulking), it is somewhat conservative compared with clear flow rainfall-runoff hydrology, which FEMA also approves for this purpose.

   Even though a detailed review of the hydrology was not in the current scope of work, the following observations are made:

   a) The FFF analysis for the Santa Clara River streamgage at Highway 101 (Montalvo) omitted the 1995 peak flow of 110,000-120,000 cfs. This issue was researched further by VCWPD in order to verify the peak flow record for this reach of the Santa Clara River. VCWPD provided the following explanation: "USGS did not have a record and the record of VCWPD was not QA/QCed. Bulletin 17B allows the omission of such missing record unless it was caused by extreme events directly." Therefore, the total 100-year peak flow rate of 226,000 cfs will not be modified.

   b) FEMA's mapping contractor has used a 'transfer equation' in order to further refine the peak flow variation in the hydraulic model. Consequently, within the Oxnard plain reach of the River from the Ocean to Highway 118, the projected 100-year flow of 226,000 cfs has been increased to 231,576 cfs. Use of the 'transfer equation' is unnecessary as the local watershed protection district has historically used the same peak flow for the entire reach of the Santa Clara River, as the local smaller drainage areas peak hours before the Santa Clara River.

   c) FEMA's MT-2 Form Section F states that, bulked flows shall not be used for Base Flood Elevation mapping. The standard flood flow frequency analysis typically includes bulking because the analysis is based on actual stream gage record. Map IX-Mainland provided the following explanation in regards to bulked flows during the November 6, 2008 meeting held at VCWPD Offices: "... the result of hydrologic analysis used for this restudy provided by VCWPD was based on frequency analysis of gauge data and does not include a bulking factor. Also, Jeff Pratt of the County emphasized that the result of the gauge data analysis (Bulletin #17 Frequency analysis) does not include any bulking factor and therefore, the peak discharges should not be reduced since the data collected at the gauge instrument includes debris and sediment. FEMA's Guidelines and Specifications does not recommend a bulking factor for the purposes of a flood insurance study unless it is requested by an agency or a community in writing to add a bulking factor to the computed discharges. In addition, the MAP IX staff explained that the item of the bulking factor listed in the MT-2 form is for map revisions involving the design of facilities (Dams, Channels, etc.) that may want to consider a bulking factor. It was agreed that the hydrologic modeling for this restudy will not be adjusted for the consideration of bulking."

d) As explained in the following sections, for the overbank floodplain areas of the Oxnard plain, a volume-based two-dimensional unsteady flow modeling approach is recommended, along with a one-dimensional steady flow model to validate the results. Therefore, the overbank floodplain analysis will require a series of hydrographs in addition to the peak flows.

(As suggested in part (b), the updated 100-year peak discharge of 226,000 cfs was used instead of 231,576 cfs. The calculation of the updated discharge was obtained from Table 3 (the excerpt shown below) of the County’s “Santa Clara River 2006 Hydrology Update, Phase 1, from Ocean to County Line”. The value was also verified by Tetra Tech through a separate hydrologic evaluation. (See the Hydrology Appendix Report))

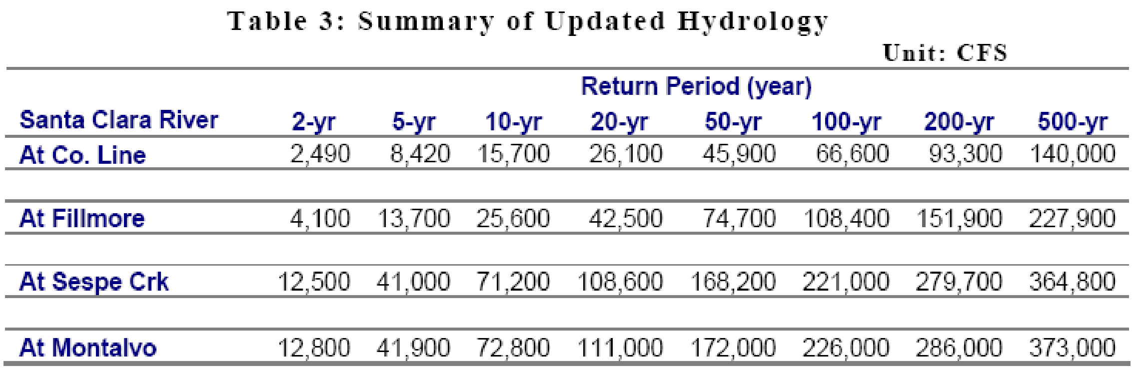


Table 3: Summary of Updated Hydrology

Unit: CFS

	Return Period (year)							
Santa Clara River	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
At Co. Line	2,490	8,420	15,700	26,100	45,900	66,600	93,300	140,000
At Fillmore	4,100	13,700	25,600	42,500	74,700	108,400	151,900	227,900
At Sespe Crk	12,500	41,000	71,200	108,600	168,200	221,000	279,700	364,800
At Montalvo	12,800	41,900	72,800	111,000	172,000	226,000	286,000	373,000

B. General Hydraulic Modeling issues. The US Army Corps of Engineers one-dimensional River Analysis System model (HEC-RAS) has been used extensively for all the natural riverine, overbank areas, and urban drainage facilities. Even thought this is the de facto hydraulic modeling tool available today, it does not lend itself well to analyzing overland floodplain situations such as what might happen in the Oxnard plain during a 100-year flood event.

The HEC-RAS models provided by FEMA's mapping contractor for the Santa Clara River are for two 'with levee' and 'without levee' conditions, along with the split flow option (Lateral Weir) along Gonzales Road. The floodways are also analyzed for the 'without levee' condition. This is a good approach, except that the mapping contractor has used the same levee-related approach in areas where technically an engineered levee does not exist, and any earthen embankment placed along the river by the farmers is treated as an engineered levee-like structure.

Perhaps, a hybrid approach (combined with and without levee model) may make better sense, by treating an engineered levee as a 'with levee', but assume no levee exists where the pile of dirt along the river's top of bank is not an engineered structure built to the COE levee standards, and no public agency maintains it.

The US Army Corps of Engineers (COE) levee from Highway 101 to 5000' upstream of Highway 118 is a real 'levee' since it is an engineered levee structure, designed and built to the COE levee design standards, and it is operated and maintained by the VCWPD within a public right-of-way.

However, many sections of the south top of bank from the Ocean to Highway 101 do not constitute as a levee, and should not be labeled and modeled as such. As shown in the enclosed Comment Tracking Matrix spreadsheet tables, many elements of the hydraulic models have been reviewed and commented on. The following presents an overall impression of these comments, but it is not meant to replace the detailed technical review comments.

(The ‘With Levee’ plan of the FIS HEC-RAS was used as basis of the levee certification study hydraulic model. This plan includes non-engineered earthen levees which would not meet FEMA’s levee requirements. However, this plan was still selected because the current levee setup of the plan would provide the most conservative water surface elevation through out the SCR-1 levee reach.)

C. **Debris on Piers.** Contrary to Map IX's intent to analyze the bridges with no debris on piers (unobstructed flow), several bridges do include 4 feet of debris on each pier. This situation happened because Map IX utilized the old FIS HEC-2 model or Ventura County's HEC-RAS model bridge information in certain cases, not realizing that those other models had included 4' of debris on piers.

The FEMA mapping contractor indicated that bridge analysis should be done for an unobstructed flow condition', and FEMA concurred with that during an October 6, 2008 Conference Call.

(The Levee Certification Study HEC-RAS model will not consider any debris loading on bridge piers.)

D. **Bridge Modeling.** The HEC-RAS model offers many Bridge Modeling Approaches. It is recommended that all applicable options be selected for the bridge analysis and let HECRAS choose the 'highest energy' low flow solution instead of forcing the computer to choose the momentum solution. This would apply to the 10, 50, and 100-year flow conditions. The 500-year flow will most likely be a high flow condition (with downstream submergence) and should probably be run separately from the other storm frequencies. This way the most appropriate approach will be applied to the correct flow condition (energy or pressure/weir).

The following summarizes the recommended low flow methods and the corresponding coefficients for the Highest Energy:

Highway 118 Bridge:	Energy	Momentum (1.2)	Yarnell (0.9)
Highway 1 01 Bridge:	Energy	Momentum (1.2)	Yarnell (0.9)
Railroad Bridge:	Energy	Momentum (1.39)	Yarnell (1.05)
Victoria Ave. Bridge:	Energy	Momentum (1.2)	Yarnell (0.9)
Harbor Blvd. Bridge:	Energy	Momentum (1.39)	Yarnell (1.05)

Use of the Highest Energy makes sense because the 100-year water surface elevation for the bridges seem to be below the low chord elevation, so low flow is the dominant condition for flows 100-year and smaller.

The energy method accounts for friction losses and changes in geometry through the bridge, and for flow transitions and turbulence 'through use of contraction & expansion losses. Pier losses may not be so severe and predominant since no additional debris is added.

The bridge geometry and internal bridge cross-section will also need to be revised to reflect the correct bridge deck, abutment, and pier configuration, and skew factor in the case of the Highway 101 Bridge.

It is estimated that the Highway 101 Bridge has a 15-20 degree skew, which translates into a 3-6% reduction in the bridge top width and flow area.

(The as-built plans were reviewed to verify whether the bridges were correctly modeled. Bridge modeling approaches for low flow condition were revised per recommendation above.)

E. **Split Flow**. An important element of the HEC-RAS model is its ability to estimate amounts of water that will leave a river system, once the river capacity is exceeded. The split flow is analyzed through the use of 'lateral structure or weir', whereby the depth and energy of water leaving the river over the lateral weir is balanced against the depth and energy of water in the river at the point of separation. FEMA's current project has treated the area between Gonzales Road and the Santa Clara River as the left bank of the River (over 5000' wide), with Gonzales Road acting as a split flow 'lateral weir'. This concept produces a very large overflow area south of Gonzales Road, which is several feet deep. This area was originally shown as a 6-square mile yellow 'approximate 100-year floodplain' on the May 2008 workmaps, but it was revised later on to a smaller blue 'approximate 100-year floodplain' area on the July 2008 revision. The different map was prepared by accounting for more accurate Gonzales Road improvement plans and as-built road elevations. However, both analyses are essentially the same, with the latter model producing a smaller lateral weir flow over Gonzales Road with a smaller inundation area south of it.

The most significant change to the floodplains in Oxnard (south of the Railroad Bridge) might come about by placing the 'lateral weir' or 'split flow' designation on the Santa Clara River's south (left) top of bank at the river's edge. This approach involves estimating the magnitude of the split flows leaving the Santa Clara River and analyzing a series of overbank floodplains through Oxnard independent from the main Santa Clara River. The recommended approach makes better sense in that the split flows leaving the Santa Clara River will likely flow in a southwesterly direction away from the River and they will not return to the main Santa Clara River channel, thus producing a more reasonable and realistic overbank floodplain.

(No action will be taken because the current FIS model setup would result in the most conservative water surface elevations.)

F. **Ineffective Flow Areas.** Areas of a floodplain where flow is not actively conveyed such as ponded inundation areas with flow velocity close to zero are typically modeled as an 'ineffective flow area'. The current FEMA models have used this feature extensively, however in certain areas, the ineffective flow area definitions require adjustment. Some examples include cross-sections where the ineffective flow designation is below ground, through the main channel, etc. Several of such inaccuracies are spelled out in the technical review comments.

(No action will be taken because the current FIS model setup would result in the most conservative water surface elevations.)

Additional Consideration. The maximum distance between two cross-sections is 3,705 feet and minimum distance between two cross-sections is 124 feet. Topographic data for the entire Santa Clara River is needed if additional cross-sections are required.

(The FIS HEC-RAS model originally included a total of twenty (20) cross sections along Santa Clara River within the limits of the SCR-1 Levee. For the Levee Certification Study model, twenty-two (22) new additional cross sections were added to the FIS HEC-RAS model in order to reduce the distances between the original cross sections which were as much as 2,470 feet apart from each other in one location. For the additional cross sections, an existing condition 3D surface was created in a Digital Terrain Model (DTM) format based on the County-provided 2005 LIDAR data. Then, the cross sections were cut along the project reach using Microstation InRoad software so that two consecutive original cross sections were not more than 500 feet apart from each other.)

Attachment B

HEC-RAS Results

HEC-RAS Plan: SCR-1LC   River: SantaClaraRiver   Reach: SantaClaraRiver   Profile: 100Yr

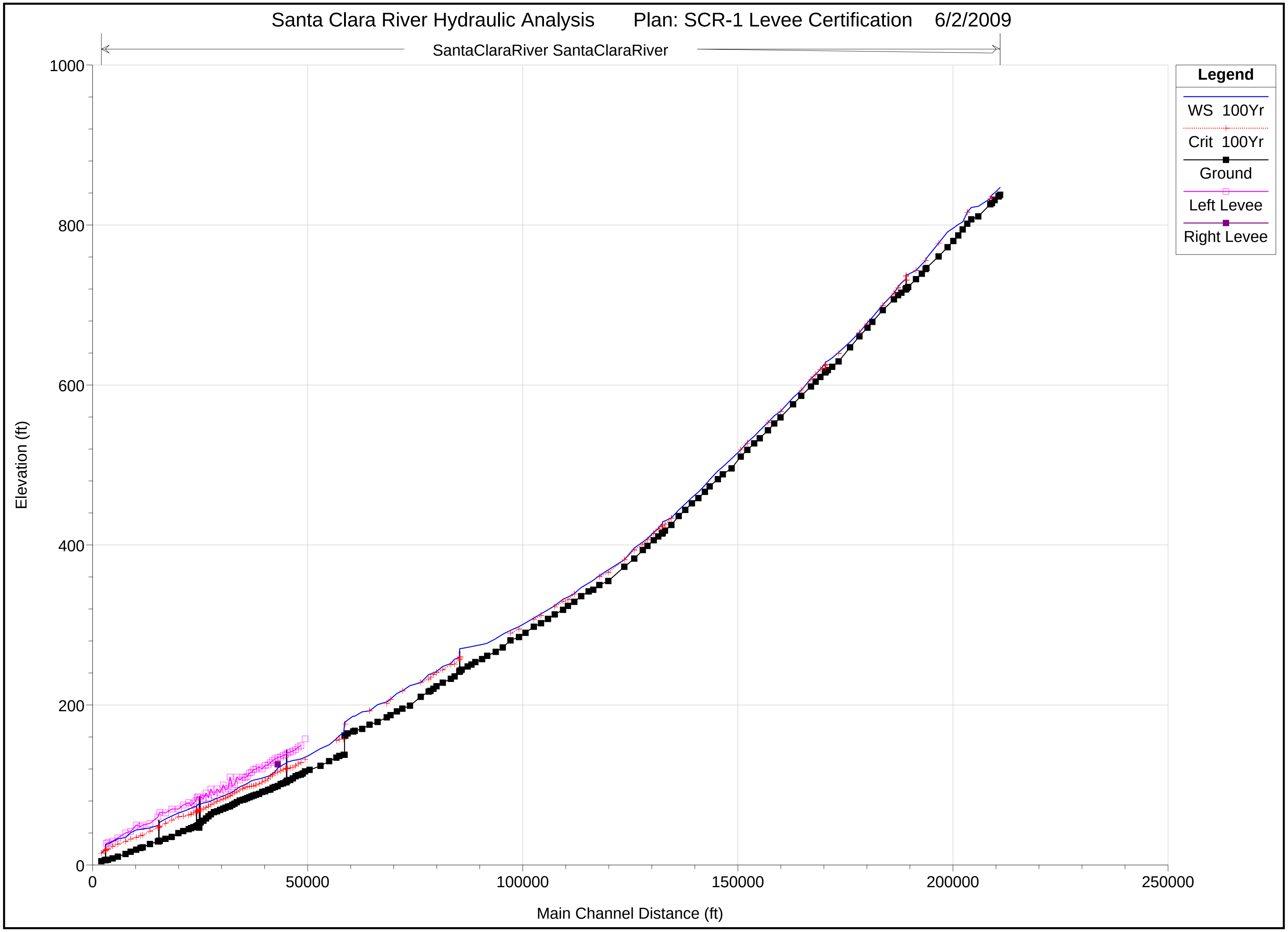
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SantaClaraRiver	210036	100Yr	66600.00	837.76	846.87		848.02	0.005211	8.95	8420.51	1315.26	0.61
SantaClaraRiver	209761	100Yr	66600.00	836.32	845.24		846.65	0.004568	9.78	7600.26	1181.43	0.65
SantaClaraRiver	209637	100Yr	66600.00	835.66	844.89		846.10	0.003504	8.98	8147.45	1234.31	0.59
SantaClaraRiver	208766	100Yr	66600.00	831.02	840.25		842.36	0.005080	11.68	5759.09	738.48	0.73
SantaClaraRiver	208119	100Yr	66600.00	827.40	837.43	835.54	838.38	0.006259	8.46	8940.55	1460.45	0.58
SantaClaraRiver	207726 TBD	100Yr	66600.00	825.97	833.00	833.00	834.98	0.011924	11.64	6397.94	1648.19	0.95
SantaClaraRiver	204958	100Yr	66600.00	810.79	823.32		824.36	0.001687	8.35	8865.60	1048.99	0.44
SantaClaraRiver	204269	100Yr	66600.00	807.09	821.83		822.49	0.000732	6.38	10310.49	760.36	0.30
SantaClaraRiver	203330	100Yr	68644.00	801.63	815.90	815.90	820.26	0.013293	17.28	4456.15	568.14	0.93
SantaClaraRiver	202257	100Yr	68644.00	794.51	803.69		805.48	0.005036	11.33	8123.56	1625.08	0.73
SantaClaraRiver	201236	100Yr	68644.00	786.92	800.66		801.52	0.002752	8.20	11858.40	1890.26	0.47
SantaClaraRiver	200095 TBD	100Yr	68644.00	779.92	796.14		797.80	0.003796	11.52	9391.58	1450.67	0.58
SantaClaraRiver	198770	100Yr	68644.00	772.23	791.31		792.36	0.004154	8.46	8702.41	713.61	0.40
SantaClaraRiver	196662	100Yr	68644.00	760.75	777.29	777.29	780.28	0.008120	16.25	7942.82	1368.23	0.74
SantaClaraRiver	193817	100Yr	68644.00	746.13	758.28		759.97	0.003023	10.52	6923.56	862.47	0.60
SantaClaraRiver	193629	100Yr	71076.00	744.96	755.73	755.73	759.00	0.006595	15.49	5364.97	882.59	0.88
SantaClaraRiver	192767	100Yr	71076.00	739.01	750.84		751.90	0.002175	8.27	8641.69	971.48	0.48
SantaClaraRiver	191396	100Yr	71076.00	732.27	743.28	743.28	746.49	0.008123	15.37	5300.71	807.67	0.86
SantaClaraRiver	189592 TBD	100Yr	71076.00	722.52	738.25		739.40	0.001582	8.68	8633.40	895.13	0.42
SantaClaraRiver	189246 TBD	100Yr	71076.00	720.99	737.90	731.33	738.80	0.001207	7.86	9679.80	940.84	0.37
SantaClaraRiver	189115 New Hall Bridge		Bridge									
SantaClaraRiver	189005 TBD	100Yr	71076.00	719.45	732.09	730.51	735.23	0.004953	14.33	5376.53	654.23	0.76
SantaClaraRiver	188028 TBD	100Yr	71076.00	715.43	727.61		730.41	0.004576	13.48	5436.79	625.53	0.73
SantaClaraRiver	187235	100Yr	71076.00	712.19	722.62	721.50	725.32	0.009551	13.42	5803.98	789.15	0.78
SantaClaraRiver	186276	100Yr	71076.00	707.02	714.98	714.61	717.32	0.007158	12.52	6656.82	1487.62	0.85
SantaClaraRiver	183682	100Yr	71076.00	693.57	700.24	699.42	701.49	0.005068	9.27	8703.55	2131.91	0.70
SantaClaraRiver	181262	100Yr	71076.00	678.90	684.49		685.47	0.008904	8.17	9630.88	3480.39	0.78
SantaClaraRiver	180132	100Yr	71076.00	671.66	678.20	677.11	678.88	0.004021	6.72	11894.70	3670.53	0.59
SantaClaraRiver	178251	100Yr	71076.00	660.84	665.71	665.71	667.20	0.010626	10.40	7612.49	2897.04	0.96
SantaClaraRiver	176080	100Yr	71076.00	647.13	653.83		654.53	0.002965	7.03	11010.60	2508.48	0.54
SantaClaraRiver	173417	100Yr	140769.00	629.36	640.67	639.55	642.86	0.005396	11.93	12580.98	2494.78	0.76
SantaClaraRiver	171940	100Yr	140769.00	622.72	633.80		635.72	0.004263	11.49	15062.29	2613.12	0.69
SantaClaraRiver	170917	100Yr	140769.00	618.56	630.00		631.61	0.003637	10.35	15222.65	2159.09	0.62
SantaClaraRiver	170439	100Yr	140769.00	617.10	628.81	625.76	630.10	0.002259	9.30	17058.72	2302.41	0.53
SantaClaraRiver	170342 Torrey Road		Culvert									
SantaClaraRiver	170241	100Yr	140769.00	615.79	626.42	624.74	628.38	0.003996	11.40	13790.44	2086.82	0.68
SantaClaraRiver	169167	100Yr	140769.00	609.97	619.68	619.31	622.59	0.006801	14.20	12031.48	1986.79	0.86
SantaClaraRiver	168073	100Yr	140769.00	604.20	613.46	613.09	615.77	0.005452	12.65	12609.42	2554.38	0.78
SantaClaraRiver	167006	100Yr	140769.00	598.09	608.04	606.96	610.17	0.004980	12.00	13937.71	2402.88	0.74
SantaClaraRiver	164728 TBD	100Yr	140769.00	586.41	593.48	593.47	595.68	0.008386	12.18	13010.27	3307.44	0.90
SantaClaraRiver	162851 TBD	100Yr	140769.00	575.95	584.19		585.29	0.003712	8.63	18522.29	4185.38	0.60
SantaClaraRiver	159921	100Yr	140769.00	559.45	567.00	566.82	569.13	0.008898	11.75	12070.56	2612.86	0.94
SantaClaraRiver	158449	100Yr	140769.00	551.89	561.36		562.42	0.002560	8.72	18447.56	2866.24	0.54
SantaClaraRiver	156996	100Yr	147130.00	543.39	553.17	553.04	556.15	0.007779	14.13	11855.18	2381.52	0.89
SantaClaraRiver	155099	100Yr	147130.00	533.45	543.14		544.28	0.004721	9.10	18460.95	3429.69	0.64
SantaClaraRiver	153815	100Yr	147130.00	527.08	536.00		537.79	0.005303	11.33	16924.85	4076.82	0.73
SantaClaraRiver	152211	100Yr	147130.00	518.91	528.44	527.25	530.13	0.004306	10.81	15760.98	3136.06	0.69
SantaClaraRiver	150650	100Yr	147130.00	510.41	518.87	518.87	521.19	0.007846	14.28	13241.40	2899.33	0.91
SantaClaraRiver	148547	100Yr	147130.00	495.83	507.96		508.95	0.003328	8.45	20226.60	3350.31	0.55
SantaClaraRiver	146490	100Yr	147130.00	488.44	497.75		499.84	0.006025	12.02	13943.54	2579.56	0.80
SantaClaraRiver	145337	100Yr	147130.00	482.25	492.58		493.80	0.004236	10.11	20019.97	3874.20	0.66
SantaClaraRiver	143450	100Yr	147130.00	473.30	481.68		483.75	0.006761	12.66	15098.58	3027.16	0.85
SantaClaraRiver	142330	100Yr	147130.00	466.49	474.62		475.97	0.006770	10.69	19578.77	4962.44	0.80
SantaClaraRiver	140835	100Yr	147130.00	458.57	466.14		466.78	0.005339	8.34	25767.22	5938.29	0.65
SantaClaraRiver	139312	100Yr	147130.00	452.08	459.29		459.81	0.003931	8.17	28887.15	6312.95	0.61
SantaClaraRiver	137762	100Yr	147130.00	443.85	451.32		452.10	0.006443	7.48	21623.52	5936.76	0.63
SantaClaraRiver	136265	100Yr	147514.00	436.20	443.83		444.73	0.003885	8.73	22440.95	5097.24	0.63
SantaClaraRiver	134555	100Yr	150057.00	425.12	433.77	433.56	435.25	0.008348	10.34	17594.33	5230.56	0.84
SantaClaraRiver	133055	100Yr	150057.00	418.02	430.06	425.89	430.83	0.001391	7.17	22142.81	5286.01	0.41
SantaClaraRiver	132544	100Yr	150057.00	415.19	429.16	423.70	430.09	0.001314	7.78	19493.89	4667.24	0.40
SantaClaraRiver	132465 Chambersbugh Roa		Bridge									
SantaClaraRiver	132358	100Yr	150057.00	414.40	426.58	423.43	427.10	0.001234	6.84	32012.31	4968.78	0.38
SantaClaraRiver	131495	100Yr	150057.00	410.73	420.65	420.04	424.09	0.007297	14.88	10093.90	3788.67	0.89
SantaClaraRiver	130431	100Yr	150057.00	406.06	415.98	414.37	417.07	0.004921	8.43	18234.26	4337.73	0.61
SantaClaraRiver	128972	100Yr	150057.00	398.90	407.99	406.41	409.06	0.006150	8.34	18343.23	4117.82	0.61
SantaClaraRiver	127913	100Yr	150057.00	393.72	403.75	400.86	404.41	0.003156	6.55	23452.66	4884.00	0.44
SantaClaraRiver	125927	100Yr	150057.00	383.00	396.21	393.64	397.22	0.004154	8.51	19895.76	4612.85	0.54
SantaClaraRiver	123597	100Yr	150927.00	372.80	381.47	381.47	383.66	0.008546	12.09	13597.92	4098.26	0.91
SantaClaraRiver	119892	100Yr	199937.00	355.00	368.91	365.89	369.68	0.002079	7.48	33652.14	6073.00	0.44
SantaClaraRiver	117806	100Yr	199937.00	350.00	361.65	360.40	362.83	0.005842	8.90	24358.86	6145.02	0.64
SantaClaraRiver	116400	100Yr	199937.00	344.00	355.84		356.36	0.003525	5.87	35428.54	6848.35	0.43
SantaClaraRiver	115329	100Yr	199937.00	342.00	352.33		352.80	0.003110	5.51	37108.71	6422.94	0.39
SantaClaraRiver	113592	100Yr	199937.00	336.00	346.79		347.35	0.003162	6.04	34204.93	6210.97	0.43
SantaClaraRiver	111978	100Yr	199937.00	329.00	339.28	338.67	340.72	0.005363	10.59	25352.07	6725.28	0.74
SantaClaraRiver	110496	100Yr	199937.00	323.97	334.80	331.64	335.83	0.002137	8.23	25185.92	5382.12	0.49
SantaClaraRiver	109374	100Yr	202328.00	319.05	332.26	329.41	333.32	0.002348	8.65	27920.04	4172.56	0.51
SantaClaraRiver	107433	100Yr	202328.00	313.24	324.12	322.61	326.55	0.005415	12.75	16643.03	3713.41	0.76
SantaClaraRiver	105875	100Yr	202328.00	307.54	318.97		319.93	0.003028	8.02	27432.71	4446.03	0.51
SantaClaraRiver	104236	100Yr	202328.00	302.31	313.99	311.76	315.10	0.002855	8.65	26397.45	4763.48	0.55
SantaClaraRiver	102556	100Yr	202328.00	297.81	308.65	306.86	309.90	0.003353	9.56	25809.27	5068.25	0.60
SantaClaraRiver	100635	100Yr	202328.00	290.22	302.64		303.49	0.003242	7.40	27352.82	3886.63	0.49
SantaClaraRiver	99130	100Yr	203747.00	284.98	298.00	295.00	298.75	0.003029	6.96	29701.74	4228.94	0.45
SantaClaraRiver	97139	100Yr	203747.00	280.71	293.30	289.75	294.21	0.001767	7.77	28666.24	3997.57	0.45
SantaClaraRiver	95357	100Yr	203747.00	271.90	288.49		289.93	0.003342	9.75	22161.91	2567.33	0.53
SantaClaraRiver	93720	100Yr	203747.00	266.41	282.80		284.50	0.003264	10.56	20640.54	2788.80	0.61
SantaClaraRiver	91724	100Yr	203747.00	261.49	277.19		278.65	0.002584	9.73	21642.84	2367.63	0.53
SantaClaraRiver	90545	100Yr	204908.00	257.41	275.52		276.31	0.001346	7.20	29697.10	2893.75	0.38

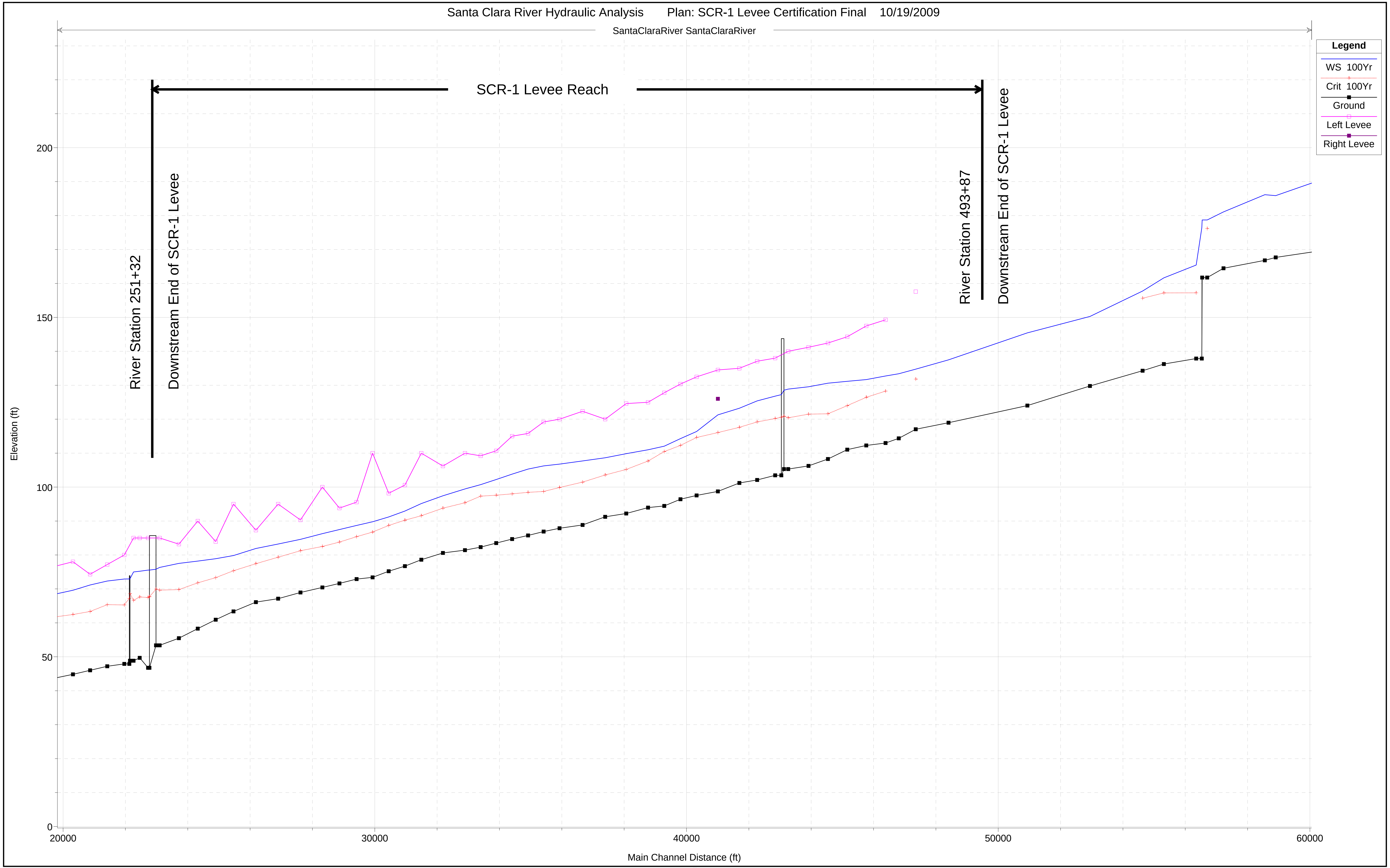
HEC-RAS Plan: SCR-1LC River: SantaClaraRiver Reach: SantaClaraRiver Profile: 100Yr (Continued)

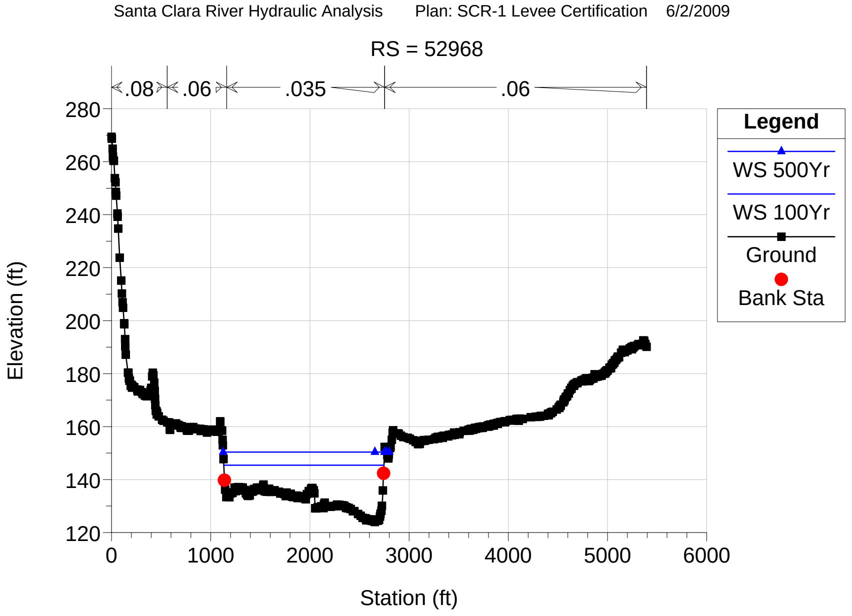
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SantaClaraRiver	88978	100Yr	205198.00	253.65	273.91		274.61	0.000869	6.77	31018.58	2458.13	0.32
SantaClaraRiver	88076	100Yr	205198.00	250.52	272.97		273.79	0.000917	7.38	29047.54	2283.39	0.33
SantaClaraRiver	87179	100Yr	205198.00	248.13	272.12		272.86	0.001124	6.94	30350.47	2219.56	0.30
SantaClaraRiver	85813 TBD	100Yr	214494.00	244.13	270.59		271.53	0.000827	8.29	28770.04	1892.14	0.33
SantaClaraRiver	85449	100Yr	214494.00	242.98	270.37	259.95	271.26	0.000566	8.15	30931.01	2070.70	0.30
SantaClaraRiver	85333 S Mountain Road		Bridge									
SantaClaraRiver	85238	100Yr	214494.00	241.62	259.48	256.69	263.76	0.003942	16.64	13005.80	1424.96	0.74
SantaClaraRiver	84161	100Yr	214494.00	235.75	257.18	251.15	259.06	0.002731	11.14	21852.32	2121.07	0.49
SantaClaraRiver	83266	100Yr	214494.00	232.75	251.82	250.57	255.84	0.004209	16.65	16197.30	2497.95	0.76
SantaClaraRiver	81401	100Yr	214494.00	227.82	248.16	244.04	249.82	0.002053	11.04	27428.21	4471.56	0.50
SantaClaraRiver	79959	100Yr	214494.00	223.44	241.88	240.53	245.54	0.004171	15.89	17197.88	2643.61	0.75
SantaClaraRiver	79239	100Yr	214494.00	220.37	240.12	238.12	242.20	0.003808	12.07	22356.68	3235.33	0.65
SantaClaraRiver	78538	100Yr	214494.00	217.68	238.69	234.09	239.99	0.002162	9.34	27295.94	3113.82	0.47
SantaClaraRiver	78125	100Yr	214494.00	216.73	237.93	232.26	239.21	0.001658	9.39	29122.79	3249.99	0.44
SantaClaraRiver	76272	100Yr	215776.00	210.19	228.03	228.03	233.46	0.006138	19.07	13214.65	1696.61	0.88
SantaClaraRiver	73761	100Yr	215776.00	199.07	224.24		225.60	0.001242	9.69	27625.25	2941.60	0.41
SantaClaraRiver	72002	100Yr	221211.00	195.38	217.71	217.71	221.60	0.004371	16.80	17805.00	2667.43	0.76
SantaClaraRiver	70738	100Yr	221211.00	192.02	214.46		216.80	0.002116	12.81	21935.21	2628.41	0.55
SantaClaraRiver	69270	100Yr	221211.00	187.23	207.49	207.16	212.27	0.004284	18.00	14720.16	2201.97	0.78
SantaClaraRiver	68384	100Yr	221211.00	184.64	203.88	201.84	207.59	0.005711	15.54	15075.40	2079.54	0.76
SantaClaraRiver	66258	100Yr	221211.00	178.78	200.50		201.38	0.001413	8.03	36643.64	4924.34	0.37
SantaClaraRiver	64389	100Yr	221211.00	175.36	192.58	192.58	196.55	0.005035	16.66	16904.52	3775.48	0.81
SantaClaraRiver	62677	100Yr	221211.00	170.05	191.44		192.17	0.000946	7.55	40292.79	4361.12	0.35
SantaClaraRiver	60936	100Yr	221211.00	167.67	185.88		188.94	0.004112	15.05	19843.42	3048.68	0.73
SantaClaraRiver	60586	100Yr	221211.00	166.80	186.14		187.44	0.001991	10.04	29810.41	3354.96	0.47
SantaClaraRiver	59260	100Yr	221211.00	164.47	181.07		183.53	0.004448	13.60	20788.93	2417.58	0.67
SantaClaraRiver	58738	100Yr	221211.00	161.73	178.71	176.17	181.13	0.004686	13.15	19089.23	2359.44	0.66
SantaClaraRiver	58571		Inl Struct									
SantaClaraRiver	58384	100Yr	221211.00	137.86	165.43	157.24	166.93	0.001354	9.91	23097.20	1511.52	0.41
SantaClaraRiver	57346	100Yr	221211.00	136.25	161.64	157.20	164.55	0.002829	13.96	17634.38	1741.39	0.59
SantaClaraRiver	56665	100Yr	221876.00	134.28	157.75	155.64	162.03	0.004405	16.80	14499.87	1685.24	0.77
SantaClaraRiver	54977	100Yr	221876.00	129.79	150.27		153.78	0.005149	15.04	14769.77	1351.44	0.80
SantaClaraRiver	52968	100Yr	221876.00	124.01	145.44		147.13	0.002001	10.44	21260.84	1614.81	0.51
SantaClaraRiver	50439	100Yr	221876.00	118.97	137.48		140.36	0.003609	13.64	16292.00	1327.76	0.68
SantaClaraRiver	49387	100Yr	226000.00	117.04	134.75	131.82	136.73	0.002855	11.72	21703.49	2261.40	0.60
SantaClaraRiver	48843	100Yr	226000.00	114.36	133.39		135.22	0.002542	10.89	20946.96	1937.30	0.56
SantaClaraRiver	48419	100Yr	226000.00	112.99	132.73	128.28	134.17	0.001923	9.62	23499.36	2650.30	0.49
SantaClaraRiver	47800	100Yr	226000.00	112.26	131.68	126.45	132.98	0.001806	9.24	25819.63	2371.27	0.45
SantaClaraRiver	47190.	100Yr	226000.00	111.04	131.16	123.99	132.01	0.001063	7.43	31257.84	2361.10	0.35
SantaClaraRiver	46570.	100Yr	226000.00	108.28	130.62	121.60	131.47	0.000727	7.50	31909.12	2108.56	0.32
SantaClaraRiver	45947 TBD	100Yr	226000.00	106.25	129.55	121.49	130.88	0.001051	9.49	26214.75	1831.61	0.39
SantaClaraRiver	45295	100Yr	226000.00	105.30	128.87	120.42	130.18	0.001082	9.27	25663.08	1780.48	0.38
SantaClaraRiver	45084 Los Angeles Aven		Bridge									
SantaClaraRiver	44878	100Yr	226000.00	103.47	126.78	120.19	129.02	0.001900	12.04	19228.92	1370.22	0.50
SantaClaraRiver	44300.	100Yr	226000.00	102.11	125.39	119.20	127.79	0.002183	12.43	18185.17	1149.42	0.55
SantaClaraRiver	43729	100Yr	226000.00	101.21	123.22	117.61	126.26	0.002525	14.02	16452.65	1034.49	0.58
SantaClaraRiver	43040.	100Yr	226000.00	98.74	121.27	116.07	124.47	0.002621	14.35	15752.09	916.95	0.61
SantaClaraRiver	42357	100Yr	226000.00	97.54	116.38	114.62	121.84	0.004993	18.75	12093.65	783.55	0.83
SantaClaraRiver	41840.	100Yr	226000.00	96.42	114.28	112.29	119.11	0.004821	17.63	12815.81	864.90	0.81
SantaClaraRiver	41320.	100Yr	226000.00	94.45	112.04	110.46	116.34	0.005232	16.64	13580.98	1067.93	0.82
SantaClaraRiver	40799	100Yr	226000.00	93.96	110.97	107.69	113.79	0.003235	13.47	16797.00	1282.10	0.65
SantaClaraRiver	40100.	100Yr	226000.00	92.22	109.81	105.19	111.66	0.002174	10.91	20712.73	1628.32	0.54
SantaClaraRiver	39424	100Yr	226000.00	91.24	108.58	103.57	110.24	0.001874	10.39	21964.97	1780.52	0.50
SantaClaraRiver	38700.	100Yr	226000.00	88.84	107.63	101.47	108.98	0.001411	9.31	24280.29	1711.63	0.44
SantaClaraRiver	37960	100Yr	226000.00	87.88	106.67	99.87	107.98	0.001248	9.21	24848.45	1804.78	0.42
SantaClaraRiver	37450.	100Yr	226000.00	86.90	106.11	98.71	107.34	0.001177	8.91	25355.62	1808.09	0.42
SantaClaraRiver	36950	100Yr	226000.00	85.75	105.16	98.46	106.66	0.001479	9.84	22973.43	1652.84	0.47
SantaClaraRiver	36441	100Yr	226000.00	84.68	103.62	98.02	105.68	0.002267	11.54	19863.56	1446.78	0.52
SantaClaraRiver	35930.	100Yr	226000.00	83.51	101.80	97.61	104.34	0.002850	12.78	17690.43	1481.86	0.65
SantaClaraRiver	35430.	100Yr	226000.00	82.31	100.46	97.33	103.03	0.002381	12.88	17553.07	1549.32	0.67
SantaClaraRiver	34928	100Yr	226000.00	81.43	99.46	95.39	101.52	0.003113	11.52	19785.48	1638.54	0.56
SantaClaraRiver	34220.	100Yr	226000.00	80.59	97.44	93.79	99.47	0.002667	11.43	19774.60	1654.78	0.58
SantaClaraRiver	33526	100Yr	226000.00	78.60	95.15	91.57	97.03	0.004639	11.00	20573.06	1801.75	0.57
SantaClaraRiver	33000.	100Yr	226000.00	76.72	92.93	90.24	94.97	0.003320	11.44	19758.42	2007.03	0.64
SantaClaraRiver	32480.	100Yr	226000.00	75.21	91.21	88.70	93.17	0.003508	11.25	20089.64	2119.46	0.64
SantaClaraRiver	31962	100Yr	226000.00	73.41	89.79	86.75	91.49	0.002760	10.53	21924.60	2365.28	0.58
SantaClaraRiver	31450.	100Yr	226000.00	72.89	88.70	85.38	90.07	0.002407	9.38	24104.54	2567.01	0.54
SantaClaraRiver	30900.	100Yr	226000.00	71.63	87.49	83.80	88.73	0.002331	8.92	25339.67	2640.42	0.51
SantaClaraRiver	30352	100Yr	226000.00	70.44	86.27	82.50	87.45	0.002258	8.76	26004.80	2714.27	0.49
SantaClaraRiver	29650.	100Yr	226000.00	68.95	84.61	81.25	85.84	0.002321	8.92	25336.93	2772.04	0.52
SantaClaraRiver	28932	100Yr	226000.00	67.13	83.22	79.35	84.28	0.001915	8.30	27475.03	2924.98	0.47
SantaClaraRiver	28220.	100Yr	226000.00	66.10	81.91	77.43	82.92	0.001864	8.04	28103.57	2744.40	0.44
SantaClaraRiver	27500	100Yr	226000.00	63.38	79.84	75.35	81.45	0.002063	10.21	22407.11	1915.96	0.51
SantaClaraRiver	26930.	100Yr	226000.00	60.92	78.90	73.32	80.25	0.001871	9.32	24261.16	1969.21	0.47
SantaClaraRiver	26356	100Yr	226000.00	58.29	78.19	71.79	79.30	0.001268	8.45	27088.44	2152.79	0.41
SantaClaraRiver	25750.	100Yr	226000.00	55.48	77.52	69.81	78.56	0.001095	8.19	27594.08	2081.71	0.38
SantaClaraRiver	25132	100Yr	226000.00	53.37	76.33	69.66	77.72	0.001330	9.45	23917.76	1895.79	0.43
SantaClaraRiver	24937 Ventura Blvd		Bridge									
SantaClaraRiver	24761	100Yr	226000.00	46.75	75.55	67.47	76.78	0.001220	8.92	25443.69	1530.42	0.38
SantaClaraRiver	24494	100Yr	226000.00	49.68	75.21	67.64	76.46	0.001131	9.50	28200.75	1938.05	0.38
SantaClaraRiver	24293	100Yr	226000.00	48.84	74.99	66.61	76.16	0.001074	8.77	26450.40	1963.02	0.37
SantaClaraRiver	24174 UPRR		Bridge									
SantaClaraRiver	23999	100Yr	226000.00	47.91	72.92	65.28	74.40	0.001586	10.26	25155.31	3142.57	0.41
SantaClaraRiver	23450.	100Yr	226000.00	47.20	72.33	65.37	73.37	0.001363	8.47	35163.69	3439.99	0.38
SantaClaraRiver	22900.	100Yr	226000.00	46.01	71.16	63.35	72.02	0.005040	7.88	35949.19	3968.53	0.34
SantaClaraRiver	22350	100Yr	226000.00	44.82	69.61	62.46	70.71	0.001353	8.77	35085.80	3327.28	0.38
SantaClaraRiver	21062	100Yr	226000.00	42.38	67.03	60.88	68.66	0.001803	10.72	31216.98	3619.24	0.45

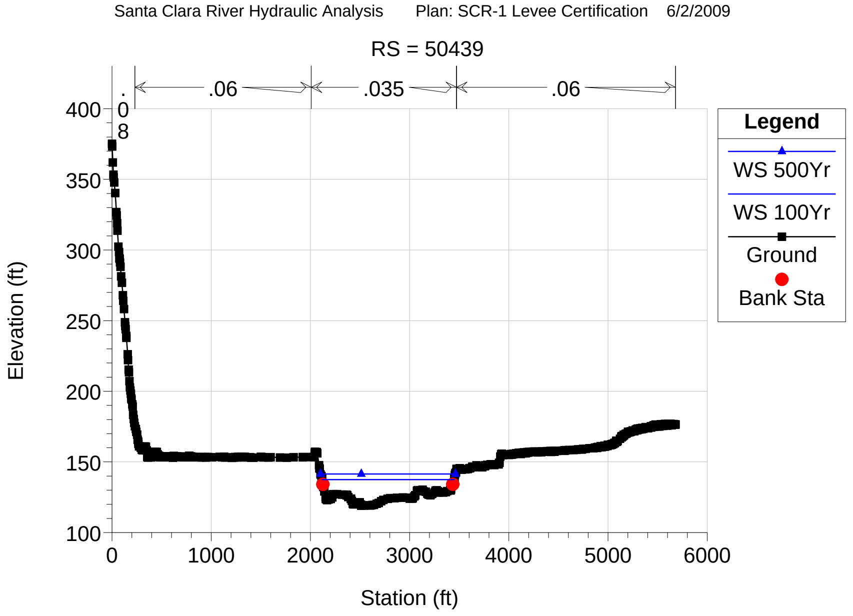
HEC-RAS Plan: SCR-1LC   River: SantaClaraRiver   Reach: SantaClaraRiver   Profile: 100Yr (Continued)

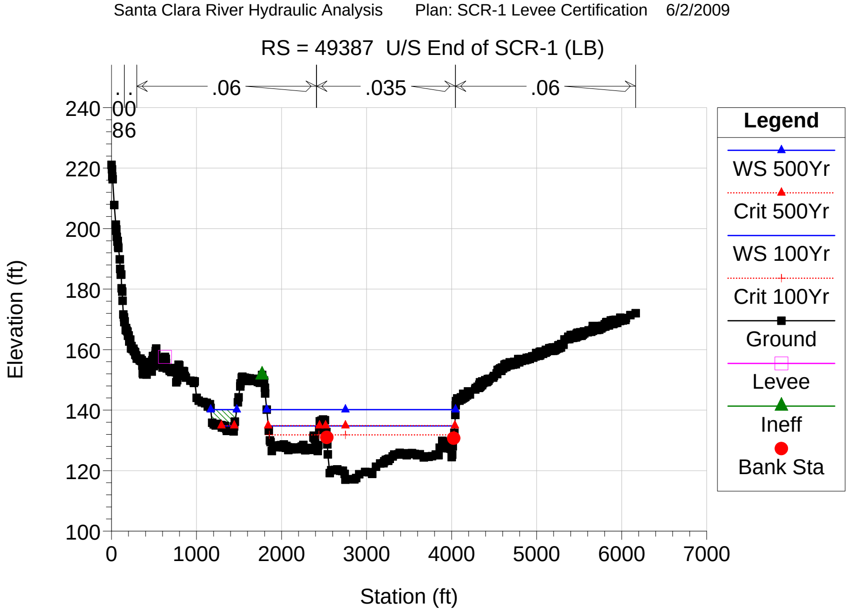
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
SantaClaraRiver	19944	100Yr	226000.00	39.82	64.86	60.25	66.53	0.001998	11.56	35154.39	3615.84	0.47
SantaClaraRiver	18391	100Yr	226000.00	35.08	61.16	56.11	62.12	0.003883	8.92	32959.43	3076.59	0.38
SantaClaraRiver	16954 TBD	100Yr	226000.00	32.72	57.53	52.06	58.64	0.001636	9.64	37751.41	3360.18	0.41
SantaClaraRiver	15610	100Yr	226000.00	30.31	53.45	48.08	55.59	0.002632	11.74	19310.47	3368.74	0.53
SantaClaraRiver	15406 Victoria Avenue		Bridge									
SantaClaraRiver	15177 TBD	100Yr	226000.00	29.47	49.52	46.57	51.22	0.002713	11.52	28020.91	3621.96	0.55
SantaClaraRiver	13347 TBD	100Yr	226000.00	26.28	46.38	42.23	47.30	0.001441	9.04	38065.90	3866.17	0.41
SantaClaraRiver	11659 TBD	100Yr	226000.00	22.11	44.83	37.27	45.50	0.000760	7.61	43020.28	3370.84	0.31
SantaClaraRiver	11169 TBD	100Yr	226000.00	21.27	44.43	36.60	45.14	0.000693	7.90	43362.17	3336.71	0.32
SantaClaraRiver	10126 TBD	100Yr	226000.00	19.14	43.81	34.34	44.17	0.001017	5.00	47160.22	3189.75	0.22
SantaClaraRiver	8849 TBD	100Yr	226000.00	16.53	40.31	32.52	41.84	0.003600	10.16	23259.58	2810.31	0.41
SantaClaraRiver	7665 TBD	100Yr	226000.00	13.85	34.43	29.13	36.94	0.004596	12.77	18073.47	3350.75	0.55
SantaClaraRiver	5860 TBD	100Yr	226000.00	10.37	32.66	26.03	33.31	0.000882	7.77	46684.37	4199.32	0.32
SantaClaraRiver	4659 TBD	100Yr	226000.00	8.23	29.10	23.31	31.45	0.002574	12.35	18660.66	4460.05	0.53
SantaClaraRiver	3592 TBD	100Yr	226000.00	6.56	26.34	20.04	28.21	0.003291	10.99	20647.38	4636.22	0.48
SantaClaraRiver	3174 TBD	100Yr	226000.00	6.43	25.82	18.62	27.01	0.001412	8.77	26645.36	5427.17	0.39
SantaClaraRiver	3014 Harbor Blvd		Bridge									
SantaClaraRiver	2838 TBD	100Yr	226000.00	6.05	19.07	17.54	19.62	0.001485	7.70	51066.97	9372.25	0.42
SantaClaraRiver	2033 TBD	100Yr	226000.00	4.75	14.80	14.80	16.88	0.007423	14.11	28742.96	9323.00	0.89

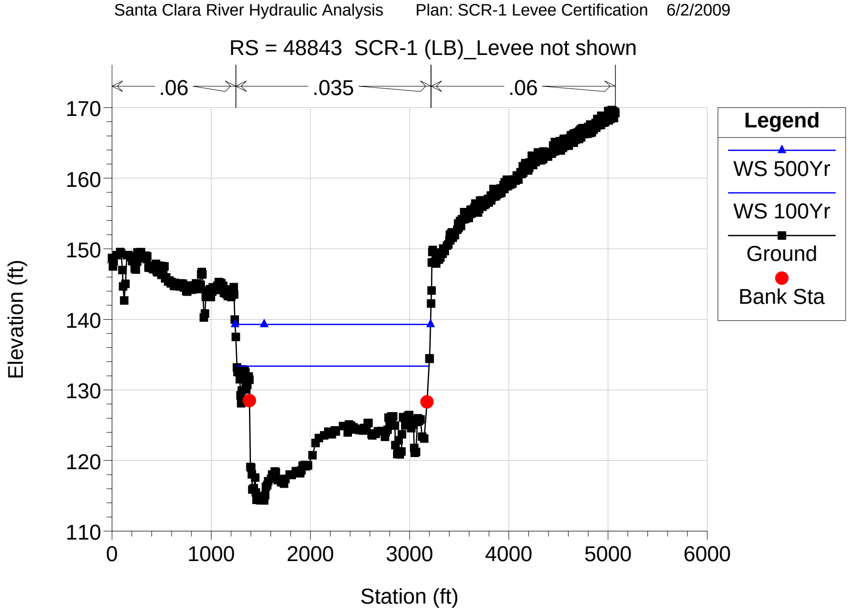

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
SantaClaraRiver SantaClaraRiver
Legend
WS 100Yr
Crit 100Yr
Ground
Left Levee
Right Levee
Elevation (ft)
1000
800
600
400
200
0
0
50000
100000
150000
200000
250000
Main Channel Distance (ft)

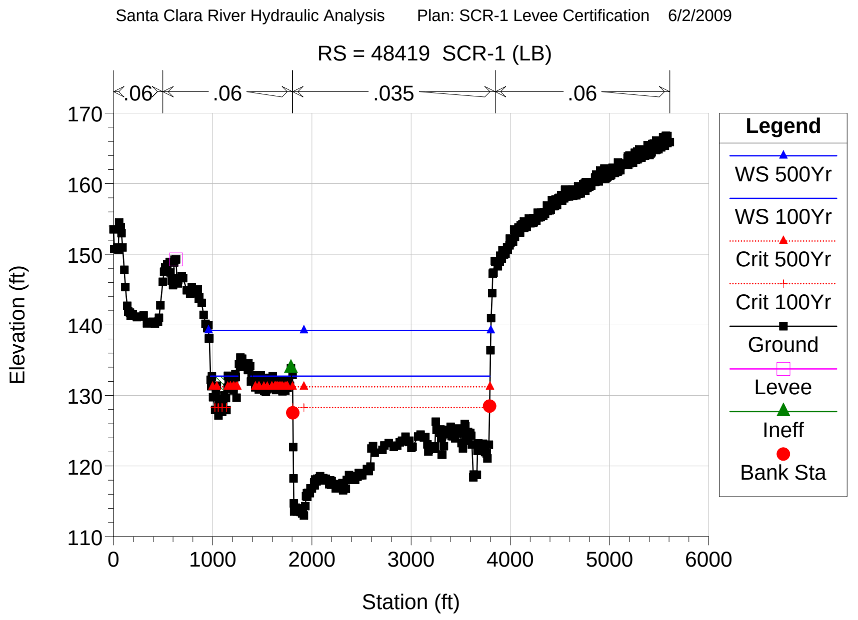

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification Final 10/19/2009
SantaClaraRiver SantaClaraRiver
SCR-1 Levee Reach
River Station 251+32
Downstream End of SCR-1 Levee
River Station 493+87
Downstream End of SCR-1 Levee
Legend
WS 100Yr
Crit 100Yr
Ground
Left Levee
Right Levee
Elevation (ft)
0
50
100
150
200
20000
30000
40000
50000
60000
Main Channel Distance (ft)

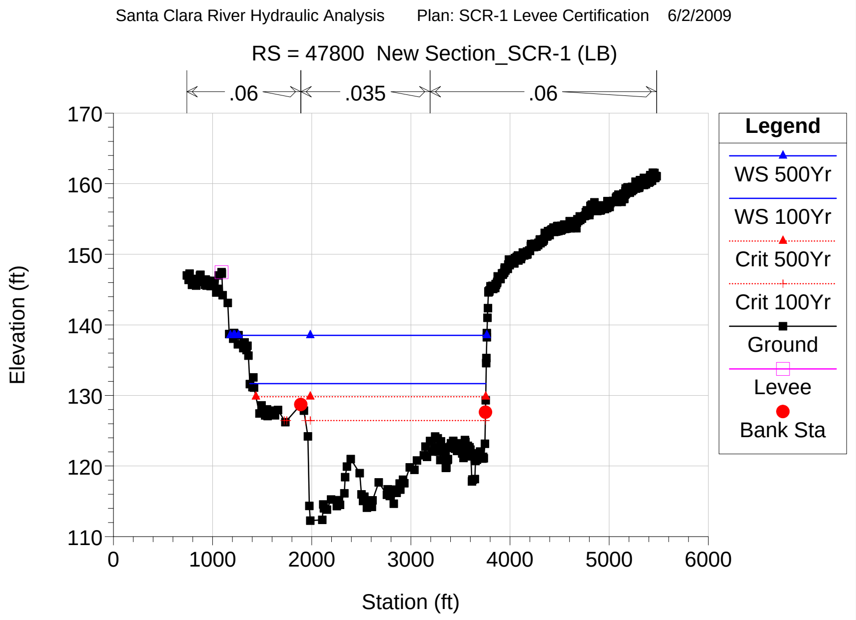

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 52968
.08
.06
.035
.06
Elevation (ft)
280
260
240
220
200
180
160
140
120
Station (ft)
0
1000
2000
3000
4000
5000
6000
Legend
WS 500Yr
WS 100Yr
Ground
Bank Sta

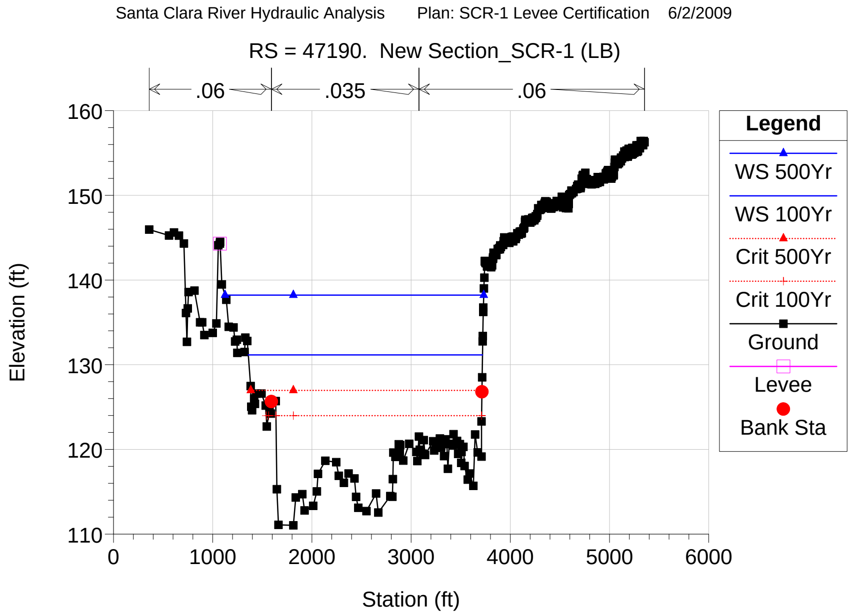

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 50439
.
0
8
.06
.035
.06
Elevation (ft)
400
350
300
250
200
150
100
Station (ft)
0
1000
2000
3000
4000
5000
6000
Legend
WS 500Yr
WS 100Yr
Ground
Bank Sta

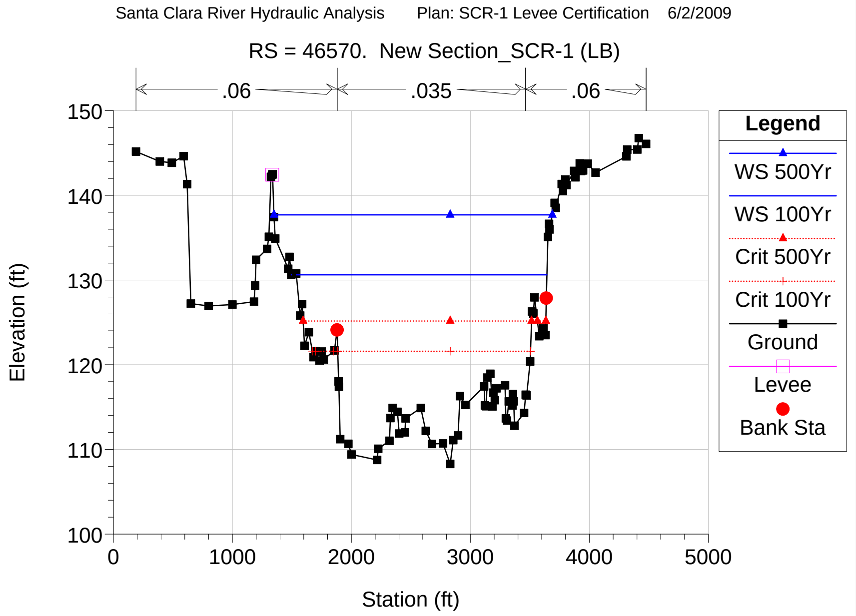

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 49387 U/S End of SCR-1 (LB)
. .
00
86
.06
.035
.06
Elevation (ft)
240
220
200
180
160
140
120
100
Station (ft)
0
1000
2000
3000
4000
5000
6000
7000
Legend
WS 500Yr
Crit 500Yr
WS 100Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta

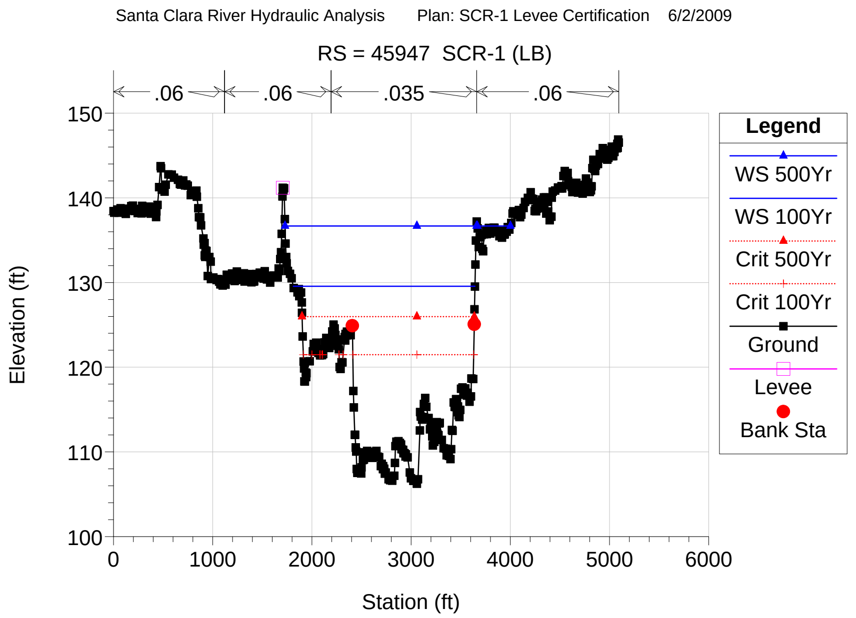

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 48843 SCR-1 (LB)_Levee not shown
.06
.035
.06
Elevation (ft)
170
160
150
140
130
120
110
Station (ft)
0
1000
2000
3000
4000
5000
6000
Legend
WS 500Yr
WS 100Yr
Ground
Bank Sta

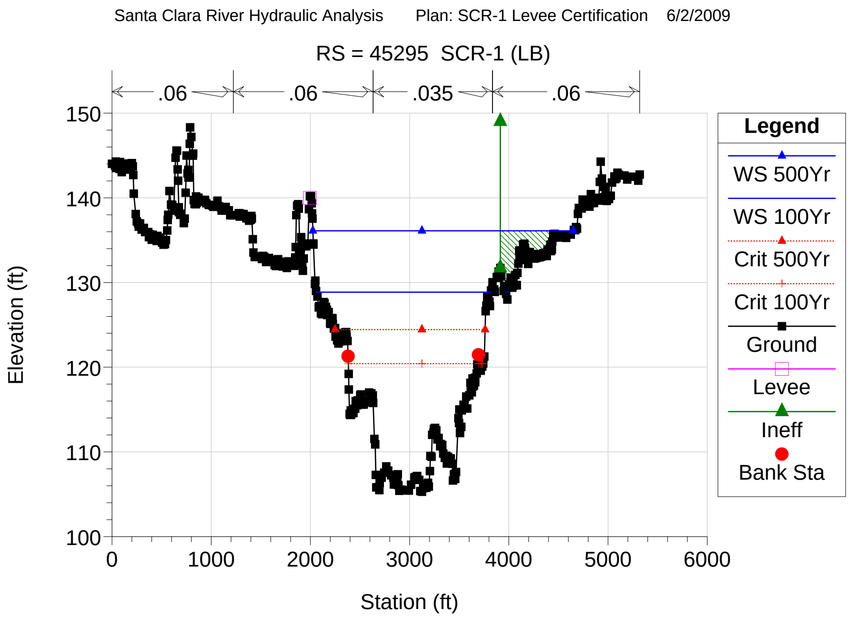

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 48419 SCR-1 (LB)
.06
.06
.035
.06
Elevation (ft)
170
160
150
140
130
120
110
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta

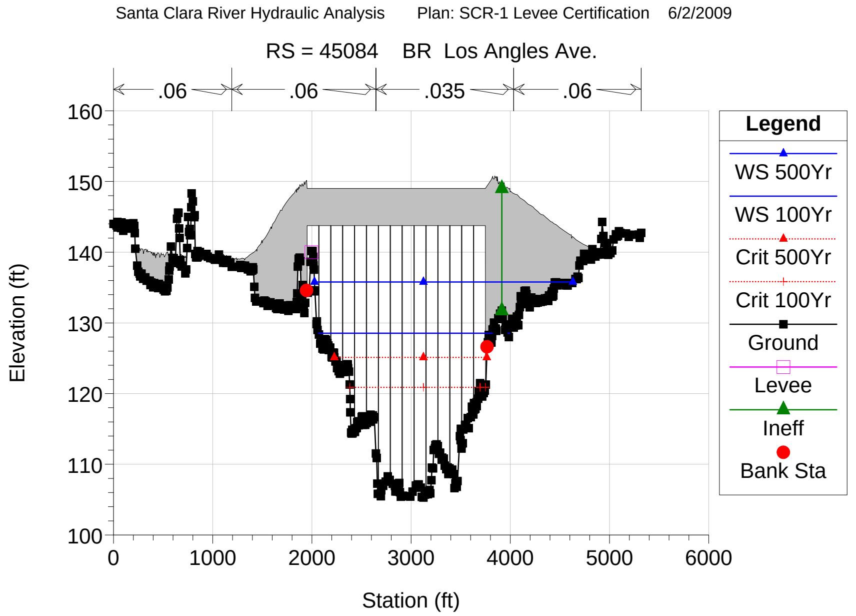

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 47800 New Section_SCR-1 (LB)
.06
.035
.06
Elevation (ft)
170
160
150
140
130
120
110
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta

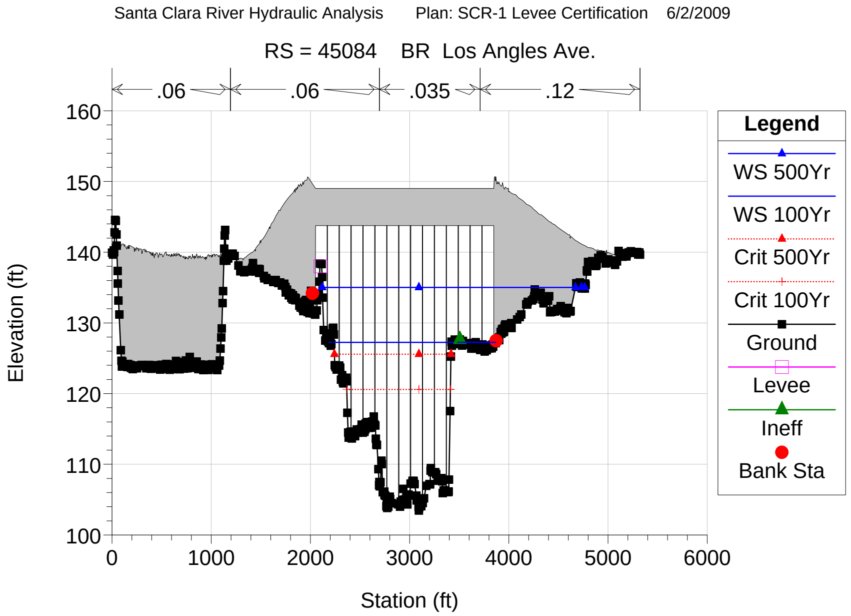

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 47190. New Section_SCR-1 (LB)
.06
.035
.06
Elevation (ft)
160
150
140
130
120
110
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta

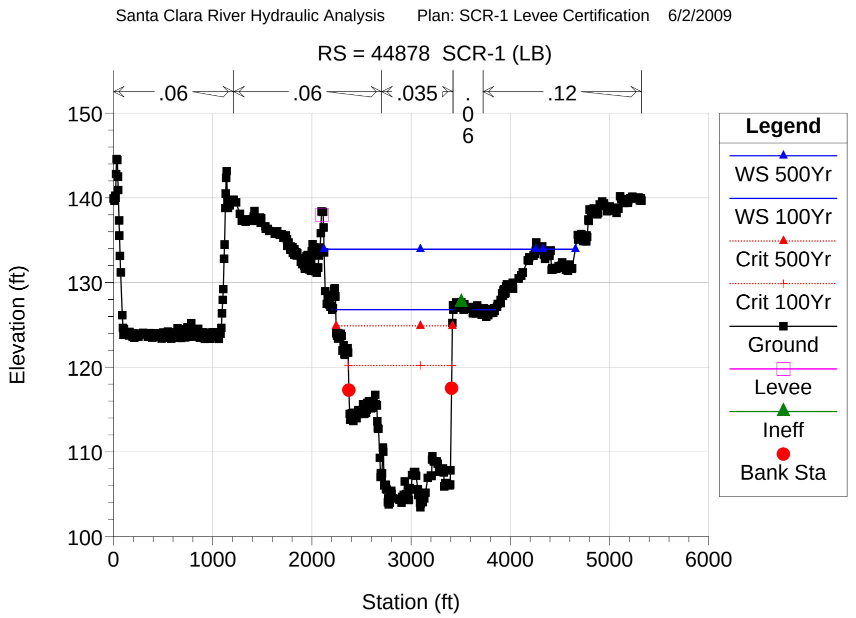

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 46570. New Section_SCR-1 (LB)
.06
.035
.06
Elevation (ft)
150
140
130
120
110
100
0
1000
2000
3000
4000
5000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta


Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 45947 SCR-1 (LB)
.06
.06
.035
.06
Elevation (ft)
150
140
130
120
110
100
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta


Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 45295 SCR-1 (LB)
.06
.06
.035
.06
Elevation (ft)
150
140
130
120
110
100
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta

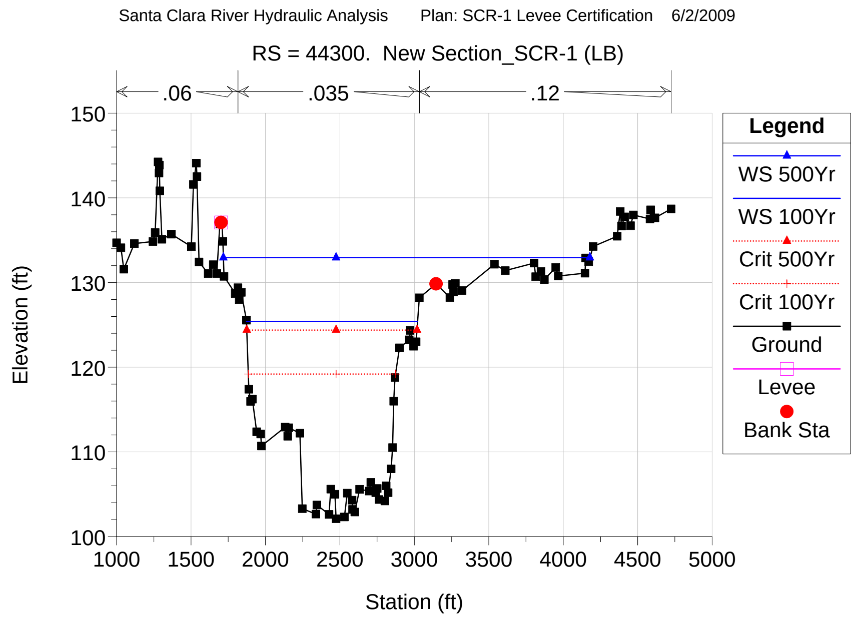

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 45084 BR Los Angles Ave.
.06
.06
.035
.06
Elevation (ft)
160
150
140
130
120
110
100
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta


Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 45084 BR Los Angles Ave.
.06
.06
.035
.12
Elevation (ft)
160
150
140
130
120
110
100
0
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta



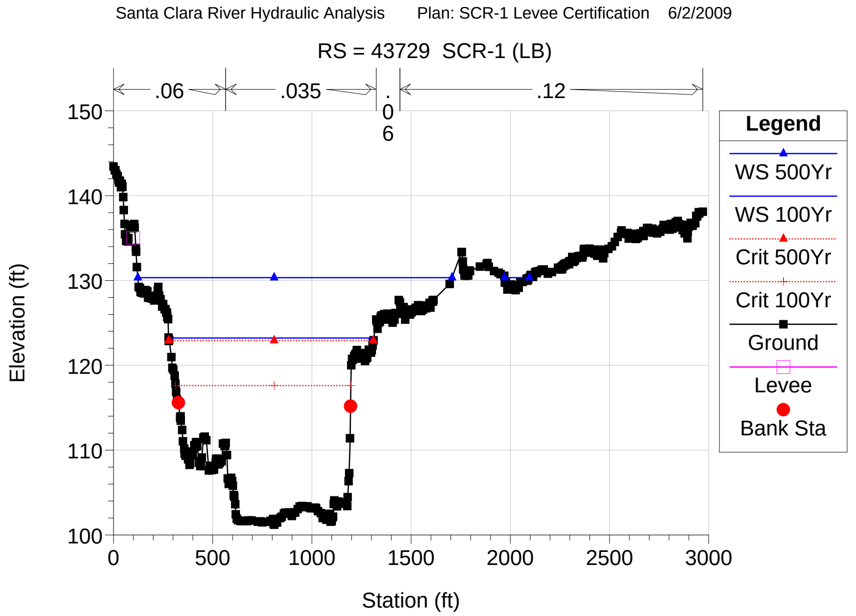
Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009

RS = 44878 SCR-1 (LB)



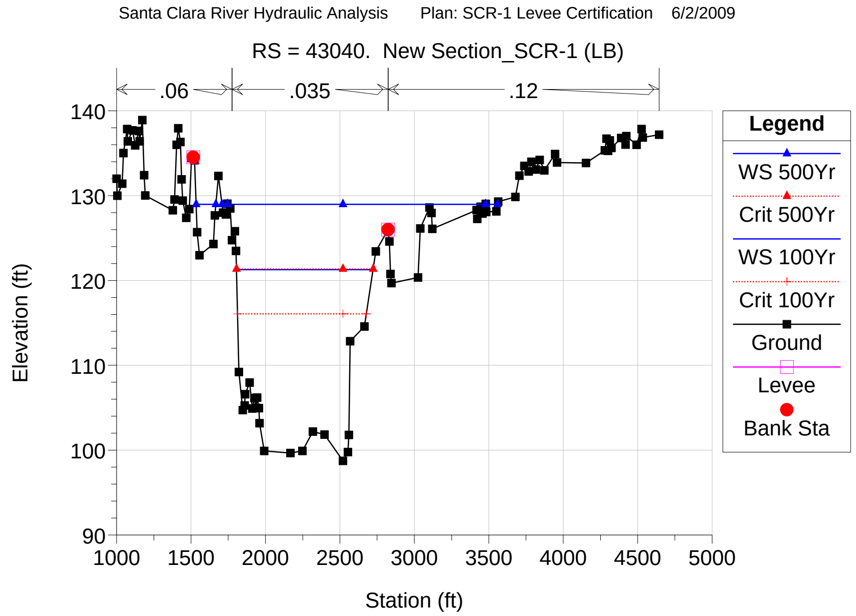
Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009

RS = 44300. New Section_SCR-1 (LB)



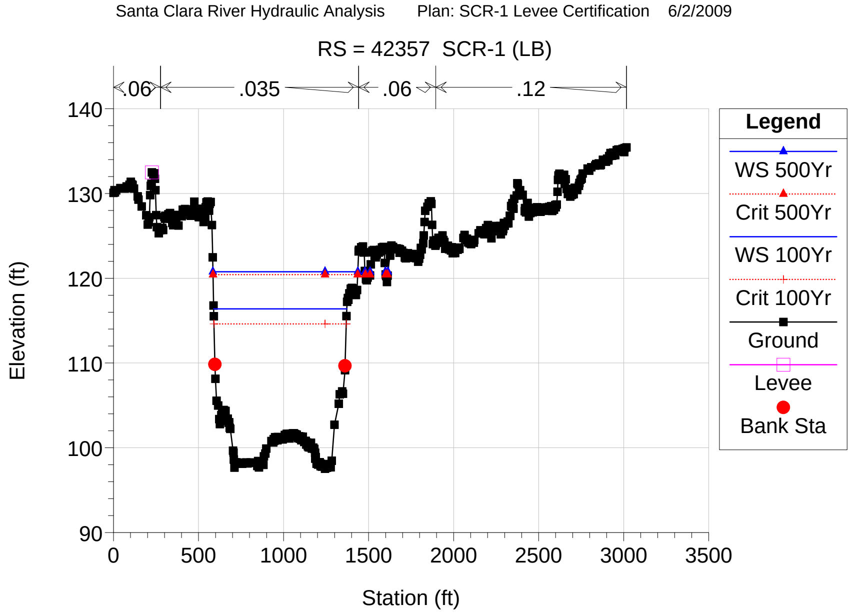
Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009

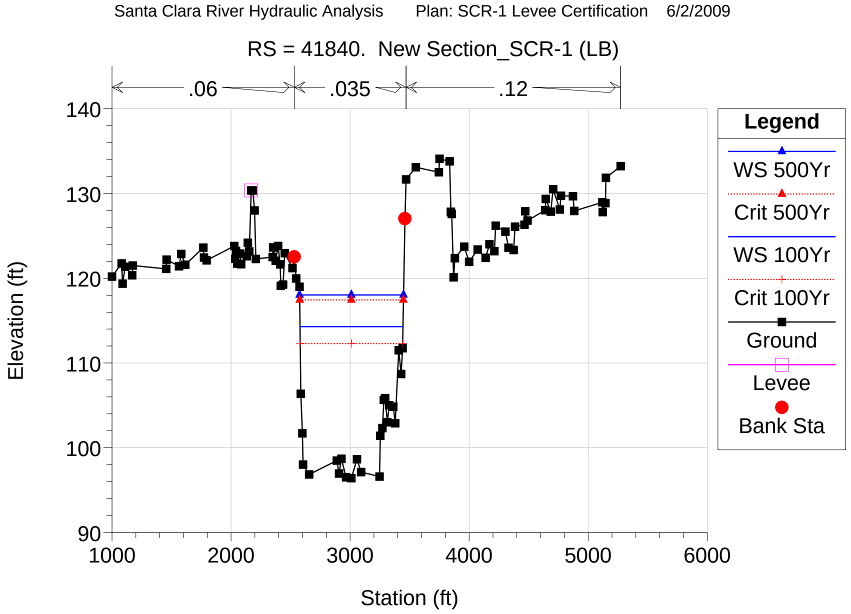
RS = 43729 SCR-1 (LB)

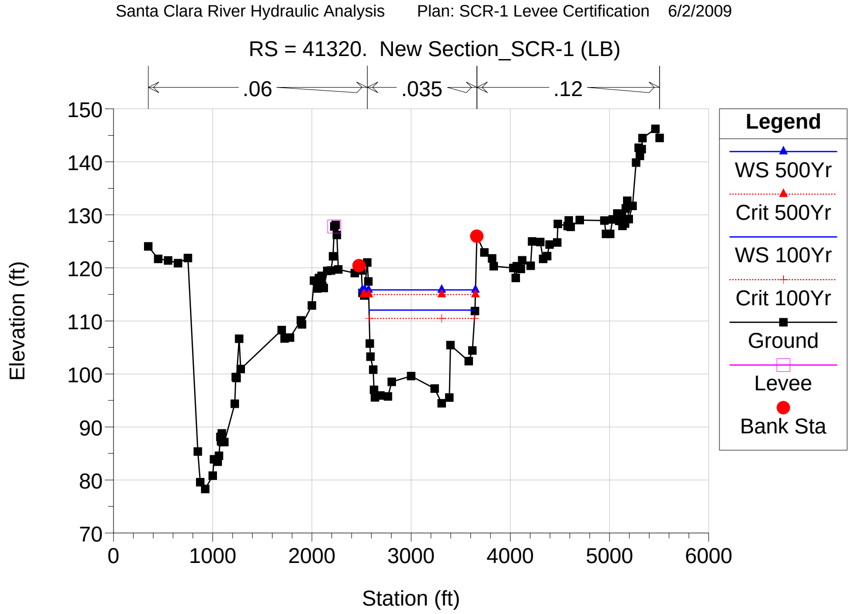


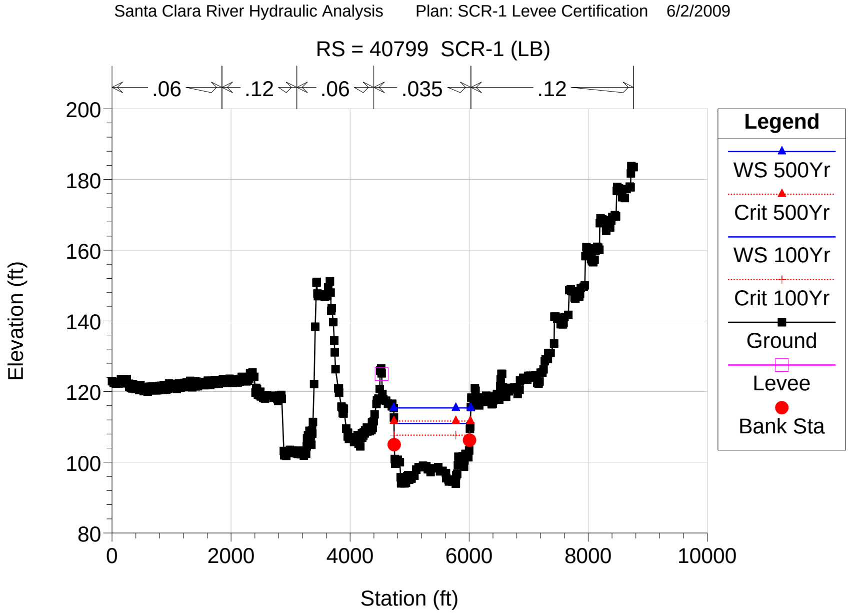
Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009

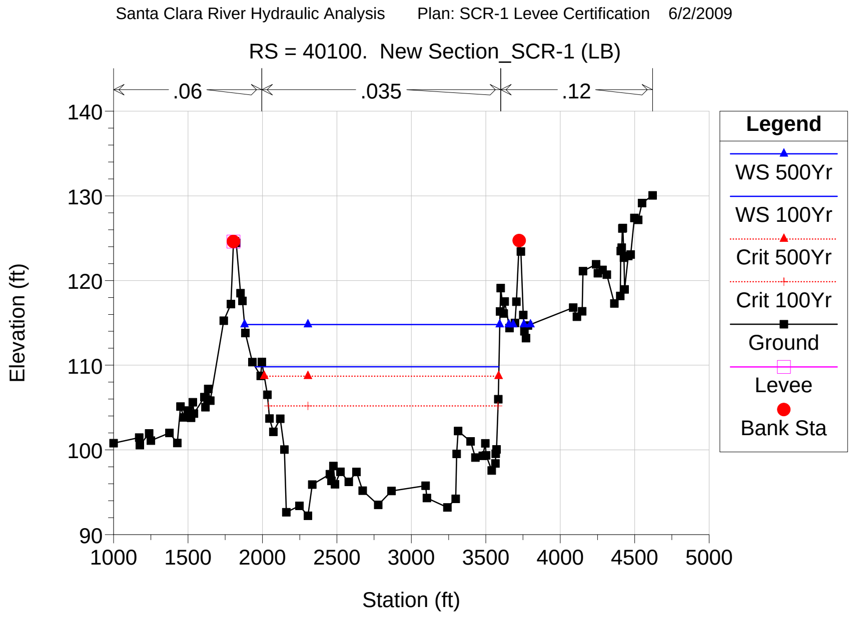
RS = 43040. New Section_SCR-1 (LB)

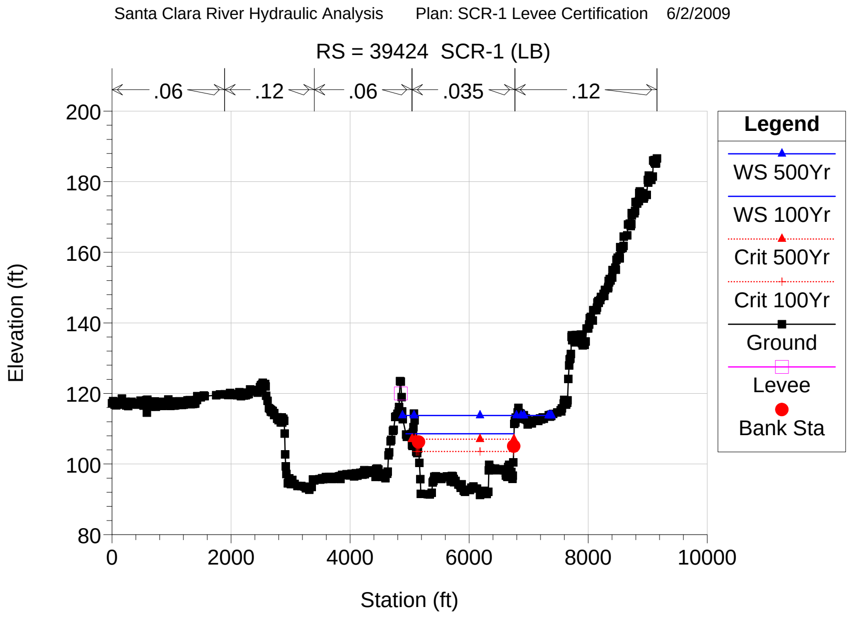

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 42357 SCR-1 (LB)
.06
.035
.06
.12
Elevation (ft)
Station (ft)
140
130
120
110
100
90
0
500
1000
1500
2000
2500
3000
3500
Legend
WS 500Yr
Crit 500Yr
WS 100Yr
Crit 100Yr
Ground
Levee
Bank Sta

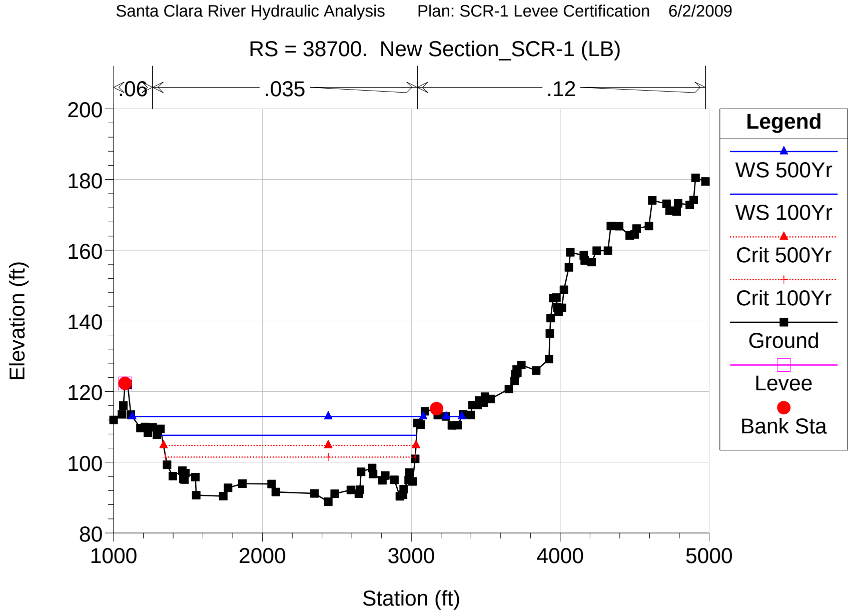

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 41840. New Section_SCR-1 (LB)
.06
.035
.12
Elevation (ft)
Station (ft)
140
130
120
110
100
90
1000
2000
3000
4000
5000
6000
Legend
WS 500Yr
Crit 500Yr
WS 100Yr
Crit 100Yr
Ground
Levee
Bank Sta

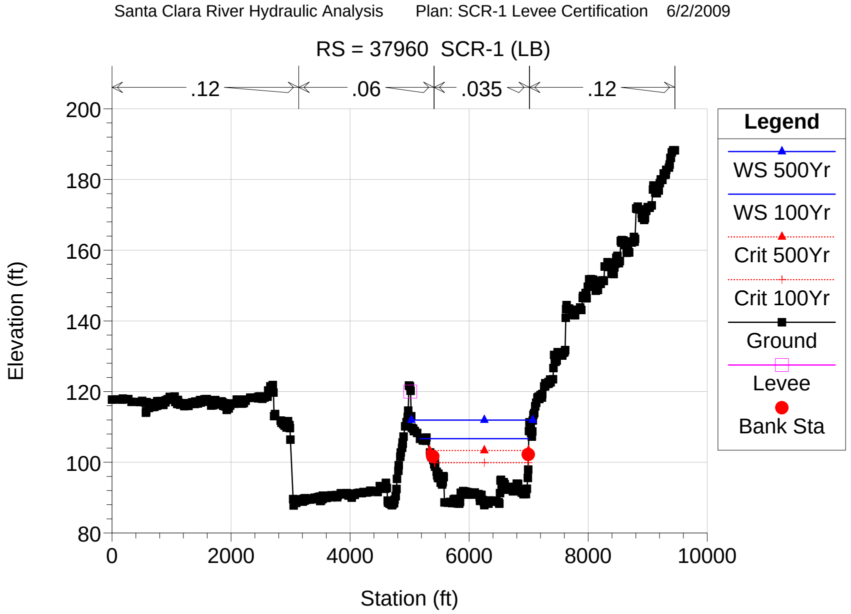

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 41320. New Section_SCR-1 (LB)
.06
.035
.12
Elevation (ft)
Station (ft)
150
140
130
120
110
100
90
80
70
0
1000
2000
3000
4000
5000
6000
Legend
WS 500Yr
Crit 500Yr
WS 100Yr
Crit 100Yr
Ground
Levee
Bank Sta

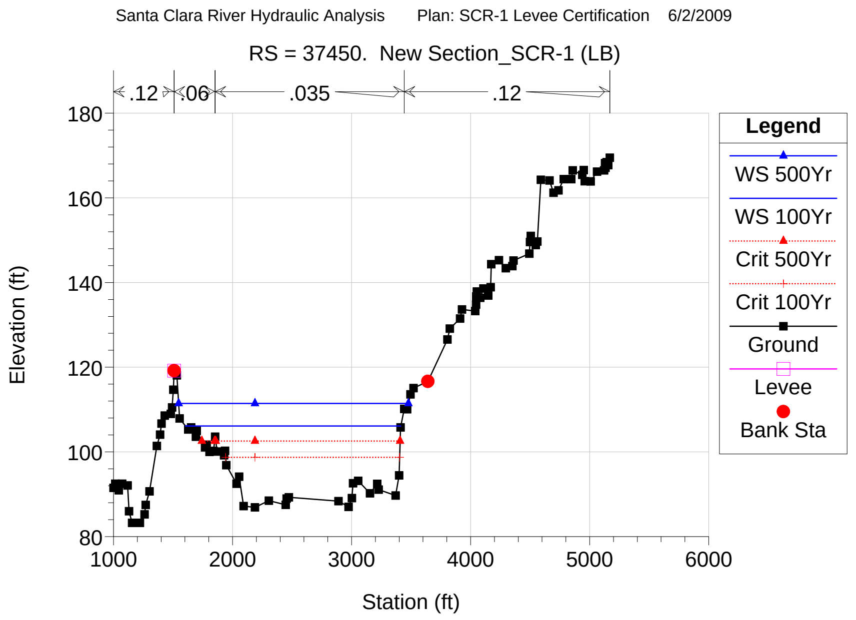

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 40799 SCR-1 (LB)
.06
.12
.06
.035
.12
Elevation (ft)
Station (ft)
200
180
160
140
120
100
80
0
2000
4000
6000
8000
10000
Legend
WS 500Yr
Crit 500Yr
WS 100Yr
Crit 100Yr
Ground
Levee
Bank Sta

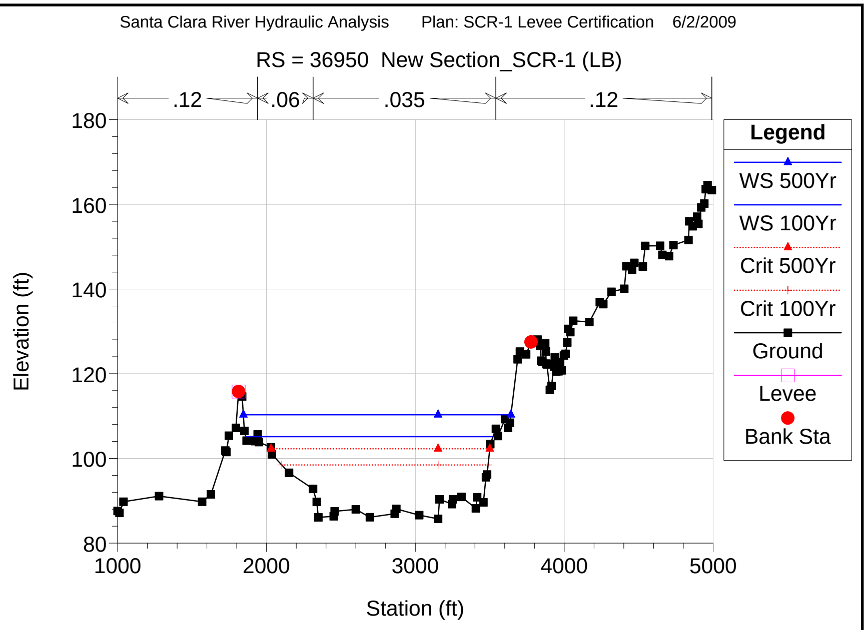

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 40100. New Section_SCR-1 (LB)
.06
.035
.12
Elevation (ft)
140
130
120
110
100
90
1000
1500
2000
2500
3000
3500
4000
4500
5000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta


Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 39424 SCR-1 (LB)
.06
.12
.06
.035
.12
Elevation (ft)
200
180
160
140
120
100
80
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta


Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 38700. New Section_SCR-1 (LB)
.06
.035
.12
Elevation (ft)
200
180
160
140
120
100
80
1000
2000
3000
4000
5000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta


Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009
RS = 37960 SCR-1 (LB)
.12
.06
.035
.12
Elevation (ft)
200
180
160
140
120
100
80
0
2000
4000
6000
8000
10000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta


Santa Clara River Hydraulic Analysis   Plan: SCR-1 Levee Certification   6/2/2009
RS = 37450. New Section_SCR-1 (LB)
.12
.06
.035
.12
Elevation (ft)
180
160
140
120
100
80
1000
2000
3000
4000
5000
6000
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta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.06
.035
.12
Elevation (ft)
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160
140
120
100
80
1000
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3000
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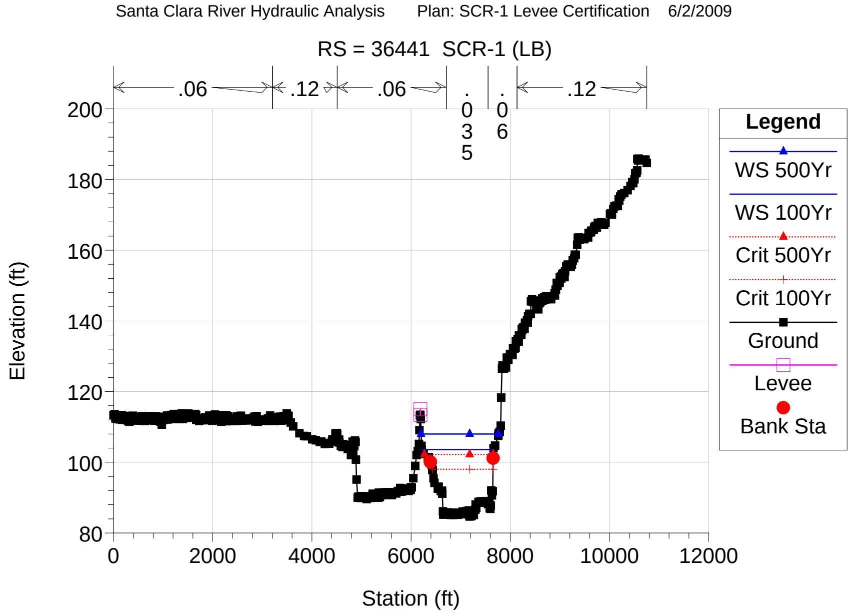
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta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0
2000
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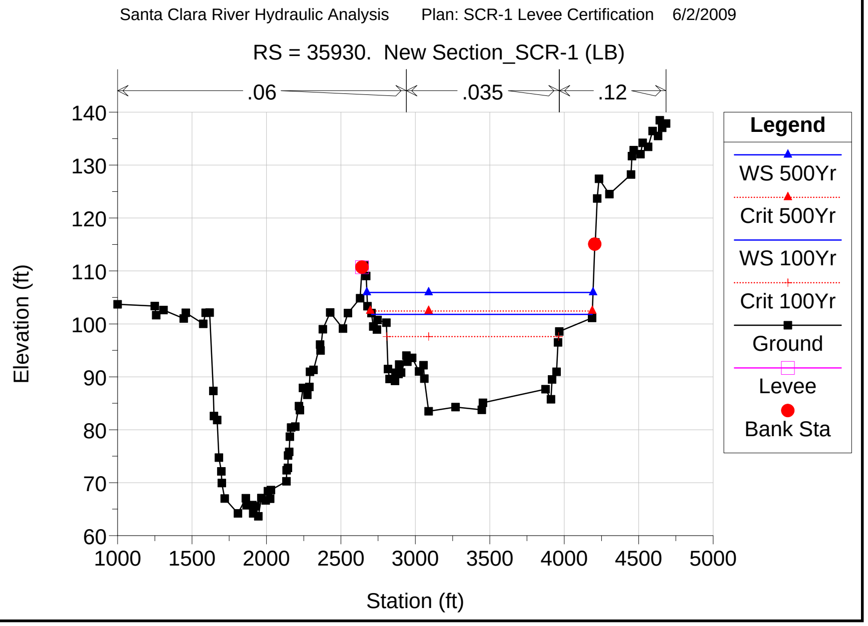
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta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3000
3500
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5000
Station (ft)
Legend
WS 500Yr
Crit 500Yr
WS 100Yr
Crit 100Yr
Ground
Levee
Bank Sta

Santa Clara River Hydraulic Analysis Plan: SCR-1 Levee Certification 6/2/2009

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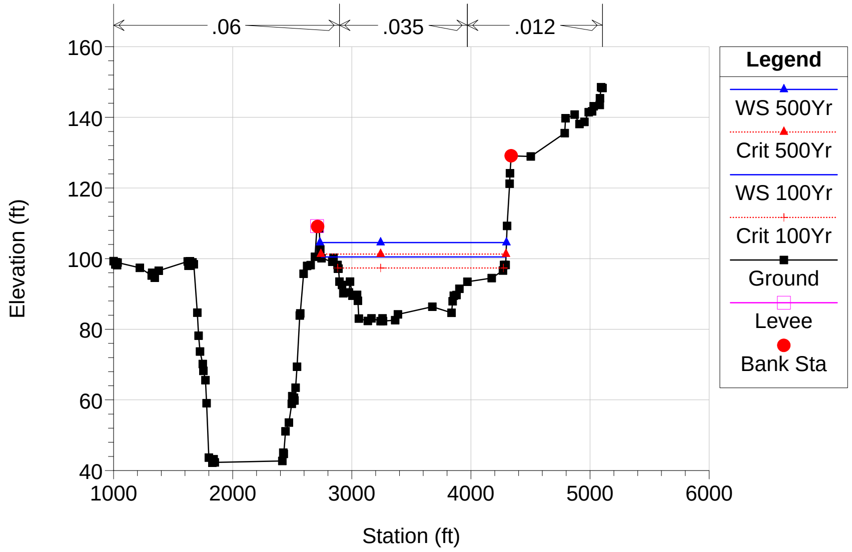

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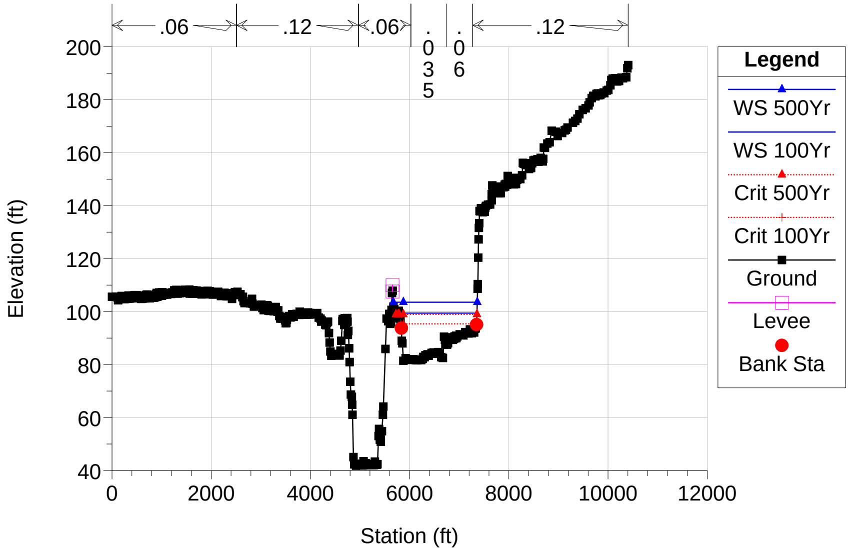

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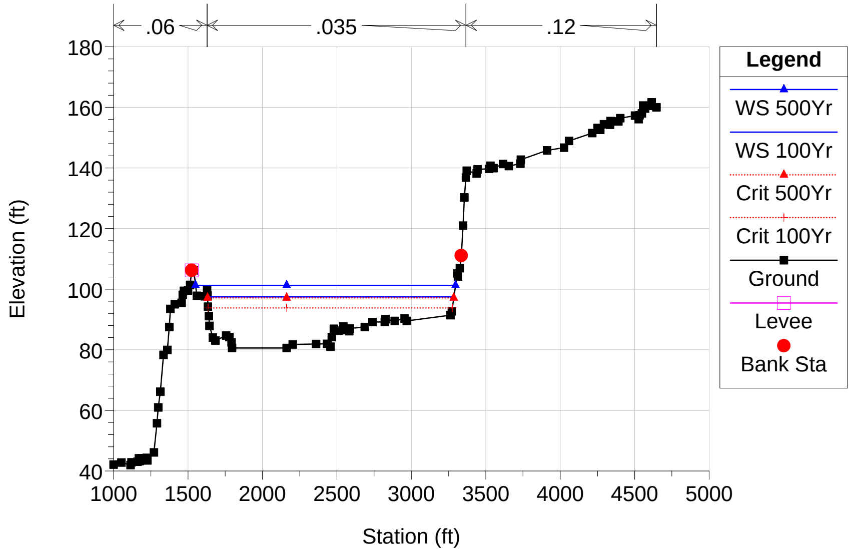

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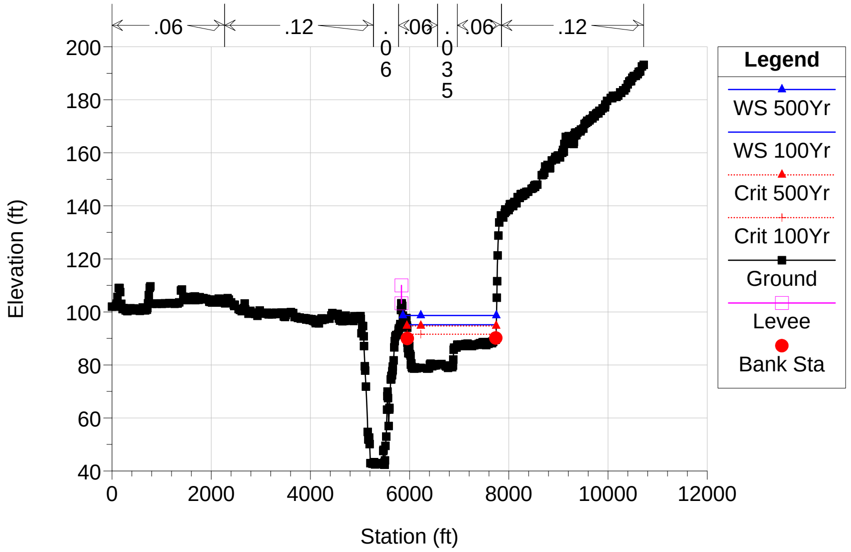

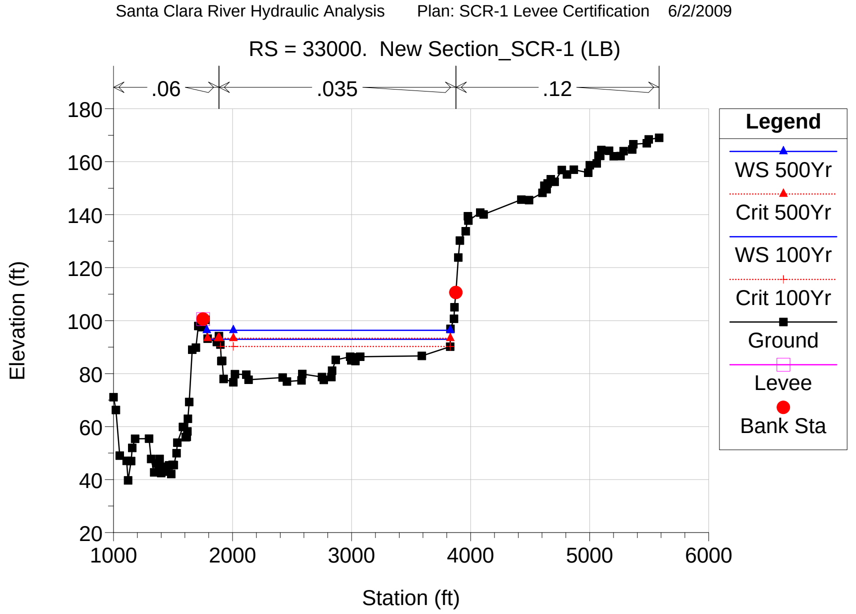
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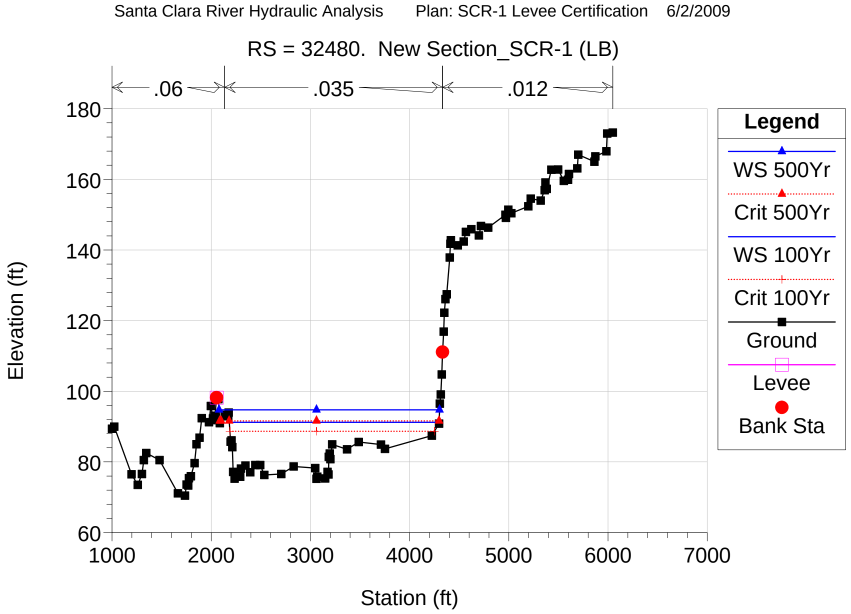
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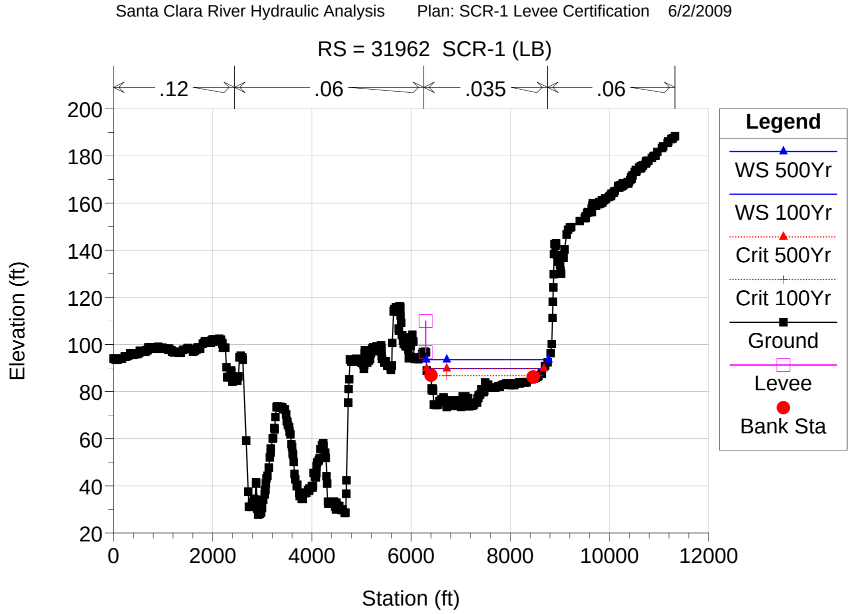
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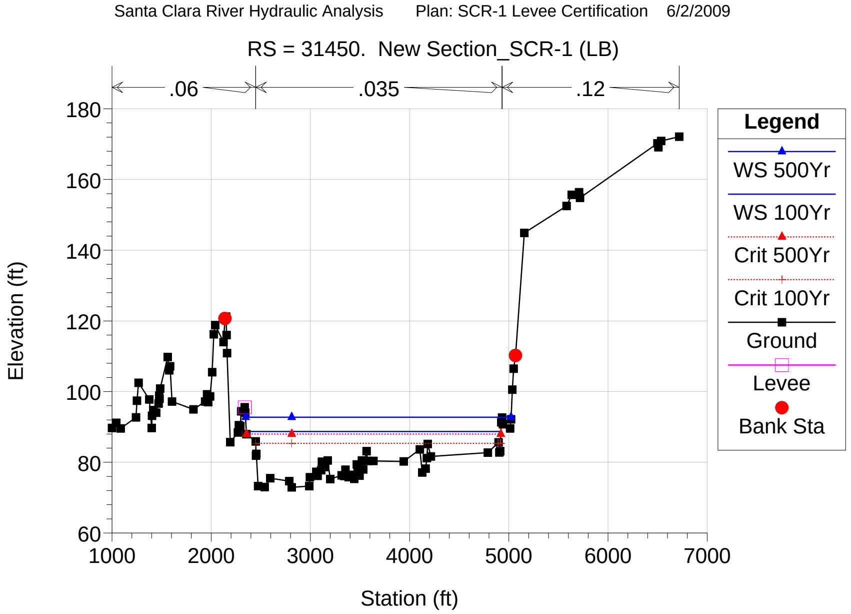
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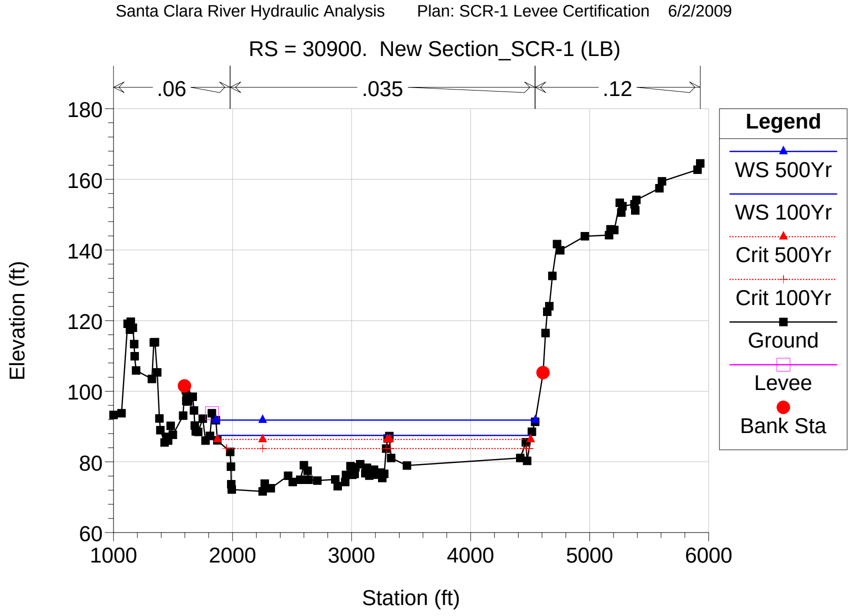
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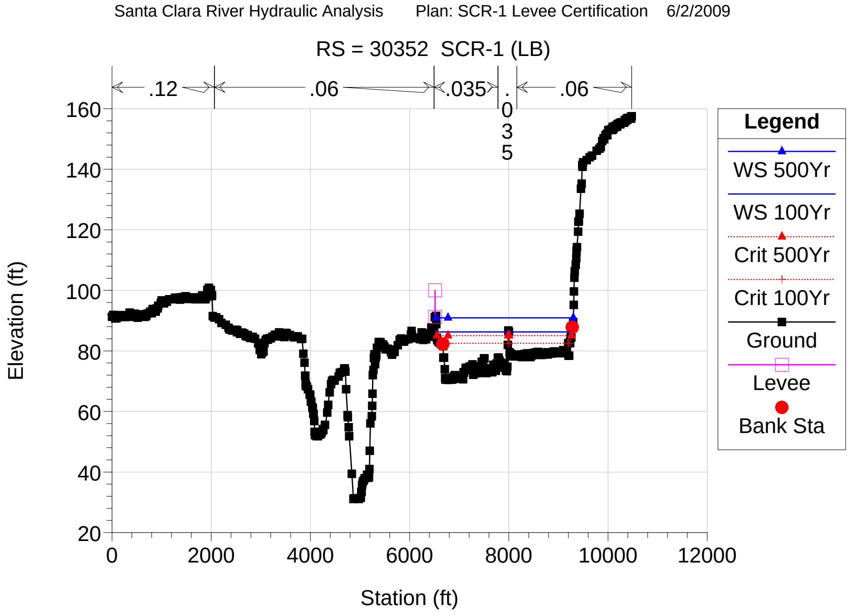
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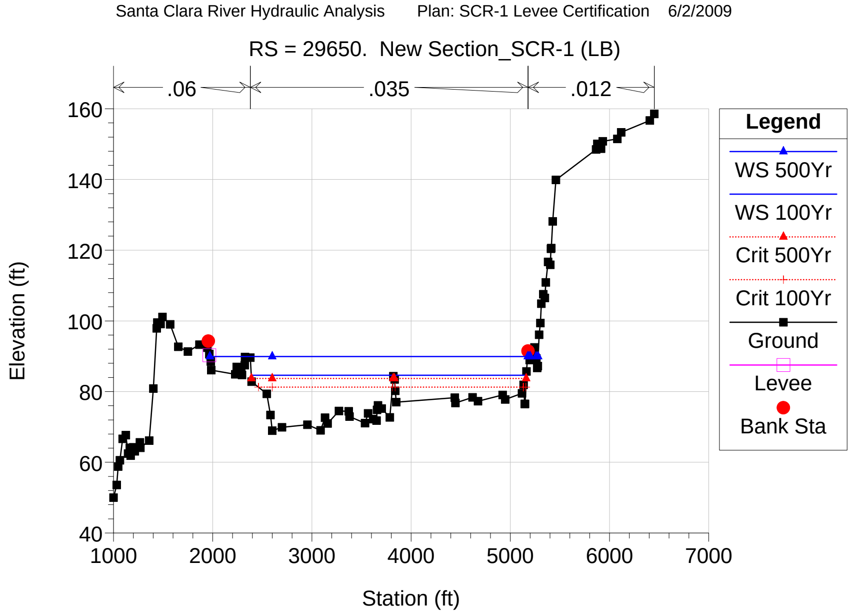
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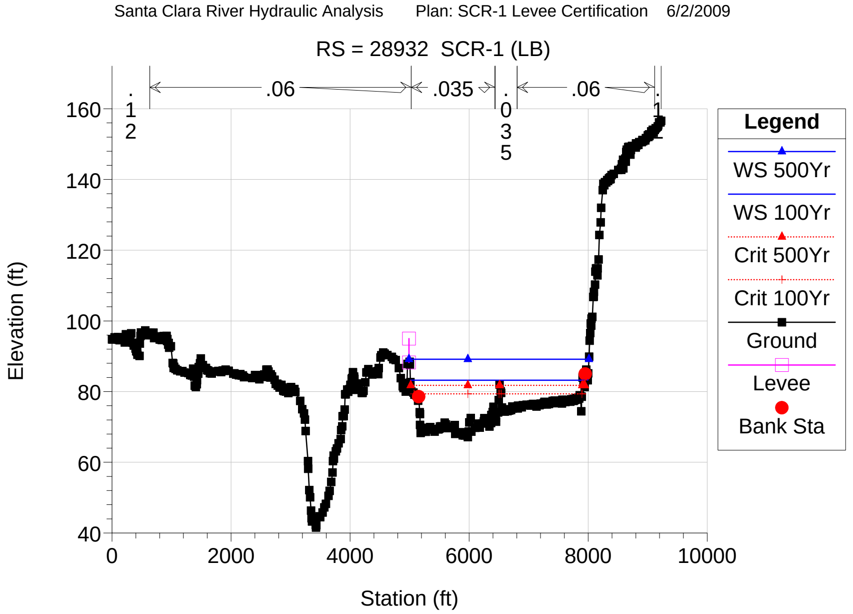
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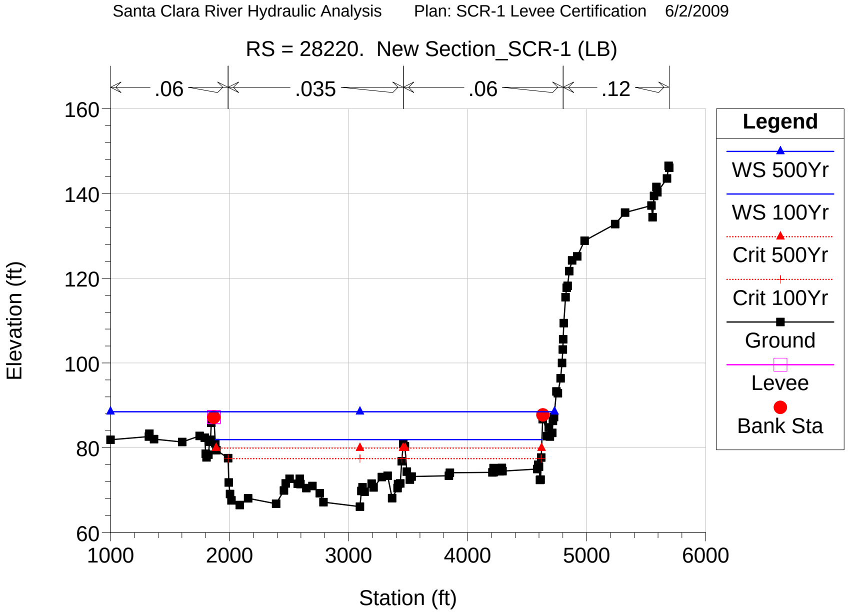

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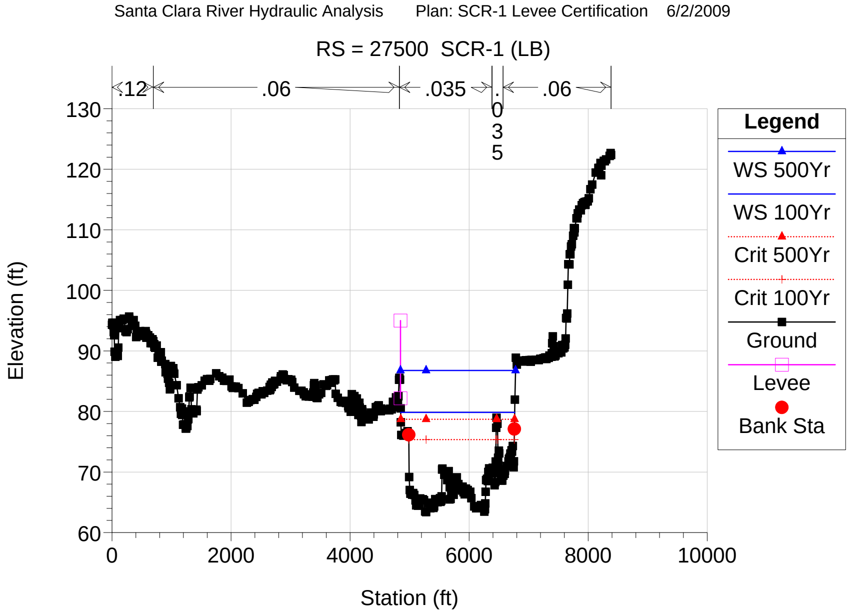

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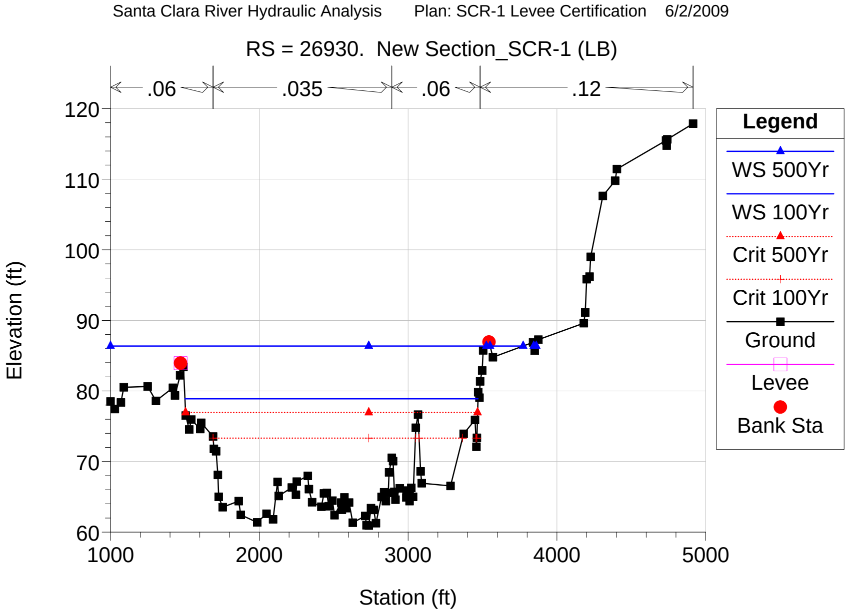

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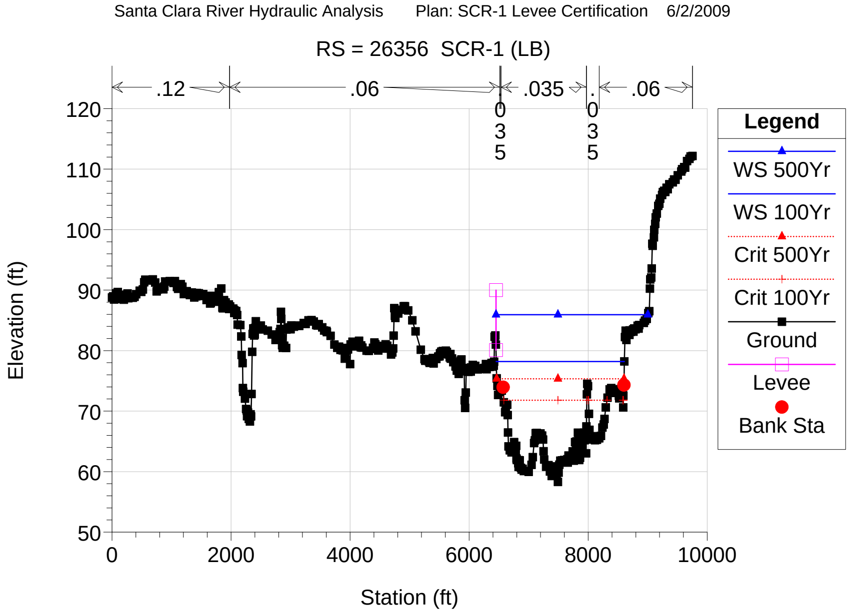

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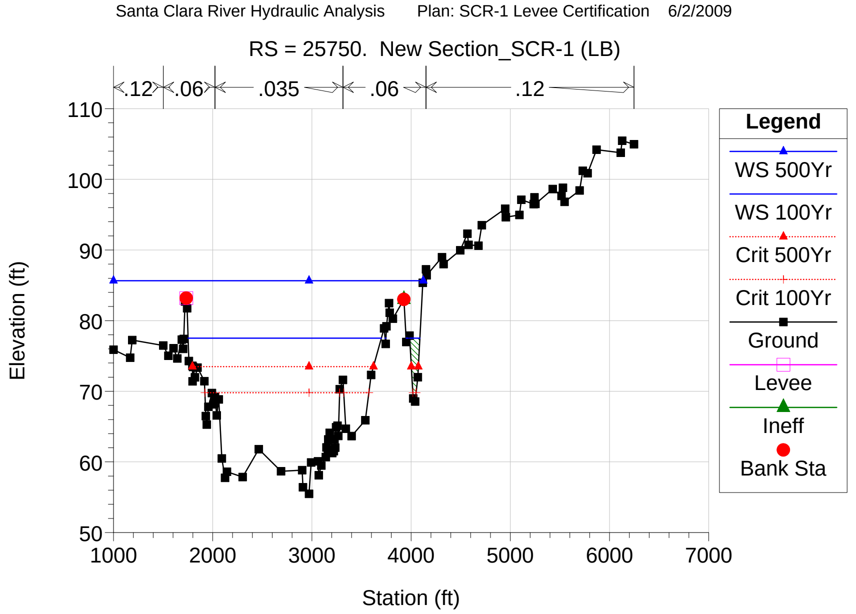
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4000
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Station (ft)
Legend
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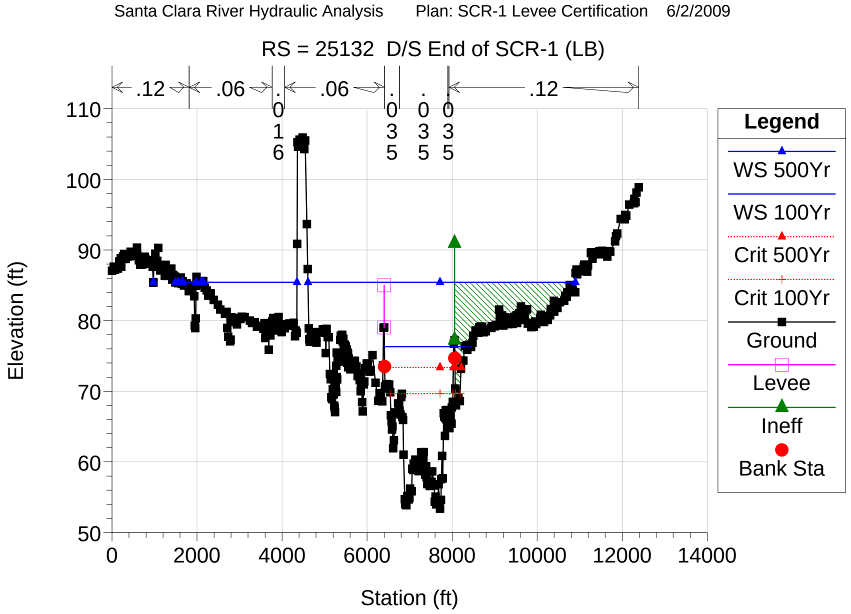
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta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4000
6000
8000
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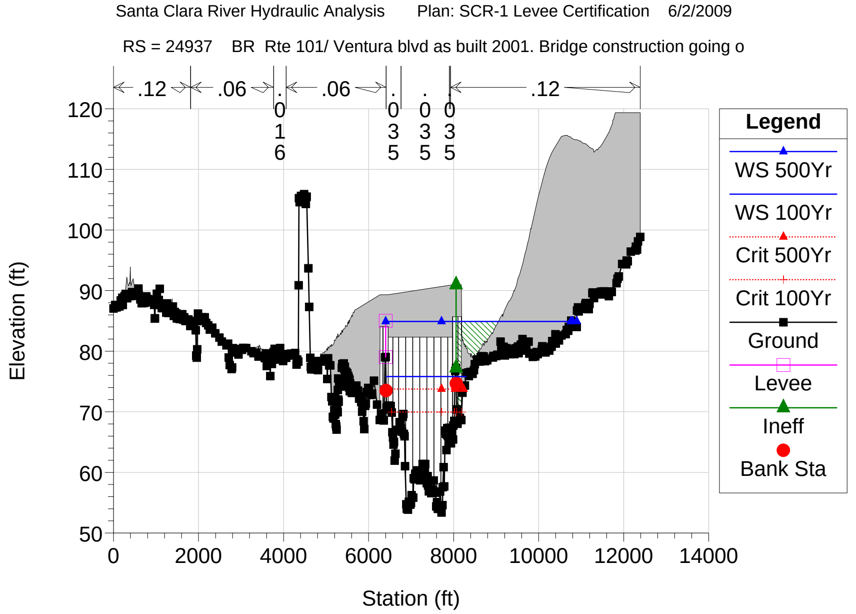
Station (ft)
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta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.035
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Elevation (ft)
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6000
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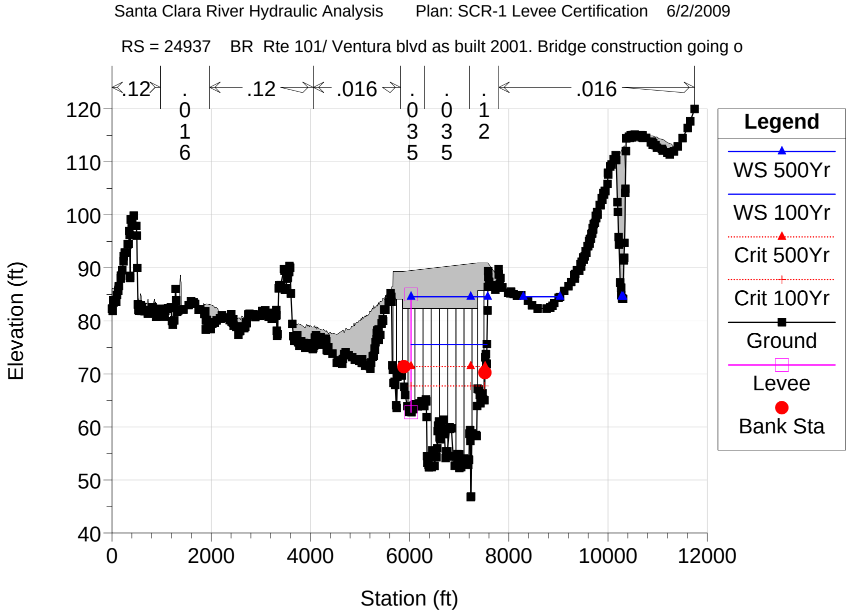
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Ineff
Bank Sta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.12
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8000
10000
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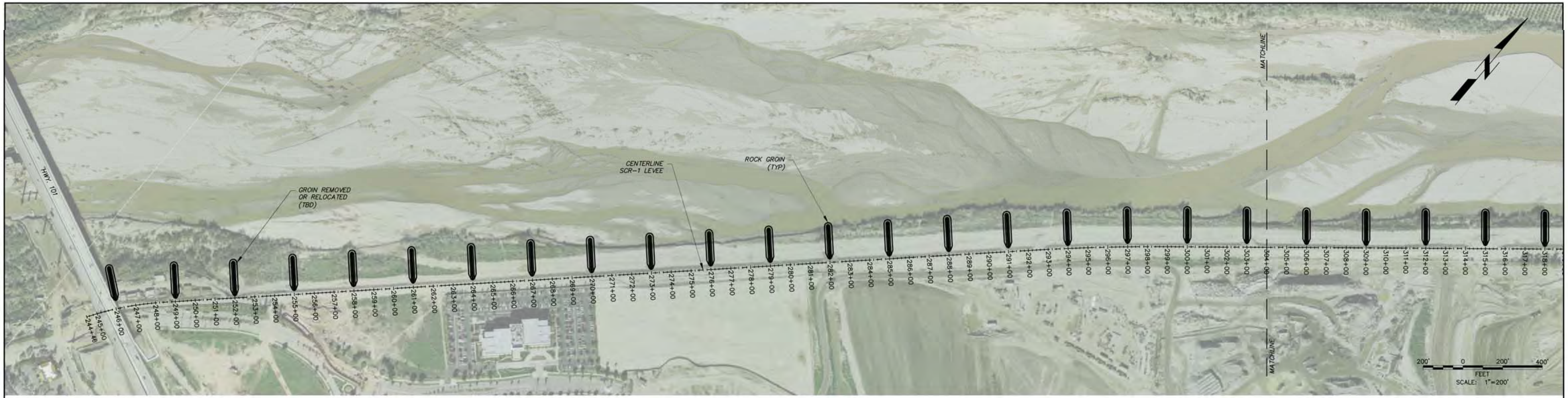
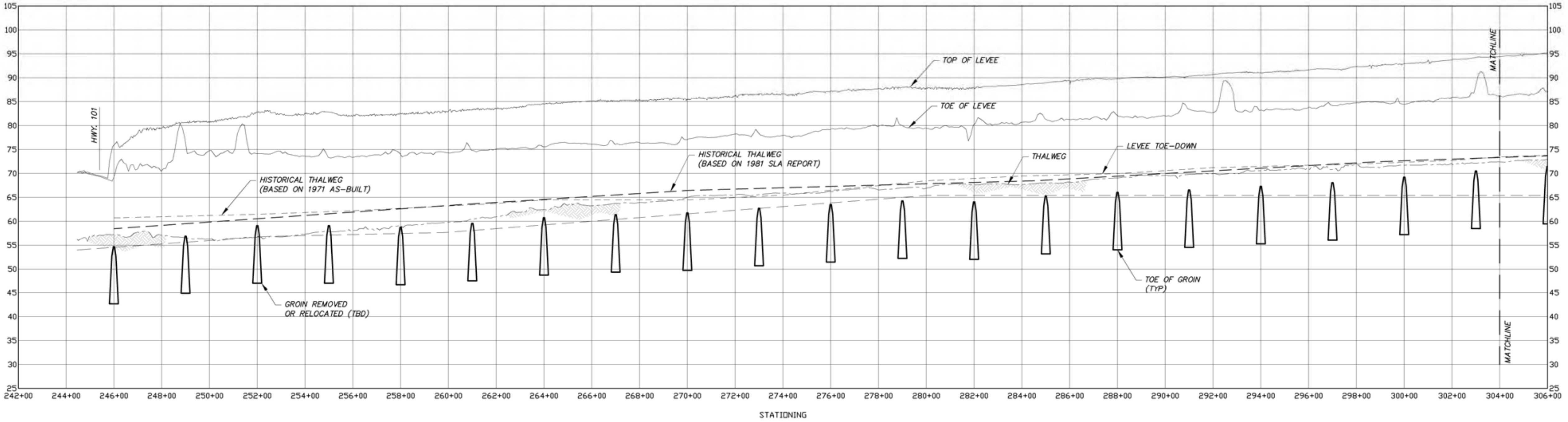
Legend
WS 500Yr
WS 100Yr
Crit 500Yr
Crit 100Yr
Ground
Levee
Bank Sta

Attachment C

Plan and Profile Exhibit





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SAVE DATE: 6/17/09 NATHAN.SCHREINER P:\WATR\T23484 VENTURA LEVEE\L03_SCR-1\10_HYDRAULICS\CADD\SCR-1_PLAN AND PROFILE.DWG

D			
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△	REVISION DESCRIPTION	APP.	DATE

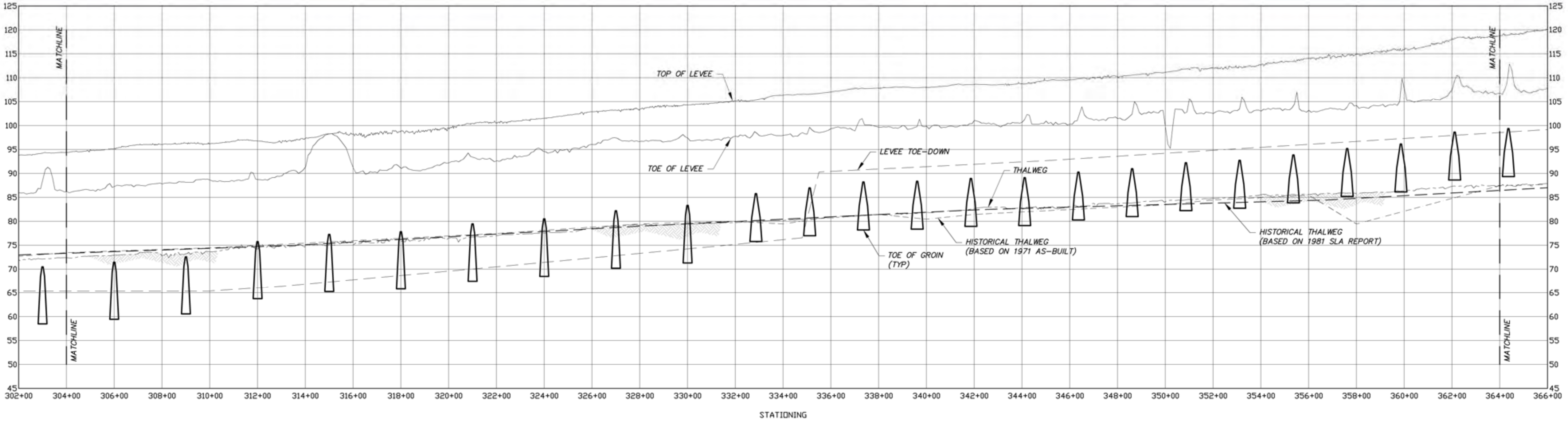
DESIGNED J NODOLF
DRAWN J NODOLF
CHECKED I PACE
PROJ. ENG.
REG. NO.
DATE
RECOMMENDED
APPROVED

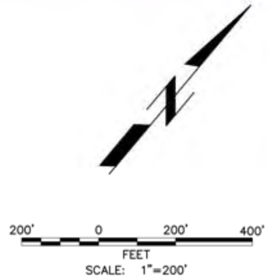
COUNTY OF VENTURA – PUBLIC WORKS AGENCY
VENTURA COUNTY WATERSHED PROTECTION DISTRICT

SPEC. NO. –
PROJ. NO. –

SANTA CLARA RIVER LEVEE
SCR–1
PLAN AND PROFILE – STA. 242+00 TO STA. 304+00

SHEET 1
OF 4
DRAWING NO. –





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DATE
RECOMMENDED
APPROVED

COUNTY OF VENTURA – PUBLIC WORKS AGENCY
VENTURA COUNTY WATERSHED PROTECTION DISTRICT

SPEC. NO. –
PROJ. NO. –

SANTA CLARA RIVER LEVEE
SCR-1
PLAN AND PROFILE – STA. 304+00 TO STA. 364+00

SHEET 2
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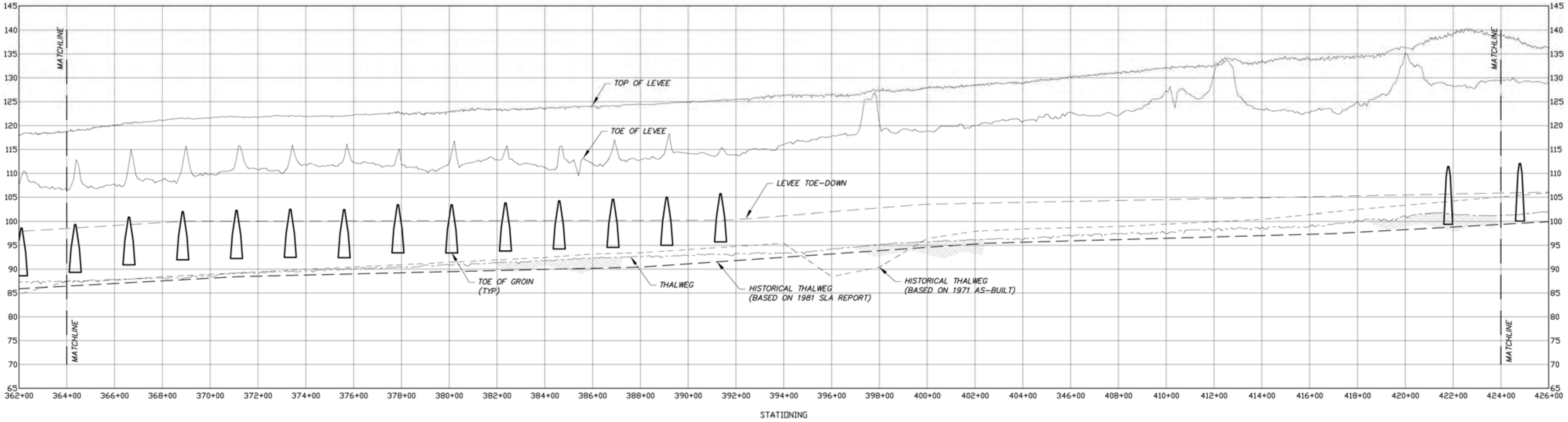

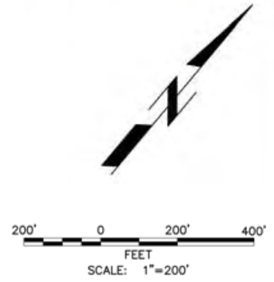

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DESIGNED J NODOLF
DRAWN J NODOLF
CHECKED I PACE
PROJ. ENG.
RECOMMENDED
REG. NO.
DATE
APPROVED

COUNTY OF VENTURA – PUBLIC WORKS AGENCY
VENTURA COUNTY WATERSHED PROTECTION DISTRICT

SPEC. NO. –
PROJ. NO. –

SANTA CLARA RIVER LEVEE
SCR–1
PLAN AND PROFILE – STA. 364+00 TO STA. 424+00

SHEET 3
OF 4
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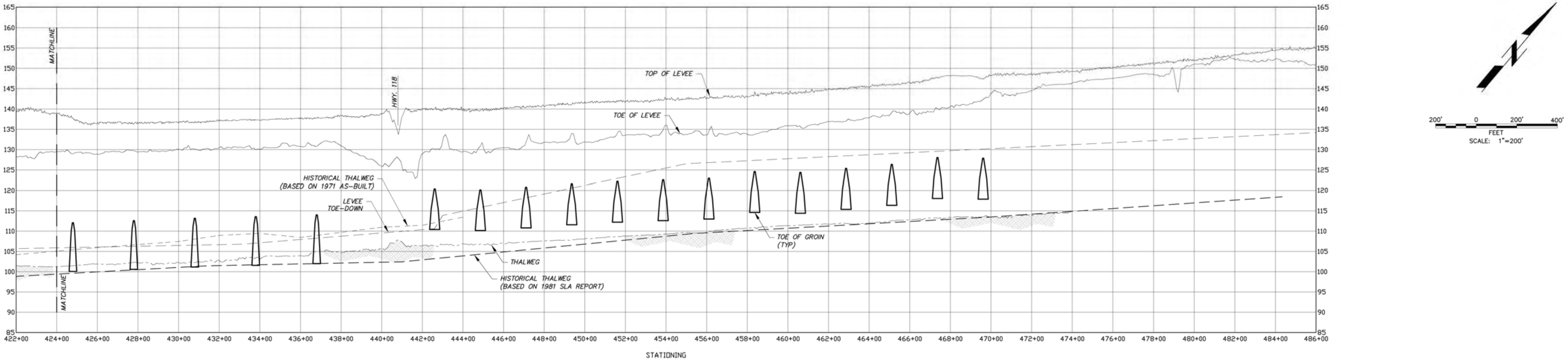

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DESIGNED J NODOLF
DRAWN J NODOLF
CHECKED I PACE
PROJ. ENG.
REG. NO. DATE
RECOMMENDED
APPROVED

COUNTY OF VENTURA – PUBLIC WORKS AGENCY
VENTURA COUNTY WATERSHED PROTECTION DISTRICT

SPEC. NO. –
PROJ. NO. –

SANTA CLARA RIVER LEVEE
SCR–1
PLAN AND PROFILE – STA. 424+00 TO STA. 486+00

SHEET 4 OF 4
DRAWING NO. –

Attachment D

Geotechnical Investigation Report by AMEC
(including Test Pit Data)

June 2, 2009
Job No. 9-212-100138

Tetra Tech
17770 Cartwright Road
Suite 500
Irvine, California 92614

Attention: Mr. Ike Pace

Re: Santa Clara River (SCR-1) Rip Rap Material Evaluation
Ventura County Watershed Protection District
FEMA Levee Certification Program
Ventura County, California

1 INTRODUCTION

This letter presents the results of the engineering study performed for the existing rip rap material associated with the Santa Clara River (SCR-1) Levee. This study was performed in support of the FEMA Levee Certification Program for the Ventura County Watershed Protection District. The existing rip rap material evaluated during this study was placed in several episodes of revetment improvements and under separate specifications. The following discussion presents the results of this study, including field methodology, laboratory testing, and conclusions.

2 LEVEE CONSTRUCTION

The Santa Clara River Levee was originally constructed in 1958 as an earthen embankment levee with a rip rap revetment on the riverside slope. A gradational filter material 6 inches thick was placed directly on the riverside slope and the rip rap revetment was placed on the filter material. Groins were also constructed at the toe of the riverside slope. Initial construction is shown on the original levee plan set dated November 1958 which was part of Design Memorandum No. 2 (dated November 1958) prepared by the Corps of Engineers.

Subsequent to the 1958 construction, additional construction including levee penetrations, additional groin protection systems, as well as the repair of existing groins was performed. One of these revisions to the original plan set required rip rap overlay of portions of the original 1958 levee and placing "sound rock" over non-sound rock from the original 1958 construction. This overlay and additional construction was shown on a plan set dated May 1961. The thickness of the rip rap revetment overlay was specified as 2 feet. The gradation requirements for the rip rap revetment stone associated with original levee construction was as follows:

REVETMENT STONE

Weight of pieces	Percent of total by weight
400 lbs. or less	100
150 lbs. or less	50 to 70
10 lbs. or less	10 to 30
1 lb. or less	0 to 5

The approximate gradation is shown on Plate I. The rip rap specifications for the 1961 overlay project stated "overlay of sound rock, 18 inches on levee…" with no discussion regarding the definition of sound rock. The available plan set did not provide any criteria regarding the specification for sound rock including gradational properties.

The available project specifications for both the original levee construction and the subsequent overlay did not present quality requirements or provide for laboratory testing of the rip rap materials incorporated as revetment stone. Based on current standards for quality of rip rap materials, AMEC has prepared a set of minimum standards for the evaluation of rip rap materials for this project. These standards are based on Caltrans Specifications Section 72-2.02, the Standard Specifications for Public Works Construction Section 200-1.6.3, and criteria provided to AMEC during telecommunications with Corps of Engineers representatives. Relevant excerpts from those documents are included in Appendix C. The recommended minimum standards for quality of rip rap are presented in the following table.

Test	Criteria
Apparent Specific Gravity	2.50 Minimum
Absorption	4.2% Maximum
Durability (Soundness Index)	52 Minimum
Abrasion (Percentage Wear)	45% Maximum

3 FIELD EXPLORATION

3.1 TEST PIT LOCATIONS

Three locations, SCR-1-TP1, SCR-1-TP2, and SCR-1-TP3, were chosen by Tetra Tech for evaluation of the existing rip rap revetment materials. Approximate locations of these test pits are depicted on Plate X. These locations were chosen based on visual observation of the surficial conditions of the revetment. At each of these three locations, a test pit through the overlying rip rap material was excavated on May 7, 2009. The test pit logs are provided on Plates II, III and IV for reference. Following logging and sampling, the test pits were backfilled by county personnel.

3.2 SITE PHOTOGRAPHS

Photographs representative of the conditions encountered are attached as Appendix A.

3.3 SUBSURFACE CONDITIONS

The subsurface conditions encountered in the test pits generally consisted of 2 to 3 feet of rip rap revetment material overlying fill material which composed the levee embankment. However, the thickness of the rip rap material was as much as 4 feet in limited areas.

The rip rap materials were generally composed of eight inch or smaller sized stone, with some material as much as 24 inch diameter, infilled with silty sand. Rip rap material was predominantly comprised of sandstone with lesser amounts of basalt, and rhyolite. The rip rap materials were generally interlocked as exposed in Test Pit SCR-1-TP3 and to a lesser extent in Test Pit SCR-1-TP1 (see photographs in Appendix A). However, a significant portion of the rip rap material in the upper portion of Test Pit SCR-1-TP2 was separated by the silty sand soil matrix as shown on the photographs on page A-2.

The underlying levee fill material generally consisted of silty sand, silty sand with gravel, and coarse sand with gravel.

Groundwater was not encountered during the test pit exploration program.

3.4 RIP RAP GRADATION

At each test pit location a backhoe removed the rip rap material in a bucket wide (approximately 3 feet) trench from the top of the levee down to the existing grade toe. Care was taken to minimize the amount of underlying levee embankment material removed to minimize potential contamination of the rip rap material. The rip rap material removed during the trenching was stockpiled at the existing grade at the toe of slope. Once the excavation was complete, the stockpile was mixed by a clamshell bucket on a crane. The mixing was performed to obtain a representative sample of the rip rap through the entire length of excavation. From this mixed stockpile, one clamshell bucket of the stockpile was picked up and placed on a tarp for evaluation. The test pit excavations were logged at this time and the logs are attached (see Plates II, III and IV).

Analysis of the rip rap sample included an evaluation of the distribution of the rock sizes by weight. This was accomplished by segregating the stockpile sample into size ranges, and physically counting the number of pieces in each range. The various size ranges utilized in the rock count were based on the original weight specification for the revetment stone. The original weight range specification was converted into a size range specification applying the method utilized by the Corps on other rock revetted levees. Given a specific gravity and assuming a stone shape midway between a cube and a sphere, an equivalent size for a given weight was calculated. Based on this procedure, the rock weight specification was divided into the following size categories: rip rap material sizes greater than 19 inches, 19 inches to 13 inches, 13 inches to 8 inches, 8 inches to 4 inches, and less than 4 inches.

In the field, the rip rap sample at each test pit location was segregated in the various size ranges. Where a rock piece had dissimilar dimensions (e.g. oblong pieces), an average dimension was utilized to sort the material. The total weight of each size range was calculated based on the total number of rock pieces, average rock size within a particular range, the specific gravity of the predominant rock type, and on assumed rock shape midway between a cube and a sphere. A summary of these rip-rap quantity counts, along with the predominate rock type from each representative sample found within each test pit, is presented in the table below.

	Quantity of Sizes					
Test Pit	**+ 19 inches**	**19 to 13 inches**	**13 to 8 inches**	**8 to 4 inches**	**Less than 4 inches (estimated total weight in lbs)**	**Predominate Rock Type**
SCR-1-TP1	1	2	11	73	107.5	Gray or Brown Sandstone
SCR-1-TP2	3	6	13	36	204.5	Gray or Brown Sandstone
SCR-1-TP3	6	3	7	78	80	Gray or Brown Sandstone

The total weight of rip rap material for each size category was estimated based on the median weight. The resulting gradation of the rip rap for each test pit is provided on Plates V, VI and VII.

4 LABORATORY TESTING

Testing on representative samples of rip rap revetment stone observed along the Santa Clara River Levee (SCR-1) revetment was conducted. A total of three samples, one sandstone, one rhyolite, and one basalt, were tested. The testing included abrasion, durability, specific gravity, and absorption. The results of the laboratory tests are included in Appendix B.

5 CONCLUSIONS AND RECOMMENDATIONS

The rip rap materials evaluated during this study generally meet applicable engineering requirements/specifications pertaining to revetment stone. The following provides for a detailed discussion of the engineering findings.

5.1 GRADATION ANALYSIS

The estimated in-situ gradation curves for the rip rap materials excavated at the three test pit locations are presented on Plate VIII. That gradation presentation includes the three gradational curves presented on Plates V, VI, and VII along with the original project specified gradation originally presented on Plate I. A comparison of the in-situ gradation with the original project specifications indicates that the existing rip rap material is coarser/heavier than the original project specifications.

As discussed previously in this report, portions of the encountered rip rap material exceeded the maximum weight of 400 pounds (approximate equivalent diameter of 19 inches). These oversize rip rap sizes result in the trend of the gradation skewed towards the heavier/coarser range and minimization of the material less than 4 inch diameter. Therefore, the gradational curves were re-evaluated based on material sizes approximately less than 400 pounds (19 inch diameter). The revised distribution curves for the three test pit locations along with the original project specifications are shown on Plate IX.

In general, the in-situ gradation of the rip rap material for the three test pit locations meets or is coarser/heavier than the original project specifications.

5.2 RIP RAP QUALITY

As previously discussed in this report, the original project specifications did not provide minimum requirements for rip rap quality. However, for the subject study, AMEC compiled generally accepted minimum rip rap quality requirements for the evaluation of the existing materials. As part of the field study, AMEC obtained representative samples of the existing rip rap material for laboratory testing and subsequent comparison with the developed criteria. The minimum requirements for this project as well as the range of results from the laboratory testing are provided in the following table.

Test	Criteria	Range of Test Results
Apparent Specific Gravity	2.5 Minimum	2.5 – 2.8
Absorption	4.2% Maximum	0.5% - 2%
Durability (Soundness Index)	52 Minimum	54 – 82
Abrasion (Percentage Wear)	45% Maximum	21% - 30%

As indicated in the above table, the on-site material evaluated by AMEC meets currently accepted criteria for rip rap quality.

5.3 RIP RAP DISTRIBUTION

The original project specifications did not provide recommendations for rip rap placement. General construction practice, however, is for rip rap material to be in contact on three points. Reference to the site photographs included in Appendix A is recommended. As shown on these photographs, the rip rap material at Test Pit locations SCR-1-TP1 and SCR-1-TP3 generally meets typical construction practices, although the majority of voids in SCR-1-TP1 are infilled with silty sand and gravel. It is possible that much of the finer grain material present within SCR-1-TP1 has been washed into the voids over the 50 plus years since original revetment construction was complete. The upper access road consists of an aggregate base structural section that is routinely maintained. That material may have, over the years, been graded and/or eroded to fill much of the voids left after rip rap placement was completed.

The rip rap material encountered in Test Pit SCR-1-TP2 was generally separated by finer grain sands and gravels and not always in a three point seated arrangement. Based on the arrangement of materials in the test pit, it appears that a significant quantity of the material finer than 4 inches was placed during original levee construction. As shown on the photographs in Appendix A, the rip rap sizes encountered in this test pit were generally larger/heavier than that encountered in the other two test pits. In addition, the rip rap material was non-uniform in gradation. The material was generally smaller near the top of levee, becoming progressively larger towards the toe of the test pit trench.

6 CLOSURE

This report is based on the project as described and the geotechnical data obtained from AMEC's investigation, field observations, testing, and pertinent reference documents. The conclusions and recommendations do not reflect possible undetected variations that may occur between the reported testing locations and other data points.

This report has not been prepared for use by parties other than Tetra Tech or their designated representatives, or for projects other than that described in the preceding text. This document may not contain sufficient information for other parties or other purposes. This report has been prepared in accordance with generally accepted geotechnical practices and makes no other warranties, either express or implied, as to the professional advice or data included.

Thank you for the opportunity to be of continued service on this project. If you have any questions or require further information please do not hesitate to contact the undersigned.

Respectfully submitted,

Chris A. Spitzer
Project Engineer
CAS/DD/dc

Douglas Dahncke
Senior Engineer

DOUGLAS DAHNCKE
No. GE 2279
Exp. 12/31/09

Encl.: Plates I through IX
Appendix A
Appendix B
Appendix C

c: Mr. Ike Pace, Addressee (1) and copy via email

APPENDIX A

Site Photographs

Photo 1: Test pit SCR-1-TP1. Looking along upstream wall of trench.

Photo 2:Test pit SCR-1-TP1. Stockpile of material.

Photo 3: Test pit SCR-1-TP2. Looking perpendicular to levee. Note fine material.

Photo 4: Test pit SCR-1-TP2. Looking downstream. Note fine material in trench and larger material at toe.

Photo 5: Test pit SCR-1-TP3. Looking perpendicular to levee. Note coarser revetment.

Photo 6: Test pit SCR-1-TP3. Sample pile.

APPENDIX B

Laboratory Testing

LABORATORY TESTING

The laboratory testing was designed to fit the specific needs of this project and was limited to testing on-site materials. A brief description of each type of test is presented below. Specific results are below.

Durability Index tests were performed on three (3) samples in general accordance with California Test Method (CTM) 229.

Abrasion Loss Tests were performed on three (3) samples in general accordance with ASTM C535.

Specific Gravity and Absorption tests were performed on three (3) samples in general accordance with CTM 206.

TESTING OF ROCK REVETMENT MATERIAL

Rock Type	Specific Gravity CTM 206	Percent Absorption CTM 206	Loss By Abrasion ASTM C535	Soundness Index (Durability) CTM 229
Sandstone	2.6	1.0%	29%	54
Basalt	2.8	0.5%	21%	82
Rhyolite	2.5	2.0%	30%	58

APPENDIX C

“Greenbook” Standard Specifications
For Public Works Construction
2006 Edition

"GREENBOOK"

Standard Specifications for Public Works Construction

2006 EDITION

200-1.5.5 Sand Gradations. The sand shall conform to the following gradations:

TABLE 200-1.5.5 (A)

Sieve Size	Percentage Passing Sieve		
	Asphalt Concrete	Portland Cement Concrete	Mortar
9.5 mm (3/8 in)	100	100	-
4.75 mm (No.4)	-	95-100	100
2.36 mm (No.8)	75-100	75-90	95-100
1.18 mm (No.16)	-	55-75	70-95
600 µm (No.30)	-	30-50	35-70
300 µm (No.50)	-	10-25	5-35
150 µm (No.100)	-	2-10	0-10
75 µm (No. 200)	0-8[1]	0-5	0-5

[1] May be exceeded to permit a maximum of 12 percent, provided the sand equivalent of the asphalt concrete sand is 35 or greater.

200-1.6 Stone for Riprap.

200-1.6.1 General. Stone for riprap shall be quarrystone or cobblestone. Quarrystone shall be angular and cobblestone shall be rounded. Stone shall be of such shape as to form a stable protection structure of the required section. Cobblestone shall not be used on slopes steeper than 1 vertical to 2 horizontal. Flat or elongated shapes will not be accepted unless the thickness of the individual pieces is at least one-third of the length.

Unless otherwise designated, for application greater than 180 tonnes (200 tons), design parameters including filter, foundation, and gradation with supporting calculations by a registered Civil Engineer, shall be submitted to the Engineer for approval.

Stone shall be sound, durable, hard, resistant to abrasion and free from laminations, weak cleavage planes, and the undesirable effects of weathering. It shall be of such character that it will not disintegrate from the action of air, water, or the conditions to be met in handling and placing. All material shall be clean and free from deleterious impurities, including alkali, earth, clay, refuse, and adherent coatings.

200-1.6.2 Grading Requirements. Stone for riprap shall be designated by class and conform to the following gradations:

TABLE 200-1.6 (A)

Rock Size	Percentage Larger Than			
	225 kg (500 lb) Class	170 kg (375 lb) Class	90 kg (Light) Class	35 kg (Facing) Class
450 kg (1000 lb)	0-5	-	-	-
320 kg (700 lb)	-	0-10	-	-
225 kg (500 lb)	50-100	10-50	0-5	-
90 kg (200 lb)	-	85-100	50-100	0-5
35 kg (75 lb)	90-100	95-100	90-100	50-100
10 kg (25 lb)	95-100	-	95-100	90-100
1 kg (2.2 lb)	-	-	-	95-100

Note: The amount of material smaller than the smallest size shown in the table for any class shall not exceed the percentage limit as determined on a weight basis. Compliance with the percentage limits shown in the table for all other sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified size compared to the total number of individual pieces larger than the smallest size listed in the table for that class.

200-1.6.3 Quality Requirements. Visual evaluation of the quarry, including examination of blast samples and diamond drill core samples, suitable tests and service records may be used to determine the acceptability of the stone. The Contractor shall notify the Agency in writing of the intended source of stone at least 60 days prior to use. To ensure the required quality, stone may be subject to petrographic analysis or X-ray diffraction.

The material shall conform to the following requirements:

TABLE 200-1.6 (B)

Tests	Test Method No.	Requirements in percent
Apparent Specific Gravity	ASTM C 127	2.50 Minimum
Absorption[1]	California 206	4.20 Maximum
Durability[1]	California 229	52 Minimum
Percentage Wear	ASTM C 131	45 Maximum

1. Based on the formula below, absorption may exceed 4.2 percent if the Durability Absorption Ratio (DAR) is greater than 10. Durability may be less than 52 if DAR is greater than 24.

$$\text{DAR} = \frac{\text{Coarse Durability Index}}{\text{\% Absorption} + 1}$$

200-2 UNTREATED BASE MATERIALS

200-2.1 General. Materials for use as untreated base or subbase shall be classified in the order of preference as follows:

Crushed Aggregate Base

Crushed Miscellaneous Base

Processed Miscellaneous Base

Select Subbase

When base material without further qualification is specified, the Contractor shall supply crushed aggregate base. When a particular classification of base material is specified, the Contractor may substitute any higher classification, following the order of preference listed above, of base material for that specified. All processing or blending of materials to meet the grading requirement will be performed at the plant or source. The materials shall compact to a hard, firm, unyielding surface and shall remain stable when saturated with water.

200-2.2 Crushed Aggregate Base.

200-2.2.1 General. Crushed aggregate base shall consist entirely of crushed rock and rock dust conforming to the requirements of 200-1.1 and 200-1.2.

200-2.2.2 Grading. The aggregate shall be uniformly graded and shall conform to the following gradation:

TABLE 200-2.2.2

Sieve	Percentage Passing Sieve
37.5 mm (1-1/2 in)	100
19.0 mm (3/4 in)	90-100
9.5 mm (3/8 in)	50-80
4.75 mm (No.4)	35-55
600 µm (No.30)	10-30
75 µm (No.200)	2-9
ASTM C 131 Test Grading	B

STANDARD SPECIFICATIONS

STATE OF CALIFORNIA
BUSINESS, TRANSPORTATION AND HOUSING AGENCY
DEPARTMENT OF TRANSPORTATION

MAY 2006

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SECTION 72: SLOPE PROTECTION

72-1 GENERAL

72-1.01 DESCRIPTION

- Slope protection consists of rock, concrete, concreted-rock or slope paving. The type of slope protection to be used will be designated in the Engineer's Estimate, the special provisions or shown on the plans. The slope protection shall be placed in conformance with these specifications, the special provisions, and the details and dimensions shown on the plans or directed by the Engineer.

72-2 ROCK SLOPE PROTECTION

72-2.01 DESCRIPTION

- This work shall consist of placing revetment type rock courses on the slopes.
- The size of the individual pieces of rock in each class shall be as indicated in the table in Section 72-2.02, "Materials," or as specified in the special provisions. The classes of rock slope protection will be designated in the Engineer's Estimate as 8T, 4T, 2T, 1T, 1/2T, 1/4T, Light, Facing, and No. 1, No. 2 or No. 3 Backing.

72-2.02 MATERIALS

- The individual classes of rocks used in rock slope protection shall conform to the following, unless otherwise specified in the special provisions, or as shown on the plans.

GRADING OF ROCK SLOPE PROTECTION					
Method A Placement, Percentage Larger Than*					
	Classes				
Rock Sizes	8T	4T	2T	1T	1/2T
16 Ton	0-5	—	—	—	—
8 Ton	50-100	0-5	—	—	—
4 Ton	95-100	50-100	0-5	—	—
2 Ton	—	95-100	50-100	0-5	—
1 Ton	—	—	95-100	50-100	0-5
1/2 Ton	—	—	—	95-100	50-100
1/4 Ton	—	—	—	—	95-100

* The amount of material smaller than the smallest rock size listed in the above tables for any class of rock slope protection shall not exceed the percentage limit listed in the above tables determined on a weight basis. Compliance with the percentage limit shown in the above tables for all other rock sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the above tables for that class.

GRADING OF ROCK SLOPE PROTECTION

Method B Placement, Percentage Larger Than*								
	Classes							
Rock Size	1T	1/2T	1/4T	Light	Facing	No. 1	No. 2	No. 3
2 Ton	0-5	—	—	—	—	—	—	—
1 Ton	50-100	0-5	—	—	—	—	—	—
1/2 Ton	—	50-100	0-5	—	—	—	—	—
1/4 Ton	95-100	—	50-100	0-5	—	—	—	—
200 lb	—	95-100	—	50-100	0-5	0-5	—	—
75 lb	—	—	95-100	—	50-100	50-100	0-5	—
25 lb	—	—	—	95-100	90-100	90-100	25-75	0-5
5 lb	—	—	—	—	—	—	90-100	25-75
1 lb	—	—	—	—	—	—	—	90-100

* The amount of material smaller than the smallest rock size listed in the above tables for any class of rock slope protection shall not exceed the percentage limit listed in the above tables determined on a weight basis. Compliance with the percentage limit shown in the above tables for all other rock sizes of the individual pieces of any class of rock slope protection shall be determined by the ratio of the number of individual pieces larger than the specified rock size compared to the total number of individual pieces larger than the smallest rock size listed in the above tables for that class.

- The material shall also conform to the following quality requirements:

Test	California Test	Requirement
Apparent Specific Gravity	206	2.5 min.
Absorption	206	4.2% max.*
Durability Index	229	52 min.*

* Based on the formula listed below, absorption may exceed 4.2 percent if DAR is greater than 10. Durability Index may be less than 52 if DAR is greater than 24.

$$\frac{\text{Coarse Durability Index}}{\text{\% Absorption} + 1} = \text{Durability Absorption Ratio (DAR)}$$

- Rocks, when conforming to the provisions in this Section 72-2.02, may be obtained from rock excavation of the roadway prism or other excavation being performed under the provisions of the contract, in conformance with the provisions in Section 4-1.05, "Use of Materials Found on the Work."
- Rocks shall be of such shape as to form a stable protection structure of the required section. Rounded boulders or cobbles shall not be used on prepared ground surfaces having slopes steeper than 2:1 (horizontal:vertical). Angular shapes may be used on any planned slope. Flat or needle shapes will not be accepted unless the thickness of the individual pieces is greater than 0.33 times the length.

72-2.025 ROCK SLOPE PROTECTION FABRIC

- Rock slope protection fabric shall be placed prior to placing rock slope protection, when the fabric is shown on the plans, or specified in the special provisions, or ordered by the Engineer.
- Rock slope protection fabric shall conform to the provisions in Section 88, "Engineering Fabrics," and shall be placed in conformance with the details shown on the plans and as specified in these specifications.
- Prior to placing rock slope protection fabric, the surfaces upon or against which rock slope protection fabric is to be placed, shall be free of loose or extraneous material and sharp objects that may damage the fabric during installation.
- Rock slope protection fabric shall be handled and placed in conformance with the manufacturer's recommendations and as directed by the Engineer. Rock slope protection fabric shall be placed loosely upon or against the surface to receive the fabric so that the fabric conforms to the surface without damage when the cover material is placed.
- Rock slope protection fabrics shall be joined, at the option of the Contractor, either with overlapped joints or stitched seams.
- When fabric is joined with overlapped joints, adjacent borders of the fabric shall be overlapped not less than 24 inches. The fabric shall be placed such that the fabric being placed shall overlap the adjacent section of fabric in the direction the cover material is being placed.
- When the fabric is joined by stitched seams, the fabric shall be stitched with yarn of a contrasting color. The size and composition of the yarn shall be as recommended by the fabric manufacturer. The number of stitches per inch of seam shall be approximately 5 to 7. The strength of stitched seams shall be the same as specified for the fabric, except when stitched seams are oriented up and down a slope, the strength shall be a minimum of 80 percent of that specified for the fabric.
- Equipment or vehicles shall not be operated or driven directly on the rock slope protection fabric.
- Rock slope protection fabric damaged during placement shall be replaced or repaired, as directed by the Engineer, by the Contractor at the Contractor's expense. Fabric damaged beyond repair, as determined by the Engineer, shall be replaced. Repairing damaged fabric shall consist of placing new fabric over the damaged area. The minimum fabric overlap from the edge of the damaged area shall be 3 feet for overlap joints. If the new fabric joints at the damaged areas are joined by stitching, the stitched joints shall conform to the requirements specified herein.

72-2.03 PLACING

- Rock slope protection shall be placed in conformance with one of the following methods as designated in the Engineer's Estimate.
- At the completion of slope protection work, the footing trench shall be filled with excavated material and compaction will not be required.

Method A Placement

- A footing trench shall be excavated along the toe of slope as shown on the plans.

- The larger rocks shall be placed in the footing trench.
- Rocks shall be placed with their longitudinal axis normal to the embankment face and arranged so that each rock above the foundation course has a 3-point bearing on the underlying rocks. Foundation course is the course placed on the slope in contact with the ground surface. Bearing on smaller rocks which may be used for chinking voids will not be acceptable. Placing of rocks by dumping will not be permitted.
- Local surface irregularities of the slope protection shall not vary from the planned slope by more than one foot measured at right angles to the slope.

Method B Placement

- A footing trench shall be excavated along the toe of the slope as shown on the plans.
- Rocks shall be so placed as to provide a minimum of voids, and the larger rocks shall be placed in the toe course and on the outside surface of the slope protection. The rock may be placed by dumping and may be spread in layers by bulldozers or other suitable equipment.
- Local surface irregularities of the slope protection shall not vary from the planned slopes by more than one foot measured at right angles to the slope.

72-2.04 MEASUREMENT

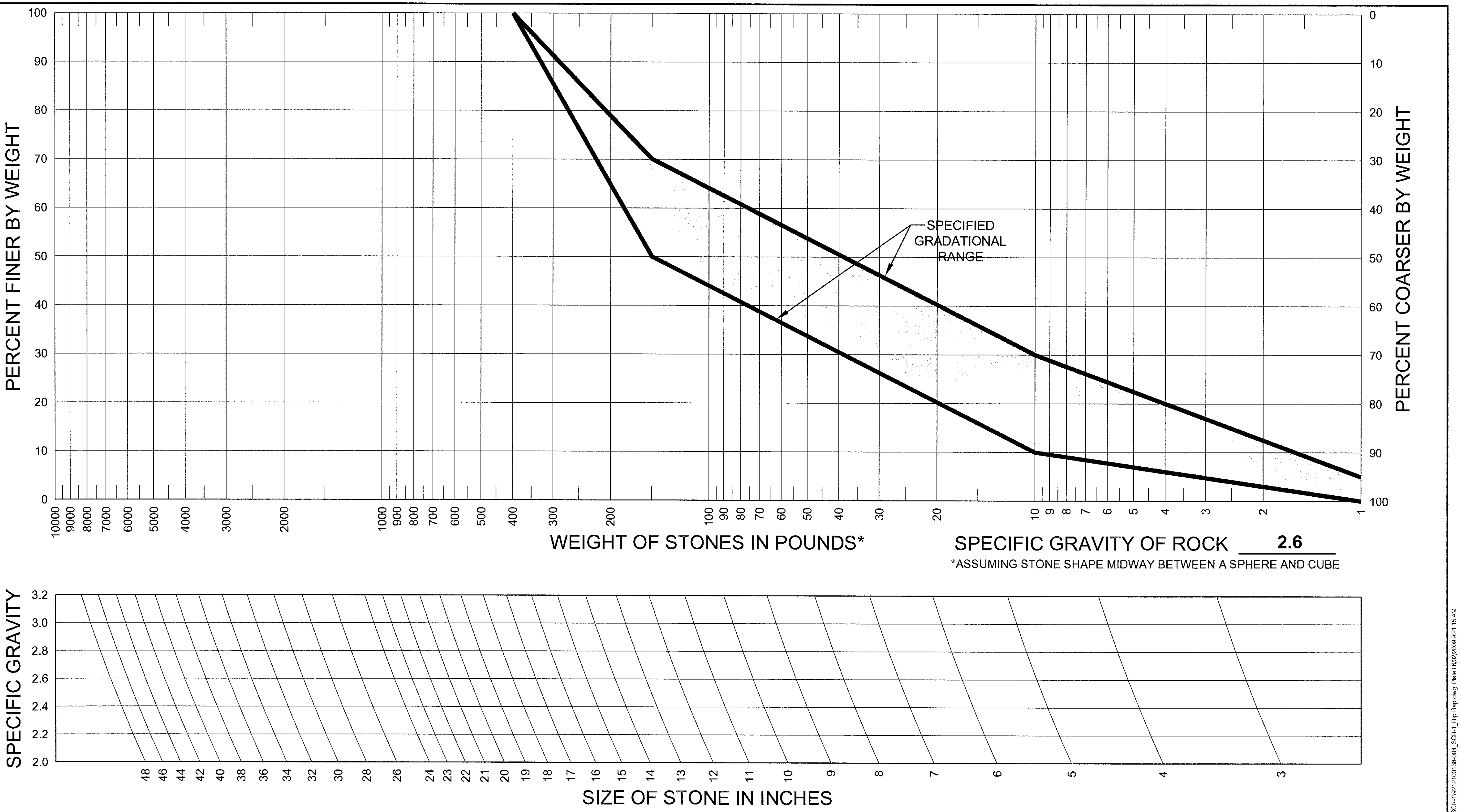
- Rock slope protection will be measured by the ton or cubic yard as designated in the Engineer's Estimate.
- Quantities of rock slope protection to be paid for by the cubic yard will be determined from the dimensions shown on the plans or the dimensions directed by the Engineer and rock slope protection placed in excess of these dimensions will not be paid for.
- Quantities of rock slope protection to be paid for by the ton will be weighed in conformance with the provisions in Section 9-1.01, "Measurement of Quantities."
- Rock slope protection fabric will be measured by the square yard. The quantity to be paid for will be the actual area covered not including additional fabric required for overlaps.

72-2.05 PAYMENT

- The contract price paid per cubic yard or per ton for rock slope protection (the class of rock and method of placement to be designated in the Engineer's Estimate) shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in constructing the rock slope protection, complete in place, including excavation, and backfilling footing trenches, as shown on the plans, and as specified in these specifications and the special provisions, and as directed by the Engineer.
- The contract price paid per square yard for rock slope protection fabric shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all the work involved in furnishing and placing rock slope protection fabric, complete in place, as shown on the plans, as specified in these specifications and the special provisions, and as directed by the Engineer.

PLATES

FILE: 9212100138-004_SCR-1_RIP RAP PLOT DATE: 6/2/2009



SPECIFIC GRAVITY OF ROCK 2.6

*ASSUMING STONE SHAPE MIDWAY BETWEEN A SPHERE AND CUBE

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DWN BY: JBD
CHK'D BY: C.S.

RIP RAP GRADATION CURVES
REVETMENT STONE
ORIGINAL LEVEEE CONSTRUCTION

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

DATE: 6/2/2009
SCALE: As Shown
PROJECT NO: 9212100138
FIGURE No. PLATE I

FILE: RIP RAP GRADATION.DWG

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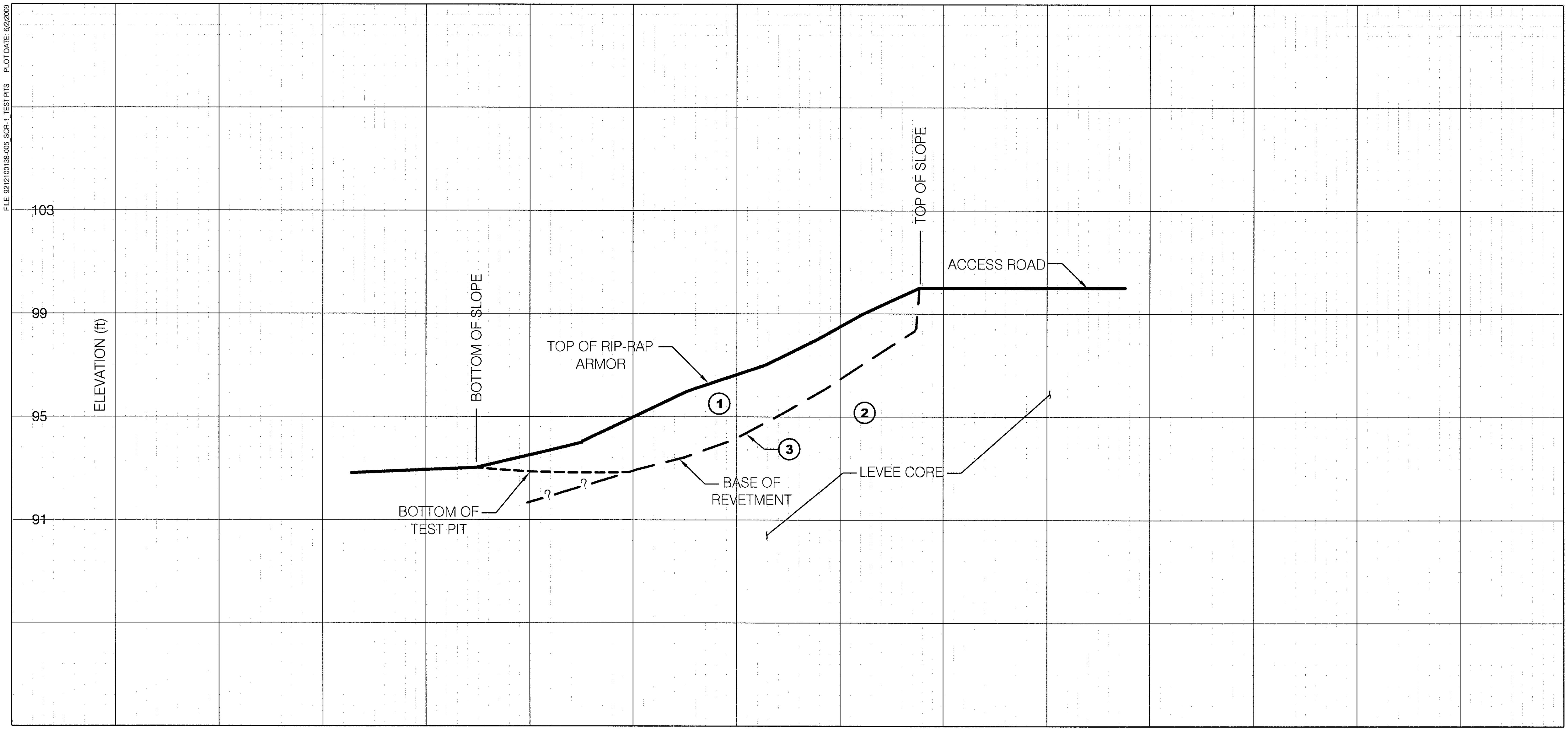
TEST PIT LOG

SCR-1-TP1

LOOKING UPSTREAM

FILE: 9212100138-005_SCR-1_TEST PITS   PLOT DATE: 6/2/2009



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EXPLANATION:

① Rip-rap is typically between 19" and 4" infilled with brown SILTY SAND. Rip-rap is composed primarily of brown and gray stone, subangular to sburounded with scattered subrounded granitic cobbles.

② Levee material is dark brown SILTY SAND with GRAVEL

③ No filter material observed below rip-rap revetment stone

NOTES:

1. No groundwater encountered.
2. Test Pit elevation based on topography provided by Tetra Tech.
3. Samples of SANDSTONE taken from this Test Pit.
4. Test Pit excavated on May 7, 2009 and backfilled by county personnel.

0 4' 8'

SCALE IN FEET

HORIZONTAL = VERTICAL

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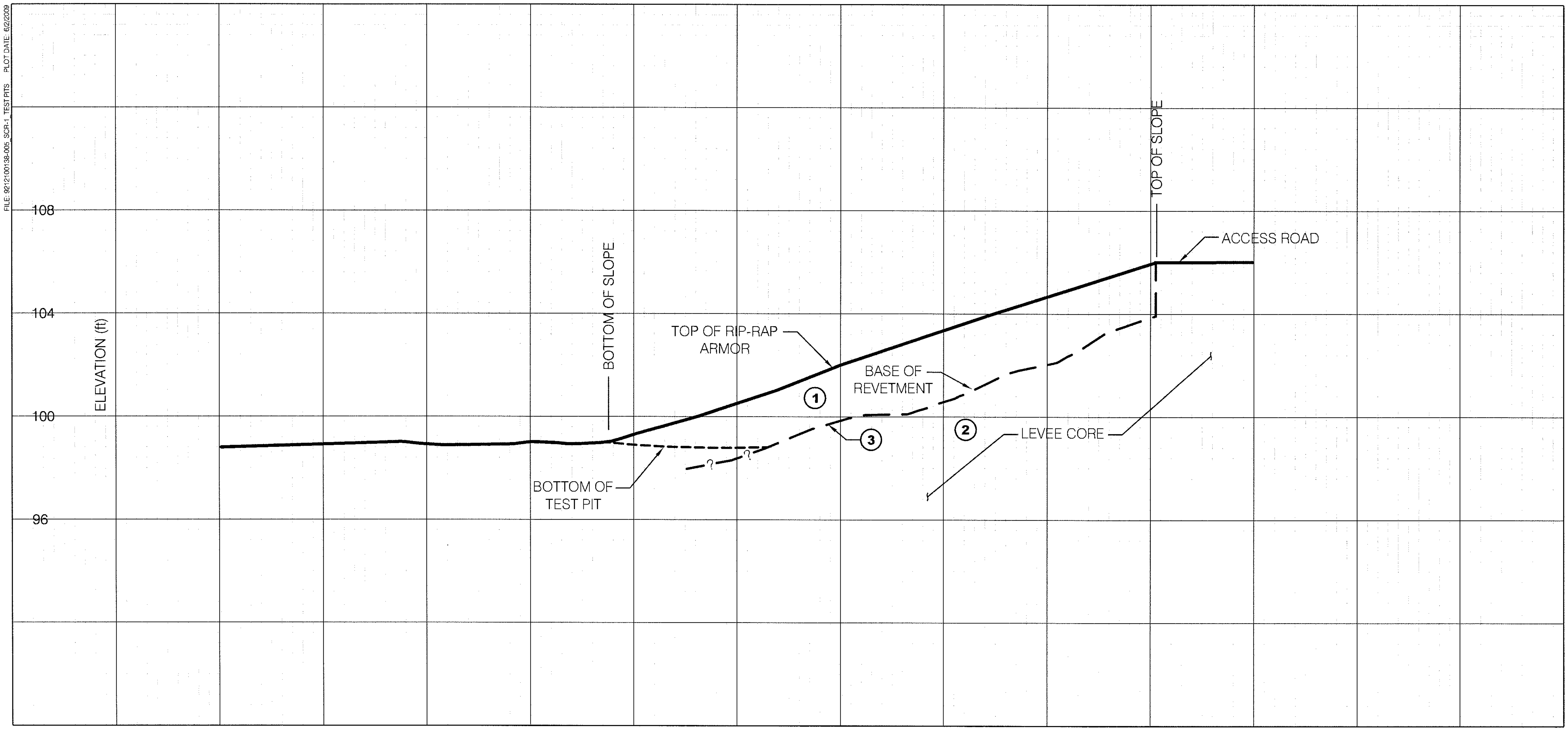
PLATE II

TEST PIT LOG

SCR-1-TP2

LOOKING UPSTREAM



EXPLANATION:

① Rip-rap is typically between 8" or less with wome larger; several large +24" boulders, infilled with brown SILTY SAND. Rip-rap is composed primarly of brown and gray sandstone, scattered, subangular (less than 2%) subrounded, granitic COBBLES.

② Levee material is dark brown SILTY SAND.

③ No filter material observed below rip-rap revetment.

(No samples taken at this location)

NOTES:

1. No groundwater encountered.
2. Test Pit elevation based on topography provided by Tetra Tech.
3. No samples of SANDSTONE taken from this Test Pit.
4. Test Pit excavated on May 7, 2009 and backfilled by county personnel.

0 4' 8'

SCALE IN FEET
HORIZONTAL = VERTICAL

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LOGGED BY: D.B.	SCALE: As Shown	TEST PIT No. SCR-1-TP2

PLATE III

FILE: 92121000138-005_SCR-1_TEST PITS PLOT DATE: 6/2/2009

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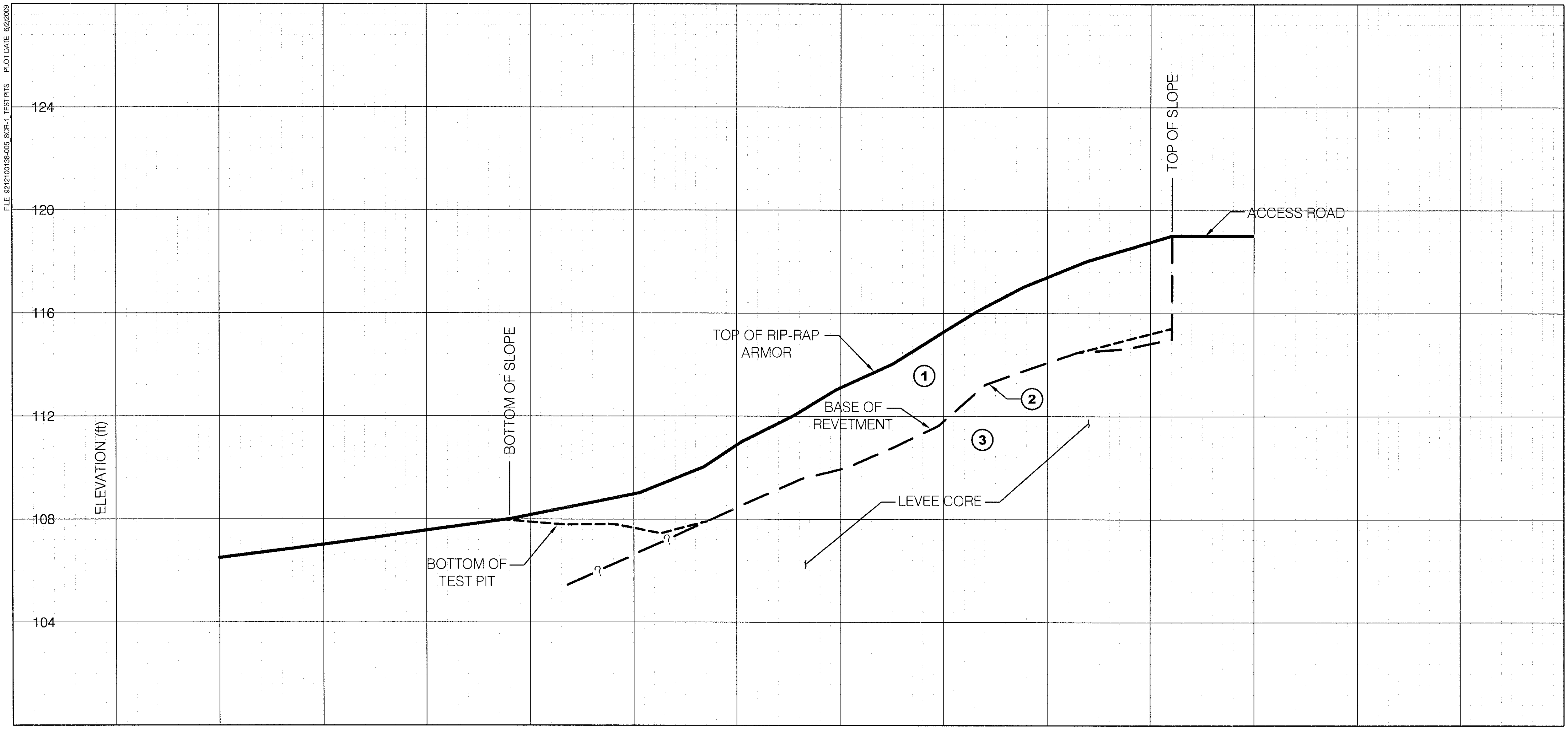
TEST PIT LOG

SCR-1-TP3

LOOKING UPSTREAM



FILE: 9212100138-005_SCR-1_TEST PITS   PLOT DATE 6/2/2009

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EXPLANATION:

① Rip-rap is predominantley brown and gray SANDSTONE 8" to 4" in diameter, angular to subrounded, minor amounts of rhyolite, 5% to 10% SAND (very little sand or fines).

② Levee material is light brown coarse grained SAND with GRAVEL.

③ No filter material observed below rip-rap revetment.

NOTES:

1. No groundwater encountered.
2. Test Pit elevation based on topography provided by Tetra Tech.
3. Rip Rap rock samples taken from this Test Pit.
4. Test Pit excavated on May 7, 2009 and backfilled by county personnel.

0 4' 8'

SCALE IN FEET
HORIZONTAL = VERTICAL

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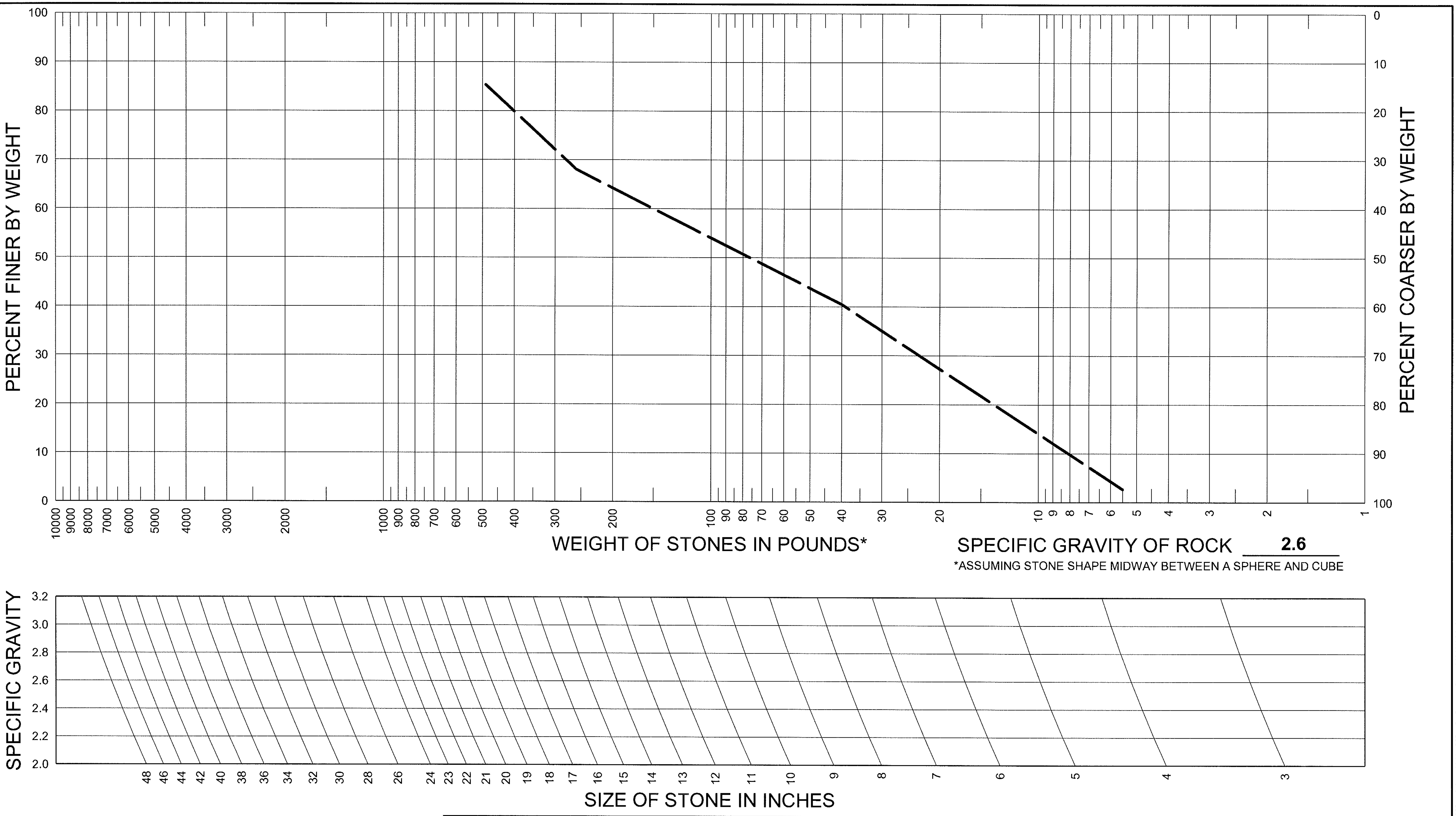
LOGGED BY: D.B.	SCALE: As Shown	TEST PIT No. SCR-1-TP3

PLATE IV

FILE: 9212100138-004_SCR-1_RIP RAP PLOT DATE: 6/2/2009



EXPLANATION:

— — TEST PIT SCR-1-TP1

FILE: RIP RAP GRADATION.DWG

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CHK'D BY: C.S.

RIP RAP GRADATION CURVES
TEST PIT SCR-1-TP1

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

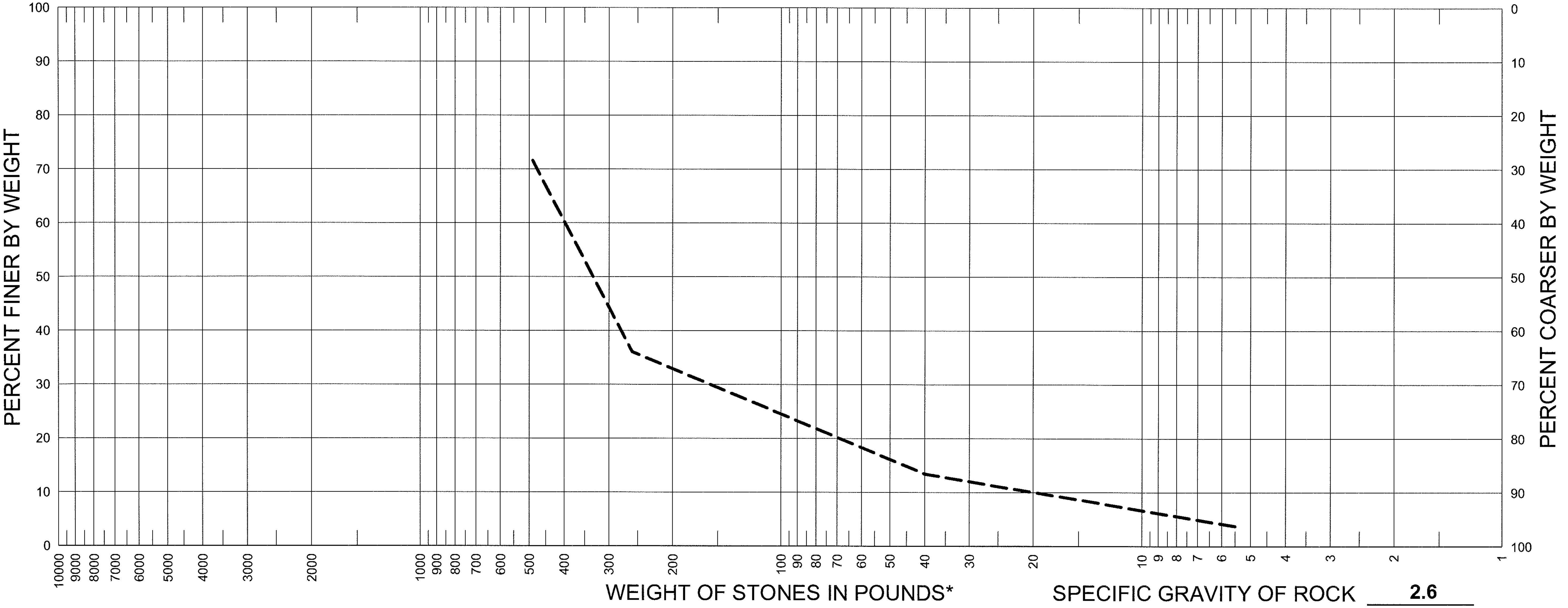
DATE: 6/2/2009

SCALE: As Shown

PROJECT NO: 9212100138

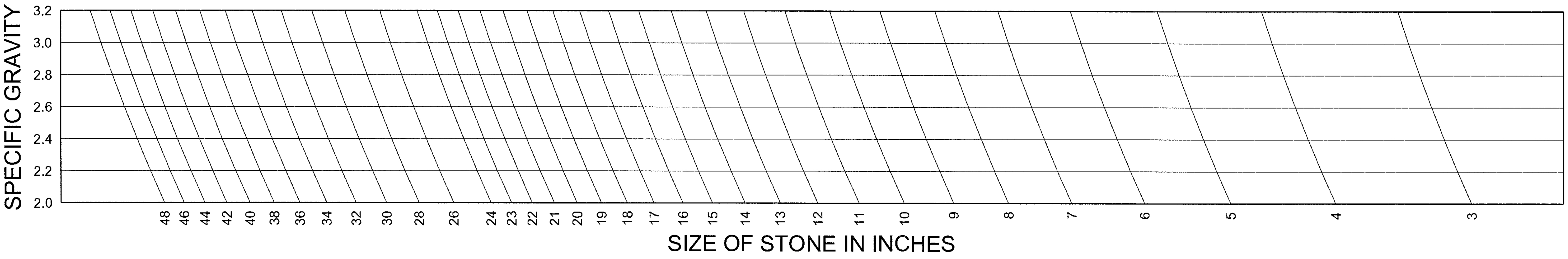
FIGURE No. PLATE V

ANAHEIM R:\Drawings\2009\Dept19\212100138_SCR-1\9212100138-004_SCR-1_Rip Rap.dwg, Plate V 6/02/2009 9:21:20 AM



SPECIFIC GRAVITY OF ROCK **2.6**

*ASSUMING STONE SHAPE MIDWAY BETWEEN A SPHERE AND CUBE



EXPLANATION:

— — — — TEST PIT SCR-1-TP2

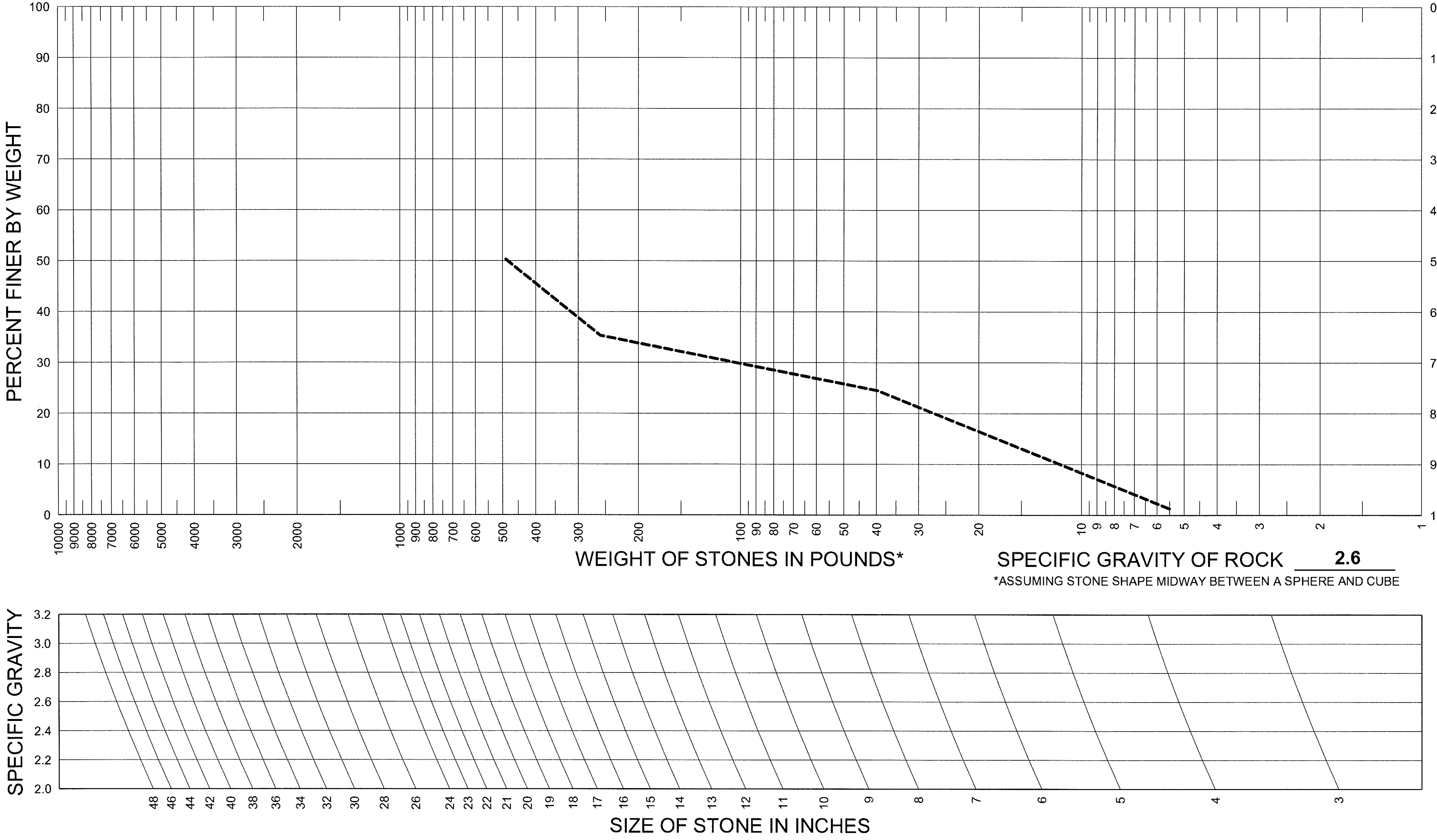
AMEC Earth & Environmental
1290 N. HANCOCK STREET, SUITE 102
ANAHEIM, CA 92807-1924
www.amec.com/earthandenvironmental

DWN BY: JBD
CHK'D BY: C.S.

RIP RAP GRADATION CURVES
TEST PIT SCR-1-TP2

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

DATE: 6/2/2009
SCALE: As Shown
PROJECT NO: 9212100138
FIGURE No. PLATE VI



EXPLANATION:

- - - - - - - - TEST PIT SCR-1-TP3

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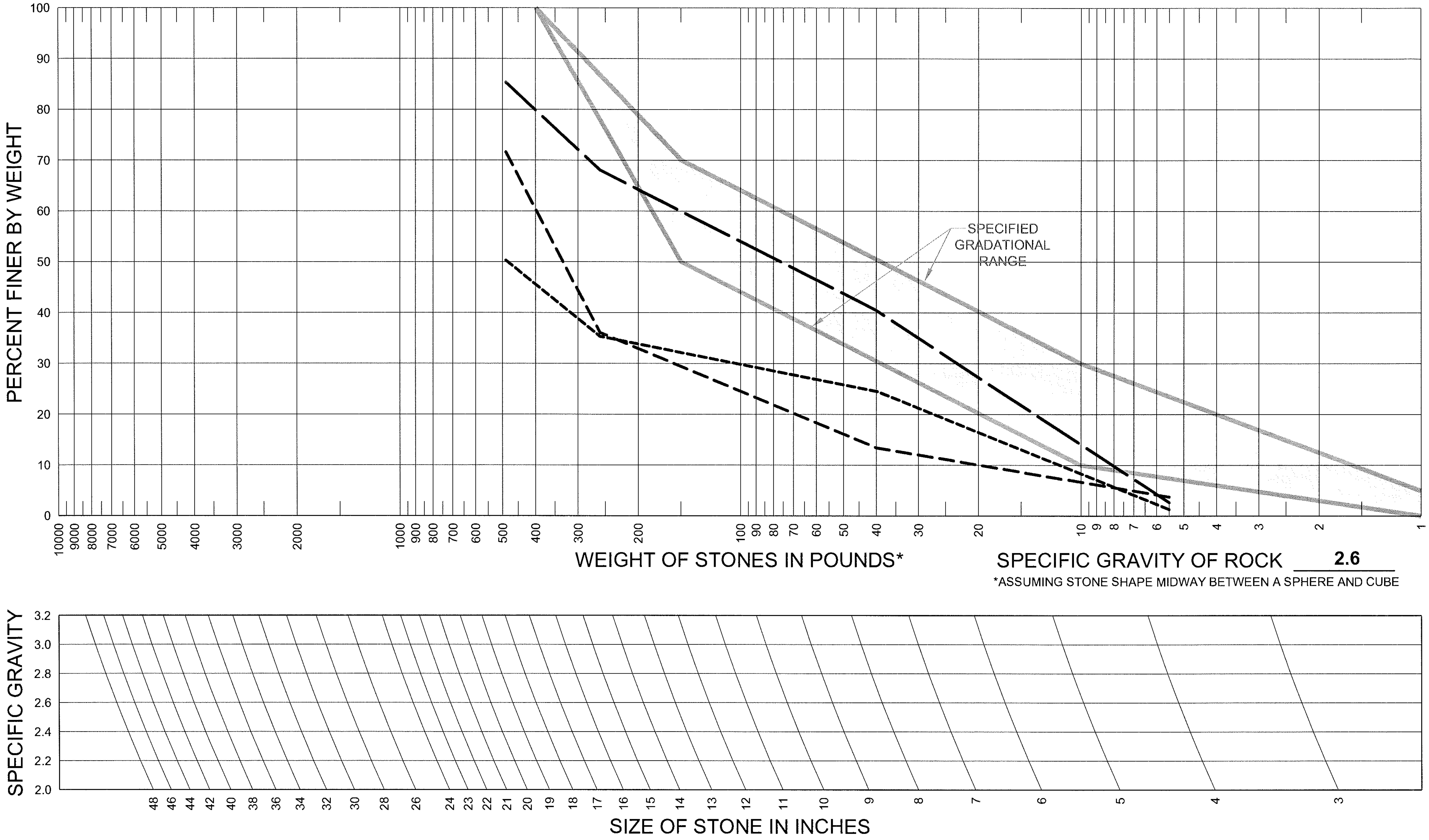
DWN BY: JBD
CHK'D BY: C.S.

RIP RAP GRADATION CURVES
TEST PIT SCR-1-TP3

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

DATE: 6/2/2009
SCALE: As Shown
PROJECT NO: 9212100138
FIGURE No. PLATE VII

FILE: 9212100138-004_SCR-1_RIP RAP PLOT DATE: 6/2/2009



EXPLANATION:

- ▬ ▬ TEST PIT SCR-1-TP1 (PLATE V)
- – – – TEST PIT SCR-1-TP2 (PLATE VI)
- - - - - TEST PIT SCR-1-TP3 (PLATE VII)

FILE: RIP RAP GRADATION.DWG

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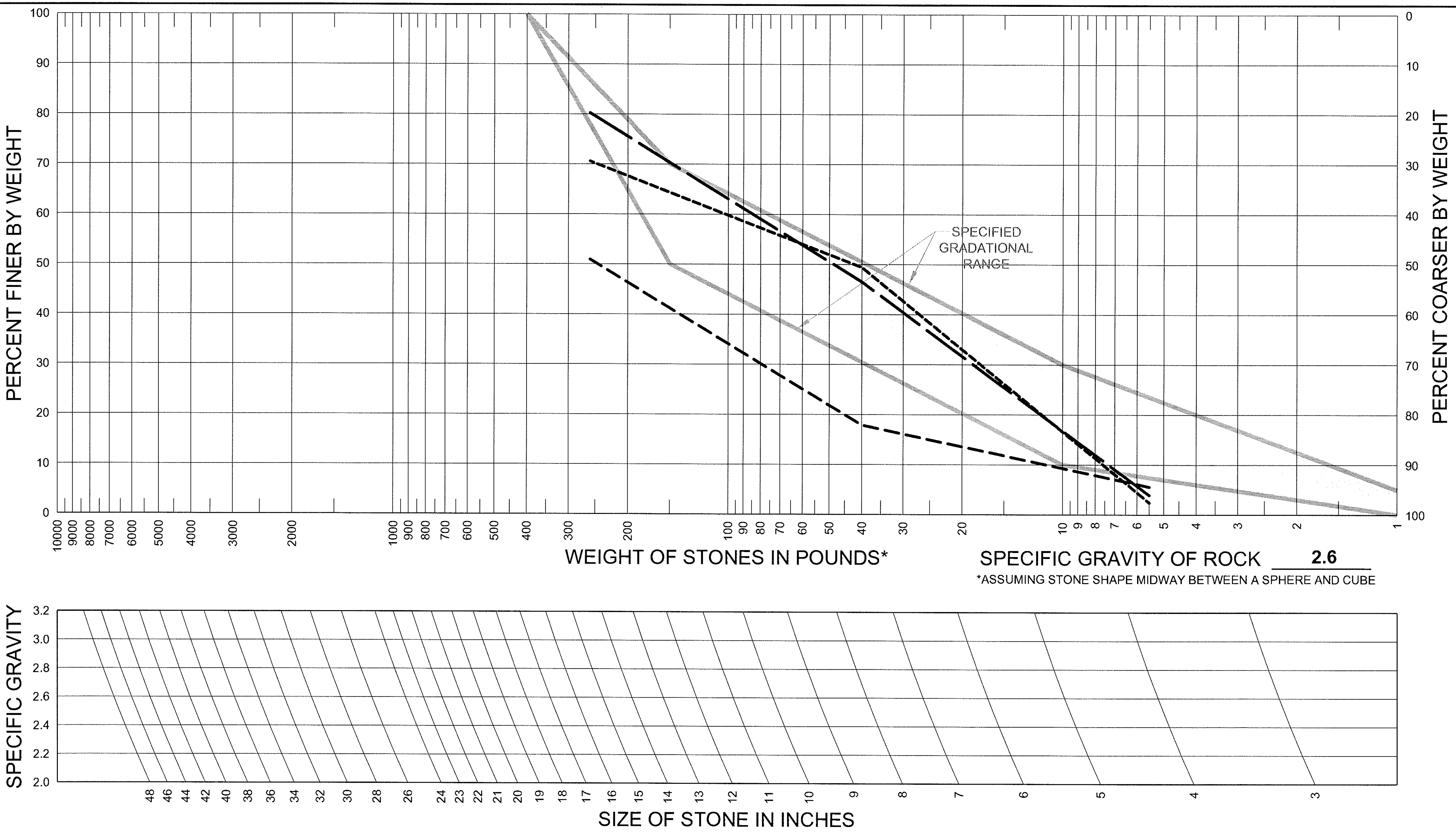
RIP RAP GRADATION CURVES
IN-SITU GRADATION vs. SPECIFICATION

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

DATE: 6/2/2009
SCALE: As Shown
PROJECT NO: 9212100138
FIGURE No. PLATE VIII

ANAHEIM R:\Drawings\2009\Dept1\9212100138_SCR-1\9212100138-004_SCR-1_Rip Rap.dwg. Plate VIII 6/02/2009 9:23:05 AM

FILE: 9212100138-004_SCR-1_RIP RAP PLOT DATE: 6/2/2009



EXPLANATION:

TEST PIT SCR-1-TP1 (ADJUSTED)

TEST PIT SCR-1-TP2 (ADJUSTED)

TEST PIT SCR-1-TP3 (ADJUSTED)

FILE: RIP RAP GRADATION.DWG

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RIP RAP GRADATION CURVES
ADJUSTED IN-SITU GRADATION vs. SPECIFICATION

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

DATE: 6/2/2009

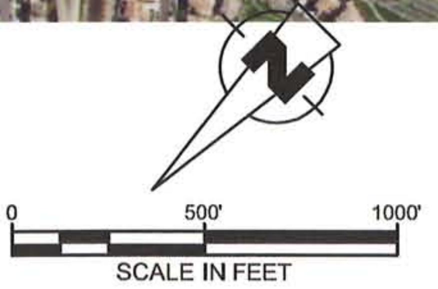
SCALE: As Shown

PROJECT NO: 9212100138

FIGURE No. PLATE IX

ANAHEIM R:\Drawings\2009\Dept11\9212100138\9212100138-004_SCR-1_Rip Rap.dwg, Plate IX 6/02/2009 9:23:54 AM

FILE: 9212100138-003_SCR-1_TEST PIT LOC   PLOT DATE: 6/2/2009



EXPLANATION:

SCR-1-TP3 LOCATION OF TEST PIT

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TEST PIT LOCATION PLAN

SANTA CLARA RIVER LEVEE - SCR-1
VENTURA COUNTY WATERSHED PROTECTION DISTRICT
FEMA LEVEE CERTIFICATION PROJECT

DATE: 6/2/2009

SCALE: As Shown

PROJECT NO: 9212100138

FIGURE No. PLATE X