Appendix A - Engineering

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Figures

Tables

Acronyms and Abbreviations

ALT	Alternative
AR	Alternatives Report, 2009, Corps of Engineer
BO	Biological Opinion
CDFG	California Department of Fish and Game
CEQA	California Environmental Quality Act
CFS	Cubic Feet per Second
Corps	United State Army Corps of Engineers
DDR	Design Documentation Report
Delta	Sacramento-San Joaquin Delta
DWR	California Department of Water Resources
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
ER	Engineering Regulation
ESA	Endangered Species Act
ETL	Engineering Technical Letter
FRR	Field Reconnaissance Report
IAP	Initial Array Plan
IWG	Interagency Working Groups
IWM	Instream Woody Material
MSWL	Mean Summer Water Level
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
O&M	Operations and Maintenance
PACR	Post Authorization Change Report
PBPP	Programmatic Bank Protection Plan
PDT	Project Delivery Team
PPA	Project Partnership Agreement
PPFM	Programmatic Plan Framework Memorandum
RM	River Mile
RAP	Reduced Array Plan
SAM	Standard Assessment Methodology
SRBPP	Sacramento River Bank Protection Project
SRFCP	Sacramento River Flood Control Project
USACE	United State Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VFZ	Vegetation Free Zone
WRDA 2007	Water Resources Development Act of 2007

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1.0 Purpose and Scope

1.1 Purpose

This Engineering Appendix is prepared as part of the Post Authorization Change Report (PACR) to the Sacramento River Bank Protection Project (SRBPP). The SRBPP was originally authorized in 1960 as bank protection work along the Sacramento River to protect the existing banks and levee elements of the Sacramento River Flood Control Project (SRFCP). Phase II was authorized in 1974, and provided 405,000 linear feet (LF) of bank protection. The Water Resources Development Act of 2007 (WRDA 2007) added 80,000 LF to Phase II. The PACR supports revisions to the SRBPP to add 80,000 LF of bank protection to Phase II as authorized. The PACR demonstrates that the SRBPP Phase II 80,000 LF is technically sound, is compliant with U.S. Army Corps of Engineers (Corps) policy, and meets environmental regulations.

The project purpose, as stated in the 1973 SRBPP, California-Second Phase, Report of the Chief of Engineers, is Flood Risk Management (FRM) to protect the existing levee system of the SRFCP. The report states that "each year streambanks and levees at additional unprotected locations throughout the Sacramento River Flood Control Project are subjected to erosion which carries away useful land, deposits sediment in downstream flood and navigation channels, damages valuable riparian vegetation and wildlife habitat, and ultimately threatens to destroy the integrity of the flood protection project and produce disastrous flooding." Thus, bank protection provides multiple beneficial effects.

To conform to Corps planning, engineering, and policy guidance, the project purpose should be associated with a basic Corps mission. Since bank protection supports the SRFCP, which was constructed primarily for flood control, Corps guidance as it applies to flood risk management projects is followed in this Engineering Appendix and PACR.

1.2 Approval

This Engineering Appendix defines the specific design concepts and establishes a baseline cost estimate for the 80,000 LF. This Engineering Appendix is prepared in accordance with Engineering Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works Projects, and other Corps regulations. The designs are in compliance with Engineering Technical Letter (ETL) 1110-2-583: Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures. The earlier vegetation management ETL 1110-2-571 was used for the design effort. This ETL expired and has been replaced by ETL 1110-2-583. The designs herein continue to comply with USACE vegetation management policy.

Since this Engineering Appendix supports the PACR, it will be approved along with the PACR, likely at the Division level. The PACR forms the basis for the Project Partnership Agreement (PPA) between the Corps and the project non-Federal Sponsor, the State of California Central Valley Flood Protection Board.

1.3 Initial Array Plan Concepts

This Engineering Appendix (EA) establishes design concepts for bank protection measures at 106 erosion sites (Note: Previous documents list 107 erosion sites; however, a discrepancy has been found in the 2009 Alternatives Report regarding the site at Natomas Cross Canal 3.0L and the site has been removed from this document) totaling approximately 80,000 LF. The erosion sites and corresponding designs were originally chosen during the development of the Corps' 2009 Alternatives Report (AR) prepared by Kleinfelder – Geomatrix. The designs in the AR were developed before the Corps vegetation management policies were established in ETL 1110-2-571. Sixty-seven of the erosion sites were found to be in compliance with the ETL and would require minimum design changes, while the 39 remaining sites were found to be non-compliant. This EA retains the bank protection designs of the 67 compliant sites. For the 39 remaining sites, the designs were revised so that all sites are ETL compliant. The new design measures are set-back levees, adjacent levees, and stone protection with no vegetation. Two sites are revised designs of riparian and wetland bench.

The aggregate of bank protection designs at erosion sites, together with on-site and off-site environmental mitigation, present a prototypical plan known as the Initial Array Plan (IAP). This plan provides the scope and guidelines for specific bank protection plans that will be developed and constructed once the PACR is approved and the PPA is signed.

Due to the dynamic and uncertain nature of erosion, sites needing bank protection are identified and selected on an annual basis. Since it is impossible to predict future erosion, the IAP provides a representation of what erosion repair will be constructed in future years. Therefore, the actual sites and bank erosion measures that will be constructed during the implementation phase will vary from the sites and measures presented in this IAP.

The IAP is a prototype for the SRBPP Phase II 80,000 LF, which is managed as a bank protection program. As a program, erosion sites are identified, monitored, and repaired on an annual basis. The description of the full process of monitoring erosion, development of bank protection designs and cost estimates, financing, environmental compliance and construction is provided in the PACR and is labeled the Programmatic Bank Protection Plan (PBPP). The IAP demonstrates how effective, fully mitigated bank protection may be achieved throughout the SRFCP system. Even though the erosion sites vary year to year, the IAP promotes a broad, system-wide perspective and avoids a piecemeal site-by site planning approach. Setback levees, for example, provide environmentally complete bank protection at one or more sites and can provide mitigation for other sites.

By including a variety of representative sites throughout the Sacramento River system, the IAP demonstrates that effective bank protection measures may be applied to any sites throughout the project area. It further demonstrates that bank protection may be achieved in compliance with ETL 1110-2-583 and other design guidelines.

The erosion protection design process included early consideration of environmental impacts and mitigation. This is important because erosion protection measures can potentially impact state and federally listed fish species. Additionally, in light of ETL 1110-2-583, bank protection may result in the loss of high value riparian vegetation. To avoid or mitigate for losses, the bank protection design process included modeling changes to fish habitat and accounting for losses of riparian vegetation. The design of bank protection at actual sites was a collaborative team effort between engineering and environmental disciplines. Bank protection designs were tested against the Standard Assessment Methodology (SAM) model to determine a design's effect on several focal fish species, including state and federal-listed threatened and endangered species that may occur in the SRBPP area. Effects to riparian vegetation were avoided or mitigated on-site, or mitigated off-site. Environmental impacts are discussed in the programmatic Environmental Impact Statement and Environmental Impact Report (EIS/EIR) that accompany the PACR.

Through the IAP, the Engineering Appendix provides conceptual designs, drawings, real estate requirements, and costs for bank protection. The cost estimates include preliminary real estate costs and environmental mitigation costs, and serve as a representation of what the 80,000 LF of bank protection might cost.

The IAP is also used to determine economic feasibility of the various economic sub-basins as discussed in the PACR main report. After determining the feasibility of each basin, a Reduced Array Plan (RAP) is developed. The RAP consists of only LF within economically feasible sub-basins. Costs from the RAP are extrapolated on a per linear foot basis to 80,000 linear feet to obtain a project cost for the SRBPP.

1.4 Location

The SRBPP program area extends south-to-north along the Sacramento River from the town of Collinsville at River Mile (RM) 0, upstream to Chico at RM 194, and includes reaches of lower Elder and Deer Creeks. The SRBPP program area also includes Cache Creek, the lower reaches of the American River (RM 0-23), Feather River (RM 0-61), Yuba River (RM 0-11), and Bear River (RM 0-21), as well as portions of Threemile, Steamboat, Sutter, Miner, Georgiana, and Cache Sloughs.

1.4.1 Sacramento River Watershed

The Sacramento River Watershed drains the northern part of the Central Valley into the middle and lower reaches of the Sacramento River (**Figure 1**). The Sacramento River is approximately 327 miles long and drains over 27,000 square miles of land. The upper watershed of the Sacramento River region includes the drainages above Lake Shasta and Lake Oroville. The valley drainages include the upper Colusa and Cache Creek watershed on the west side of the valley, and the Feather River and American River watersheds on the east side of the valley.

Land uses in the Sacramento River Basin are principally agricultural, silvicultural, and open space, with urban development focused around the City of Sacramento. Other urban developed areas include Marysville, Davis, Woodland, Vacaville, Dixon, Redding, Chico, Yuba City and various Sierra Nevada foothill towns. Agriculture is the dominant land use followed by urban development. About 2,300 mi^2 in the watershed are devoted to agricultural use.

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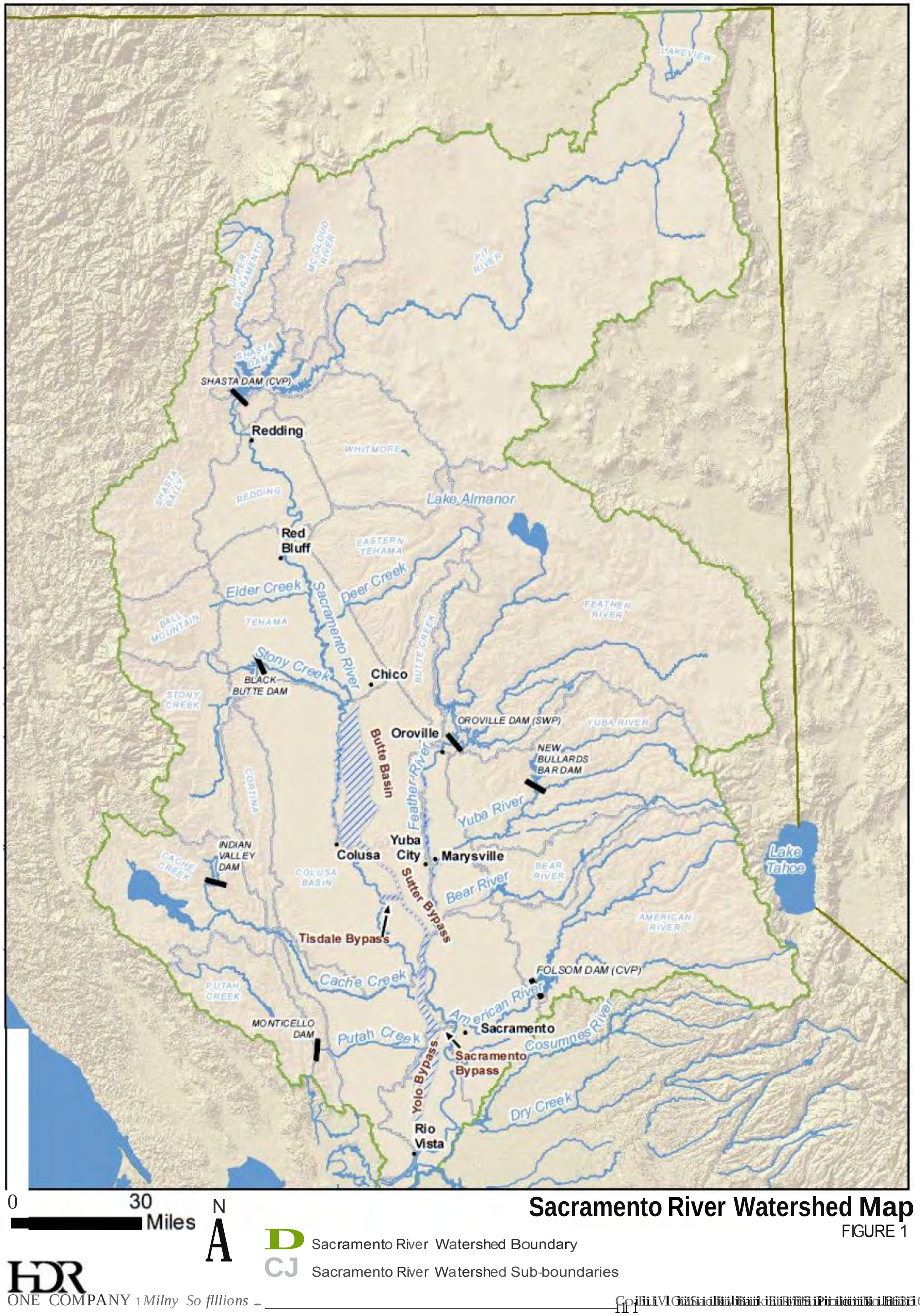
Figure 1 - Sacramento River Watershed Map



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1.5 Scope

1.5.1 Functional Scope

As described in the 1973 Chief's Report, the SRBPP is a long-range program of bank protection and levee setbacks to protect the existing banks and levees within the SRFCP. Bank protection in the form of erosion repairs will be either on the waterside berm or the levee if there is no berm. Critical areas must continue to be protected to maintain the safety of the SRFCP. The SRBPP does not specifically include other levee corrective measures such as seepage and cutoff walls, slope stability, or raising low spots along the levee crests. However, these may be included to meet USACE standards, such as with the construction of a setback levee. Incidental improvement in levee seepage conditions is possible if the repair results in a lengthening and preservation of the levee's seepage path.

1.5.2 Geographic Scope

The geographic scope includes the banks and levees of the SRFCP. The SRFCP is along the Sacramento River from Elder Creek near Tehama to its confluence with the San Joaquin River in the Delta. The SRFCP includes a number of tributaries, sloughs, and bypass channels (**Figure 2**).

In 1982, Congress specifically authorized extension of the SRBPP upstream of the SRFCP levee system from RM 176 left/184 right to RM 194 (public law 97-377).

As summarized below, the SRBPP is separated into 4 geographic locations: 1A, 1B, 2, and 3. See Figure 11 of the PACR and refer to the EIS/EIR for further detail on these regions.

- **Region 1a -** Within Region 1a, the Sacramento River flows below Isleton (River Mile (RM) 20) into the Delta, forming a distribution network of sloughs and channels.
- **Region 1b -** Region 1b includes the mainstream Sacramento River from Isleton (RM 20) in the Delta, upstream past the city of Sacramento, to the Feather River confluence (RM 80) at Verona. Region 1b also includes the lower American River from the confluence with the Sacramento River upstream to RM 13, Natomas East Main Drain, Natomas Cross Canal, and Coon Creek Group Interceptor Unit 6.
- **Region 2 -** Within Region 2, the mainstream Sacramento River flows from Colusa (RM 143) downstream of the Colusa Bypass to the confluences with the Feather River and Sutter Bypass at Verona (RM 80). Feather River and its tributaries in Region 2 extend from the confluence with the Sacramento River to RM 31 at the Western Canal Left Bank.
- **Region 3 -** Region 3 includes the Sacramento River downstream of Chico Landing (RM 194) to Colusa (RM 143).

1.6 Sacramento River Flood Control Project

The SRFCP was authorized by the Flood Control Act of 1917 (Public Law 64-367) and includes a system of levees, weirs, pumping plants, and bypasses designed to safely convey

Sacramento River and tributary flood flows. The project provides protection to about 2.1 million acres of highly productive agricultural land, as well as protection to the cities of Sacramento, West Sacramento, Yuba City, Marysville, Colusa, Gridley, and other communities. The SRFCP is operated and maintained by the Department of Water Resources, State of California. The Corps provides assurance that the project is maintained to Federal standards. The flood management system responsible for protecting these resources in the Sacramento Valley has expanded with the addition of projects, such as the Sacramento River and Major and Minor Tributaries Flood Control Project, the American River Common Features Project and the Sacramento River Flood Control System Evaluation Project. This project includes the following major features (see **Figure 2**):

- Approximately 1,300 miles of levees along the Sacramento River extending from River Mile (RM) 0 at Collinsville to Chico Landing, RM 194, distributary sloughs, the lower reaches of the major tributaries (American, Feather, Yuba and Bear Rivers) and additional minor tributaries;
- The Moulton, Colusa, Tisdale, Fremont, and the Sacramento Flood Overflow Weirs; and
- The Butte Basin and Sutter and Yolo Bypasses and Sloughs.

The project levees begin on the right (west) bank just downstream of Chico Landing. Upstream of the levees, high flows on the river flow into the Butte Basin, a trough created by subsidence, to the east. The Colusa Basin Drain, a similar trough located to the west of the river, intercepts runoff from west side tributaries. The Yolo Bypass directs high flows to protect the Cities of Sacramento and West Sacramento.

The SRFCP relies on a system of weirs and bypasses to supplement the capacity of the Sacramento River main channel. Sacramento River flows spill over the Tisdale Weir, through the Tisdale Bypass and into the Sutter Bypass. The Colusa Weir is the next structure to spill; it directs flows into the lower Butte Basin via the Colusa Bypass. Flows spill over the Moulton Weir into the Butte Basin. The Fremont Weir spills Sacramento River flood flows into the Yolo Bypass. The Sacramento Weir spills flows into the Sacramento Bypass, which in turn feeds the Yolo Bypass. The Yolo Bypass diverts flood flows around Sacramento and West Sacramento and empties back into the Sacramento River in the Delta.

The Tisdale Weir is usually the first flood overflow structure to spill. When the Sacramento River reaches 23,000 cubic-feet per second (cfs), flows spill over the Tisdale Weir, through the Tisdale Bypass and into the Sutter Bypass. The Colusa Weir is the next structure to spill; when the river reaches 30,000 cfs, flows spill into the lower Butte Basin via the Colusa Bypass. Flows spill over the Moulton Weir into the Butte Basin at 60,000 cfs. In comparison, at 90,000 cfs upstream of the levees, overflows start into the Butte Basin, and if flood flows exceed 300,000 cfs upstream of the levees, the Sacramento River could be expected to spill into the Colusa Basin.

During major flood events, the four major upstream reservoirs: Shasta on the Sacramento River, Folsom on the American River, Oroville on the Feather River, and the Butte Basin intercept and store initial surges of runoff and provide a means of regulating floodflow releases to downstream levee streams, channels, and bypass floodways. To achieve the full benefits of the reservoirs, specific downstream channel capacities must be maintained. Reservoir operation is coordinated not only among various storage projects but also with downstream channel and floodway carrying capacities.

Shasta is a multipurpose dam that regulates flows from its 6,420 square mile watershed. The watershed excludes Goose Lake. The project serves agricultural, municipal, and industrial demands through provision of 4.5 million acre-feet of total storage, 1.3 million acre-feet of which is allocated to flood control. Electric power generation is an integral component of system operation. At Colusa, the local drainage area of the Sacramento River, between Shasta Dam and Colusa, is 6,180 square miles. The only flow control in the reach is Black Butte Dam on Stony Creek. This dam creates a 144,000 acre-foot multipurpose reservoir. Oroville Dam provides 3.5 million acre-feet of storage on the Feather River for several purposes; 750,000 acre-feet of storage is allocated to flood control. The north fork of the Yuba River is uncontrolled except for New Bullards Bar Dam, which provides 960,000 acre-feet of storage (170,000 acre-feet is for flood control).

The Sacramento Flood Control System (reservoirs, original levees, and bypasses) provides protection to about 2.1 million acres of highly productive agricultural land, as well as to the cities of Sacramento, West Sacramento, Yuba City, Marysville, Colusa, Gridley, Live Oak, Courtland, Isleton, Rio Vista and numerous smaller communities. Approximately 2.5 million lives will be protected by the project. The Valley is laced with agriculture and related infrastructure, including irrigation works (diversions, pumping plants, canals and drains), roads and bridges. Major transportation routes are Interstate Highways 5 and 80, and State Highways 50, 99, 45, 20, and 160. Under existing, without project conditions, an estimate $250 million worth of damages can be expected annually to the Sacramento River Basin.

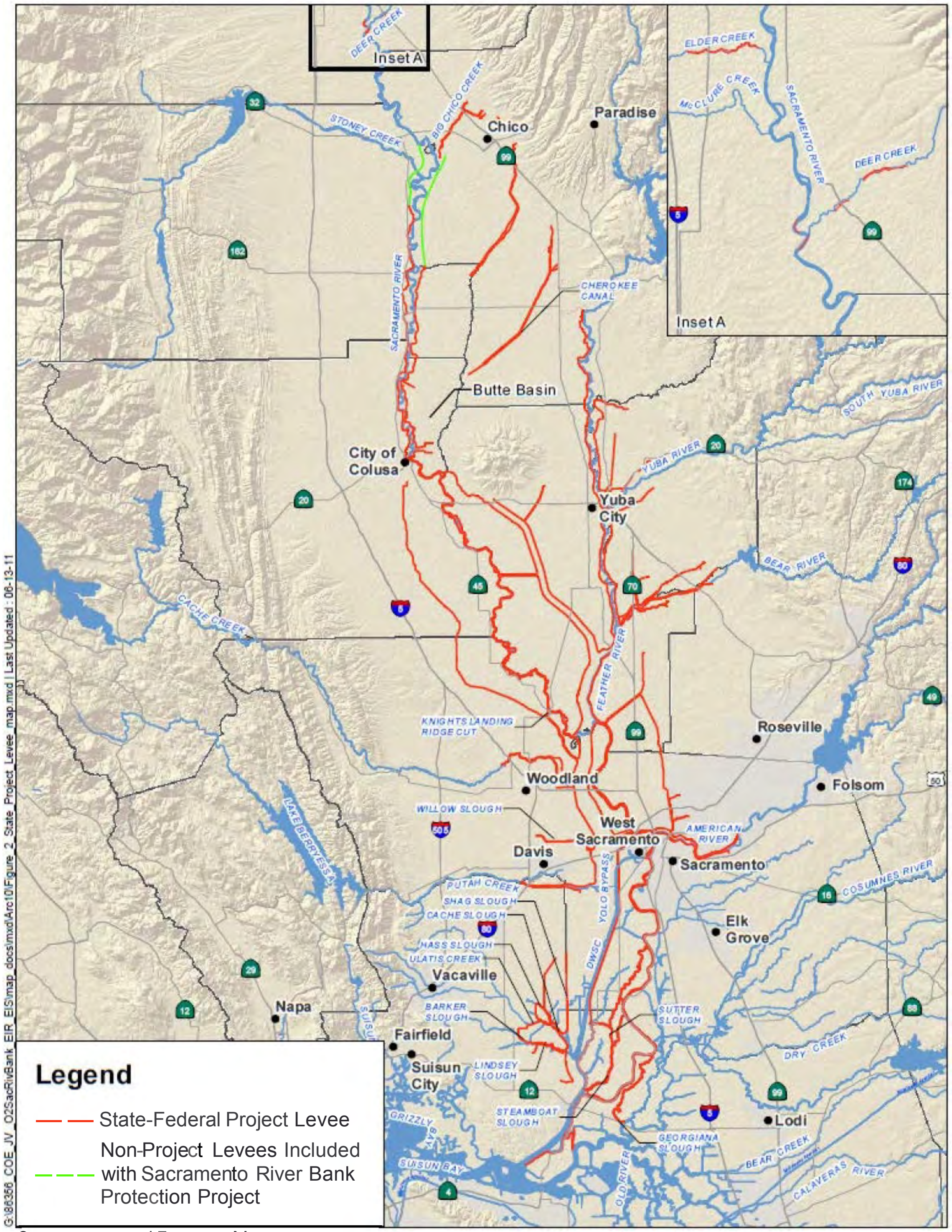
1.7 Other Related Projects

Major projects have improved or altered SRFCP elements. Unless otherwise noted, the Corps is the lead agency for the projects. These include the following:

- Yuba River Basin Project is strengthening and realigning levees along the Yuba and Feather Rivers, as well as strengthening the ring levee around Marysville.
- American River Common Features Project has raised and strengthened many miles of levees along the Lower American River and some portions of the Sacramento River protecting the City of Sacramento. Studies are underway that could lead to further improvements to levees protecting the Natomas area of Sacramento.
- West Sacramento Project has improved levees that protect West Sacramento.
- Hamilton City Project will setback or raise the west levee of the Sacramento River protecting Hamilton City, in Glenn County.

- Sacramento Metropolitan Area Project raised and strengthened Sacramento River project levees protecting Sacramento and West Sacramento.
- Sacramento River Systems Evaluation Project strengthened Sacramento River project levees that were found to be deficient.
- Natomas Levee Improvement Program primarily corrects levee underseepage problems and Sacramento River project levees and other levees that protect the Natomas basin. The improvements are currently being done in phases. Construction is financed and being accomplished by the Sacramento Area Flood Control Agency.
- Early Implementation Program Projects is a state initiative to fund urban flood improvement projects. Projects that are in construction or have been recently completed within the SRBPP area are West Sacramento Levee Improvement Program, West Feather River Levee Project, and Three Rivers Levee Improvement Authority which includes improvements surrounding the South Yuba County Area.
- Other projects that have affected the SRFCP are the Sacramento River Major and Minor Tributaries Project and the Chico Landing to Red Bluff Project.

Figure 2- Sacramento Flood Control Project Levees



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Sacramento River Flood Control Project Levees

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2.0 Programmatic Bank Protection Plan Overview

Erosion along the Sacramento River is a dynamic, unpredictable process that demands flexibility to adapt to changing conditions. An IAP, rather than a typical specific plan and design, is necessary to provide the flexibility needed to respond to the variable characteristics of erosion. This IAP will be followed up by a series of specific, supplemental Design Document Reports (DDRs) that will provide a basis for design of bank protection at sites identified through the site selection process.

The IAP is representative of how and where the added 80,000 LF of bank protection will be constructed. The plan establishes bank protection measures at each of 106 erosion sites from the AR, totaling 77,436 LF, which approximates the 80,000 LF authorized in WRDA2007.

2.1 SRBPP Phase II Program

The SRBPP Phase II is a program developed for bank and levee rehabilitation responding to erosion problems that are identified in the field during annual reconnaissance and site selection. Erosion problems occur throughout the Sacramento River Flood Control System and are unpredictable. A plan of definitive bank protection cannot be developed due to the unpredictable nature of erosion. Therefore, an AIP is developed. The IAP provides a realistic representation of the measures, real estate requirements, construction footprint and costs for the 80,000 LF.

2.2 Initial Array Plan Defined

The IAP identifies 106 actual erosion sites on the SRFCP that total 77,436 LF. These 106 actual erosion sites are used as a representative sample of what the Phase II SRBPP will have to address during implementation. Out of a pallet of bank protection measures developed by the Corps, one measure is applied to each site. A conceptual design and cost estimate is then developed for each site.

2.3 Initial Array Plan Development Process

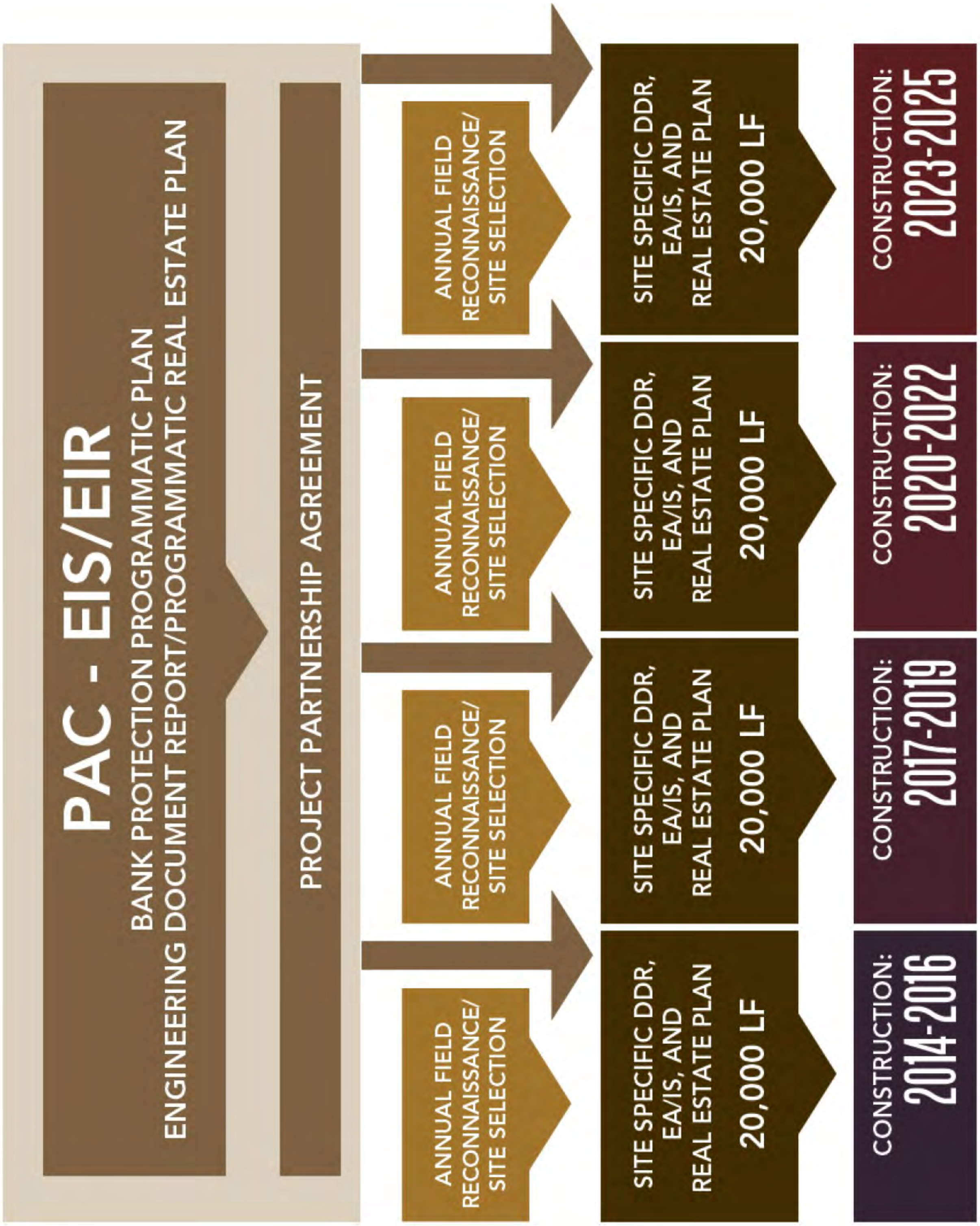
Development of the IAP follows a rational process to achieve a technically sound and complete plan. Measures are applied consistently throughout the system taking into account the unique characteristics of each site. The process builds on work already accomplished by the Corps, as presented in the AR. The AR did not define a vegetation free zone. Delineation of this zone is needed to develop bank protection that is in conformance with vegetation management policy. The IAP was developed taking into account the vegetation free zone so that as much on-site environmental mitigation as possible is included.

This process was done by a multidisciplinary team that included environmental specialists as well as engineers. A major aspect of this plan is avoiding or mitigating negative impacts to fish habitat. The Sacramento River and tributaries are spawning and juvenile rearing habitat for a number of migratory fish species listed under the Federal Endangered Species Act. The process includes evaluating the bank protection measures at sites using the SAM model, which determines gains and losses to fish habitat. The SAM model, as well as many of the bank protection measures discussed below, was developed through consultations between the Corps and the U.S. Fish and Wildlife Service and the National Marine Fisheries Service under provisions of the Endangered Species Act. These consultations were carried out for bank protection actions previous to the current 80,000 LF.

2.4 Implementation Phase

During the implementation phase, sites to receive bank protection will be identified on an annual basis. Geotechnical analyses, hydraulic analyses, and surveys will be conducted, and a bank protection measure identified. Supplemental environmental documentation will be required, and a supplemental DDR may be prepared, as well as plans and specifications. Implementation is further discussed in **Section 8.2 Site Selection and Implementation** of the **PACR** and its **Site Selection Process appendix**, **Appendix B**. If about 8,000 LF are constructed each year, the program would last ten years, to 2025 (see **Figure 3)**.

Figure 3 - Relationship between the Programmatic Plan and Implementation



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3.0 Erosion Protection Measures

A number of erosion protection measures have been developed by the Project Development Team (PDT). A range of measures is formulated to meet the varying erosion and mitigation requirements at a variety of sites throughout the system. The measures may be implemented at a given erosion site. The measures are described in detail in the main report of the PACR, Engineering Appendix, Appendix 1 Programmatic Plan Framework Memorandum, and the EIS/EIR. The Programmatic Plan Framework Memorandum (PPFM) and EIS/EIR demonstrate how bank protection would be applied given a number of different levee and bank conditions.

Table 1 gives a summary/comparison listing the details associated with each repair measure. These measures were revised and expanded from what are listed as alternatives in the AR. For reference, **Table 2** lists the measures in the AR and matches them with the measures of this Engineering Appendix.

Table 1 – Repair Measures Summary

Details	Measure 1: Setback Levee	Measure 2 : Bank Fill Stone Protection with No On-site Vegetation	Measure 3: Adjacent Levee	Measure 4a: Riparian Bank with Revegetation and IWM above Summer/Fall Waterline	Measure 4b: Riparian Bench with Revegetation and IWM above and below Summer/Fall Waterline	Measure 4c: Riparian and Wetland Benches with Revegetation	Measure 5: Bank Fill Stone Protection with On-Site Vegetation
Revegetation Outside of VFZ				X	X	X	
Riparian Bank/Bench			X	X	X	X	
IWM above Summer/Fall Waterline				X	X		
IWM below Summer/Fall Waterline					X		
Installation of Stone Protection		X		X	X		x
Adjacent Levee Construction			X				
Setback Levee Construction	X						
Existing Levee Breach	X		X				

Table 2 – AR Report and EA Erosion Repair Measures Comparison

2009 Alternatives Report	Phase II 80,000 Linear Feet Engineering Documentation Report
Alt 1: No Action	No Action
Alt 2: Design 1 – Bank fill rock slope with revegetation Alt 3: Design 1 with Site Specific Modification	Measure 2: Bank Fill Stone Protection with No On-site Vegetation Measure 5: Bank Fill Stone Protection with On-Site Vegetation
Alt 4: Design 2 – Low riparian bench with revegetation and large wood material enhancements *above* the summer/fall waterline recommended for sites upstream of RM 30 Alt 5: Design 2 with Site Specific Modification	Measure 4a: Riparian Bank with Revegetation and IWM above Summer/Fall Waterline
Alt 6: Design 3 – Low riparian bench with revegetation and large woody material enhancements above and below the summer/fall waterline recommended for sites upstream of RM 30 Alt 7: Design 3 with Site Specific Modification	Measure 4b: Riparian Bench with Revegetation and IWM above and below Summer/Fall Waterline
Alt 8: Design 4 – Delta smelt design – low riparian and wetland benches with revegetation recommended for sites downstream of RM 30 Alt 9: Design 4 – With Site Specific Modification	Measure 4c: Riparian and Wetland Benches with Revegetation
Alt 10: Setback Levee	Measure 1: Setback Levee
(No Alternative)	Measure 3: Adjacent Levee

4.0 Plan Development Details

A rigorous process was conducted to evaluate each erosion site and assign a revised repair measure if required. Erosion repairs, as described in the AR, must be vetted for ETL compliance. If the repair alternative is non-compliant then a new repair measure must be defined.

This plan development defines five erosion protection measures and the process for which a protection measure is assigned to an individual site, or in some instances a group of sites. The process takes into consideration the geographical location, the quantity and quality of existing riparian and riverine aquatic habitat, channel hydraulics, and major structures (houses, pumping plants, etc.) adjacent to the landside toe of the levee. The overall goal is to balance programmatic cost with retaining existing habitat and reduce potential mitigation for fish and wildlife.

4.1 Develop Erosion Site Cross Sections

4.1.1 Step 1: Site selection

Most but not all erosion sites presented in the AR were identified in the annual Field Reconnaissance Report (FRR) prepared by the Corps in 2007. Each year, beginning in 1998, personnel from the Sacramento District Corps and the California Department of Water Resources (DWR) Division of Flood Maintenance (acting on behalf of the local sponsor, the Central Valley Flood Protection Board) conduct a field reconnaissance review of the Sacramento River Flood Control System. The primary purpose of the review is to monitor and document the condition of the previously identified erosion sites, inventory any new erosion sites, and identify critical erosion sites that appear to be an imminent threat to the structural integrity of the flood control system.

The sites are geographically distributed throughout the SRFCP area and are representative of varying conditions found in different reaches throughout the project. Sites are along the Sacramento River main-stem, Delta sloughs, and along a number of tributaries. These include Bear River, Feather River, Cache Creek, Georgiana Slough, Yolo Bypass, Cherokee Canal, Cache Slough, Deep Water Ship Channel, Deer Creek, Elder Creek, Knights Landing Ridge, Cut Lower American River, Natomas Cross Canal, Steamboat Slough, Sutter Slough, Willow Slough and Yuba River.

The AR recommended a selected repair alternative for each of the 106 erosion sites from a group of ten bank protection alternatives. The ten alternatives provided in the AR include the four designs proposed by the Corps Sacramento District (described in the Framework Memo) which is referred to in the AR as designs 1 through 4. Each of the four designs included an additional alternative with a site specific modification, as well as a no action and setback alternative. A description of each alternative can be found in the AR. The AR also includes an aerial view exhibit of each erosion site which provides the location of critical points such as the upstream and downstream limits, existing encroachments, location of cross section measured during site reconnaissance and location of site photo. In addition, the AR includes a conceptual repair cross section which provides the erosion surface at the most critical point and the selected repair alternative. The AR evaluated a minimum of three alternatives for most sites while considering the no action alternative for all sites. Each site was evaluated based on the following criteria:

- General Site Description
- Levee and Bank Conditions
- Existing Environmental Conditions and Constraints
- Site Features and Improvements
- Site Access
- Evaluation of Bank Protection Alternatives
- Input from Agencies
- Recommended Alternative, Conceptual Design and Preliminary Cost
  - For a more detailed description of the AR evaluation criteria refer to EA Appendix 2 Civil Design with MCACES Estimate.

4.1.2 Step 2: Site Reconnaissance

Site evaluation includes establishing the landside and waterside toe, delineating levee geometry such as levee crown elevation and width, side slopes, waterside levee geometry, i.e. benches and water surface elevation. Site evaluation also includes establishing the quantity and quality of vegetation and identifying any major structures that might be impacted by a repair alternative.

Sources of information:

- Alternatives Report – 80,000 linear feet (106 Sites) Sacramento River Bank Protection Project, 2009: This report and associated field notes provided existing levee geometry, mean summer water surface elevation and upstream and downstream existing levee and bank geometry conditions.
- Sacramento River HEC-RAS model. A steady state HEC-RAS model of unverifiable origin and purpose likely based on the USACE Comprehensive Study UNET model geometry. Despite the questions about this model, a spot check of the model indicates that the model can be used for the purposes of this programmatic document. However, the model should not be used in any future work efforts on this or other projects. The spot check and the results are documented in a separate memorandum of record with the subject of "Sacramento River Bank Protection Project, Phase II 80,000 LF, PACR/EA/EIS/EIR, Sufficiency of Hydraulic Model Used”. The spot check indicates the geometry is likely similar or identical to the Comprehensive Study geometry. The origin of the hydrology of this model is not known and it is not certified. However this analysis does not use the hydrology information, only the model geometry.

- Revetment Database: US Army Corps of Engineers, 2007. Sacramento River Bank Protection Project Database. US Army Corps of Engineers, Sacramento District. The U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) issued biological opinions (BOs) in 2001, under their jurisdiction pursuant to the Endangered Species Act (ESA), in response to the threatened and endangered status of several fish species that use the SRBPP area for habitat or passage.

  In early 2002, an interagency working group (IWG) comprised of representatives from the Corps, the California State Reclamation Board (the local sponsor for the SRBPP), Department of Water Resources (DWR), USFWS, NMFS, and California Department of Fish and Game (CDFG) developed protocols for collecting revetment data in the SRBPP act area (USFWS 2002). The IWG was established in 2001 to support the work of the SRBPP. Its primary goals are to identify, evaluate, design, and endorse conservation measures that are consistent with biological opinions.

  Development of levee and bank geometry was completed using the above sources and is presented in EA Appendix 2 Civil Design with MACES Estimate. No additional topographic surveys or geotechnical evaluations were completed for this report, although these items may be required during design.

4.1.3 Step 3: Overlay Vegetation Free Zone (VFZ) on Site Alternatives

Using the procedures outlined in the Programmatic Plan Framework Memorandum, the levee and bank geometry and critical structure were defined for each site. The critical structure must be established to determine the VFZ. The VFZ is established by identifying the landside and waterside levee toes, then extending 15 feet outward from each toe to establish the VFZ boundary. The waterside levee toe is established by projecting the landside levee toe horizontally to the point where it intersects the projected 3:1 waterside levee slope. The entirety of the levee surface within this boundary would be prohibited from planting as defined in the ETL. The vegetation free zone is then overlaid on the levee erosion site **(Figure 4).**

4.1.4 Step 4: Retain Acceptable Sites

Each erosion site from the AR was evaluated for ETL compliance. With the VFZ defined for each site it was determined which of the repair alternatives, as presented in the AR, proposed planting within VFZ. The initial analysis revealed that some repair alternatives were clearly *not* within the VFZ while others were clearly within the VFZ. But a number of the sites were marginally encroaching into the VFZ. Therefore the initial analysis revealed that 34 sites were compliant, 33 sites marginally encroached and 39 sites would require an alternative repair measure. Upon further analysis of the marginal sites, it was determined that the repair as presented in the AR could be slightly modified by reducing the planting area which would make the site compliant with the ETL. As a result, only 39 sites would require a revised Alternative Repair Measure.

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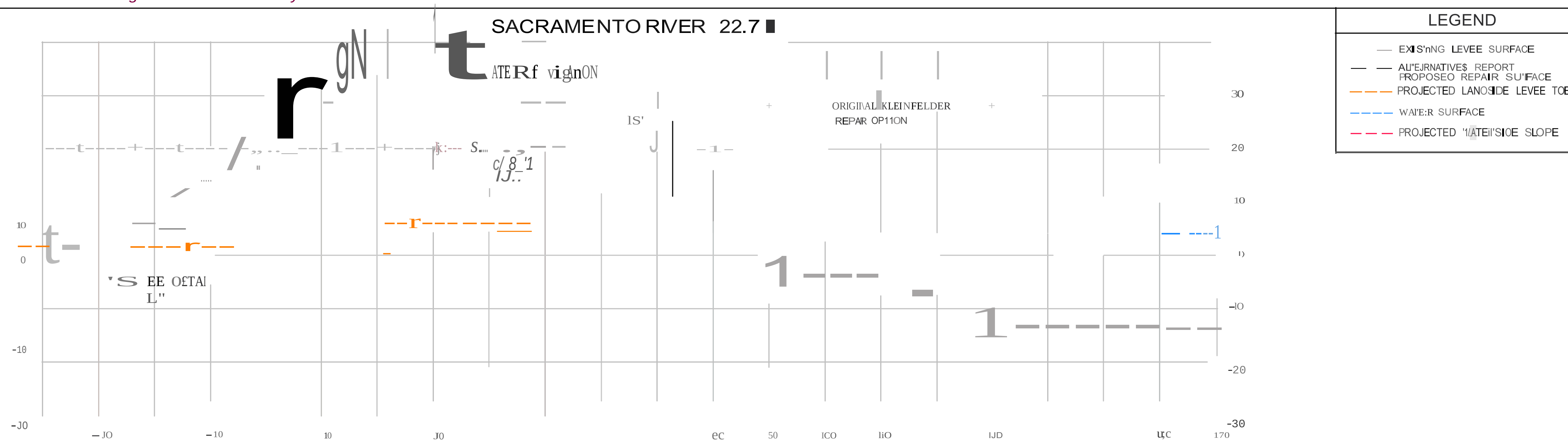
Figure 4- Conceptual Cross Section- Vegetation Free Zone Analysis

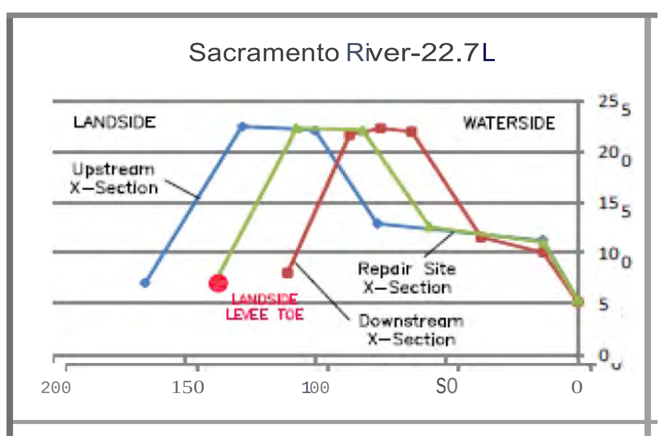
DETAIL 1



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.4
1'3.2	11.1
56.8	12.6
82,1	22.0
107,6	22.3
138.1	7.5

KEY DATA FOR DETERMINING
LANDSIDE TOE

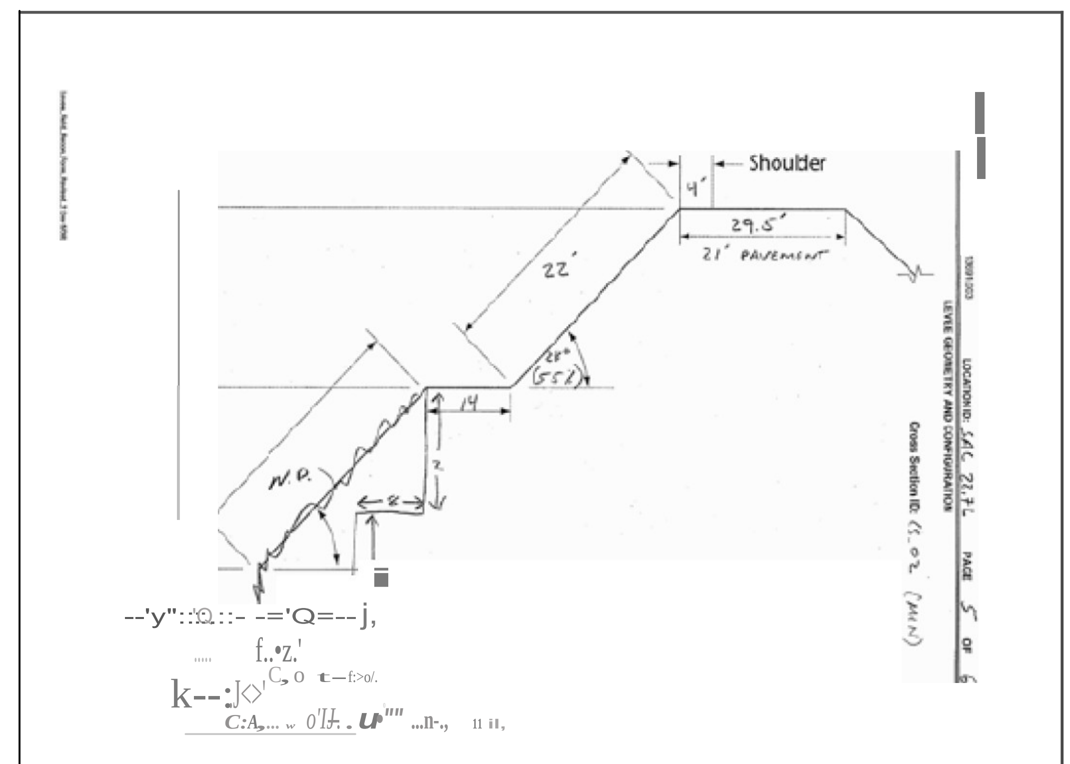
Comp Study Levee Crown Elevation	22.3
Comp Study Landside Toe Elevation	7.5
Camp Study Difference	14,8

Alternatives Report Analysis Levee Crown Elevation	20.0

Landslde Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landslde Toe	5.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



4.2 Bank Protection Measures Selection

4.2.1 Step 5: Assign Erosion Protection Measures to Non-ETL Compliant Sites

The AR used different versions of Alternative 2 Bank Fill Stone Protection Slope and Alternative 4 a, b, and c, banks with vegetation and in-stream woody material. For the sites which need a viable alternative, this evaluation attempted to apply Alternative 1 Setback Levee and Alternative 3 Adjacent Levee.

After completing the ETL compliance analysis, 39 of the 106 erosion sites required a revised alternative repair measure. Certain criteria were used to assign Alternative 1 or 3 to an erosion site. These criteria include the quantity and quality of the existing vegetation, the amount of existing waterside vegetation based on the riprap database, channel hydraulic impacts and landside structures. Of the 39 sites assessed, ten of the sites were assigned Alternative 1 – Setback Levee, and 16 sites were assigned Alternative 3 – Adjacent Levee. Refer to EA Appendix 2 Civil Design with MCACES Estimate for a detailed discussion.

A summary of AR erosion sites that were combined or singularly assigned the setback or adjacent repair measure is summarized below in **Table 3**. **Figures 5 and 6** present the extents of the combined repair measures.

Table 3 – Summary of Sites Assigned Setback or Adjacent Repair Measure

Site Identification				Recommended Repair Measure
Georgiana Slough	RM	0.3	L	Combined Setback Levee
Georgiana Slough	RM	1.7	L	
Georgiana Slough	RM	2.5	L	
Georgiana Slough	RM	3.6	L	Combined Setback Levee
Georgiana Slough	RM	3.7a	L	
Georgiana Slough	RM	3.7b	L	
Georgiana Slough	RM	4.0	L	
Georgiana Slough	RM	4.3	L	Combined Adjacent Levee
Georgiana Slough	RM	4.5	L	
Georgiana Slough	RM	4.6	L	
Georgiana Slough	RM	5.3	L	
Georgiana Slough	RM	6.1	L	Single Site Adjacent Levee
Georgiana Slough	RM	6.4	L	Combined Setback Levee
Georgiana Slough	RM	6.6	L	
Georgiana Slough	RM	6.8	L	Single Site Adjacent Levee
Georgiana Slough	RM	8.3	L	Single Site Adjacent Levee
Steamboat Slough	RM	18.8	R	Single Site Adjacent Levee
Steamboat Slough	RM	23.9	R	Single Site Adjacent Levee

Site Identification				Recommended Repair Measure
Steamboat Slough	RM	24.7	R	Single Site Adjacent Levee
Steamboat Slough	RM	25.0	L	Single Site Adjacent Levee
Steamboat Slough	RM	25.8	R	Single Site Adjacent Levee
Steamboat Slough	RM	26.0	L	Single Site Adjacent Levee
Sutter Slough	RM	24.7	R	Single Site Setback Levee
Sacramento River	RM	22.7	L	Single Site Adjacent Levee
Sacramento River	RM	23.2	L	Single Site Adjacent Levee

Figure 5 - Regional Location Map

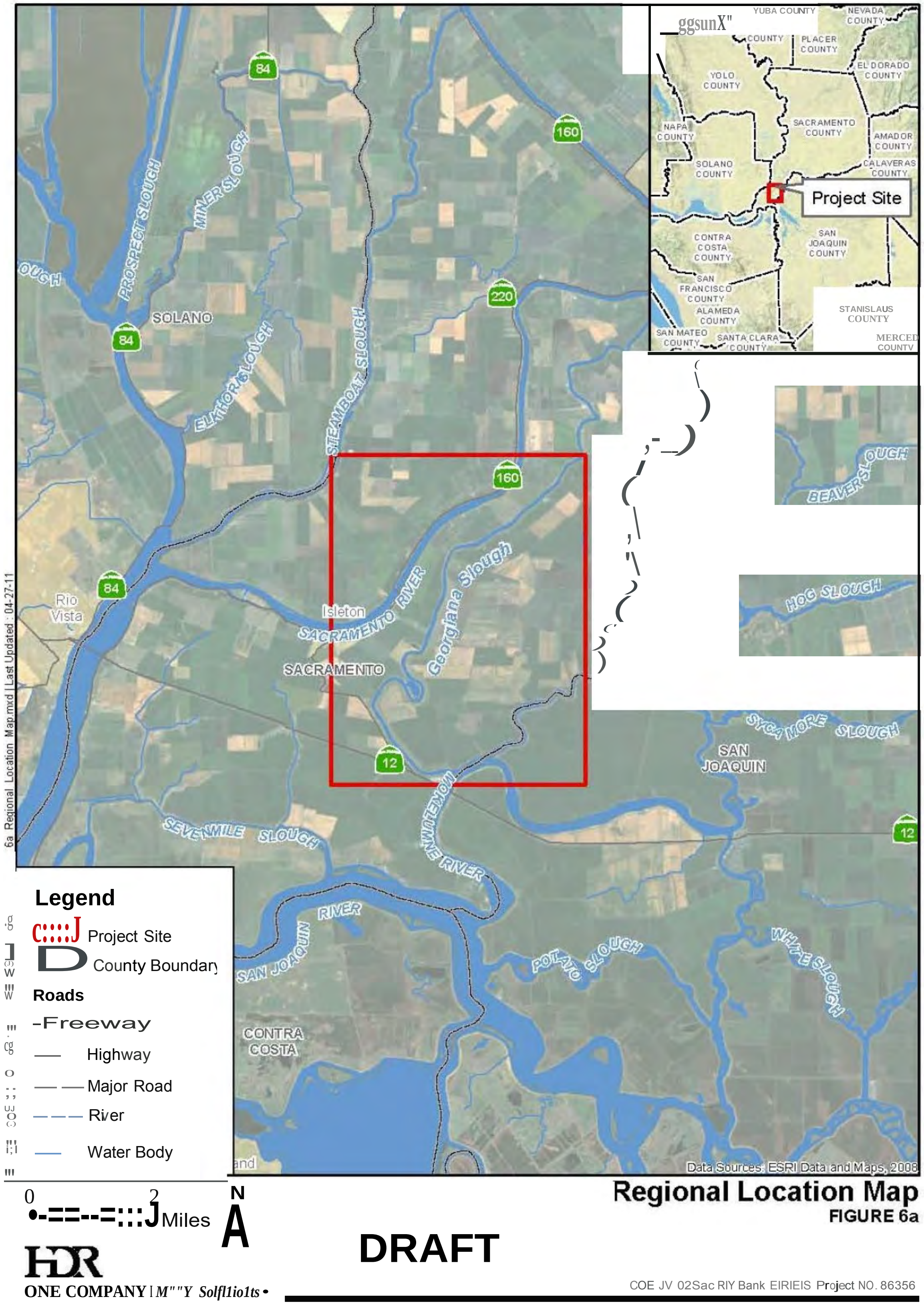


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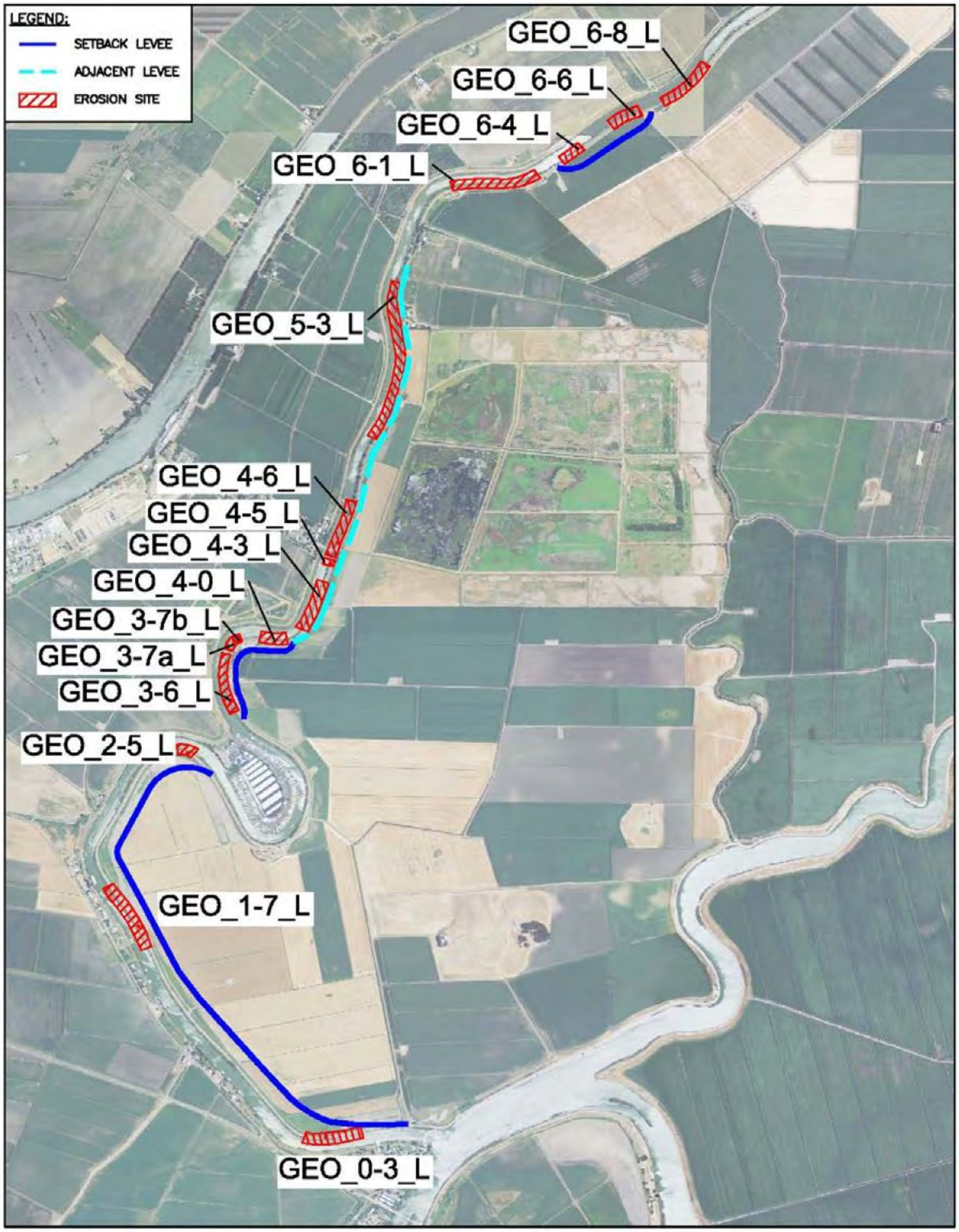
Figure 6- Conceptual Multi-Suite Erosion Locations



N

CONCEPTUAL MULTISITE REPAIR ALTERNATIVES

f'IGURE 13

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4.2.2 Step 6: Assign Measures to Remaining Sites

Sites with setback and adjacent levees were evaluated using the SAM model. Positive environmental effects at sites are noted so that a measure could also serve as near-site mitigation for another site with negative environmental effects. Where multiple erosion sites were grouped together for a multi-site setback or adjacent levee, the additional length between the actual erosion site boundaries was included in the calculation effects.

For the 14 remaining sites, an erosion protection measure is assigned that would minimize loss of fish habitat. This could be Alternative 1 Bank Fill Stone Protection Slope or similar to what was proposed in the AR. The environmental impacts of these measures would be evaluated and reported for each site or aggregate of sites.

A summary of the remaining AR erosion sites that were assigned an Measure other than the Setback or Adjacent repair measure is presented below in **Table 4**.

Table 4 – Summary of Sites Assigned ALT 2 or ALT 4c Repair Measure

Site Identification				Recommended Repair Measure
Cache Slough	RM	15.9	L	Measure 2
Cache Slough	RM	23.6	R	Measure 2
Knights Landing Ridge Cut	LM	0.2	R	Measure 2
Knights Landing Ridge Cut	LM	3.0	L	Measure 2
Knights Landing Ridge Cut	LM	3.1	L	Measure 2
Knights Landing Ridge Cut	LM	4.3	L	Measure 2
Knights Landing Ridge Cut	LM	5.3	L	Measure 2
Willow Slough	LM	6.9	R	Measure 2
Yolo Bypass	LM	0.1	R	Measure 2
Yolo Bypass	LM	2.0	R	Measure 2
Yolo Bypass	LM	2.8	R	Measure 2
Sacramento River	RM	21.5	L	Measure 4c
Sacramento River	RM	22.5	L	Measure 4c
Sacramento River	RM	24.8	L	Measure 2

4.3 Evaluate Mitigation Measures

4.3.1 Step 7: Evaluate Site's Impact to Fish Habitat

Once the VFZ is established the value of the sites' resulting diminishment of existing or potential vegetation may be determined.

Impacts to migratory fish were assessed by calculating the value of the existing riverbank habitat for rearing Chinook Salmon fry/juveniles, a species/life stage that is greatly associated with near shore habitat and is therefore susceptible to the effects of bank protection actions.

Habitat value was estimated using the relationships from SAM model, which relate several features of the river bank habitat to assumed responses from fish. The model and evaluation are described in the Environmental document.

There are two main variables in the SAM model that could be affected by VFZ restrictions: shade and aquatic vegetation. A reduction in trees reduces the amount of shaded cover, potentially increasing susceptibility to predation and, in smaller tributaries, increasing water temperature. A reduction in trees and other vegetation within the VFZ reduces the amount of inundated physical refuge habitat during higher water levels.

4.4 Develop Planning-Level Project Cost Estimate

4.4.1 Step 8: Develop Mitigation Plan

The aggregate environmental effects of all 106 sites were evaluated. The SAM model was used to determine effects to fish habitat. Losses in riparian and fish habitat were established by the environmental team.

In the lower regions of the study area, the Delta, the setback and adjacent levees provide net positive effects to fish habitat and riparian vegetation. Where multiple erosion sites were grouped together for a multi-site setback or adjacent levee, the additional length of non-eroded levee bank between the erosion sites was included in the calculation of effects. The positive effects of these levees were used to compensate for negative effects caused by bank protection at the other erosion sites in this region. Thus, in the lower Delta region no additional mitigation is required.

In the regions upstream of the Delta, most mitigation occurs on-site. For biological reasons it was not considered appropriate to use the beneficial effects of Delta adjacent and setback levees to compensate for construction upstream and removed from the Delta region. No setback or adjacent levees were proposed in these regions. For some sites there is no realistic opportunity to construct setback or adjacent levees due to neighboring development. For many sites on-site mitigation was accomplished by taking opportunities to protect and restore vegetation on portions of banks beyond the VFZ.

The construction cost estimate does not assume mitigation costs for cultural resources. Cultural resources recovery costs are included in the total project cost as $1 million, about one-half percent of construction cost. Cultural resources recovery costs are added onto the project cost as shown in the PACR.

4.4.2 Step 9: Off-Site Mitigation Plan

The aggregate environmental effects of all 106 sites is evaluated and summarized in the Environmental document. In the lower Delta regions it is self mitigating. The setback and adjacent levees fully mitigate all regional erosion sites. In the regions upstream of the Delta, most mitigation may occur on-site. However some off-site mitigation areas will be required to provide full mitigation. Off site mitigation will be considered to compensate for losses. Sites are identified as part of the NEPA and CEQA process and are described in the Environmental document.

Any net positive effects to riparian vegetation will be reported.

No cultural resources mitigation costs were added.

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5.0 Description of Initial Array Plan

5.1 Overall Description

This section provides a discussion of the numbers of alternatives at sites, site relationships and groupings, environmental mitigation.

Table 5 presents a summary of erosion site attributes which includes Region, Site Identification listed in the AR, Site Length from the AR, AR Repair Measure and Revised Repair Measure. A blank cell under 'Revised Repair Measure' means the AR recommended either No Action, or the site was ETL compliant and no revision to the site repair was necessary. The distribution of erosion sites within the Sacramento Flood Control System (**Figures 7-25**) presents each site, identified by the abbreviation of the tributary and its associated River or Levee Mile location. **Figure 26** shows the process used to screen the 106 sites for compliance to ETL 1110-2-571 (now ETL 1110-2-583) and determine repair measures and cost opinions for the PBPP.

Table 5 – Summary of Erosion Site Attributes

Region	Site Identification				Site Length	Alternatives Report Repair Measure	Revised Repair Measure
1A	Cache Creek	LM	3.9	L	433	Setback Levee	
1A	Cache Slough	RM	15.9	L	182	Design 4	Measure 2
1A	Cache Slough	RM	22.8	R	630	Design 4	
1A	Cache Slough	RM	23.6	R	1209	Design 4	Measure 2
1A	Deep Water Ship Channel	LM	5.0	L	N/A	No Action	
1A	Deep Water Ship Channel	LM	5.01	L	N/A	No Action	
1A	Georgiana Slough	RM	0.3	L	1027	Design 4	Measure 1 Combined Setback Levee
1A	Georgiana Slough	RM	1.7	L	1250	Design 4	
1A	Georgiana Slough	RM	2.5	L	736	Design 4	
1A	Georgiana Slough	RM	3.6	L	1364	Design 4	Measure 1 Combined Setback Levee
1A	Georgiana Slough	RM	3.7a	L	209	Design 4	
1A	Georgiana Slough	RM	3.7b	L	268	Design 4	
1A	Georgiana Slough	RM	4.0	L	705	Design 4	
1A	Georgiana Slough	RM	4.3	L	1319	Design 4	Measure 3 Combined Adjacent Levee
1A	Georgiana Slough	RM	4.5	L	90	Design 4	
1A	Georgiana Slough	RM	4.6	L	1346	Design 4	
1A	Georgiana Slough	RM	5.3	L	3171	Design 4	
1A	Georgiana Slough	RM	6.1	L	1729	Design 4	Measure 3
1A	Georgiana Slough	RM	6.4	L	398	Design 4	Measure 1 Combined Setback Levee
1A	Georgiana Slough	RM	6.6	L	744	Design 4	
1A	Georgiana Slough	RM	6.8	L	1335	Design 4	Measure 3
1A	Georgiana Slough	RM	8.3	L	483	Design 4	Measure 3

Region	Site Identification				Site Length	Alternatives Report Repair Measure	Revised Repair Measure
1A	Georgiana Slough	RM	9.3	L	1228	Design 4	
1A	Knights Landing Ridge Cut	LM	0.2	R	768	Design 1	Measure 2
1A	Knights Landing Ridge Cut	LM	3.0	L	1279	Design 1	Measure 2
1A	Knights Landing Ridge Cut	LM	3.1	L	368	Design 1	Measure 2
1A	Knights Landing Ridge Cut	LM	4.3	L	577	Design 1	Measure 2
1A	Knights Landing Ridge Cut	LM	5.3	L	8564	Design 1	Measure 2
1A	Steamboat Slough	RM	18.8	R	485	Design 4	Measure 3
1A***	Steamboat Slough	RM	23.2	L	N/A	No Action	
1A	Steamboat Slough	RM	23.9	R	369	Design 4	Measure 3
1A	Steamboat Slough	RM	24.7	R	911	Design 4	Measure 3
1A	Steamboat Slough	RM	25.0	L	272	Design 4	Measure 3
1A	Steamboat Slough	RM	25.8	R	244	Design 4	Measure 3
1A	Steamboat Slough	RM	26.0	L	516	Design 4	Measure 3
1A	Sutter Slough	RM	24.7	R	1736	Design 4	Measure 1
1A	Sutter Slough	RM	26.5	L	568	Design 4	
1A	Willow Slough	LM	0.2	L	N/A	No Action	
1A	Willow Slough	LM	0.7	L	N/A	No Action	
1A	Willow Slough	LM	6.9	R	869	Design 1	Measure 2
1A	Yolo Bypass	LM	0.1	R	430	Design 1	Measure 2
1A	Yolo Bypass	LM	2.0	R	563	Design 1	Measure 2
1A***	Yolo Bypass	LM	2.5	R	148	Design 1	
1A	Yolo Bypass	LM	2.6	R	N/A	No Action	
1A	Yolo Bypass	LM	3.8	R	1860	Design 1	Measure 2
1B*	Lower American River	RM	7.3	R	446	No Action	
1B	Sacramento River	RM	21.5	L	162	Design 4	Measure 4c
1B	Sacramento River	RM	22.5	L	852	Design 4	Measure 4c
1B	Sacramento River	RM	22.7	L	309	Design 4	Measure 3
1B	Sacramento River	RM	23.2	L	589	Design 4	Measure 3
1B	Sacramento River	RM	23.3	L	257	Design 4	
1B	Sacramento River	RM	24.8	L	782	Design 4	Measure 2
1B	Sacramento River	RM	25.2	L	338	Design 4	
1B	Sacramento River	RM	31.6	R	446	Design 1	
1B***	Sacramento River	RM	35.3	R	197	Design 2	
1B***	Sacramento River	RM	35.4	R	96	Design 2	
1B	Sacramento River	RM	38.5	R	359	Design 1	
1B	Sacramento River	RM	56.5	R	373	Design 3	

Region	Site Identification				Site Length	Alternatives Report Repair Measure	Revised Repair Measure
1B	Sacramento River	RM	56.6	L	86	Design 2	
1B	Sacramento River	RM	56.7	R	665	Design 3	
1B*	Sacramento River	RM	58.4	L	707	Design 1	
1B***	Sacramento River	RM	60.1	L	455	Design 2	
1B	Sacramento River	RM	62.9	R	175	Design 3	
1B	Sacramento River	RM	63.0	R	87	Design 3	
1B	Sacramento River	RM	74.4	R	200	Design 3	
1B	Sacramento River	RM	75.3	R	2761	Design 1	
1B	Sacramento River	RM	77.7	R	224	Design 1	
1B	Sacramento River	RM	78.3	L	657	Design 1	
2	Bear River	RM	0.8	L	233	Design 1	
2	Cherokee Canal	LM	14.0	L	184	No Action	
2	Cherokee Canal	LM	21.9	L	1800	Design 1	
2	Feather River	RM	0.6	L	288	Design 2	
2**	Feather River	RM	5.0	L	910	Design 2	
2	Sacramento River	RM	86.3	L	3134	Design 1	
2***	Sacramento River	RM	86.5	R	72	Design 3	
2	Sacramento River	RM	86.9	R	289	Design 3	
2	Sacramento River	RM	92.8	L	200	Design 1	
2	Sacramento River	RM	95.8	L	190	Design 1	
2	Sacramento River	RM	96.2	L	560	Design 1	
2	Sacramento River	RM	99.0	L	160	Design 1	
2	Sacramento River	RM	101.3	R	352	Design 3	
2	Sacramento River	RM	103.4	L	N/A	No Action	
2	Sacramento River	RM	104.0	L	3459	Design 1	
2	Sacramento River	RM	104.5	L	301	Design 2	
2	Sacramento River	RM	116.0	L	612	Design 2	
2	Sacramento River	RM	116.5	L	2465	Design 2	
2	Sacramento River	RM	122.0	R	248	Design 3	
2	Sacramento River	RM	122.3	R	341	Design 3	
2	Sacramento River	RM	123.3	L	208	Design 3	
2	Sacramento River	RM	123.7	R	120	Design 2	
2	Sacramento River	RM	127.9	R	801	Design 1	
2	Sacramento River	RM	131.8	L	339	Design 2	
2	Sacramento River	RM	132.9	R	363	Design 2	
2	Sacramento River	RM	133.0	L	1291	Design 2	
2	Sacramento River	RM	133.8	L	197	Design 2	
2	Sacramento River	RM	136.6	L	615	Design 2	
2	Sacramento River	RM	138.1	L	1365	Design 2	
2	Yuba River	LM	2.3	L	1356	Setback Levee	

Region	Site Identification				Site Length	Alternatives Report Repair Measure	Revised Repair Measure
3	Deer Creek	LM	2.4	L	496	Design 1	
3	Elder Creek	LM	1.44	L	334	Design 2	
3	Elder Creek	LM	3.0	R	65	Design 2	
3***	Elder Creek	LM	4.1	L	N/A	No Action	
3	Sacramento River	RM	152.8	L	198	Design 3	
3	Sacramento River	RM	163.0	L	1213	Design 3	
3	Sacramento River	RM	168.3	L	546	Design 3	
3	Sacramento River	RM	172.0	L	525	Design 3	

* Sacramento River 58.4 and Lower American River 7.3 have been erroneously included in the analysis. These are not found in the erosion site inventory. They do not meet the requirements for an erosion site under SRBPP. Leaving them in the analysis, however, does not make a significant difference because of the programmatic nature of the bank protection plan and they still can function as representative sites.

** Feather River 5.0L was erroneously referred to as Feather River 4.9L in the Alternatives Report and potentially other documents.

*** Sacramento River 35.3R, 35.4R, 60.1L, 86.5R, Elder Creek 4.1L, Steamboat Slough 23.2L, and Yolo Bypass 2.5R have been repaired.

5.1.1 Step 10: Real Estate Requirements

Areas of land required for setback and adjacent levees were calculated. The acquisition cost for these sites was estimated at $10,000 per acre, which is representative for agricultural land in the Sacramento Valley. No lands costs were included for sites with Bank Fill Stone Protection or with Riparian and Wetland Banks with Revegetation. No relocations costs were assumed for the cost estimate.

An acquisition challenge at some sites is the disposition of encroachments, both permitted and not permitted. Resolving permits and determining resultant relocation requirements at some sites may add to the cost of the project. This issue is discussed in more detail in Appendix C of the PACR, Programmatic Real Estate Plan.

5.1.2 Step 11: Cost Estimate

The opinions of probable costs are summarized in **Table 6**. The summary is organized by region and each site is identified by tributary/channel name, the levee/river mile marker and which bank the repair resides on. Each total cost includes the following markups:

- Escalation – 2%
- Contingency – 20%
- Supervision, Inspection and Overhead – 8%
- Home Office Overhead – 8%
- Profit – 8%

- Bond – 1.25%

The total cost for the 77,436 LF of bank protection is $203,561,167 which gives an average liner foot cost of $2,629.

After this cost for the IAP was prepared a more detailed cost estimate was developed and is displayed in Appendix 2 of this Engineering Appendix, Civil Design Appendix with MCACES Estimate. This is shown as Appendix d. to the Civil Design Appendix, Cost Opinion, This estimate was used for the benefit – cost analysis described in the Economic Appendix. The cost is at an alternative comparison level of detail.

These costs summarized below are initial cost opinions. More detailed cost analyses will be required on a site by site basis as these erosion sites are developed for construction. For a more detailed analysis of the cost opinions refer to Appendix d, Costs of Appendix 2, Civil Design with MCACES Estimate of the EA.

Table 6 – First Cost Price Level Summarization

Region	Site Identification				First Construction Cost
1A	Cache Creek	LM	3.9	L	$638,661
1A	Cache Slough	RM	15.9	L	$1,619,596
1A	Cache Slough	RM	22.8	R	$527,206
1A	Cache Slough	RM	23.6	R	$1,376,525
1A	Deep Water Ship Channel	LM	5.0	L	$0
1A	Deep Water Ship Channel	LM	5.0	L	$0
1A	Georgiana Slough	RM	0.3	L	$30,143,038
1A	Georgiana Slough	RM	1.7	L	
1A	Georgiana Slough	RM	2.5	L	
1A	Georgiana Slough	RM	3.6	L	$6,331,912
1A	Georgiana Slough	RM	3.7a	L	
1A	Georgiana Slough	RM	3.7b	L	
1A	Georgiana Slough	RM	4.0	L	$16,809,762
1A	Georgiana Slough	RM	4.3	L	
1A	Georgiana Slough	RM	4.5	L	
1A	Georgiana Slough	RM	4.6	L	
1A	Georgiana Slough	RM	5.3	L	
1A	Georgiana Slough	RM	6.1	L	$3,572,860
1A	Georgiana Slough	RM	6.4	L	$3,838,557
1A	Georgiana Slough	RM	6.6	L	
1A	Georgiana Slough	RM	6.8	L	$2,710,953
1A	Georgiana Slough	RM	8.3	L	$1,037,195

Region	Site Identification				First Construction Cost
1A	Georgiana Slough	RM	9.3	L	$4,551,611
1A	Knights Landing Ridge Cut	LM	0.2	R	$69,460
1A	Knights Landing Ridge Cut	LM	3.0	L	$408,793
1A	Knights Landing Ridge Cut	LM	3.1	L	$177,096
1A	Knights Landing Ridge Cut	LM	4.3	L	$459,340
1A	Knights Landing Ridge Cut	LM	5.3	L	$3,263,940
1A	Steamboat Slough	RM	18.8	R	$1,552,251
1A***	Steamboat Slough	RM	23.2	L	$0
1A	Steamboat Slough	RM	23.9	R	$1,084,698
1A	Steamboat Slough	RM	24.7	R	$2,819,727
1A	Steamboat Slough	RM	25.0	L	$660,720
1A	Steamboat Slough	RM	25.8	R	$519,721
1A	Steamboat Slough	RM	26.0	L	$1,262,770
1A	Sutter Slough	RM	24.7	R	$5,804,608
1A	Sutter Slough	RM	26.5	L	$2,363,454
1A	Willow Slough	LM	0.2	L	$0
1A	Willow Slough	LM	0.7	L	$0
1A	Willow Slough	LM	6.9	R	$258,406
1A	Yolo Bypass	LM	0.1	R	$266,788
1A	Yolo Bypass	LM	2.0	R	$447,880
1A***	Yolo Bypass	LM	2.5	R	$83,442
1A	Yolo Bypass	LM	2.6	R	$0
1A	Yolo Bypass	LM	3.8	R	$1,902,181
1B*	Lower American River	RM	7.3	R	$0
1B	Sacramento River	RM	21.5	L	$563,325
1B	Sacramento River	RM	22.5	L	$1,869,692
1B	Sacramento River	RM	22.7	L	$733,394
1B	Sacramento River	RM	23.2	L	$1,422,810
1B	Sacramento River	RM	23.3	L	$1,169,341
1B	Sacramento River	RM	24.8	L	$3,395,102
1B	Sacramento River	RM	25.2	L	$1,004,012
1B	Sacramento River	RM	31.6	R	$3,084,148
1B***	Sacramento River	RM	35.3	R	$1,652,501
1B***	Sacramento River	RM	35.4	R	$340,496
1B	Sacramento River	RM	38.5	R	$2,522,344
1B	Sacramento River	RM	56.5	R	$1,262,827
1B	Sacramento River	RM	56.6	L	$290,378

Region	Site Identification				First Construction Cost
1B	Sacramento River	RM	56.7	R	$5,695,436
1B*	Sacramento River	RM	58.4	L	$1,332,361
1B***	Sacramento River	RM	60.1	L	$2,841,635
1B	Sacramento River	RM	62.9	R	$402,035
1B	Sacramento River	RM	63.0	R	$451,201
1B	Sacramento River	RM	74.4	R	$499,086
1B	Sacramento River	RM	75.3	R	$3,143,933
1B	Sacramento River	RM	77.7	R	$907,020
1B	Sacramento River	RM	78.3	L	$1,539,346
2	Bear River	RM	0.8	L	$675,163
2	Cherokee Canal	LM	14.0	L	$0
2	Cherokee Canal	LM	21.9	L	$1,158,689
2	Feather River	RM	0.6	L	$1,288,932
2**	Feather River	RM	5.0	L	$3,181,373
2	Sacramento River	RM	86.3	L	$6,011,173
2***	Sacramento River	RM	86.5	R	$243,224
2	Sacramento River	RM	86.9	R	$1,226,930
2	Sacramento River	RM	92.8	L	$1,355,902
2	Sacramento River	RM	95.8	L	$1,031,518
2	Sacramento River	RM	96.2	L	$3,926,336
2	Sacramento River	RM	99.0	L	$1,114,291
2	Sacramento River	RM	101.3	R	$1,579,059
2	Sacramento River	RM	103.4	L	$0
2	Sacramento River	RM	104.0	L	$13,306,210
2	Sacramento River	RM	104.5	L	$1,063,851
2	Sacramento River	RM	116.0	L	$1,271,528
2	Sacramento River	RM	116.5	L	$8,083,110
2	Sacramento River	RM	122.0	R	$606,015
2	Sacramento River	RM	122.3	R	$1,012,648
2	Sacramento River	RM	123.3	L	$567,168
2	Sacramento River	RM	123.7	R	$1,022,553
2	Sacramento River	RM	127.9	R	$2,108,298
2	Sacramento River	RM	131.8	L	$562,176
2	Sacramento River	RM	132.9	R	$1,402,910
2	Sacramento River	RM	133.0	L	$1,635,862
2	Sacramento River	RM	133.8	L	$976,181
2	Sacramento River	RM	136.6	L	$1,547,692
2	Sacramento River	RM	138.1	L	$4,093,959

Region	Site Identification				First Construction Cost
2	Yuba River	LM	2.3	L	$1,227,930
3	Deer Creek	LM	2.4	L	$448,710
3	Elder Creek	LM	1.4	L	$717,833
3	Elder Creek Elder	LM	3.0	R	$106,712
3***	Creek Sacramento	LM	4.1	L	$0
3	River Sacramento	RM	152.8	L	$1,260,297
3	River Sacramento	RM	163.0	L	$2,160,285
3	River	RM	168.3	L	$1,869,826
3	Sacramento River	RM	172.0	L	$1,031,255

* Sacramento River 58.4 and Lower American River 7.3 have been erroneously included in the analysis. These are not found in the erosion site inventory. They do not meet the requirements for an erosion site under SRBPP. Leaving them in the analysis, however, does not make a significant difference because of the programmatic nature of the bank protection plan and they still can function as representative sites.

** Feather River 5.0L was erroneously referred to as Feather River 4.9L in the Alternatives Report and potentially other documents.

*** Sacramento River 35.3R, 35.4R, 60.1L, 86.5R, Elder Creek 4.1L, Steamboat Slough 23.2L, and Yolo Bypass 2.5R have been repaired.

Figure 7– Alternatives Report Erosion Sites

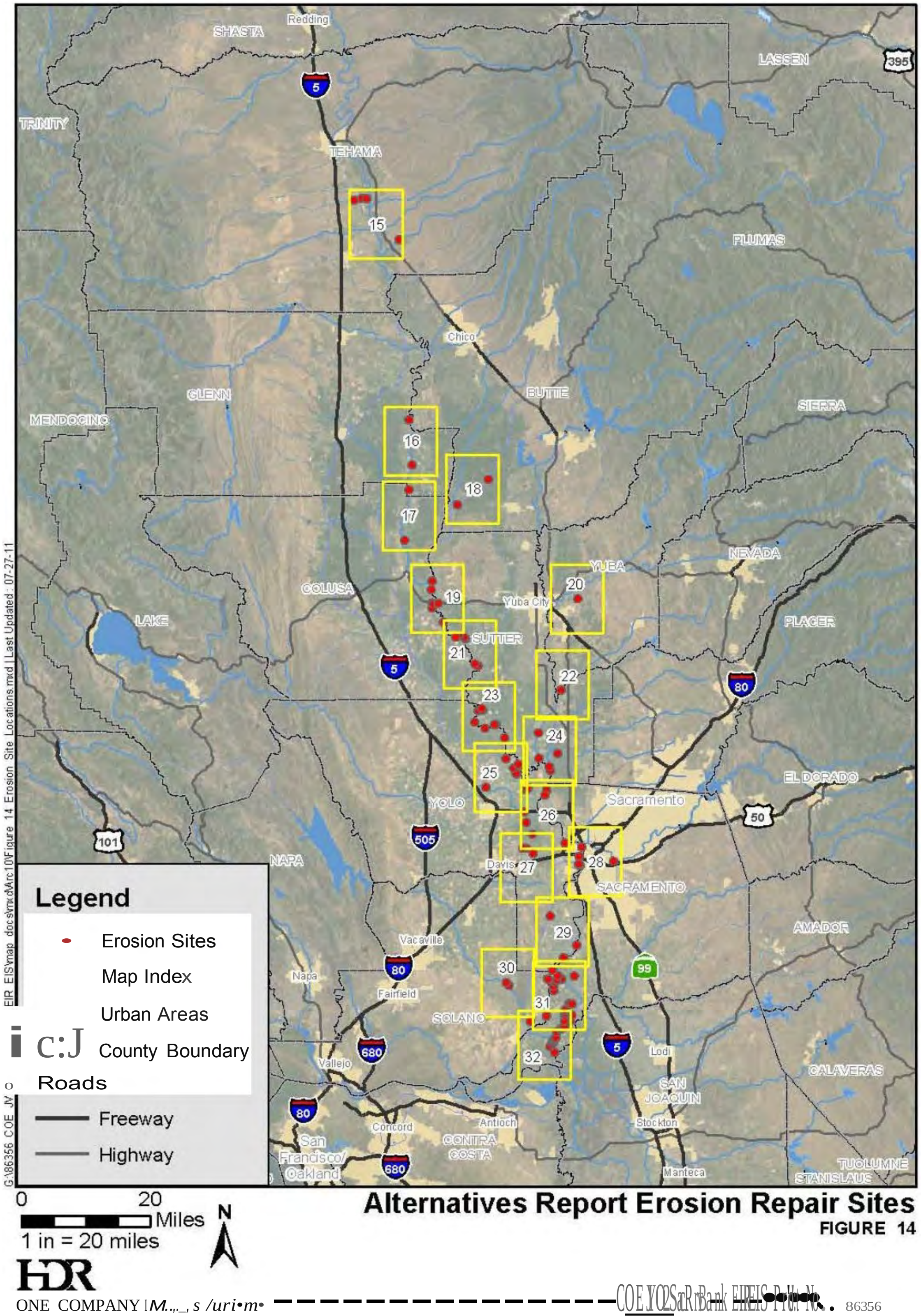

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Figure 8- Alternatives Report Erosion Sites

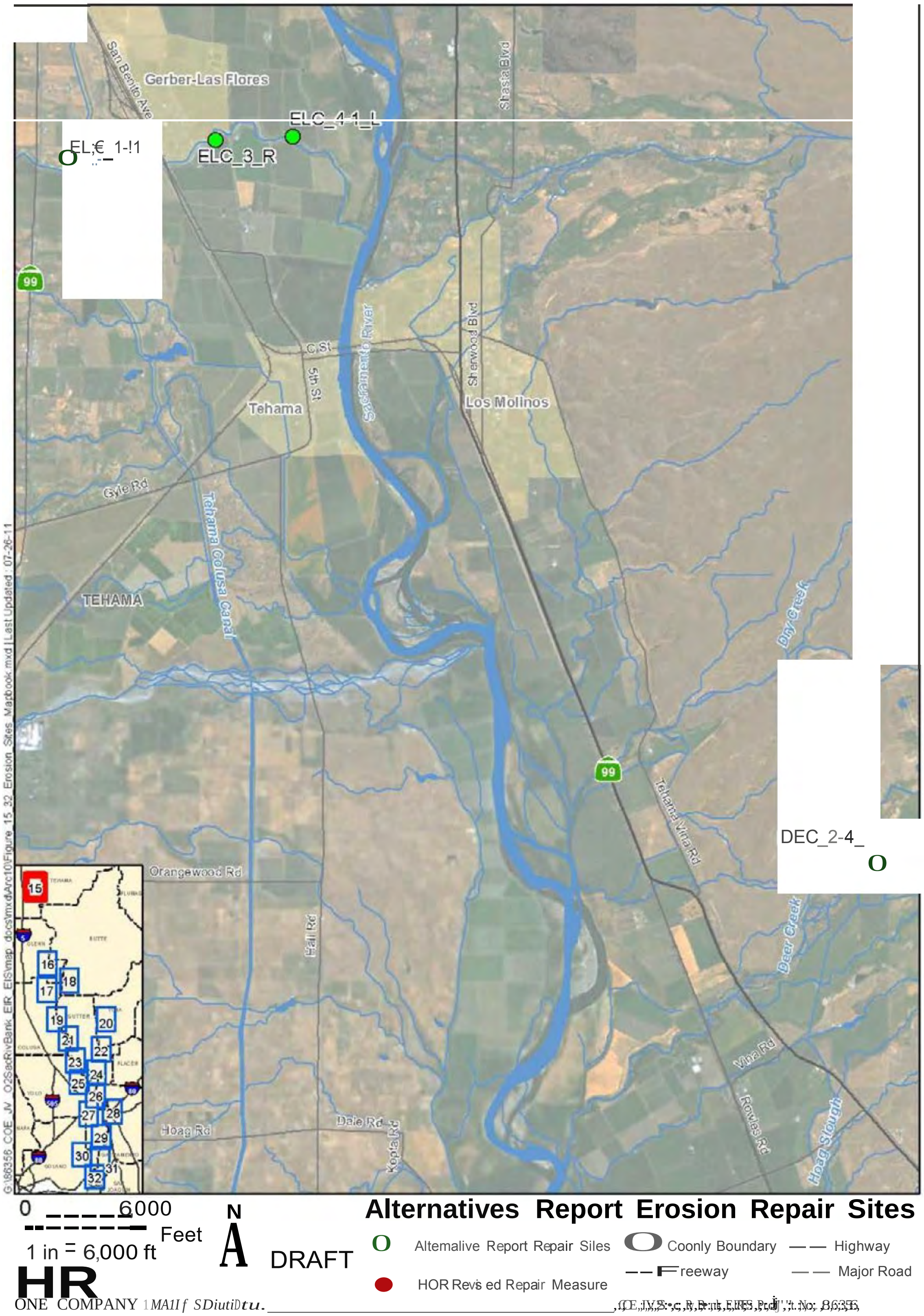

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Figure 9- Alternative Report Erosion Sites

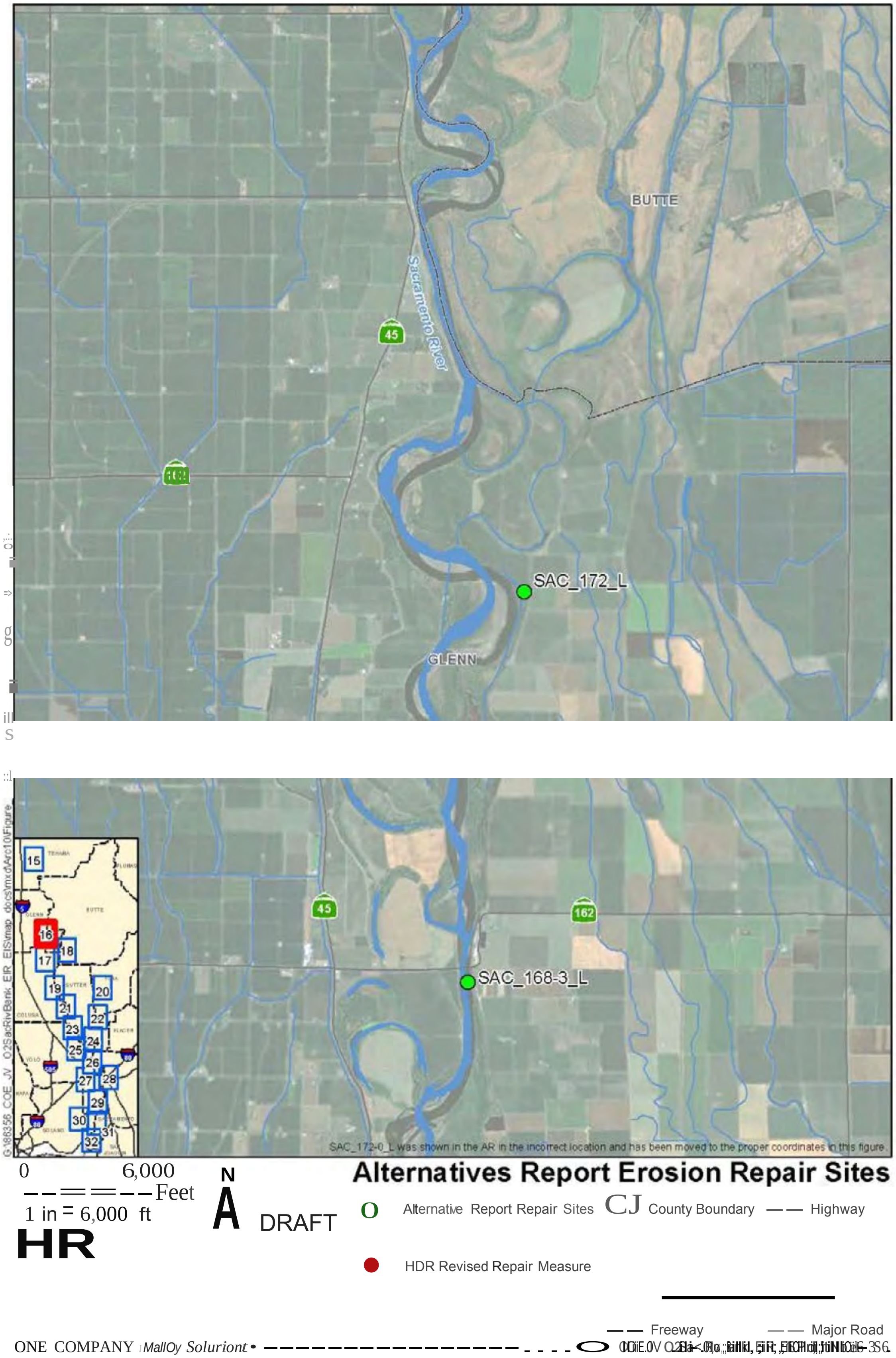

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Figure 10- Alternatives Report Erosion Sites

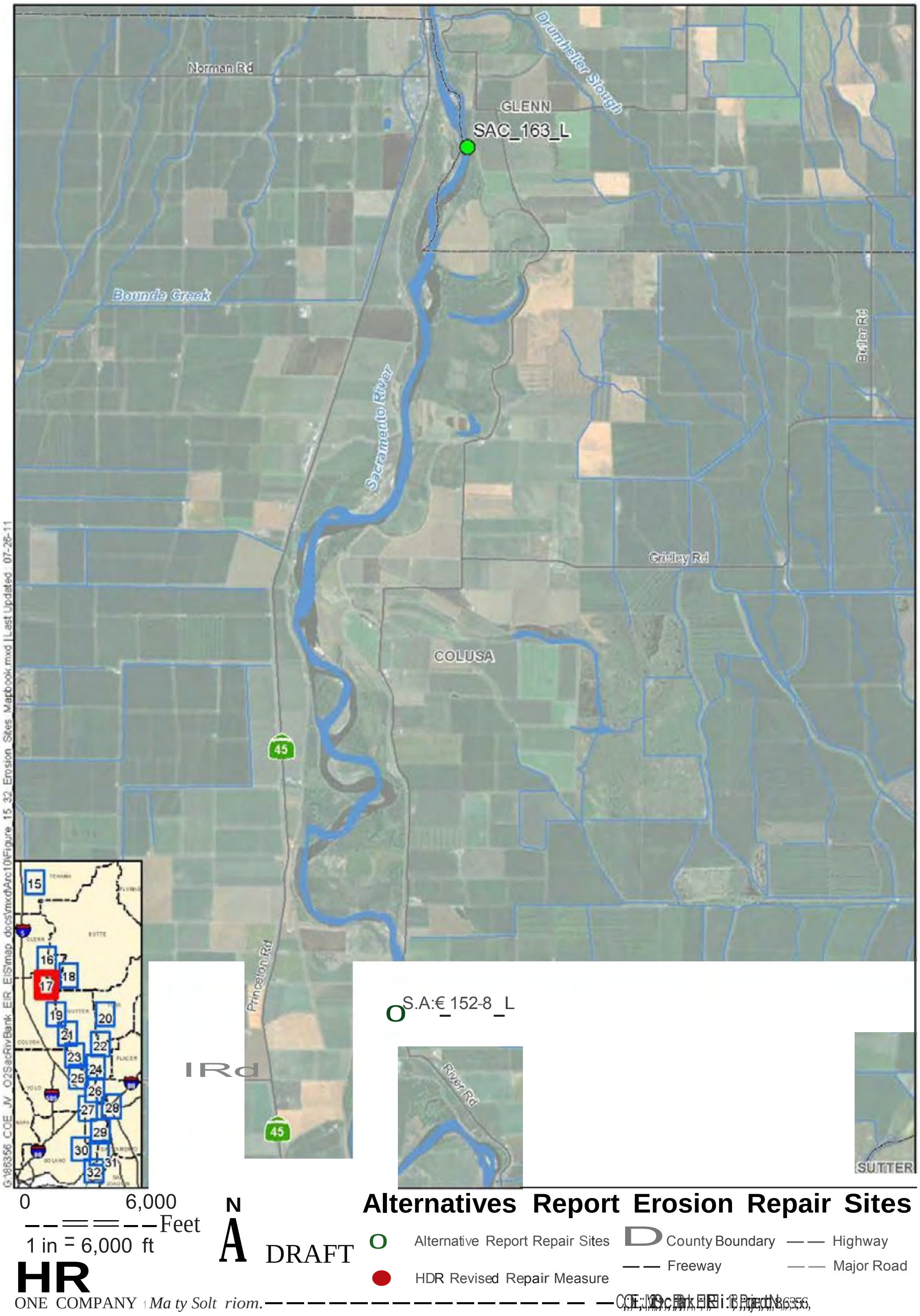

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Figure 11 -Alternatives Report Erosion Sites

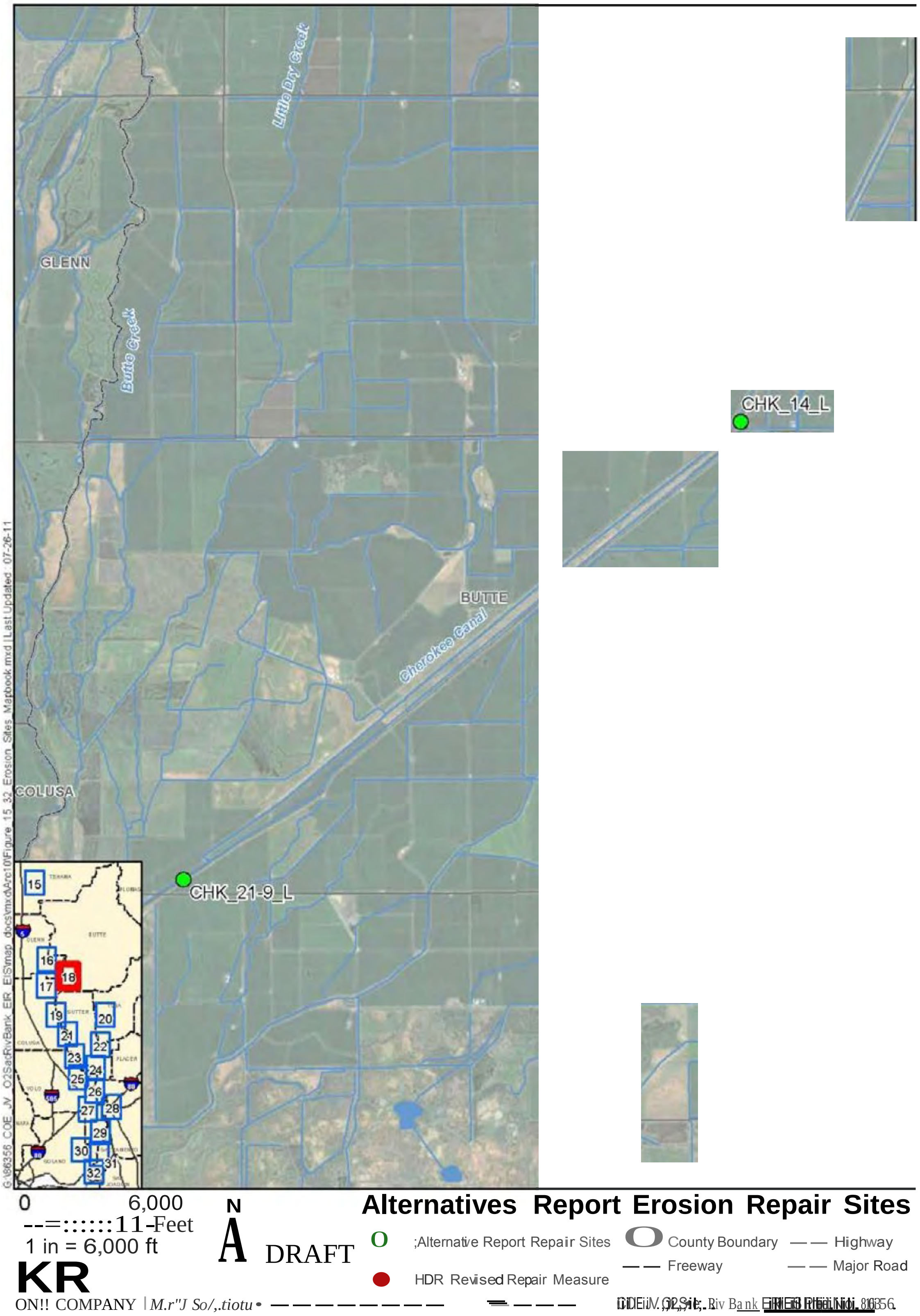

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Figure 12- Alternatives Report Erosion Sites

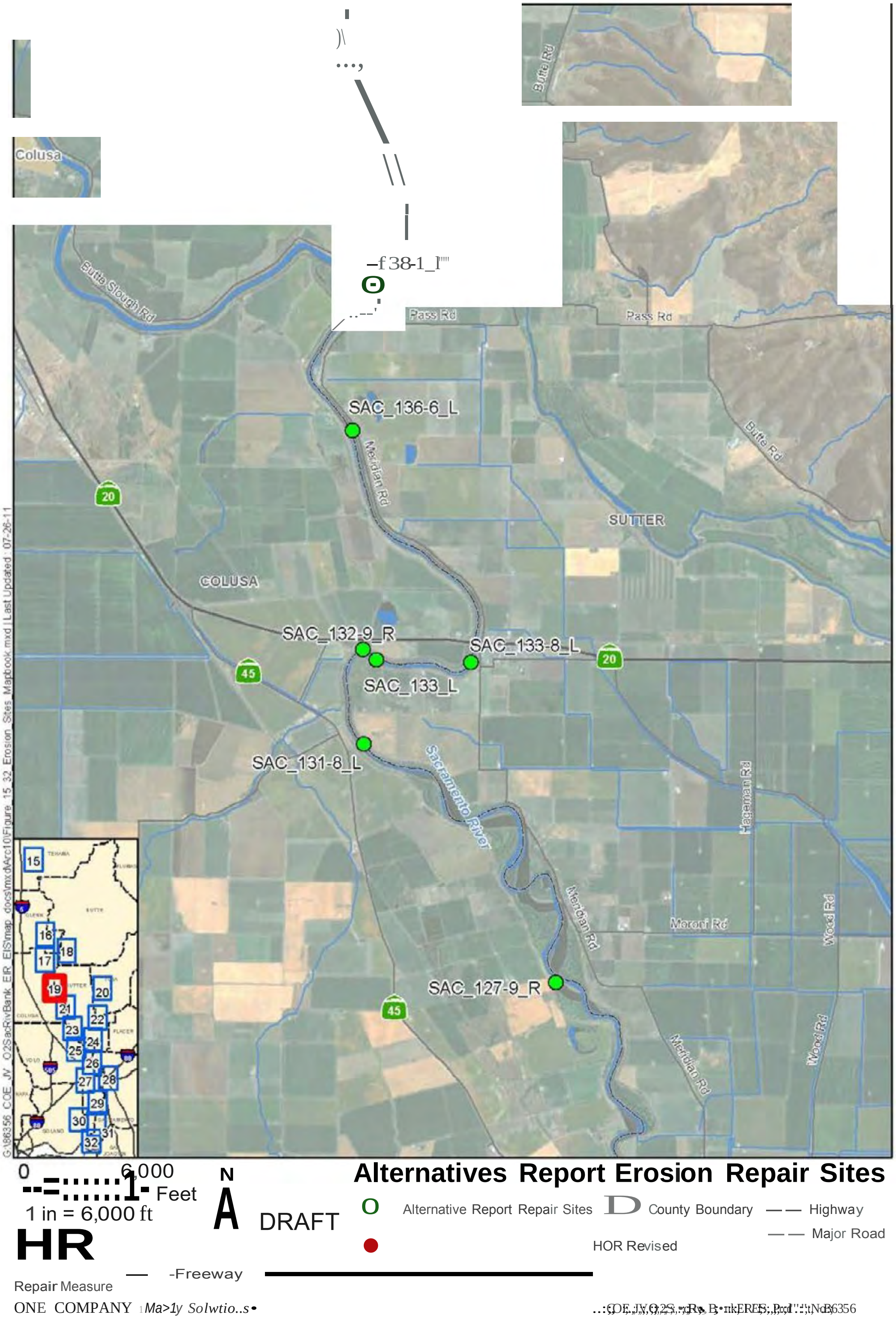

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Figure 13 -Alternative Report Erosion Sites

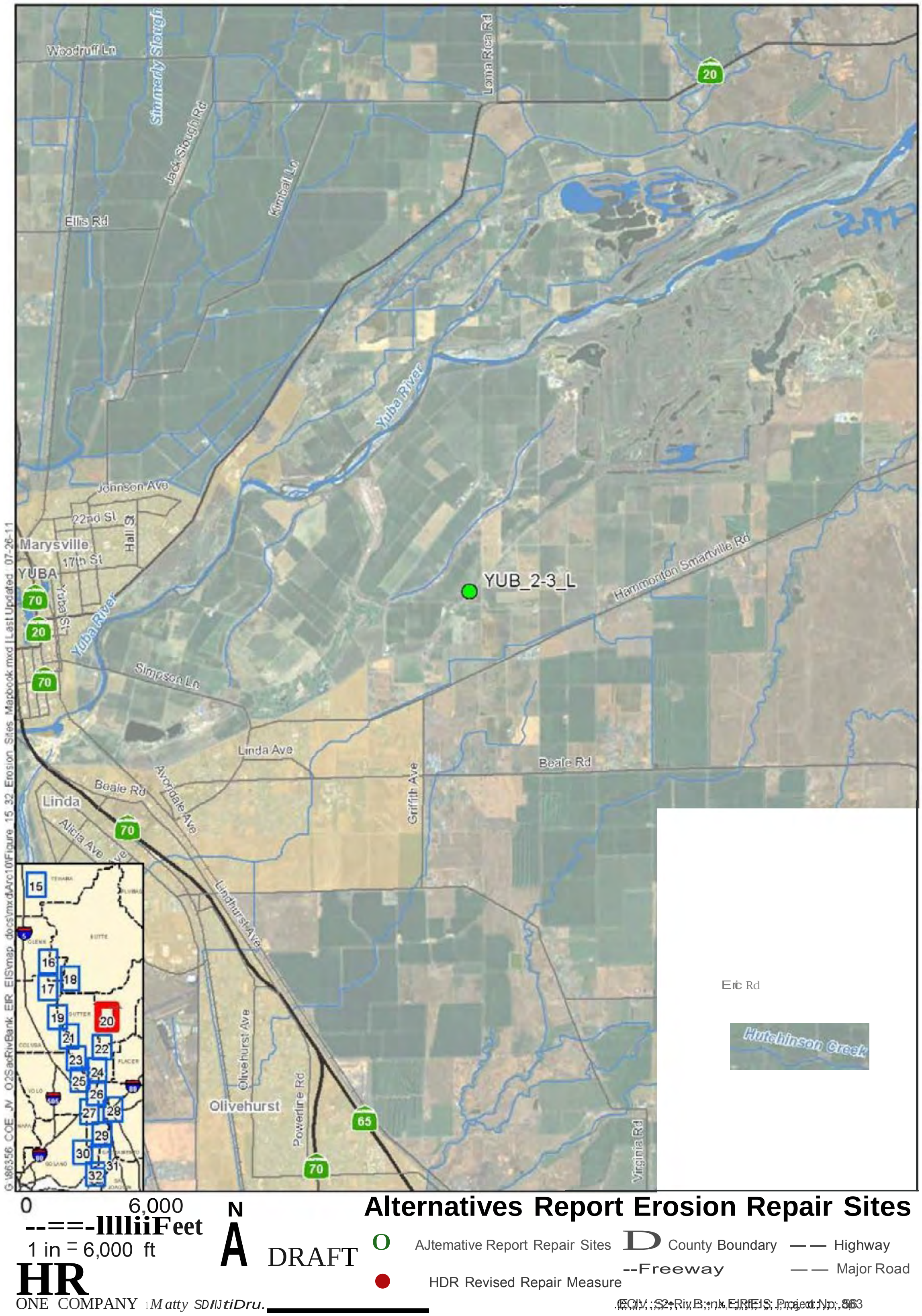

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Figure 14- Alternatives Report Erosion Sites

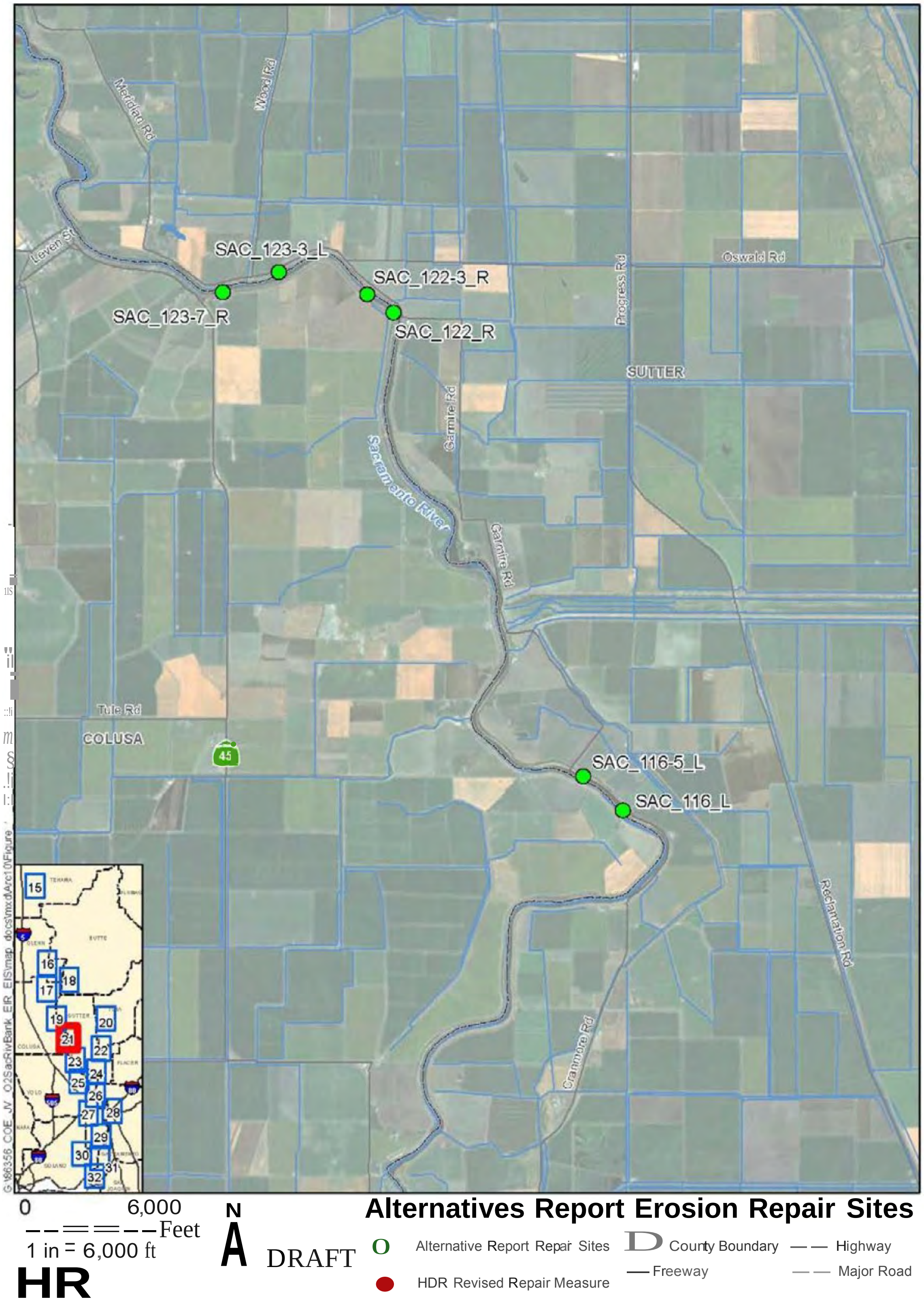

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Figure 15 -Alternatives Report Erosion Sites

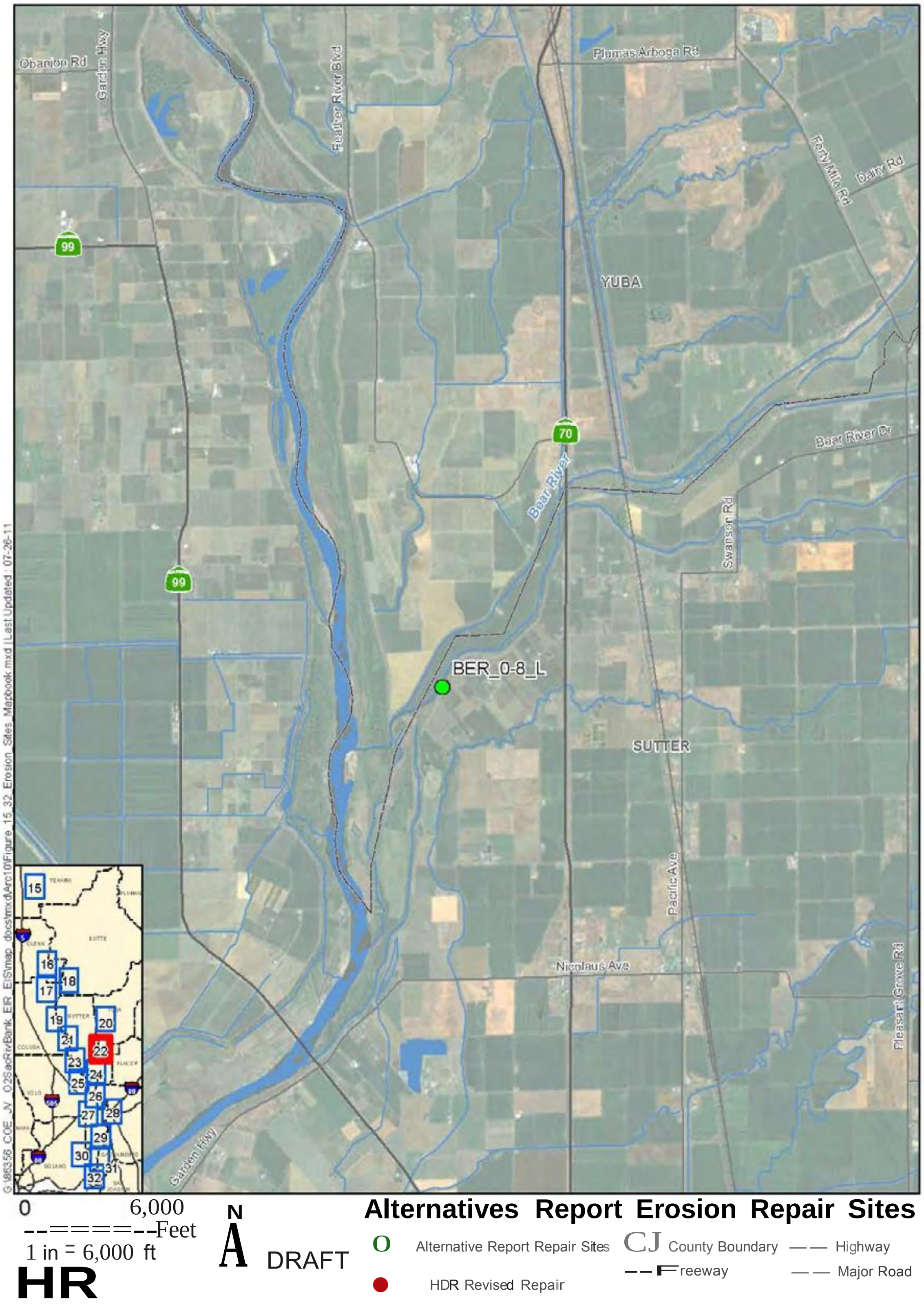

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Figure 16- Alternatives Report Erosion Sites

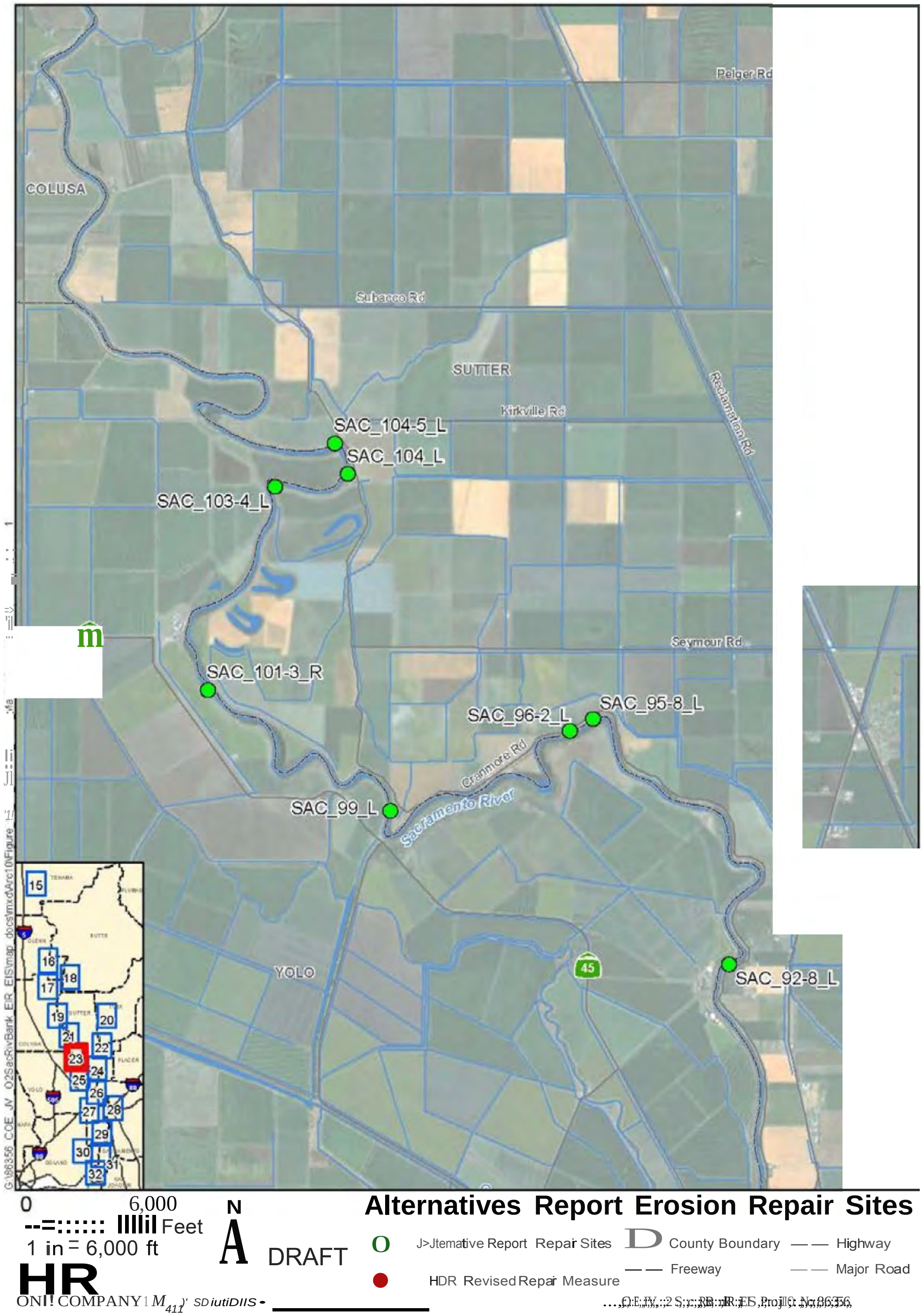

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Figure 17- Alternatives Report Erosion Sites

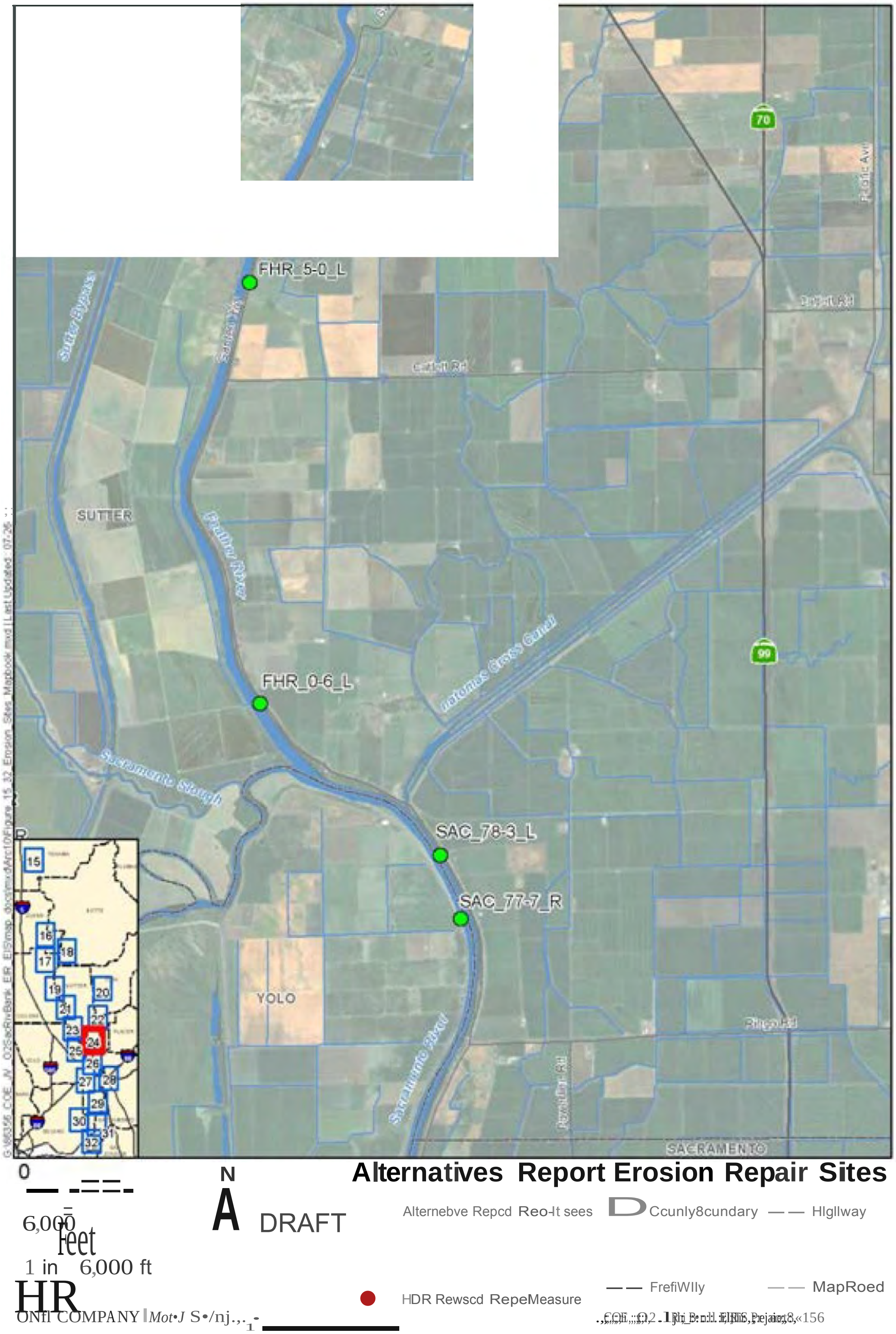

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Figure 18- Alternatives Report Erosion Sites

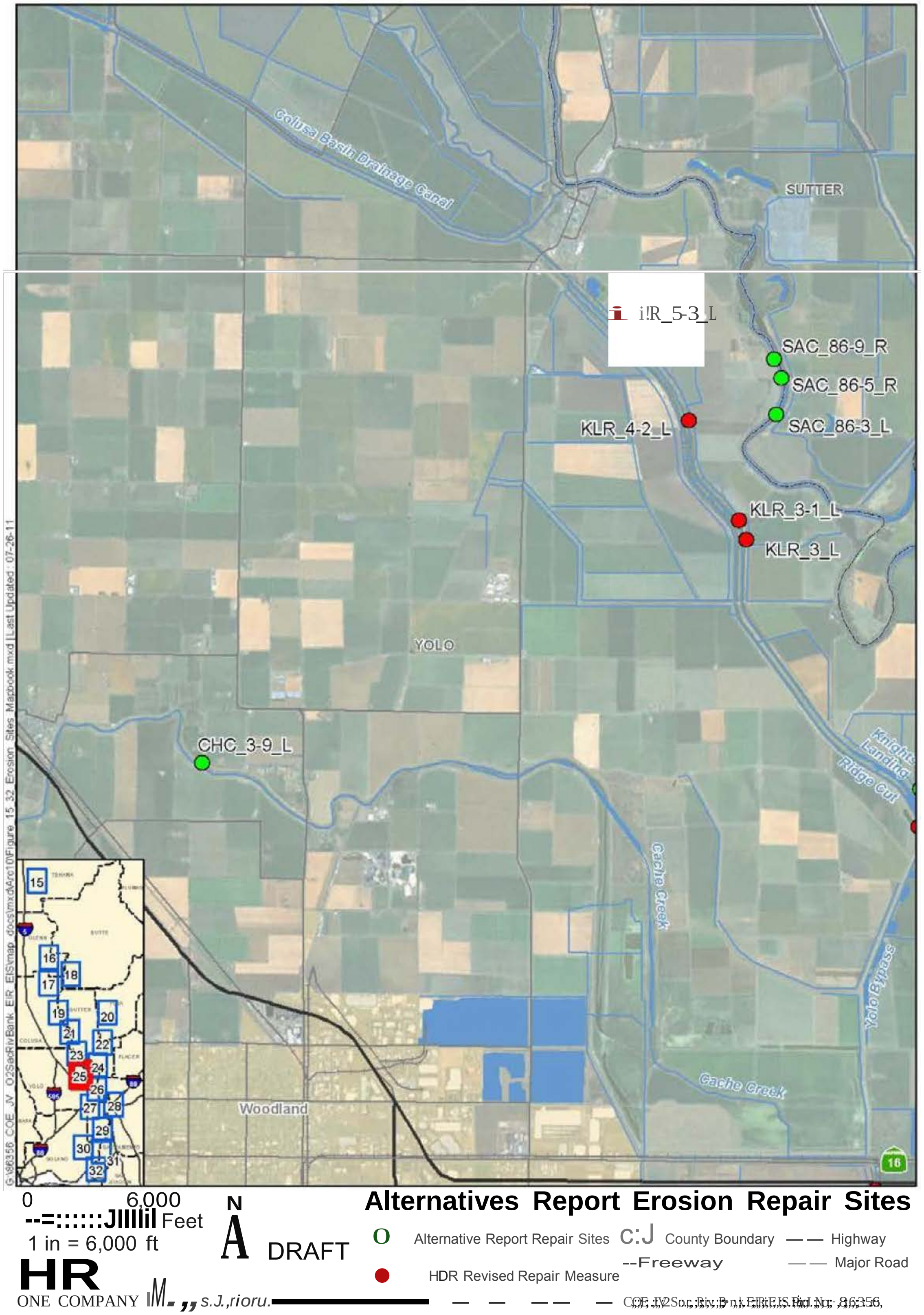

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Figure 19- Alternatives Report Erosion Sites

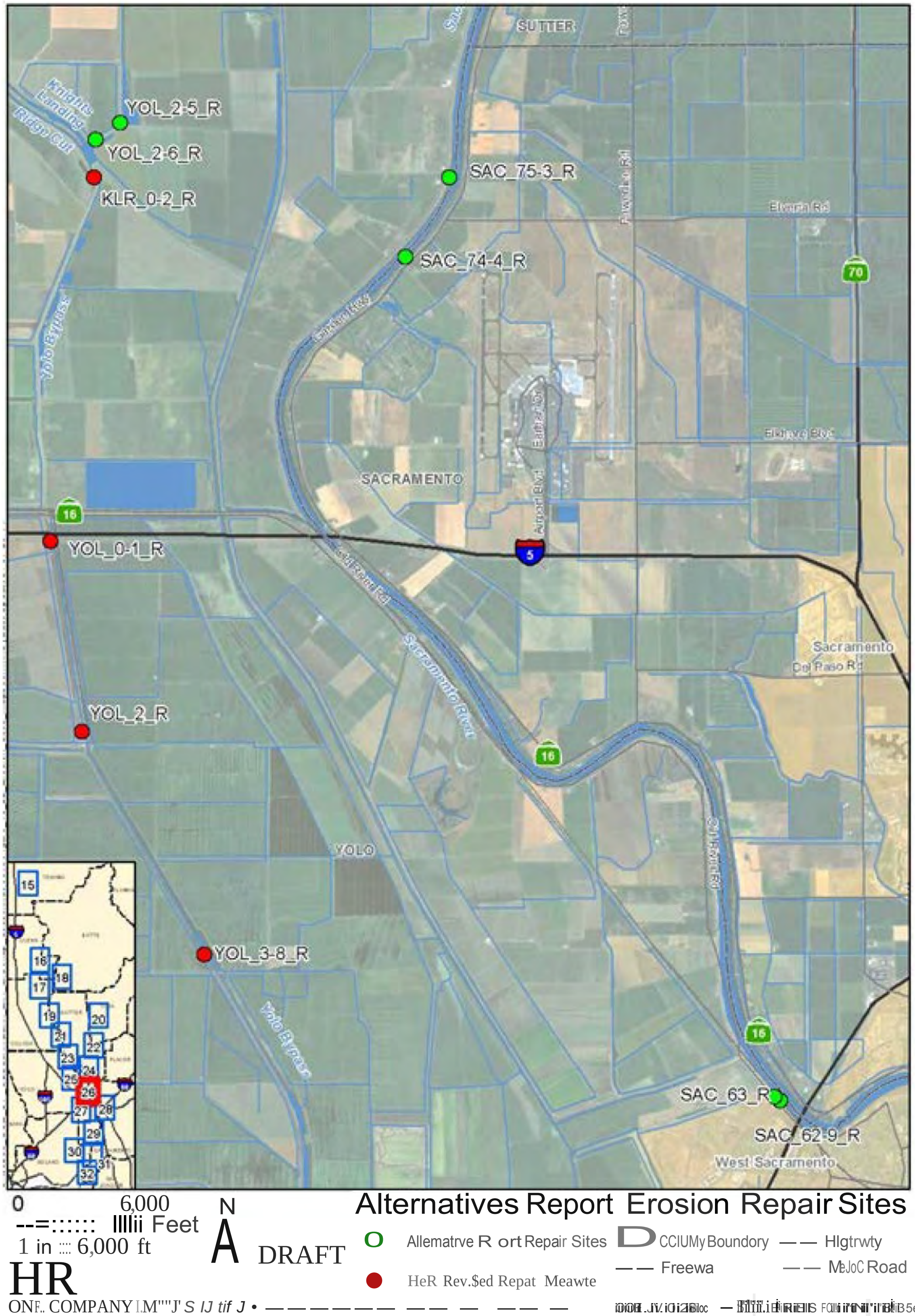

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Figure 20- Alternatives Report Erosion Sites

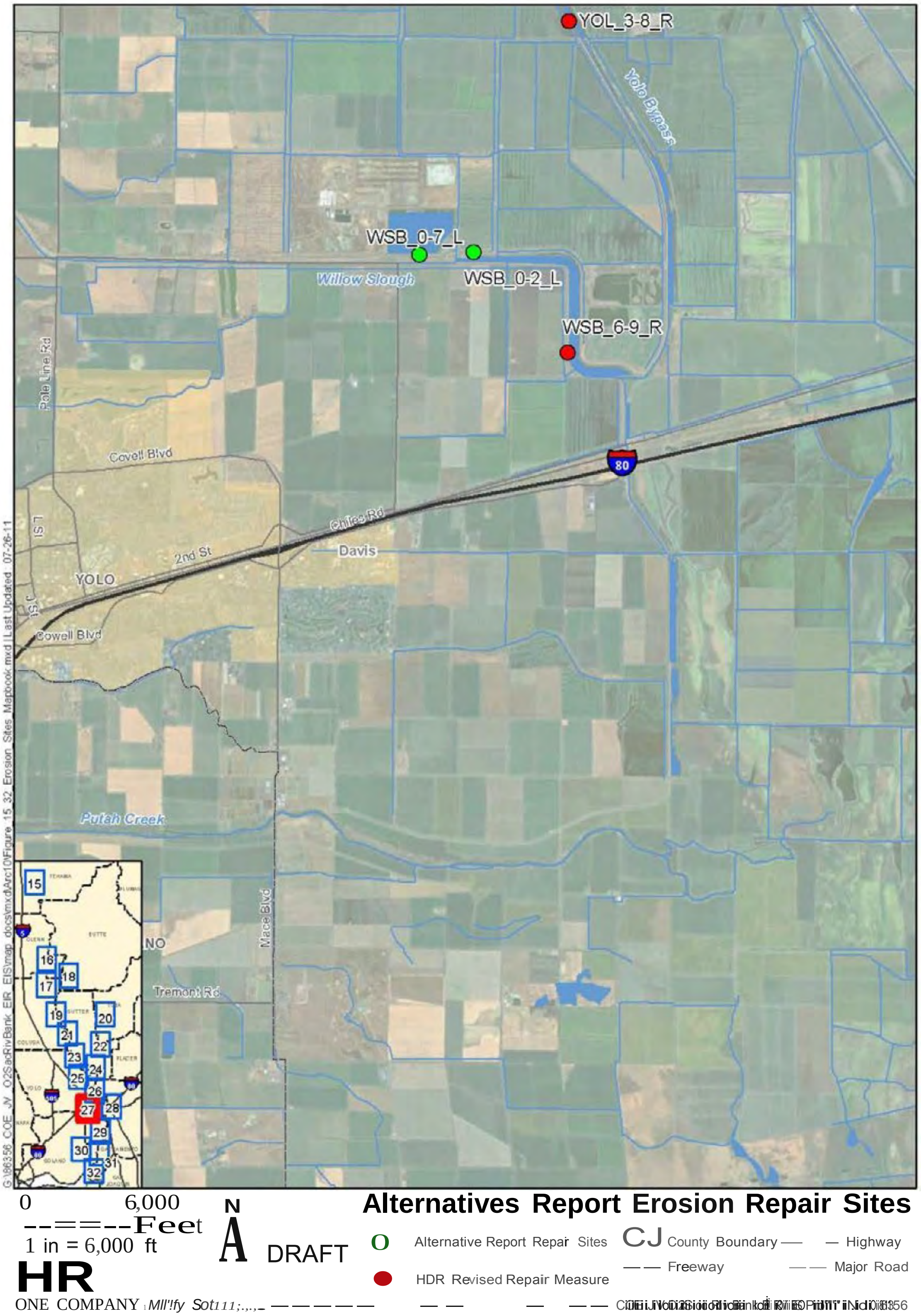

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Figure 21 -Alternatives Report Erosion Sites

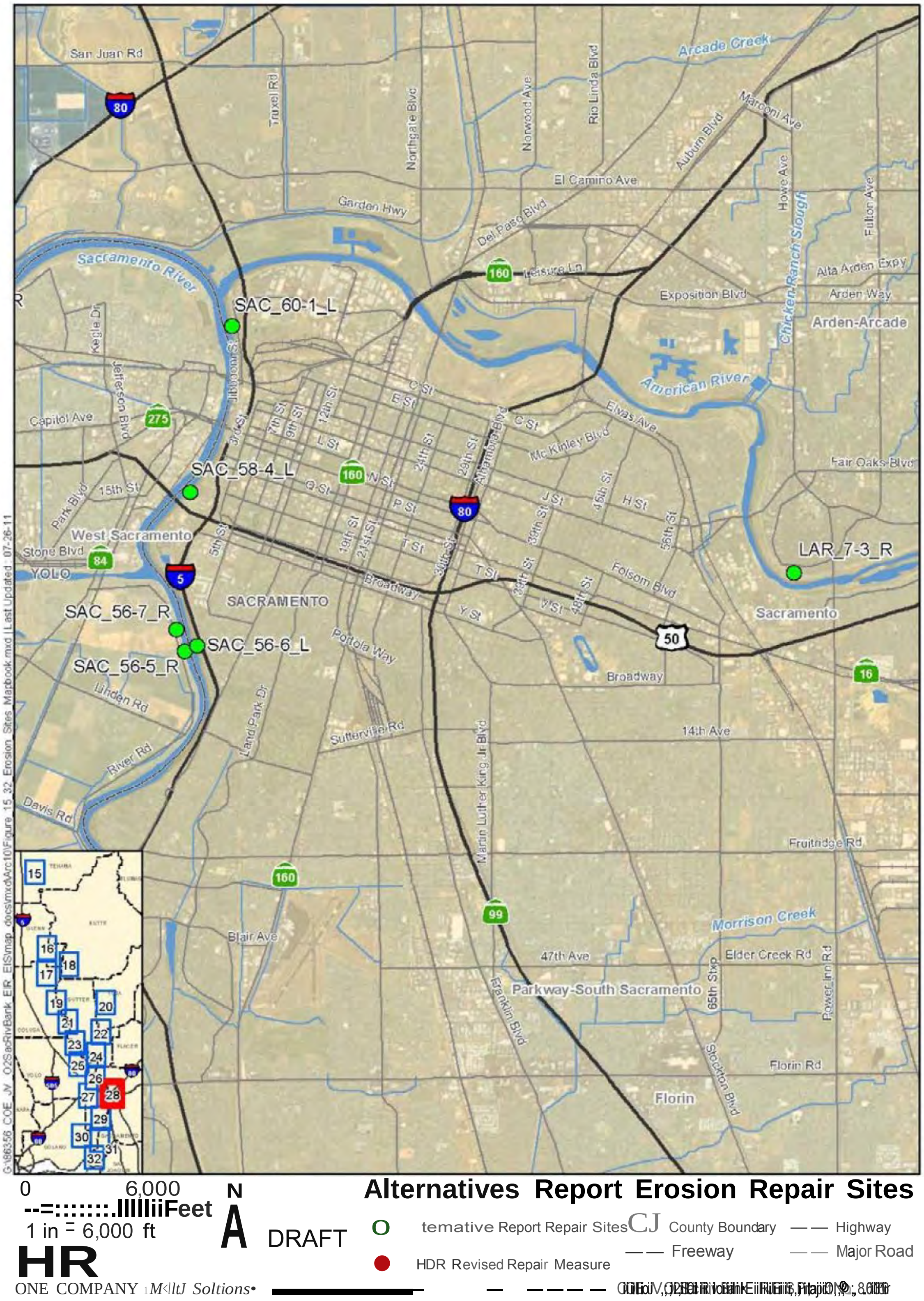

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Figure 22- Alternatives Report Erosion Sites

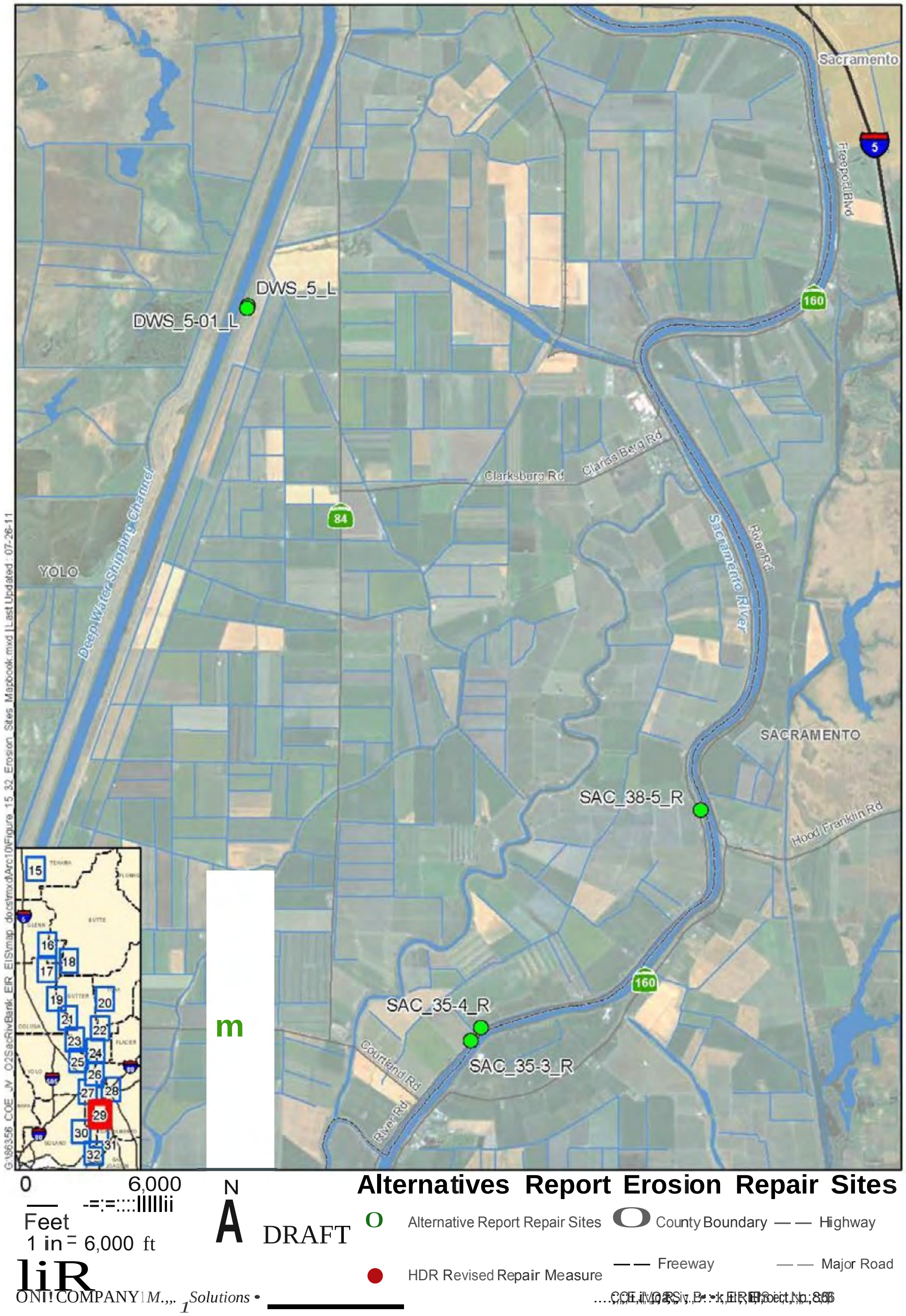

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Figure 23- Alternatives Report Erosion Sites

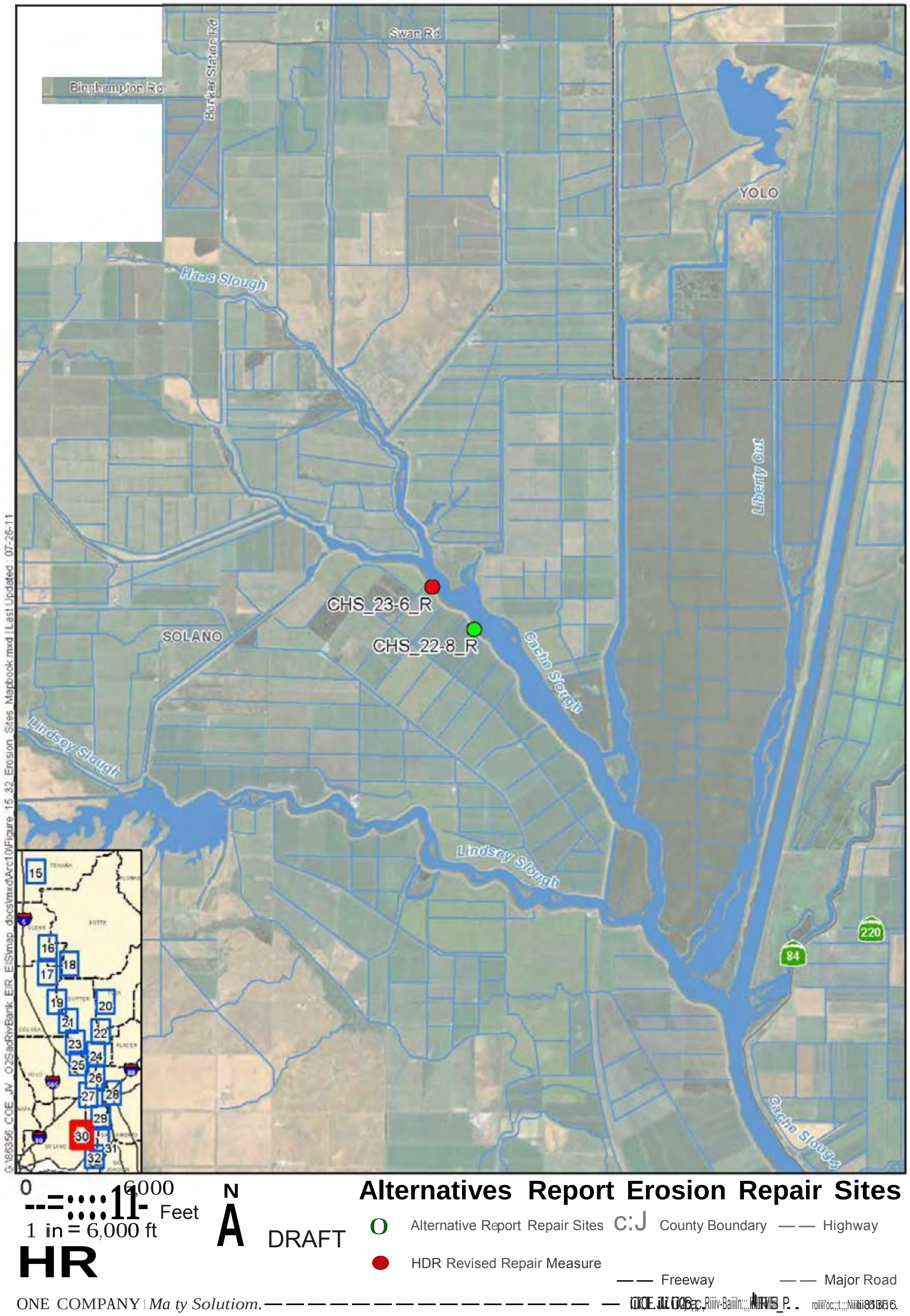

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Figure 24- Alternatives Report Erosion Sites

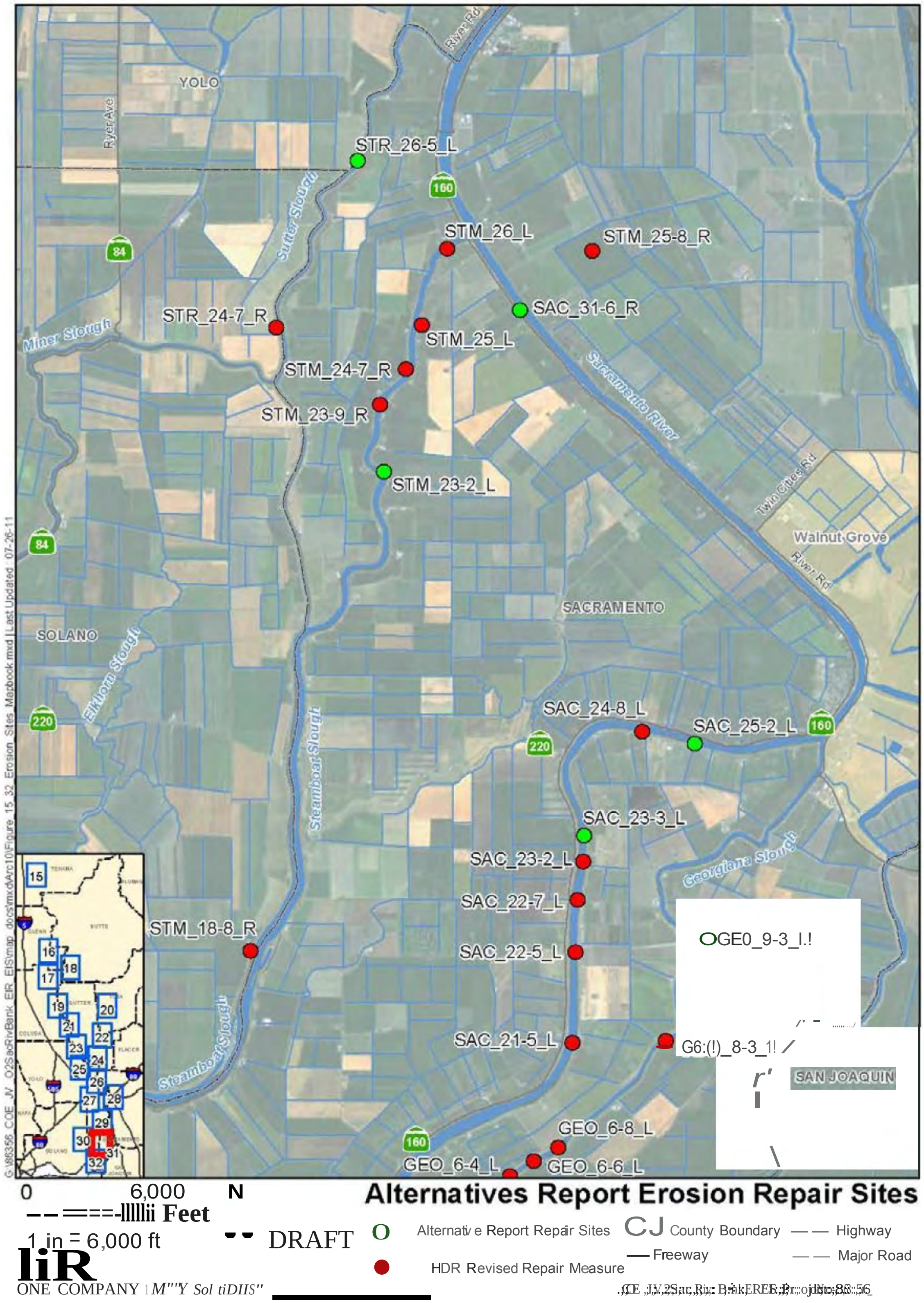

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Figure 25- Alternatives Report Erosion Sites

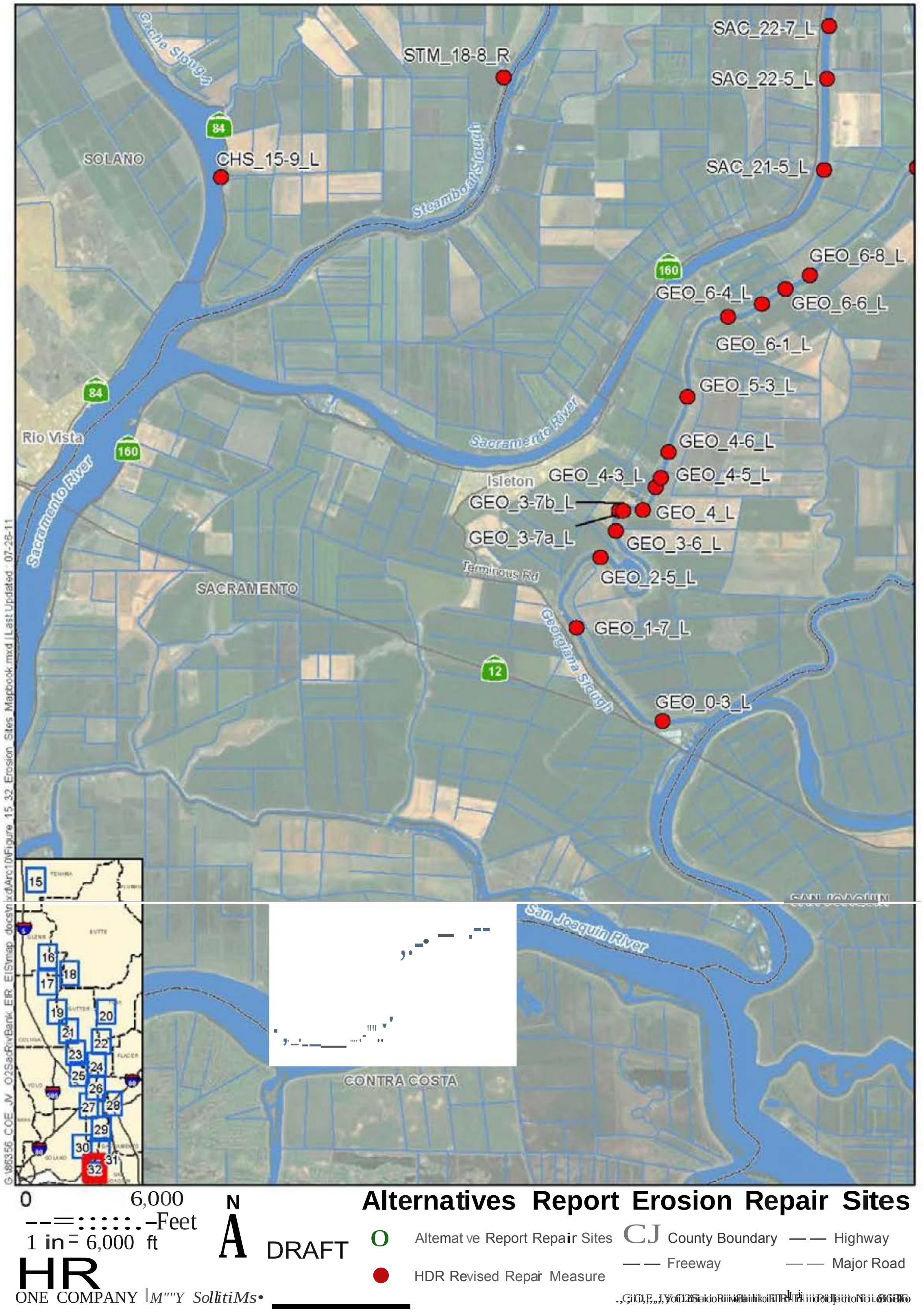

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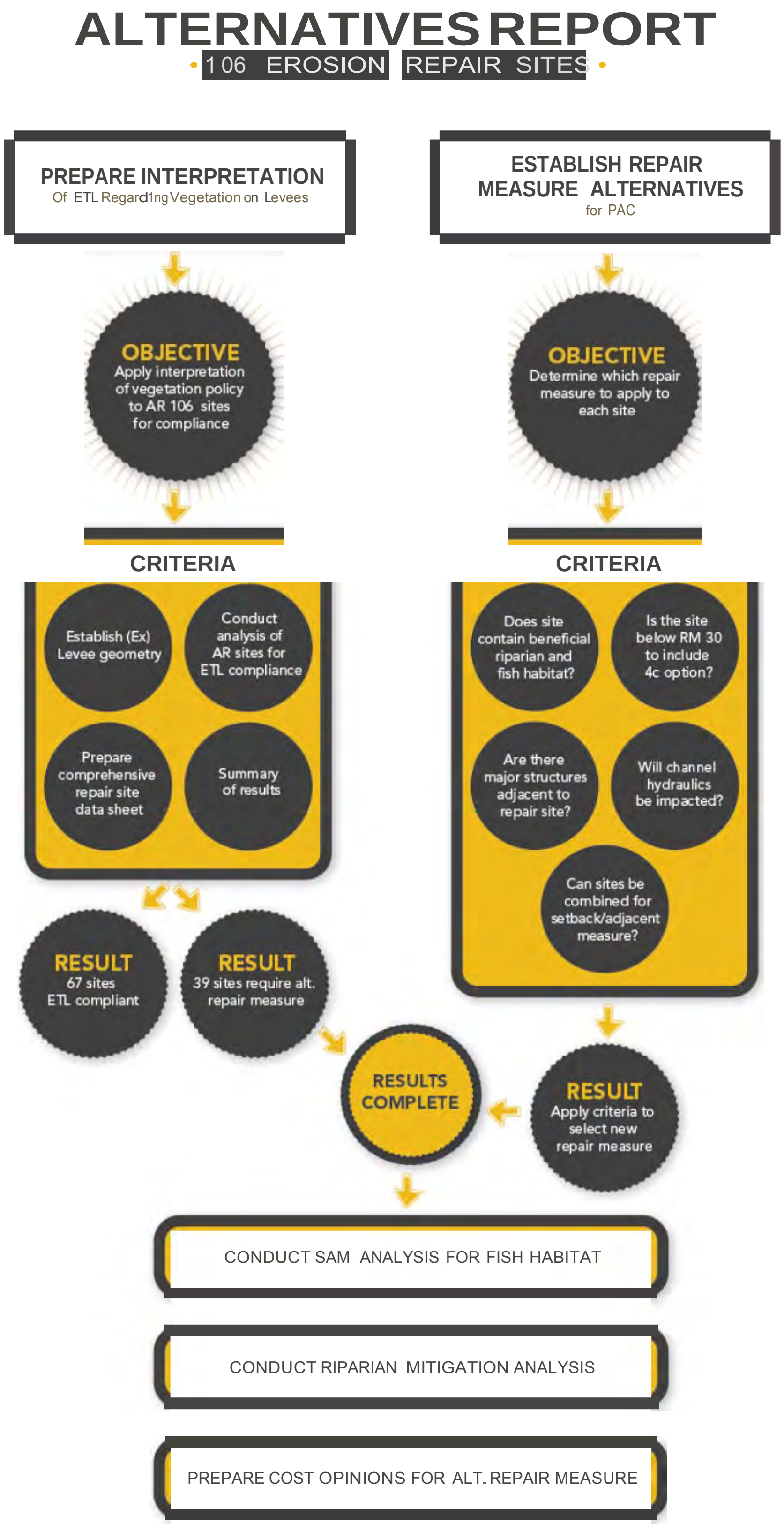
Figure 26 - Network Diagram of Process



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6.0 Plan Alternatives

This Engineering Appendix describes a single bank protection programmatic plan, the IAP. However, NEPA and CEQA generally require that an EIS and EIR, respectively, consider a range of alternatives that would attain most of the basic project purpose, need, and objectives while avoiding or substantially lessening project effects. A range of reasonable alternatives is analyzed to define the issues and provide a clear basis for choice among the options. The NEPA and CEQA analysis also analyzes a no-action or no-project alternative.

In addition to a no-action alternative, five action alternatives are analyzed. The five action alternatives, or "NEPA/CEQA alternatives," apply site-specific bank protection measures (design solutions) to the same 106 sites. The site-specific bank protection measure applied to each site will in most cases vary from one NEPA/CEQA alternative to another. The IAP is one of the NEPA/CEQA alternatives.

A description of the six NEPA/CEQA alternatives is in the PACR and the Programmatic EIS/EIR.

6.1 Intra-Group Efficiencies

The IAP demonstrates how intra-group efficiencies may take place. By grouping geographically clustered sites, construction at one site could provide benefits to, or facilitate bank protection at a neighboring site. To realize these efficiencies, a commitment is required to view the river as a system and plan groupings of bank protection and mitigation sites, rather than designing and constructing on an individual site-by-site basis. Advantages of a systematic approach are:

- Ability to use one site as off-site mitigation for one or more other sites. Example is a setback levee that would provide ecosystem benefits that could off-set losses at another site). Other sites might be stone protection.
- Provide mitigation in advance of environmental impacts caused by bank protection.

6.2 Operations and Maintenance

Generally, operations and maintenance (O&M) for bank protection sites will include periodic inspections, repair of bank protection if there is erosion undermining or otherwise damaging the bank or levee, maintenance of vegetation on banks and in floodplains created by setback levees, and inspection and maintenance of off-site mitigation areas. Bank protection O&M is in addition to on-going SRFCP levee inspection and maintenance.

O&M requirements of bank protection generally coincide with the O&M requirements of the SRFCP. The SRFCP is divided into 65 levee maintenance units. There is an O&M manual for each unit. These are supplemental manuals to the overall Standard Operations and Maintenance Manual which covers the entire SRFCP. Upon construction of bank protection, the supplemental manual that includes that site is updated. EA Appendix 7, Standard Procedure for Updating Supplemental O&M Manuals, describes how the supplemental manuals are updated.

6.3 Construction Schedule

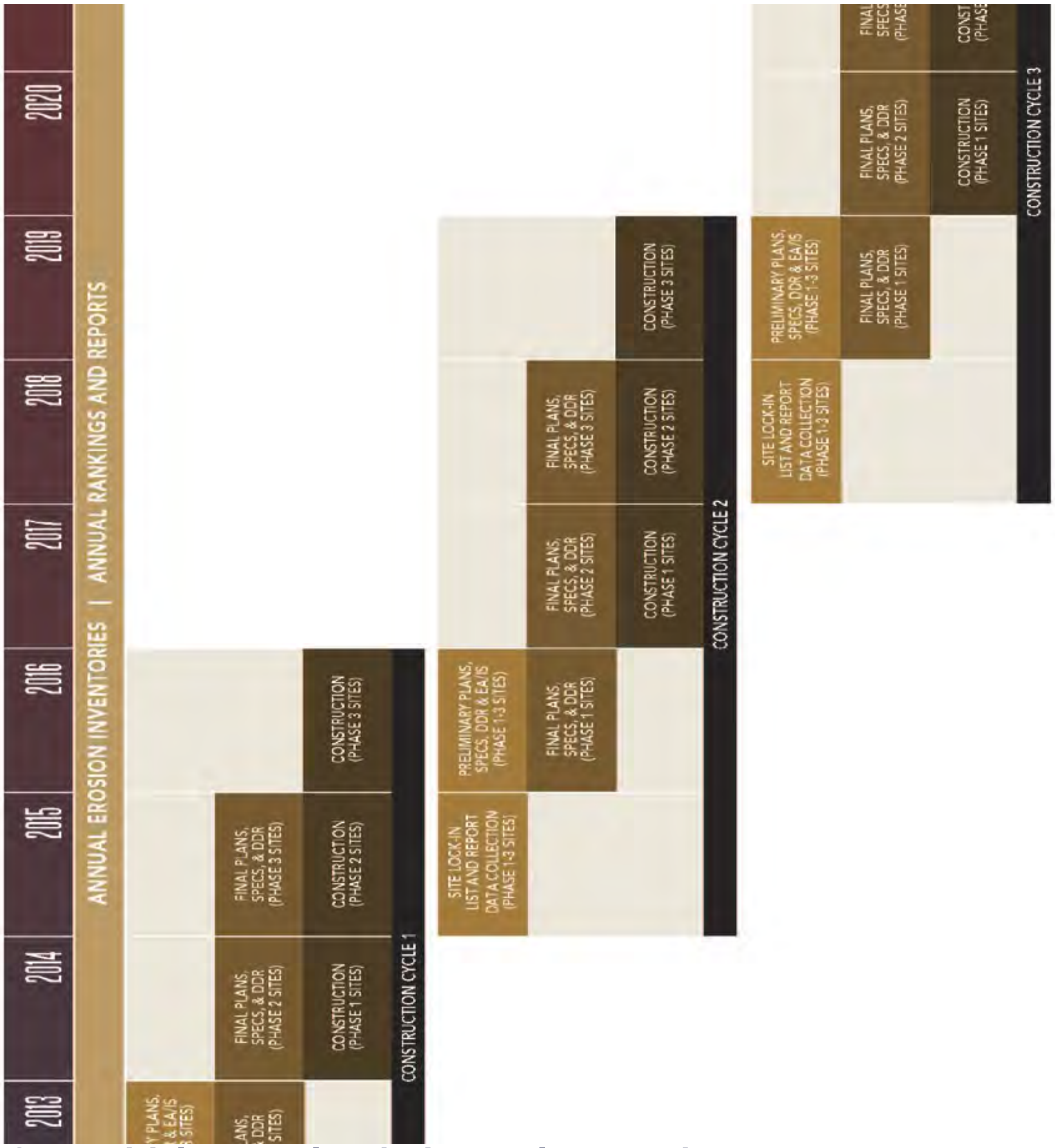
Construction of the Phase II 80,000 LF of bank protection is scheduled to begin in 2014 (**Figure 27**). Historically, a good rule of thumb for the SRBPP is that bank protection is constructed at about 8,000 LF per year. At this rate, construction of the 80,000 LF is estimated to be completed in ten years from start of construction. A series of specific, supplemental DDRs include a specific Real Estate plan and specific NEPA/CEQA documents. Sites selected from annual erosion surveys are further detailed in the **PACR, Section 8.2 Site Selection and Implementation**.

Repair of critical erosion sites will be expedited as much as possible. Some sites may require a more extensive design process, such as a setback levee, or otherwise could experience schedule delays. Repairs will continue at other sites if these critical erosion sites experience delays. Some sites may require a long permitting process. During this process construction will continue at other sites so as not to delay erosion repair at critical erosion sites. Some sites will require a more extensive design process, such as a setback levee.

The schedule for repairing a single erosion site or constructing a setback levee will vary on a site by site basis. The schedule depends on a number of factors including the measure selected, site length, bank width, accessibility, environmental restraints, planting factors, and other factors unique to each site.

Section 8.2 Site Selection and Implementation of the **PACR** provides a more detailed account of construction scheduling.

Figure 27 – Construction Schedule



6.4 Deviations from Initial Array Plan during Implementation

As discussed earlier, the IAP is a representation of 80,000 LF of bank protection. The actual constructed bank protection will be different. The IAP demonstrates how bank protection meets project goals, complies with Corps policy and environmental regulations, and it serves a valuable starting point to guide implementation of the bank protection program. The program, however, will evolve to adapt to changes in erosion, environmental, and market conditions, and revisions to policy.

Possible anticipated changes to the plan are listed below:

- As erosion problems vary year to year, the bank protection plan will adapt to changing conditions. The annual surveys may identify erosion sites as critical if erosion problems worsen at a particular site. Other sites will be removed as an erosion sites once they are repaired.
- Detailed explorations, surveys, and hydraulic modeling of sites could result in revisions to the erosion protection designs or changes to measures themselves.
- Detailed designs and real estate appraisals, and changes to market prices could revise cost estimates.
- As discussed above, the IAP complies with ETL 1110-2-583, with no variances. Currently, no variances apply for the IAP. If variances were requested and granted, it could relax the extent of the vegetation removal, increase vegetation and/or in-stream woody material placement, or result in revised measures.
- Mitigation requirements could change due to revisions to bank protection measures and more detailed field surveys and analysis are completed. Supplemental Biological Opinions and NEPA-CEQA documents will be developed during the implementation design phase.
- The construction schedule is not fully determined and is subject to change. Funding, the number and extent of selected critical erosion sites, and complexity of detailed planning and design are factors that influence schedule.

Engineering Appendix Subappendices

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Subappendix 1. Programmatic Framework Memorandum

PHASE II PROGRAMMATIC PLAN FRAMEWORK MEMORANDUM

Sacramento River Bank Protection Project ***September 18, 2009***

1. References

a. Corps of Engineers. ETL 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures. 10 April 2009

b. Programmatic Biological Assessment for the Sacramento River Bank Protection Project Phase II. US. Army Corps of Engineers. October 2007. Prepared by Stillwater Sciences, Davis, CA.

c. Biological Opinion, Section 7 Programmatic Formal Consultation on the Sacramento River Bank Protection Project Phase II, Contra Costa, Sacramento, Solano, Sutter, Yolo, Placer, San Joaquin, butte, Colusa, Glen, and Tehama Counties, California. U.S. Fish and Wildlife Service. June 23 2008 (amended June 24 2008 and July 2 2009).

d. Biological Opinion, Programmatic Consultation for Phase II of the Sacramento River Bank Protection Project. National Marine Fisheries Service. July 2, 2008 (amended July 30 2008 and July 27 2009).

e. California Levees Roundtable. California's Central Valley Flood System Improvement Framework. February 2009

f. Corps of Engineers. Alternatives Report – 80,000 LF (104 Sites) Sacramento River Bank Protection Project. Contractors: Kleinfelder, Geomatrix. April 2009

g. Draft Decision Document Report, Sacramento River Watershed, Sacramento River Bank Protection Project – Phase III, Phase I & II. August 2008

h. Geotechnical Levee Practice. Corps of Engineers, Sacramento District, Engneering Division, Geotechnical Engineering Branch. Effective April 11 2008.

2. Introduction

The Army Corps of Engineers (Corps) is charged to implement an additional 80,000 linear feet of bank protection as part of Sacramento River Bank Protection Project (SRBPP) Phase II. A Post Authorization Change (PAC) report is required before construction can proceed. The PAC will include an EDR, Real Estate Plan and a programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR). Common to all documents will be a programmatic bank protection plan.

This plan will include actual erosion sites. One or more alternative methods of protection will be specified at each site. Actual sites and construction may vary from the programmatic plan, but the plan must be realistic so that the PAC can report on environmental effects, costs, and benefits.

An early and important step in the development of the programmatic bank protection plan is to establish a pallet of alternatives that are effective, complete, acceptable, and efficient. For the plan to be acceptable, it must comply with ETL 1110-2-571 (ETL), reference 1.a.

3. Objectives and Scope

This memo applies Corps ETL guidance to bank protection conceptual alternatives. This has been reviewed by Corps and State of California DWR Product Delivery Team members and represents a consensus that the alternatives herein are acceptable and effective. This memo provides a basis to move forward with the bank protection programmatic plan.

This memo establishes rules and a framework for development of the programmatic bank protection plan. A pallet of constructible alternative bank protection measures is described in this memo, along with a preliminary analysis of under what circumstances they might be used. A vegetation free zone per the ETL is overlaid onto attached cross sections.

It should be emphasized that the alternative development concepts, while appropriate for the planning phase, will require further engineering analysis during design phase. Much of the descriptions are for purposes of development of a programmatic plan and a programmatic EIS and EIR. In the future, detailed hydraulic analyses and geotechnical designs at actual sites will determine the extent of critical structures, projections of levee prisms, vegetation-free zones and vegetation management zones. Vegetation management and in-stream woody material (IWM) placement will be further evaluated to assure levee inspection, flood fighting, and structural integrity. The concepts herein are considered sufficiently conservative to provide a realistic picture of bank protection that would satisfy Corps design guidelines.

4. Background

The Corps is developing a PAC and EIS/R on the SRBPP Phase II 80,000 linear feet of erosion protection at sites on the Sacramento River & tributaries.

Authorization

WRDA 2007 authorized that 80,000 linear feet of bank protection be added to the original Phase II authorization. The original authorization was in 1974. WRDA 2007 authorization reads as follows:

> Sec. 202. The Secretary of the Army, acting through the Chief of Engineers is authorized to initiate the second phase of the bank erosion control works and setback levees on the Sacramento River California, authorized by the Flood Control Act of 1960, in accordance with the Recommendations of the Chief of Engineers in House Document Numbered 93-151; except that the lineal feet in the second phase shall be increased from 405,000 lineal feet to 485,000 lineal feet.

House Document numbered 93-151 is a Chief of Engineers Report on Sacramento Bank Protection Project, California - Second Phase, dated September 13 1973. This document discusses the need for bank protection. It states that "To adequately protect the levees" that have eroded or where their berms have eroded and threatens the safety of the levee, "it has been necessary to clear the waterside levee slope, and face it with stone, …..". The report also states the need to avoid destruction to fish and wildlife habitat. The report also provides standards of design. "The berm or levee would be cleared as necessary with due consideration for preserving vegetation." Plate III of the document shows typical sections, with trees and other vegetation preserved on all parts of the levee.

ETL 1110-2-571

ETL 1110-2-571 provides vegetation management guidelines for levees and other flood risk management structures. This ETL does the following:

- Establishes a "vegetation free zone" on levees that spans all critical structures of the levee (toe-to-toe) plus a minimum additional 15' on each side.
- Provides for the construction of an overbuilt structure on a root free zone for planting on the land side of levees
- Describes how to apply for a variance and under what circumstances a variance might be granted.

Biological Opinions (SRBPP ESA Consultation)

Due to the presence of Endangered Species Act – listed species, the FWS and NMFS in 2001 issued separate Biological Opinions (BO's) for Phase II bank protection that pre-dates the 80,000 linear feet. In response to the BO's the Corps in 2007 finalized a Programmatic Biological Assessment (reference 1.b.). FWS and NMFS, in response to the Corps' request for consultation under the Endangered Species Act, used information from the Biological Assessment to prepare the most recent BO's. The FWS BO is dated June 23 2008 (reference 1.c.); the NMFS BO is dated July 2 2008 (reference 1.d.). The NMFS BO was amended in July

2008 to include 13 additional sites, and July 2009 to include 12 sites. The FWS BO was amended in June 2008 to include 13 sites and July 2009 to include 12 sites.

- The BO's list and describe alternative bank protection measures that are acceptable as on-site mitigation. Opportunities for off-site mitigation are described.

- While NMFS and FWS have not issued BO's for the 80,000 LF it is assumed herein that these resource agencies would require similar mitigation to avoid a Jeopardy Opinion.

- BO's issued by NMFS and FWS for the previous phase II work.

  - specifies 4 designs:
    - rock slope with revegetation, and
    - 3 designs with riparian and wetland berms.
  - specifies "off site compensation" at 2 sites

California's Central Valley Flood System Improvement Framework

The Central Valley Flood System Improvement Framework (reference 1.e.) is a collaboration by the California Levees Roundtable, a partnership of Federal, State, and local agencies (including the Corps) that was formed in 2007 to address vegetation issues affecting the levee system in the Central Valley. This presents an outline of short-term actions underway or to be initiated before the Central Valley Flood Protection Plan is completed in 2012.

The framework recognizes numerous threats to performance of Central Valley levees, including encroachments, through-seepage, under-seepage, seismic loading, structural instability, and vegetation. These threats will be looked at comprehensively in the Central Valley Flood Protection Plan and other planning studies, such as the Corps' Central Valley Integrated Flood Management Study, and Sacramento River Bank Protection Project Phase III General Reevaluation. Pending completion of studies, the state must demonstrate positive progress in achieving the Framework's short term goals and maintenance objectives to remain eligible for PL84-99 emergency and rehabilitation assistance. One important short term milestone is managing vegetation on levees. Levee maintaining agencies are required to maintain vegetation in accordance with DWR's Interim Levee Inspection Criteria for Vegetation. The Criteria is:

> Trees must be trimmed up five feet above the ground (12 feet above the crown road) and thinned enough for visibility and access. Brush, weeds, or other vegetation over 12 inches high blocking visibility and access within these levee areas should be trimmed, thinned, mowed, burned, dragged, or otherwise removed in an allowed manner. These criteria apply on the entire landside slope plus a 10-foot wide easement beyond the landside toe. On the waterside, these criteria apply to vegetation

on only the top 20 feet (slope length) of the levee slope. Below the 20 feet, all vegetation is allowed.

The Framework recognizes that the criteria do not meet ETL guidance but do provide for short-term measureable progress. These criteria will remain in effect until 2012, at which time it will be reconsidered based on contents of the Central Valley Flood Protection Plan.

SRBPP Phase II Alternatives Report

To initiate a programmatic plan an alternatives report was developed by Kleinfelder Associates under contract to the Corps (reference 1.f.). The report provides conceptual designs for bank protection to 153 sites in the study area. For each site, an erosion protection alternative was described and a cross section provided. The sites employ BO-approved alternatives.

The Alternatives Report was prepared before finalization of ETL 1110-2-571, therefore the issue of vegetation free zones was not addressed. The total length of the bank protection is about 77,000 linear feet. Some sites may be constructed in the near future under the original phase II authority.

It is the intent of the PDT to use the Alternatives Report as much as possible to aid the development of the EDR programmatic plan.

5. Historic Approach to Bank Protection

Phase I and Phase II bank protection measures

The Draft Decision Document (reference 1.g.) summarizes Phase I and Phase II bank protection measures. These include setback levees, meander belt (allow streams to meander within existing levees), limited bank protection (rock revetment to sustained high-water mark), and bank protection (revetment, modified revetment, and non-revetment). The appendices list completed bank protection work. Although the Phase II list is incomplete, it shows that rip rap was used extensively.

Since 2001 the Corps has been working with NMFS and FWS to improve bank protection designs and provide on-site compensation. The referenced BO's specify repairs that the SRBPP is to use for the 24,000 LF of remaining Phase II sites (previous to the 80,000 LF). Most repairs will be accomplished by incorporating rock berms that serve as buffers against extreme toe scour and shear stress while providing space for planting riparian vegetation and creating a platform to support aquatic habitat features, and provide shallow-water habitat for juvenile fish rearing and refugia. This design is intended to protect existing shaded riverine aquatic habitat and create elements of natural shaded riverine aquatic habitat that otherwise would be lost as a result of project construction activities and continued erosion. Two types of berms will be used: (1) riparian berms, and (2) wetland berms.

6. Corps Guidance for Vegetation on Levees

ETL 1110-2-571

Guidance is in Ref. 1.a. ETL 1110-2-571, Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures.

Vegetation Free Zone

This is a 3 dimensional corridor that surrounds all levees and critical appurtenant structures. The only acceptable vegetative ground cover is perennial grasses that are able to tolerate mowing to as low as 3 inches (sec. 4-8)

Purpose:

The vegetation free zone must be free of obstructions to assure access by personnel and equipment for surveillance, inspection, maintenance, monitoring, and flood-fighting (sec. 2-2). A secondary purpose is to provide a distance between root systems and levees to moderate reliability risks associated with (1) piping and seepage, and (2) structural damage (e.g. wind-driven tree overturning) (sec 2-4).

Extent:

The minimum width of the vegetation free zone shall be the width of the levee plus 15 feet on each side, measured from the outer edge of the outermost critical structure (sec. 2-2, 2nd bullet).

- The ETL does not specifically mention if the vegetation free zone includes or excludes “natural bank”, but the term “structure” suggests it does not include the natural bank (if its is not a structural part of the levee). Figure 23, found on page 6-17 of the ETL, shows that the extent of the vegetation free zone is measured from the toe of the structural levee. The landside toe is where the structural levee landside slope meets the natural grade. Figure 23 shows the waterside toe may be determined by projecting from the landside toe. However, during design phase an engineering analysis is needed to more accurately determine the waterside toe of the structural levee.

- There may be instances where it may be prudent to extend the vegetation free zone beyond the structural levee, or establish a vegetation management zone. An example is if there is no substantial natural bank, and / or if there are other risk reducing factors such as the levee slope is greater than 3:1, or especially erosive hydraulic forces are present, protection of the slope below the structural levee may be considered critical.

Planting Berm

Planting berms (or banks) are overbuild structures with no system reliability function. They must be of sufficient depth to accommodate proposed vegetation while precluding root penetration into the root-free zone. Planting berms may be considered for use on the land side only (sec 4-2).

Root Free Zones provide a margin of safety between vegetation on planting berms and the structural levee (sec 2-5). Root Free Zones are a minimum of 3' deep (Figures 13-15).

Vegetation Management Zones

This is an option that allows further vegetation removal and management outside the vegetation free zone. This may be appropriate on planting berms which are deemed critical defenses for levees.

Variances

The local sponsor may request a variance to further enhance environmental values or to meet state or Federal laws & regulations. A vegetation variance must ensure 4 points: (1) safety, functionality, structural integrity are maintained; (2) accessibility for surveillance, monitoring, inspection, maintenance and flood fighting are maintained; (3) periodic clearing of some types of vegetation will be performed to maintain items above; and (4) will not substitute for poor maintenance (sec. 1-3 (b)).

At the time of this memorandum, new rules regarding variances are being written. As the rules are being revised, the Corps will not accept new variance requests.

7. Application of ETL 1110-2-571 to SRBPP Phase II

The following are descriptions of how the ETL is interpreted for development of the programmatic plan for the 80,000 linear feet.

The ETL Provides the Appropriate Standard for SRBPP Phase II

Since bank protection is rehabilitation of a Federal Project Levee, the programmatic plan should follow the ETL Federal guidance. A potential alternative standard, developed by the California Levees Roundtable and shown above as part of the Central Valley Framework, is for short term maintenance. The Framework is interim guidance to 2012. Construction of bank protection will begin in 2011 and last approximately 8 years. Thus, most of the bank protection work would be done after the Framework expires. In an IRC held on 12 November 2008, the vertical team directed that bank protection must comply with the ETL. Thus the bank protection plan will use the standard provided by the ETL for both the design of berms and slope protection and for removal of existing vegetation on the waterside of sections of levee receiving bank protection.

ETL Takes Precedence over Chief's Report

The SRBPP Phase II 80,000 linear feet was authorized in WRDA 2007. The authorization (see citation above) references House Document Numbered 93-151, which is the SRBPP Phase II Chief's Report dated 13 September 1973. The Chiefs Report indicates that existing vegetation may be incorporated into the bank protection of levees and berms. Thus, there is an argument that direction from Congress is to preserve vegetation on levees, and that this direction supersedes ETL 1110-2-571. However, there are several reasons that make the case that the ETL takes precedence over the authorization. They are: (1) the authorization only indirectly specifies bank protection designs by referencing the Chief of Engineers Report; (2) Corps vegetation management policy has evolved since the Chief of Engineers Report, and (3) Direction from Congress does not include technical design guidance; the intent typically is what to build, not how to build it. The programmatic plan will follow the Chief of Engineers Report to the extent that bank protection designs are in conformance with ETL 1110-2-571.

Regional Variance to the ETL

The programmatic bank protection plan will assume that a regional variance is not required for implementation of any alternative bank protection. The alternative bank protection measures are intended to be compliant with the ETL without the need for a variance. A variance request is not part of the scope of this PAC and not reflected in its schedule.

Instream Woody Material is Treated Similar to Vegetation

Instream woody material (IWM) is dead branches and limbs that are anchored to the bank near the summer/fall water surface. IWM is on-site mitigation for loss of fish habitat. For the programmatic plan, IWM will not be placed in vegetation free zones.

Waterside Toe Establishes the Minimum Outermost Critical Structure

The waterside toe of the levee is the edge of the structural levee, which, for the bank protection alternatives, is the outermost critical structure, according to the ETL. For this programmatic plan, the waterside toe generally is the point of intersection between the 3:1 waterside slope and the projection of the landside natural grade. The waterside toe is a point on the physical levee slope, or on the levee prism if it is greater. In the case of the physical levee exceeding the levee minimum geometry, the programmatic plan will use the actual physical slope to establish the waterside toe.

See Section 8 below for a discussion of levee minimum geometry and levee reshaping.

The vegetation free zone extends on the levee a minimum of 15 feet to the waterside of the waterside toe. Although the above rule is adequate for the programmatic plan, a more accurate placement of the toe will be determined during design through engineering analysis. At some sites the berm may be considered crucial to the performance of the levee. In this case the berm may be considered the outermost critical structure, and the vegetation free zone may be expanded in the programmatic plan, or during design phase a vegetation management zone may be instituted.

The Adjacent Setback Levee Alternative Complies with the ETL

An adjacent setback levee is shown in Figure CS-1. A new adjacent landside levee incorporates part of the old levee into its structure. A levee prism may be projected on the new adjacent levee. As determined by geotechnical analysis, the prism defines the structural levee. Portions of the old, former levee may be outside the levee prism, and all or part of the waterside slope may be outside the vegetation free zone of the structural levee. The adjacent levee as conceptualized in figure CS-1and for the programmatic plan, complies with the ETL. During design phase, geotechnical evaluation may be required to show that the material in the former levee within the new levee prism is structurally sound.

Vegetation Management Zones

It is anticipated that for the programmatic plan no vegetation management zones will be delineated. If levee access and inspection are needed beyond the minimum, the vegetation free zone would be expanded. Vegetation management zones may be instituted during design and construction phase.

8. Changes to Existing Levee Geometry

Figure 1 is a cross section of a minimum levee prism or geometry. The geometry is from Geotechnical Levee Practice (reference 1.h.). Levee geometry is a geometrical rendering of the levee that defines height, width, and slopes. The levee geometry starts with a landside toe which projects upward at a 3:1 slope for Sacramento River levees, major tributary levees, and bypass levees. The landside slope extends to a hinge point at the top of the levee. From the hinge point there is a 20' wide crown towards the waterside hinge point. The levee projects down from this point at a 3:1 slope. The waterside toe is the intersection of the waterside slope (or slope projection) with the natural grade. For the purposes of the programmatic plan, for most sites the natural grade is a horizontal line extending from the landside toes.

At most sites a natural or man-made bank or berm extends water-ward from the levee. The berm is outside of the levee geometry. The berm may be extended and fortified with rock both to provide additional levee defense and to provide a place for planting vegetation.

The actual levee cross sections vary in height, width, and shape throughout the project area. Some levees exceed the geometry and some levees have dimensions and/or slopes that do not meet the minimum geometry. For levee sections that exceed the minimum geometry, the full physical levee will be considered the critical structure. The initial assumption is that the original design as exists on the ground is correct. The waterside toe will be the intersection of the physical levee waterside slope with a horizontal line drawn from the waterside toe.

Levee protection against erosion is the basic objective of the project. However at some sites there may be opportunities to extend and/or reshape levee sections to meet the minimum geometry thereby improving levee stability. There is leeway within the project to stabilize a levee if, besides having a critical erosion problem, it also has a high risk of failure from slipping or overturning. There are other instances where meeting minimum levee geometry is not practicable. For instance, in the Sacramento San Joaquin Delta extending the waterside slope to 3:1 would reduce channel capacity. If improving levee stability is not practicable, erosion protection would be the only improvement,

The basic rule that the programmatic plan will follow is that the minimum levee geometry or the actual physical levee, whichever is bigger, will determine the size of levee. In some instances it is not practicable to widen levees as the new levee slope would extend too far into the channel. The bank protection would place rock along the waterside slope with a slope of greater (steeper) than 3:1 but less than 2:1 slope. If the slope is steeper than 2:1 the plan would include broadening and reshaping the levee.

9. Levee Alternative Measures

The following are descriptions of basic bank protection alternatives that may or may not comply with the ETL 1110-2-571. Section 9 describes how existing vegetation would be treated for those alternatives that involve protection of the existing levee. Section 10 is an evaluation of how each alternative complies with the ETL.

No-Action Alternative

Under the no-action alternative, the Corps would not implement bank protection along Sacramento River levees. The result is likely to be the continued gradual or sporadic loss of remnant floodplain (berm) and the riparian vegetation it supports, and ultimately the erosion could encroach into the cross section of the levee foundation, creating critical erosion sites. It is possible that the Corps or state flood control agencies would eventually implement bank protection along various sites along Sacramento River levees through emergency action. In any case, the risk of levee failure and possibly catastrophic flooding would increase substantially as more erosion sites become critical and repair is limited to emergency response.

Continued erosion prior to the Federal or state action would result in loss of mature riparian habitat but would increase the value of shallow aquatic habitat by the addition of in-stream woody material into the river system. (Although bank erosion is a natural phenomenon, the channelization of project reaches have increased erosive forces. Thus, in the case of the Sacramento River, at lease some erosion may be considered induced by the SRFCP.) In addition, vegetation may be removed as part of local O&M. This vegetation loss would be mitigated by those performing the O&M action.

Alternative 1: Setback Levee

The levee setback alternative entails constructing a new levee some distance landward of the existing levee. The new levee would have minimum levee geometry in accordance with Geotechnical Levee Practice (2008). The land between the setback and the old levee would act as a floodplain. Land use in the new floodplain would be determined on a site-by-site basis. The floodplain may be used for off-site mitigation, such as vegetation planting or IWM placement, for other bank erosions sites. The old levee could be breached in several locations or removed completely to allow high flows to inundate the new floodplain. Vegetation on the new setback levee and 15' from each toe would be restricted to mown perennial grass and managed as a vegetation-free zone.

Alternative 2: Bank Fill Rock Slope with no On-Site Vegetation

The bank fill rock slope with only mown grass or no revegetation design entails installing revetment along the levee slope and stream bank from the levee's toe to crest, or other elevation determined through engineering analysis. For purposes of the programmatic plan, it is assumed rock slope protection will extend from the levee's toe to the 1957 profile. If needed, the levee waterside slope would be regraded to a 3H to 1V slope or other slope determined through engineering analysis. Vegetation would be limited to grass that would be mowed. If there is a natural bank distinct from the levee that requires erosion protection, it would be treated with rip rap.

Alternative 3: Adjacent Levee

The adjacent levee alternative involves the construction of a new levee embankment adjacent to and landward of the existing levee. The new levee would be to Corps standards and would have minimum levee geometry in accordance with Geotechnical Levee Practice (2008). The landward portion and possibly all or portions of the water side of the old levee could be an integral, structural part of the new levee. Vegetation and IWM could be placed on the old levee but would be done so that roots do not affect the new levee. Placement of trees would not occur in the vegetation free zone of the new adjacent levee. This vegetation free zone would be determined along with the structural elements of the new levee by engineering analysis during design.

Alternative 4a: Riparian Berm with Revegetation and IWM above Summer/Fall Waterline

The low riparian berm with revegetation and IWM above the summer/fall waterline design entails installing revetment along the levee toe and upper bank as well as creating a rock/soil berm. For the programmatic plan rock would be placed to the 1957 profile elevation, although this could change during design. Riparian vegetation and IWM would be limited to the vegetation free zone. The berm may be widened to accommodate a minimum planting space. This design is typically applicable to sites above Sacramento River Mile 30. If needed, the levee waterside slope would be regraded to a 3 to 1 slope or other slope determined by engineering analysis.

For the purpose of the programmatic plan the riparian berm is considered to be a non critical structure. Later detail design may determine that the berm may be deemed a Vegetation Management Zone where vegetation would be maintained for access and inspection and thus preserve the integrity of the berm as a line of defense for the levee.

Instances of Alternative 4a are illustrated as cross sections in Figures CS-3, CS-4, CS-5, CS-6, CS-8, and CS-9. The cross sections do not distinguish between Alternatives 4a or 4b because the alternatives only vary with respect to vegetation and IWM. The berm designs do not vary. Alternativs 4a and 4c may have their berms placed below the summer/fall waterline.

Alternative 4b: Riparian Berm with Revegetation and IWM above and below Summer/Fall Waterline

The low riparian berm with revegetation and IWM above and below the summer/fall waterline design entails installing revetment along the levee toe and upper bank and levee waterside slope to the 1957 profile elevation, although this could change during design. Riparian vegetation and IWM would be limited to the vegetation free zone. The rock/soil berm will provide space to support riparian vegetation and provide a place to anchor IWM. IWM will also be placed beyond the berm below the summer/fall waterline, thereby increasing the types and extent of mitigation. This design is typically applicable to sites above Sacramento River Mile 30. If needed, the levee waterside slope would be regraded to a 3 to 1 slope or other slope determined by engineering analysis.

For the purpose of the programmatic plan the riparian berm is considered to be a non critical structure. Later detail design may determine that the berm may be deemed a critical structure requiring a Vegetation Management Zone. In this case, vegetation would be maintained for access and inspection and thus preserve the integrity of the berm as a line of defense for the levee.

Instances of Alternative 4b are illustrated as cross sections in Figures CS-3, CS-4, CS-5, CS-6, CS-8, and CS-9.

Alternative 4c: Riparian and Wetland Berms with Revegetation

The low riparian and wetland berm with revegetation and IWM design entails installing revetment along the levee toe and upper bank and levee waterside slope to the 1957 profile elevation, although this could change during design. Riparian and wetland vegetation and IWM would be limited to the vegetation free zone. The rock/soil berm will provide space to support riparian vegetation and provide a place to anchor IWM. The design also includes a wetland berm below the summer/fall waterline to further increase habitat quality. This design is intended for sites downstream of Sacramento River Mile 30 and is targeting mitigation of impacts to delta smelt habitat. If needed, the levee waterside slope would be regraded to a 3 to 1 slope or other slope determined by engineering design.

For the purpose of the programmatic plan the riparian berm is considered to be a non critical structure. Later detail design may determine that the berm may be deemed a Vegetation Management Zone where vegetation would be maintained for access and inspection and thus preserve the integrity of the berm as a line of defense for the levee.

Instances of Alternative 4c are illustrated as cross sections in Figures CS-3, CS-4, CS-5, CS-6, CS-7, CS-8, and CS-9.

Alternative 5: Bank Fill Rock Slope with On-Site Vegetation (No Berm)

Note that this alternative, as discussed in Section 10, does not comply with the ETL and is not considered an alternative for use in the programmatic bank protection plan.

The bank fill rock slope with revegetation design entails installing revetment along the levee slope and streambank from the levee's toe to crest or other elevation determined by engineering analysis including revegetation and IWM placement on the lower and upper bank. If needed, the levee waterside slope would be regraded to a 3 to 1 slope or other slope determined by engineering analysis. This design typically applies to locations where no berm exists.

10. Treatment of Existing Vegetation

Alternative 1

Vegetation on an old levee or portions of an old levee with a setback levee behind it could remain assuming the old levee is not part of the new structural levee.

Alternatives 2 and 4

For Alternatives 2 and 4 existing vegetation other than approved grasses on the waterside slope and on the natural bank within 15' of the waterside toe would not be in compliance with the ETL and would be removed. Vegetation removal would occur on the waterside slope of the levee section that receives bank protection. Although some of this vegetation may be outside the footprint of the construction, it is important that the project investment result in a levee that meets design and maintenance criteria. The SRBPP Phase II does not include removal of existing vegetation from the landside levee slope.

Natural bank vegetation beyond the 15' vegetation free zone but still within the construction footprint could remain if it does not compromise construction of bank protection or levee integrity, there is a reasonable chance the vegetation would survive rock placement, and it does not impede levee inspection or flood fighting.

Removal of existing vegetation, including clearing of vegetation in the construction footprint, is a local O&M responsibility. The programmatic plan and EIS/EIR, however, will use the without project condition that the vegetation is not removed. Therefore, vegetation removal will be part of the project. Vegetation removal and its mitigation will be shown as a 100 percent non-Federal expense. There is an efficiency to including removal in the plan because mitigation opportunities would be better identified in the plan. The cost of mitigation for vegetation removal, either on-site or off-site, would also be a local expense.

Alternative 3

Vegetation on the original waterside levee may lie within the vegetation free zone for the new adjacent levee and therefore may need to be removed. Also vegetation on the old levee may have to be removed as part of site preparation work for the new levee. For these cases, this vegetation would be removed as part of the bank protection project but at 100 percent local expense. The cost of mitigation for this vegetation removal, either on-site or off-site, would also be a local expense. Other vegetation that may require removal for the new adjacent levee would be removed as a cost shared part of the project. See Figure 2.

11. Viability of Alternatives for the Programmatic Plan

The alternatives vary in terms of compliance to the ETL, cost, and environmental impact. The following is an analysis to determine the alternatives viability for inclusion in the bank protection programmatic plan.

Alt 1 Setback Levee

ETL Compliance: Would be in full compliance.

Positives:

- Supported by resource agencies.
- Potential to provide off-site mitigation for other bank protection activities.
- Incidental but substantial river restoration benefits.
- Potential incidental reduction in flood risk.

Negatives:

- Expensive to construct.
- Land acquisition expensive and difficult or infeasible in many areas.
- Would be technically difficult or infeasible in many areas due to topography, soils, hydraulic problems.

Reliance as an Alternative:
Setback levees can be very effective, but due to cost, existing land use, and technical issues, opportunities for setback levees in the programmatic plan may be limited.

Alt 2 Rock Slope

ETL Compliance: Would be in full compliance.

Positives:

- Proven and effective & efficient bank protection measure.

Negatives:

- Not supported by resource agencies unless vegetation & IWM added (only possible if eroding bank is of a substantial size, removed by 30' (?) or more from the waterside levee toe.
- May require hard to come by off-site mitigation.

Reliance as an Alternative:
Rocking is an important alternative that the programmatic plan will find appropriate at many erosion sites. This is especially appropriate where the waterside levee toe is a substantial distance from the natural bank. It has limited application where the natural bank either does not exist or has a critical structural role.

Alt 3 Adjacent Levee

ETL Compliance: As stated above, this framework considers vegetation on original levees to the water side of adjacent levees as in compliance with the ETL if it is determined to be outside the structural adjacent levee vegetation free zone and the root free zone and it does not impede inspection of the new levee.

Positives:

- The old levee may act as a riparian berm, thus likely supported by resource agencies.
- The old levee may be degraded to increase the size of the vegetation berm and increase natural floodplain.
- Potential to preserve existing riparian vegetation.
- Possible but limited river restoration benefits.
- New levee would be constructed to Corps standards, thus potential incidental reduction in flood risk.
- Could negate local levee encroachment issues.

Negatives:

- Expensive to construct.
- Land acquisition may be infeasible in some areas.

Reliance as an Alternative:
This alternative bank protection measure may be the only viable solution at some erosion sites. It should be retained as an alternative as long as it is considered in ETL compliance or with assurance that a variance will be granted. This is an important alternative that would be appropriate at many sites.

Alt 4 Berm with Riparian or Wetland Vegetation

ETL Compliance: This alternative complies with the ETL. The berm is not considered at the programmatic plan phase as an engineered, critical structure. A portion of a berm may be adjacent to the waterside levee toe and within the vegetation free zone. However vegetation would be acceptable 15' or more out from the toe on the berm, whether or not the berm is natural or constructed.

Positives:

- Supported by resource agencies.
- Effective & potentially inexpensive mitigation to rock placement.

Negatives:

- There may be instances where a berm is a critical structure.
- A large berm could cause hydraulic problems.

Reliance as an Alternative:
This alternative would be appropriate for many, perhaps a majority of sites. A planted berm may serve as on-site mitigation or possibly mitigate for other neighboring sites. It might not be a viable alternative for reaches where hydraulics is critical and flows are erosive. This is an appropriate alternative for the programmatic plan.

Alt 5 Bank Fill Rock Slope with On-Site Vegetation (No Berm)

ETL Compliance: Would not be in compliance. A variance would be difficult to justify due to root penetration into the levee

Positives:

- Supported by resource agencies.
- Effective & potentially inexpensive mitigation to rock placement.

Negatives:

- Does not meet Corps standards.

Reliance as an Alternative:
This is not a viable alternative and should not be included in the programmatic plan.

12. Summary Bank Protection Palette for Bank Protection Plan

The proposed palette includes 4 of the 5 alternatives.

- The Rock Placement is in full compliance with ETL.

- The Setback Levee alternative is in full compliance with ETL.

- The Berm with Riparian Vegetation (all variations) is in ETL compliance and would be used extensively under some natural bank situations and would be a useful alternative

- Adjacent levee is a useful alternative where the natural bank is a critical structure and landside acquisition is limited.

13. Cross Sections

Attached are eleven cross sections that show how bank protection alternatives would be applied under different site-specific circumstances. For all alternatives a waterside toe and the vegetation free zone are shown.

Three of these Figures apply to Alternative 3: Adjacent levee. Cross Section CS-1 is with an existing berm, Cross Section CS-2 is without an existing berm and Figure 2 shows the vegetation removal for CS-2.

The seven remaining cross sections apply to Alternative 4a, 4b, or 4c, slope protection with berm. These vary by the presence and condition of an existing berm, the need for slope regrading, and the summer-fall water surface above or below the landside elevation.

14. Evaluation of Kleinfelder Alternatives Report Cross Sections

The Alternatives Report (reference 4th bullet) primarily uses variations of Alternatives 4 and 5.

The Alternatives Report employs 8 bank protection designs (excluding no action and setback levee alternatives). All 8 designs include vegetation on the revetment placed on levees and berms. The cross sections however do not specify where vegetation would be placed, nor do they show the waterside toes or the locations of vegetation free zones. Based on the bank protection alternative descriptions, vegetation would be planted on levee slopes. In this respect the cross sections of the Alternatives Report do not agree with the vegetation free zones depicted in the ETL and this evaluation's cross sections.

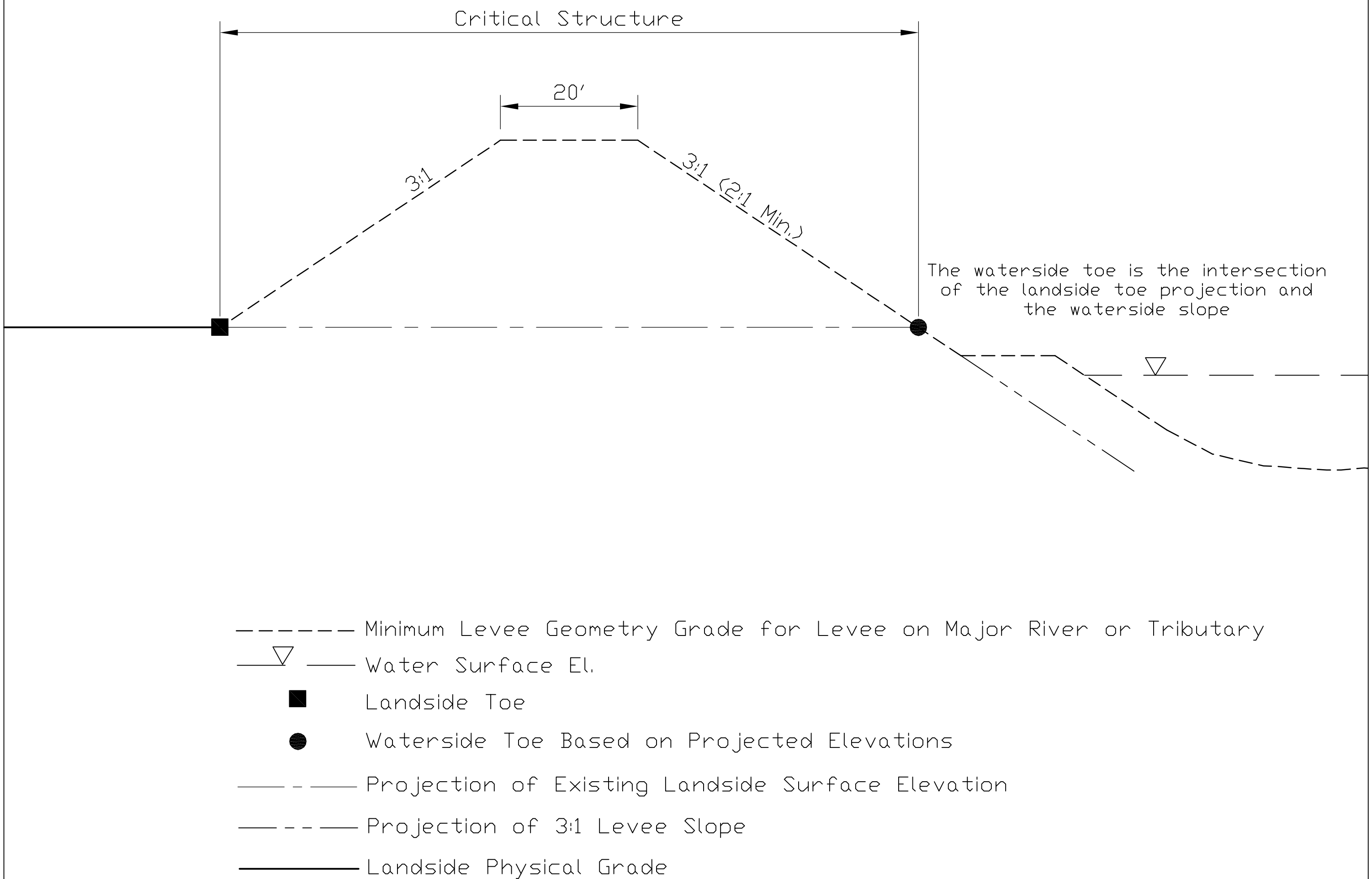
15. Key Assumptions on Vegetation Management and SBPP Phase II Programmatic Plan

- Bank protection will be in accordance with House Document 93-151 to the extent that designs conform to the ETL.

- Alternatives conform to the ETL without the need for a variance.

- For the purposes of the programmatic plan, the waterside toe is the intersection of the waterside slope of the levee with the natural grade. In the case of an oversized levee, the programmatic plan will use the natural waterside slope (not a projected levee prism slope) to determine the waterside toe. Final determination of the structural levee will be performed during the design phase.

- Vegetation may be planted on natural bank or artificial berms 15' from toe.
- In-stream woody material (IWM) is considered vegetation subject to the ETL.
- Existing vegetation inside the vegetation free zone (waterside portion of the levee only) would be removed as part of the project. The cost of removal and mitigation would be part of the SRBPP but would be a 100 percent non-Federal cost.



For the programmatic plan, the waterside levee toe is established as the intersection of the existing slope with a horizontal line waterward from the landside hinge point.

The levee, from toe to toe, is the critical structure used in ETL 1110-2-571 as a basis for establishing the vegetation free zone.

DRAFT

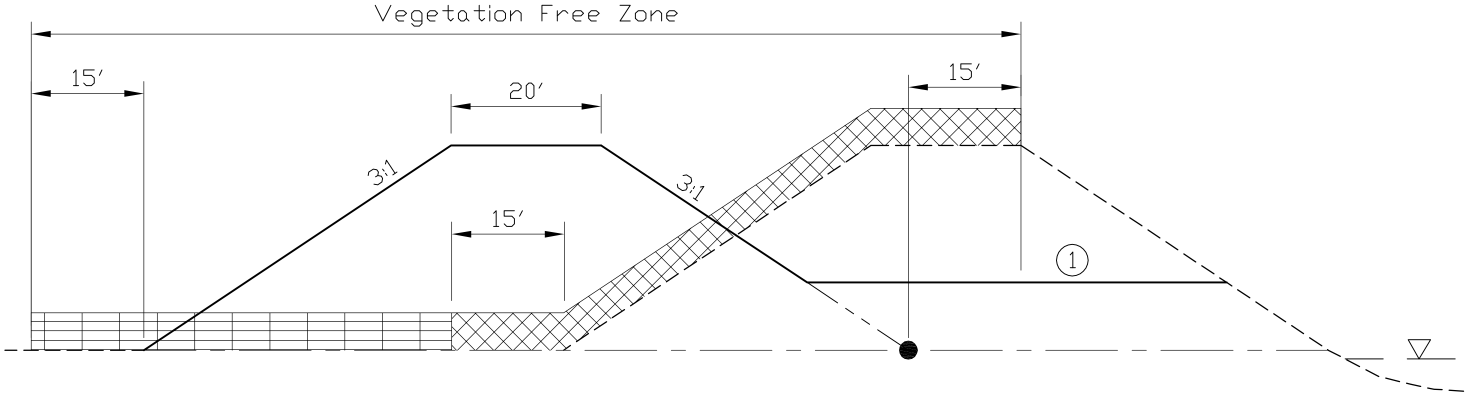
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Minimum Levee Geometry

Date September 18, 2009

Figure 1



Post Construction Levee Geometry (dimensions and grades are minimum)

Pre Construction Grade

Water Surface El.

Established Toe Based on Projected Elevations

Projection of Existing Landside Surface Elevation

Projection of 3:1 Levee Slope (older levee material would be analyzed during Design Phase to confirm that the new levee is structurally adequate)

Existing Vegetation removal is O&M of the existing levee. To be Removed at 100% Local Expense, as part of the project

Existing Vegetation Removal is Cost Shared

1 Old Levee may be degraded if there is an opportunity to increase the size of the floodplain/berm for environmental mitigation.

The Vegetation Free Zone dimensions are minimums. This zone may be extended or a Vegetation Management Zone may be instituted to allow for access and inspection of the old levee.

DRAFT

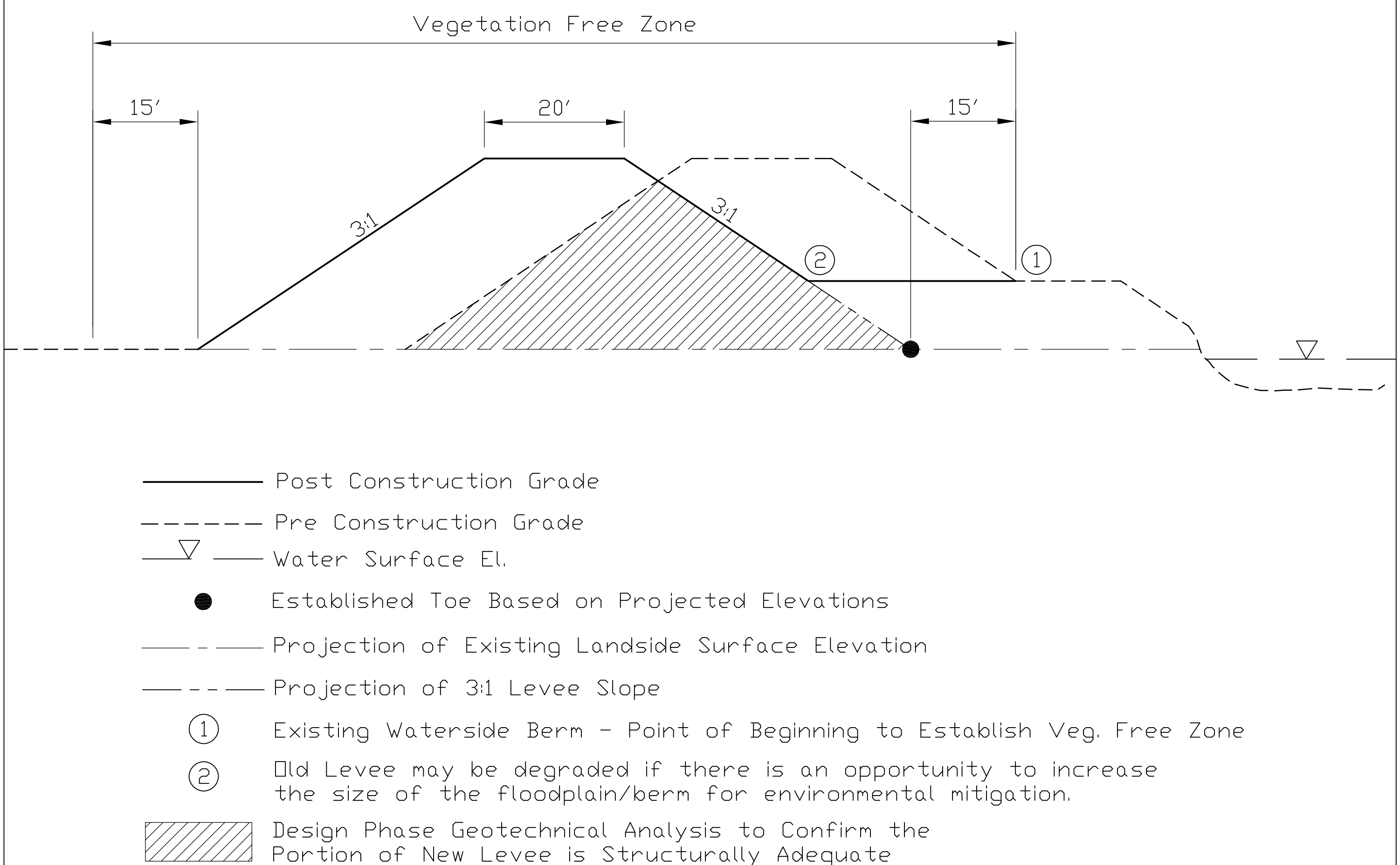
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Vegetation Removal for Adjacent Levee Alternative

Date September 18, 2009

Figure 2



The intersection of the existing waterside slope and berm would be considered the point of beginning to establish the waterside boundary of the vegetation free zone. Establishing a boundary limit at this point will allow for vegetation to be planted on the existing berm without infringing into the vegetation free zone. The adjacent levee waterside toe, at a minimum, will be a point 15 feet landside of the existing berm/slope intersection. Its elevation will be equal to the projection of the existing landside surface. The proposed adjacent levee with the appropriate geometry will then be established relative to this point. During Design Phase, the levee material of the old waterside levee would be analyzed to determine suitability for use in the new levee.

The Vegetation Free Zone dimensions are minimums. This zone may be extended or a Vegetation Management Zone may be instituted to allow for access and inspection of the old levee.

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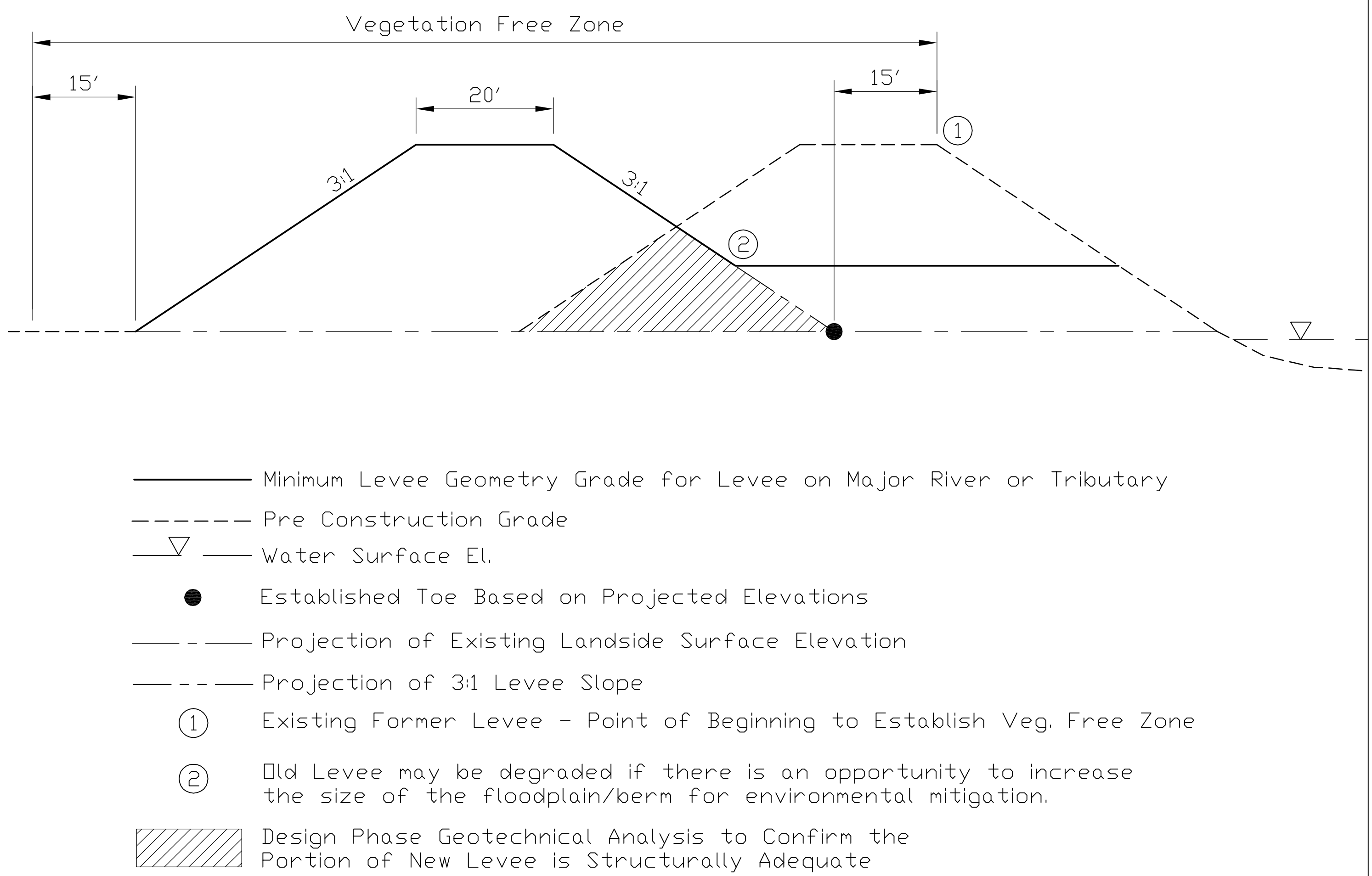

The existing waterside hinge point would be considered the point of beginning to establish the waterside boundary of the vegetation free zone. Establishing a boundary limit at this point will allow for vegetation to be planted or remain on the existing waterside levee slope without infringing into the vegetation free zone. The adjacent levee waterside toe, at a minimum, will be a point 15 feet landside of the established hinge point. Its elevation will be equal to the projection of the existing landside surface. The proposed adjacent levee with the appropriate geometry will then be established relative to this point. The levee prism in the old waterside levee would be further defined in design phase through geotechnical surveys and analyses.

The Vegetation Free Zone dimensions are minimums. This zone may be extended or a Vegetation Management Zone may be instituted to allow for access and inspection of the old levee.

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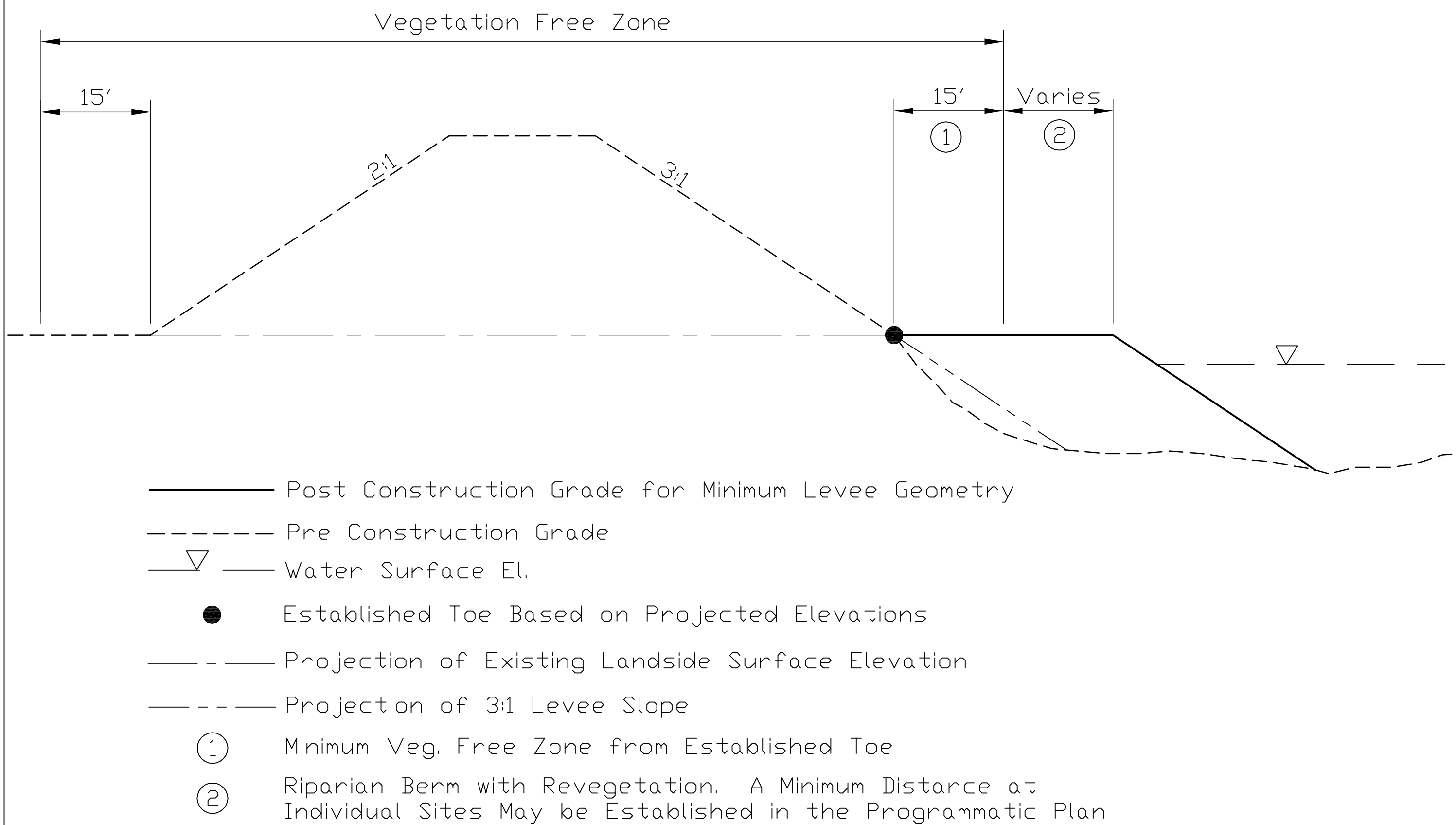

The existing waterside slope is established by projecting the existing landside surface elevation to the intersection of the existing waterside slope. This intersecting point is considered the established waterside levee toe. When considering a riparian berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe. A minimum berm size for planting may be required. The planting portion can be widened as needed. Vegetation on the berm may be managed to allow access and inspection.

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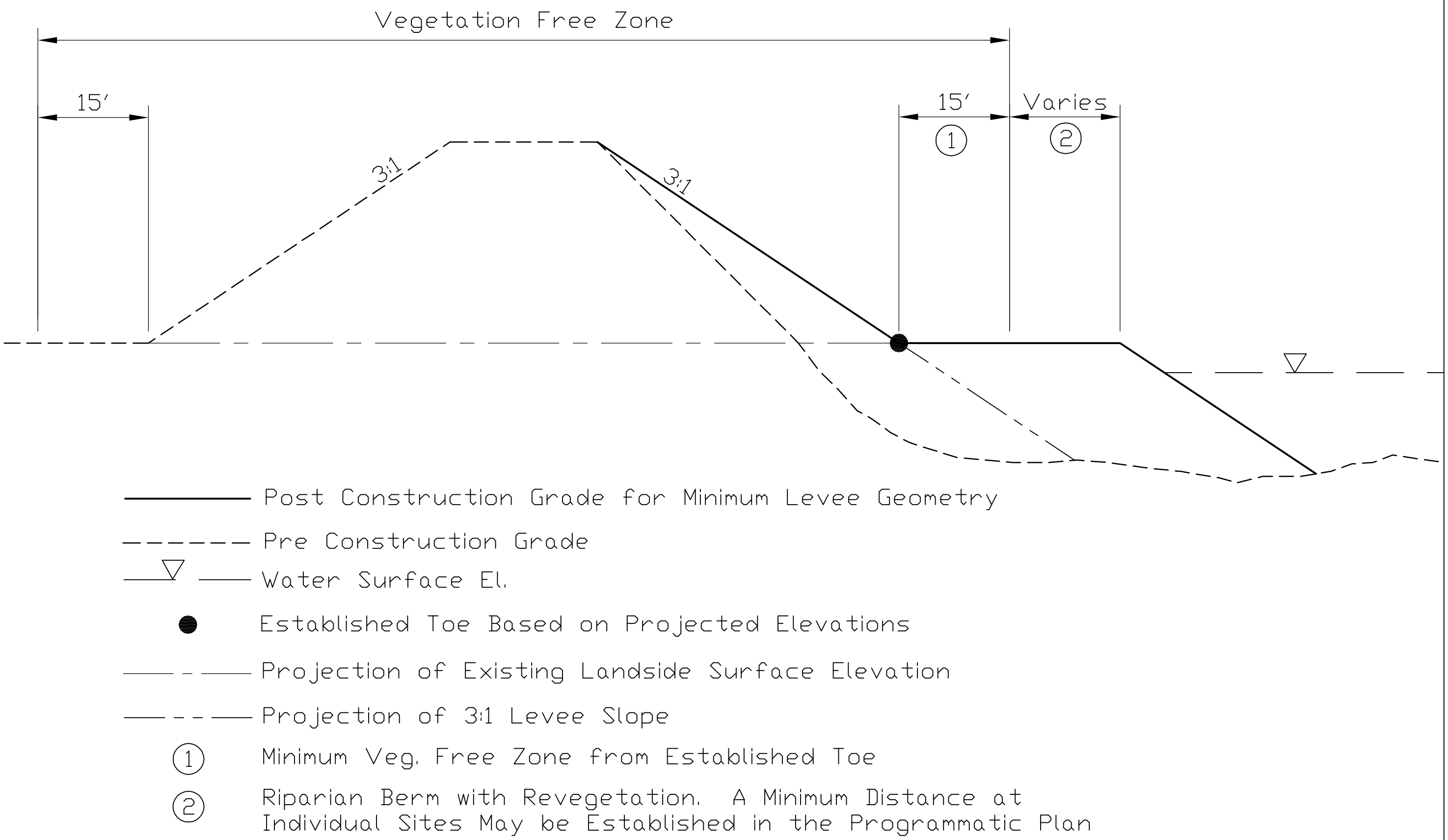
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Existing Waterside Slope equal to 3:1
No Existing Berm
WSE Below Landside Elevation

Date September 18, 2009

Figure CS-3



The waterside levee toe is established by projecting a 3:1 slope from the existing levee hinge point down to the projected existing landside surface elevation. This intersecting point is considered the established waterside levee toe. When considering a riparian berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe. A minimum berm size for planting may be required. The planting portion can be widened as needed. Vegetation on the berm may be managed to allow access and inspection.

DRAFT

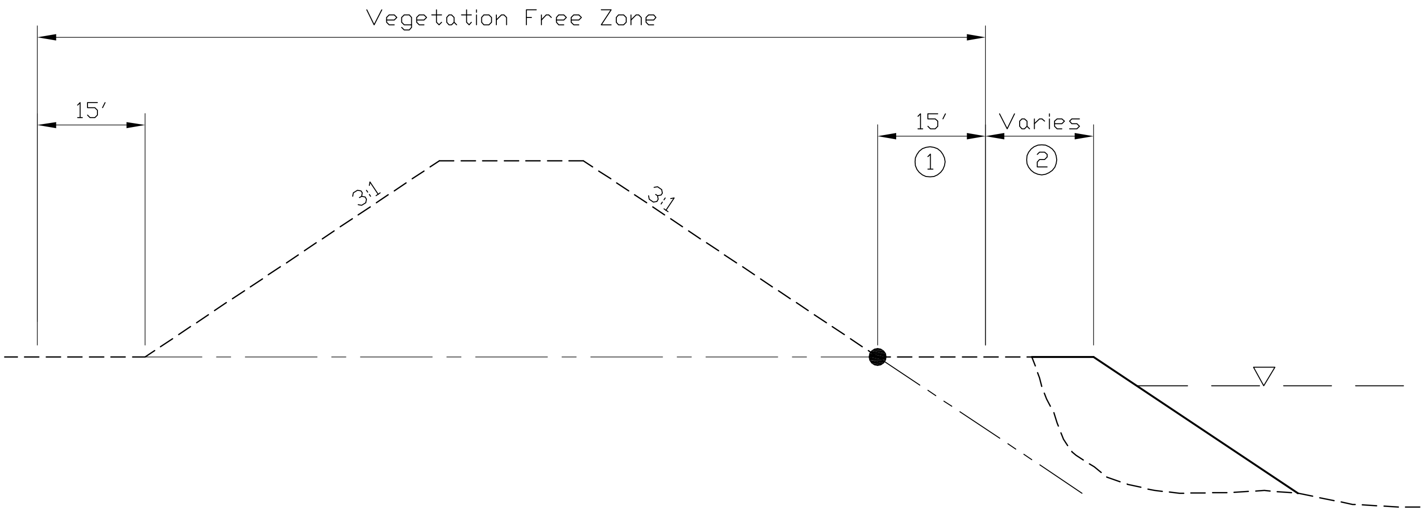
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Existing Waterside Slope Less than 3:1
WSE Below Landside Elevation

Date September 18, 2009

Figure CS-4



Post Construction Grade for Minimum Levee Geometry
Pre Construction Grade
Water Surface El.
Established Toe Based on Projected Elevations
Projection of Existing Landside Surface Elevation
Projection of 3:1 Levee Slope
① Minimum Veg. Free Zone from Established Toe
② Riparian Berm with Revegetation. A Minimum Distance at Individual Sites May be Established in the Programmatic Plan

The existing waterside toe is established by projecting the existing landside surface elevation to the intersection of the existing waterside slope. When considering a riparian berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe. A minimum berm size for planting may be required. The existing berm may be widened as needed. Vegetation on the berm may be managed to allow access and inspection.

DRAFT

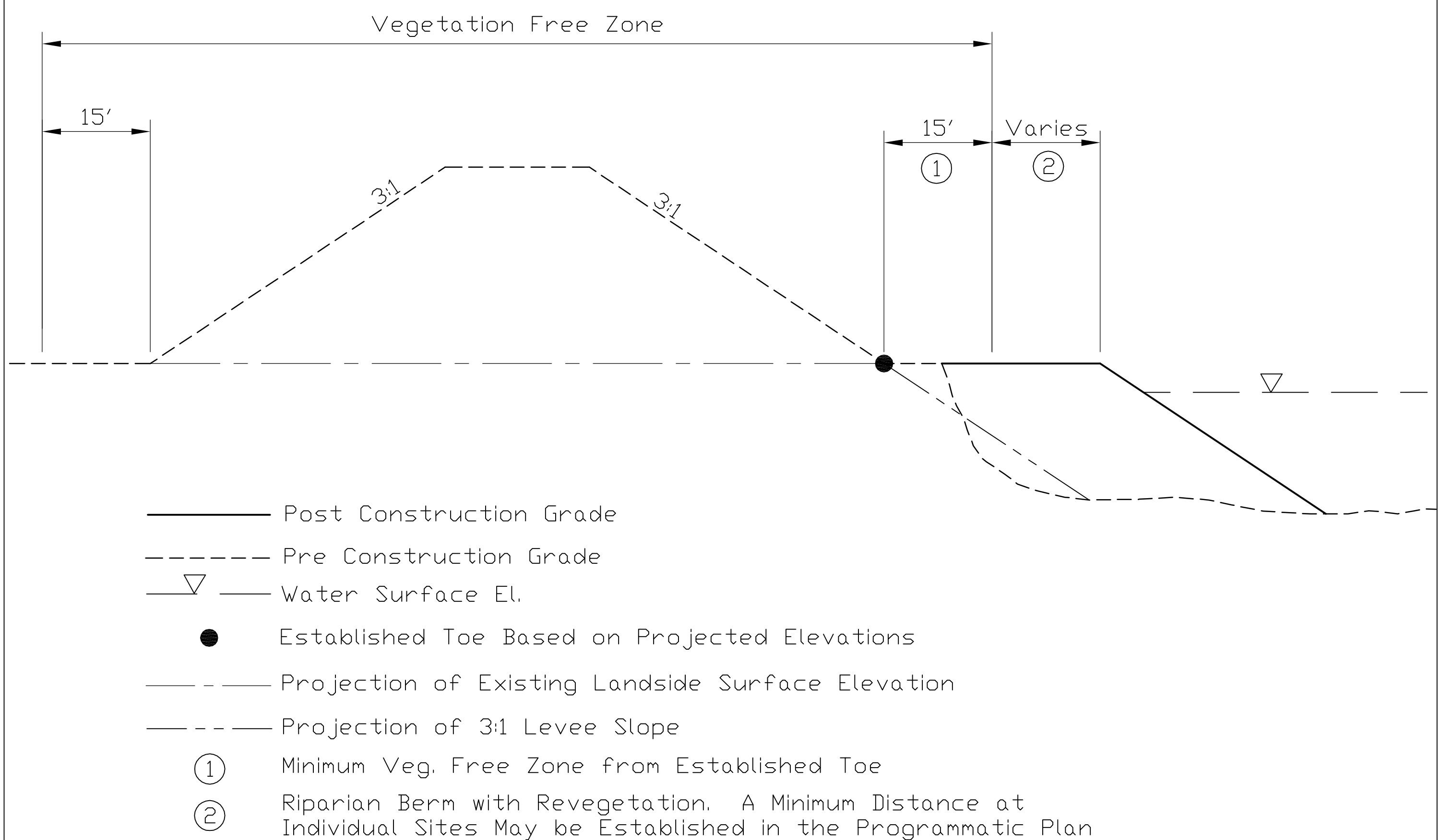
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Existing Waterside Slope equal to 3:1
Existing Berm Less than 30'
Scour outside 3:1 Projection

Date: September 18, 2009

Figure: CS-5



The existing waterside slope is established by projecting the existing landside surface elevation to the intersection of the existing waterside slope. This intersecting point is considered the established waterside levee toe. When considering a riparian berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe. A minimum berm size for planting may be required. The planting portion may be widened as needed. Vegetation on the berm may be managed to allow access and inspection.

DRAFT

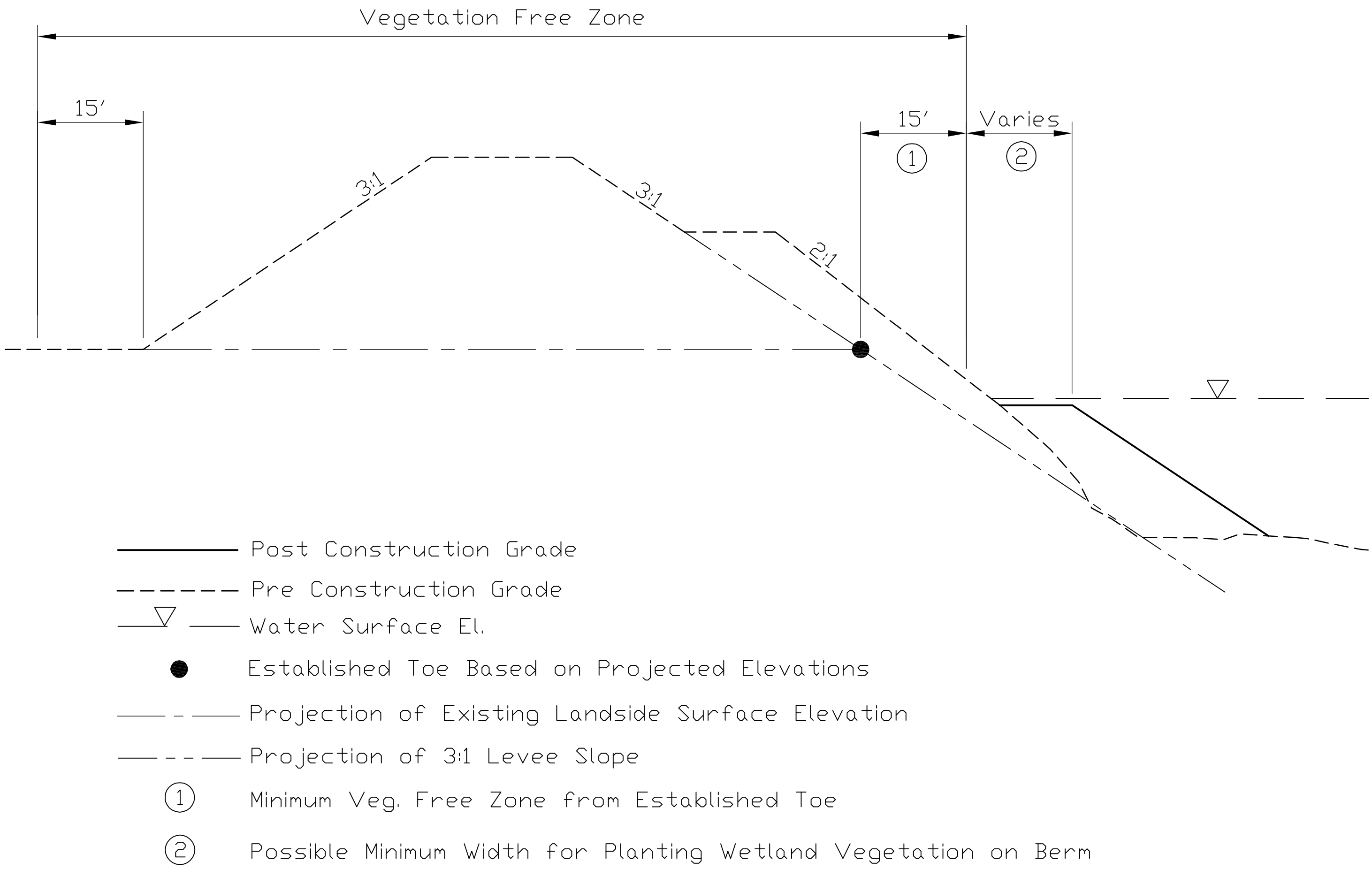
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR
HDR Engineering, Inc.

Existing Waterside Slope equal to 3:1
Existing Berm Less than 30'
Scour into 3:1 Projection

Date September 18, 2009

Figure CS-6



The existing waterside toe is established by projecting the existing landside surface elevation to the intersection of the existing waterside slope. This intersecting point is considered the established waterside levee toe. When considering a wetlands berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe plus an additional minimum width for planting (distance varies). The planting portion can be widened as needed.

DRAFT

Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

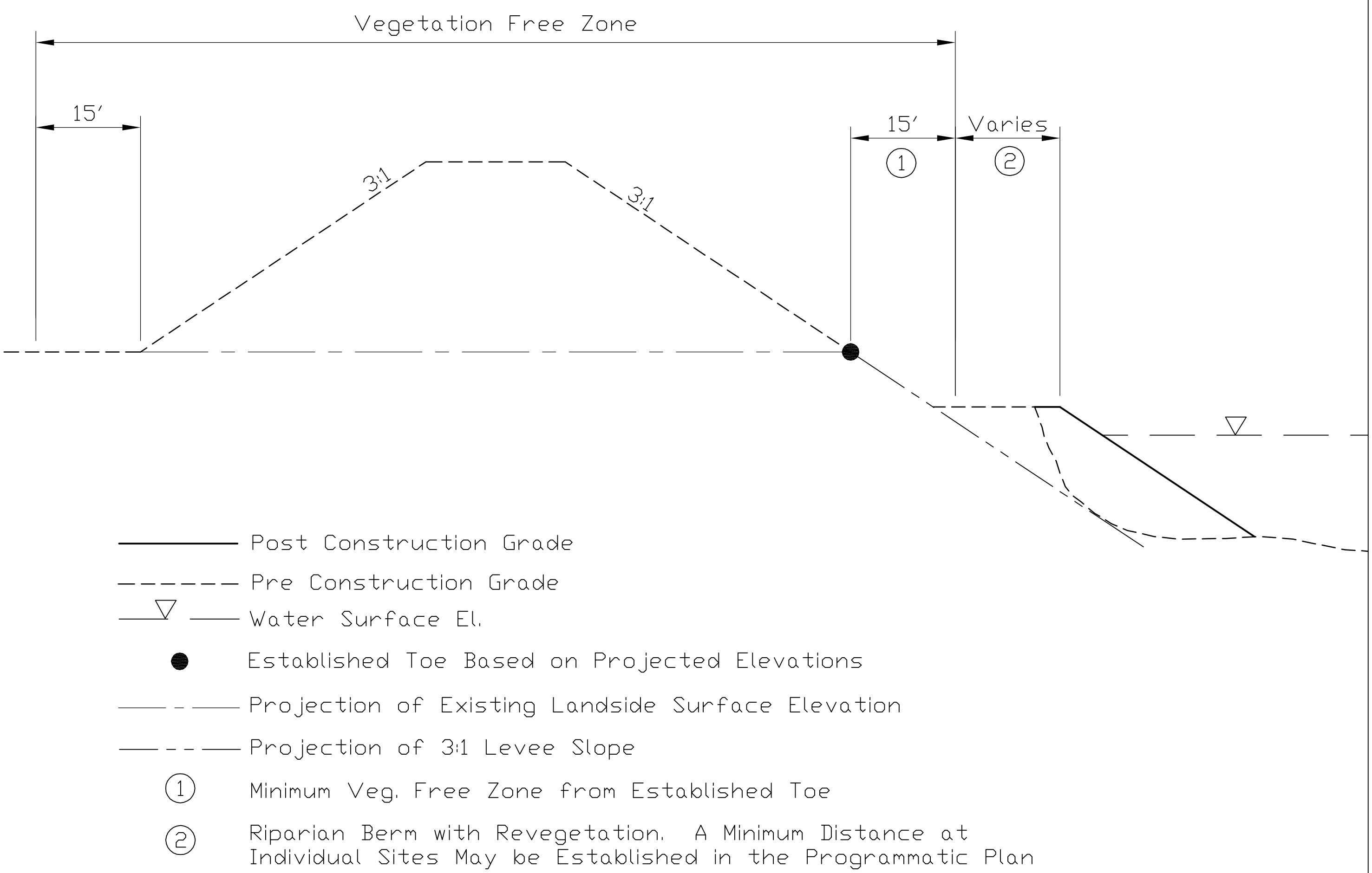
HDR

HDR Engineering, Inc.

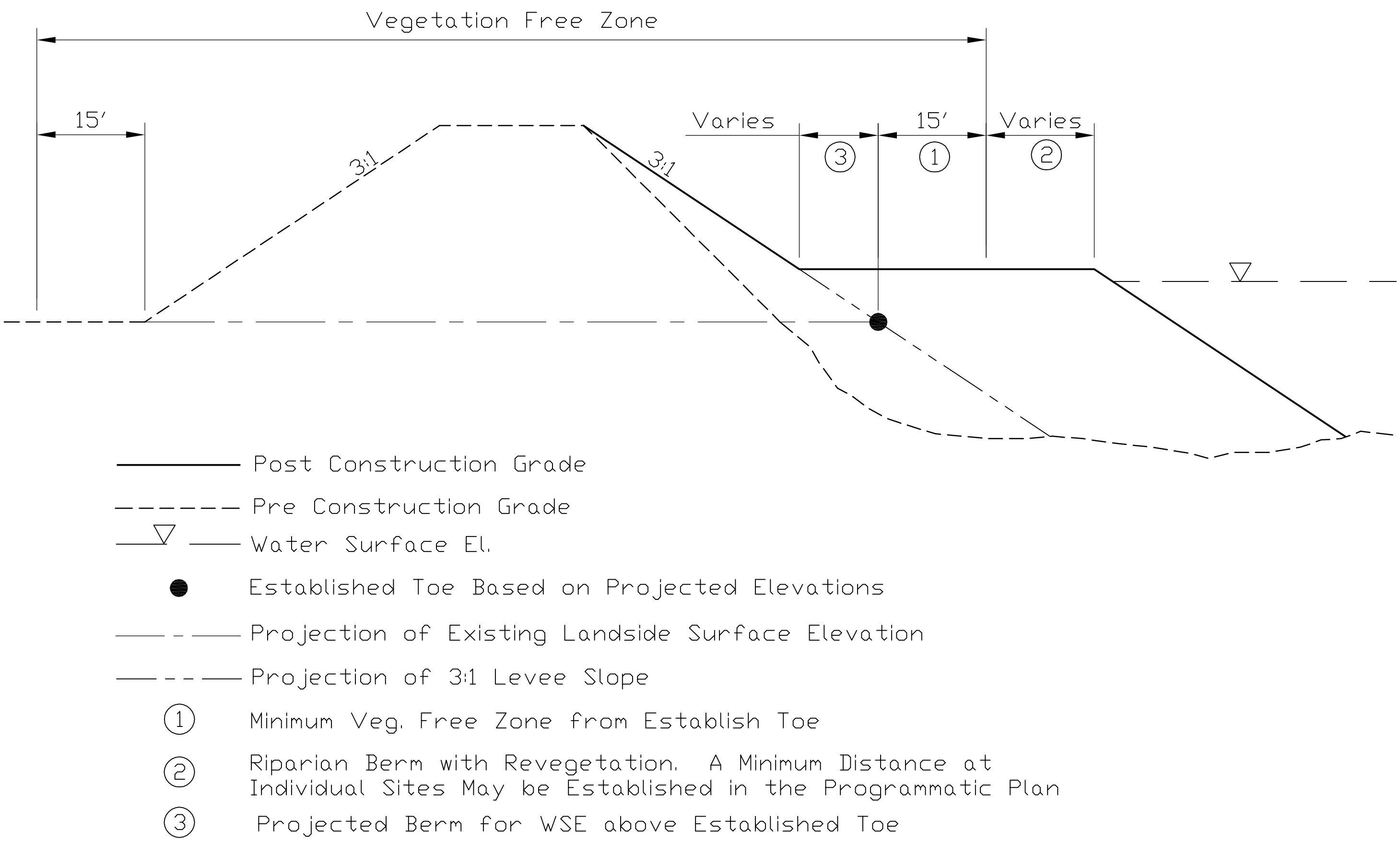
Existing Waterside Slope equal to 3:1
Existing Berm Above Waterside Toe
Constructed Berm below WSE and
Below Waterside Toe

Date: September 18, 2009

Figure: CS-7



The existing waterside toe is established by projecting the existing landside surface elevation to the intersection of the existing waterside slope. This intersecting point is considered the established waterside levee toe. When considering a riparian berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe. A minimum berm size for planting may be required. The planting portion can be widened as needed. Vegetation on the berm may be managed to allow access and inspection.



The waterside levee toe is established by projecting a 3:1 slope from the existing levee hinge point down to the projected existing landside surface elevation. This intersecting point is considered the established waterside levee toe. When considering a riparian berm w/ vegetation, the berm must be sized to accommodate the required 15 foot vegetation free zone from the waterside levee toe. A minimum berm size for planting may be required. The planting portion may be widened as needed. Vegetation on the berm may be managed to allow access and inspection. In this case the existing water surface elevation is above the established waterside levee toe. From the location of the established toe is an infinite projection upward. From this projection the 15 feet is measured water ward to establish the vegetation free zone. This case requires that the berm be widened by projecting the berm surface land ward to intersect with the established waterside levee slope. This width will vary depending on the existing water surface elevation.

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Subappendix 2. Civil Design Subappendix with Cost Estimates

Civil Design Subappendix a. Repair Site Data Sheets

Civil Design Subappendix b. Levee Geometry Analysis

Civil Design Subappendix c. Hydraulic Evaluation

Civil Design Subappendix d. Initial Array Plan (IAP) Costs

Civil Design Subappendix e. Total Project Cost Summary

Civil Design Subappendix F. Cost Schedule Risk Analysis

US Army Corps
of Engineers®

Sacramento River Bank Protection Project (SRBPP)

Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Sacramento District

Prepared by:

U.S. Army Corps of Engineers
Cost Engineering Mandatory Center of Expertise, Walla Walla

December 16, 2014

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Sacramento District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Sacramento River Bank Protection Project (SRBPP) Limited Reevaluation Report (LRR). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

The SRBPP is a long-range construction project to identify significant erosion problems, prioritize sites, and design and construct bank protection. Corrective measures are applied only to affected banks and levees that are part of the Federal Sacramento River Flood Control Project (SRFCP). Per Section 3031 of the Water Resources Development Act of 2007 (WRDA 2007), an additional 80,000 LF of bank protection was added to the original SRBPP Phase II project authorization. The portion included in this analysis represents an approximate 8,000 linear feet of protection deemed as the economically justified portion of the authorization.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and per cent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded

Table ES-1. Project Contingency Results

Base Case Project Cost Estimate (Excluding Real Estate)	**$25,754,000**	
Confidence Level	**Project Value ($$)**	**Contingency (%)**
5%	$1,030,000	4%
50%	$4,378,000	17%
80%	**$6,439,000**	**25%**
95%	$8,241,000	32%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on 8 April 2014. It quickly became evident that the team understands the project, the experienced risks and those risks already incorporated into the current designs and estimated costs (i.e., the major risks have already been experienced and mitigated through various means). The key risk drivers identified through sensitivity analysis suggest an 80% confidence level total contingency of $6.4M. Findings indicate no schedule risks that would result in any substantial cost impacts or resulting contingencies.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- EST-1: Quantities - During design or awarded it could be determined additional erosion has occurred and quantities will increase.
- RE-4: Onsite Mitigation - Resource agencies requirements for onsite mitigation continue to evolve, resulting in additional onsite mitigation requirements. ESA consultations have yet to occur. Until consultations occur, restoration ratios have not been established.

Moderate risks, when combined, can also become a cost impact; though no major contributors were noted other than Water and Air Quality, Differing Site Conditions, Offsite Mitigation and Construction Oversight.

Schedule Risks: All schedule risk drivers where either outside the scope of this risk analysis and therefore not modeled or will be resolved prior to schedule impacts being realized. Specific schedule risks identified included:

- PPM-3: Internal Red Tape – Discussions on Economic Justification have delayed schedules. Economically disadvantaged sites are some 5 years or more from implementation, allowing   for sufficient time for resolution prior to site implementation. This issue is not a Risk for Economically Justified Sites so will not be considered for this evaluation.
- PPM-4: Project Partnership Agreement Signature – PPA signature is due within the next year and must be signed for project to continue. USACE HQ and State sponsor are currently at an impasse on signature of the PPA due to current ETL policy (levee vegetation requirements). If PPA is not signed, project funding will cease and project schedule will slip. Given the potential huge project impact if PPA is not achieved, modeling this risk is outside scope of this risk analysis and will not be included.
- PR-2: Design Criteria Agreement – Sponsor and USACE agreements on Levee Vegetation. While the sponsor and USACE have managed to work around this issue in the past, it is possible this issue will come to a head; requiring either resolution or termination of this project. That discussion is outside the scope of this risk analysis and will not be modeled here.

MAIN REPORT

1.0 PURPOSE

Under the authority of the US Army Corps of Engineers (USACE), Sacramento District presents this cost and schedule risk analysis, identified major risks and recommendations for the total project cost and schedule contingencies for the Sacramento River Bank Protection Project (SRBPP).

2.0 BACKGROUND

The SRBPP is a long-range construction project to identify significant erosion problems, prioritize sites, and design and construct bank protection. Corrective measures are applied only to affected banks and levees that are part of the Federal Sacramento River Flood Control Project (SRFCP). Per Section 3031 of the Water Resources Development Act of 2007 (WRDA 2007), an additional 80,000 LF of bank protection was added to the original SRBPP Phase II project authorization. The portion included in this analysis represents an approximate 8,000 linear feet of protection deemed as the economically justified portion of the authorization.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for construction features. The CSRA excludes Real Estate costs and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Sacramento District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.
- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.
- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Sacramento District staff to provide expertise and information gathering. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis. Follow on meetings updated project development and refined risk modeling. Participants in the risk identification meeting included:

Risk Register Development Meeting

Tuesday, April 8, 2014

Attendance	Name	Representing
Civil Design	Hans Carota	Sacramento District
Civil Design – Tech Lead	Pamlyn Hill	Sacramento District
Planning	Karin Lee	Sacramento District
Cost Engineer	Joe Reynolds	Sacramento District
Real Estate	Greg Garner	DWR
Environmental	Kip Young	DWR
Planner	Thomas Adams	HDR
Cost Engineer	Robert Vrchoticky	Sacramento District
Real Estate	Kelly Boyd	Sacramento District
Cost Engineer	Tri Duong	Sacramento District
Project Manager	Cynthia Brooks	Sacramento District
Risk Analyst	William Bolte	Cost Engineering MCX

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting held 8 April 2014 included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers of cost and time) of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in Appendix A for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in determining the cost and schedule risks.

a. The Sacramento District provided a 1 December 2014 Total Project Cost Summary Excel Spreadsheet file electronically. The CSRA was performed on the final TPCS Project Costs (excluding Real Estate).

b. The cost comparisons and risk analyses performed and reflected within this report are based on project experience related to previous Phase 1 projects. The project scoping is well understood, the bulk of risks have been incorporated into more recent design and estimated construction costs. The contingency outcome of 20-25% was expected to be lower than a standard Feasibility Report of 25-35%.

c. The Cost Engineering MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

d. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk "watch list".

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a

documented framework from which risk status can be reported in the context of project controls.
- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The project cost contingencies for the P5, P50, P80 and P95 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $6.4 Million at the P80 confidence level (25% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P95 confidence levels was quantified as 17% and 32% of the baseline cost estimate, respectively.

Table 1. Project Cost Contingency Summary

Base Case Project Cost Estimate (Excluding Real Estate)	**$25,754,000**	
Confidence Level	**Project Value ($$)**	**Contingency (%)**
5%	$1,030,000	4%
50%	$4,378,000	17%
80%	**$6,439,000**	**25%**
95%	$8,241,000	32%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

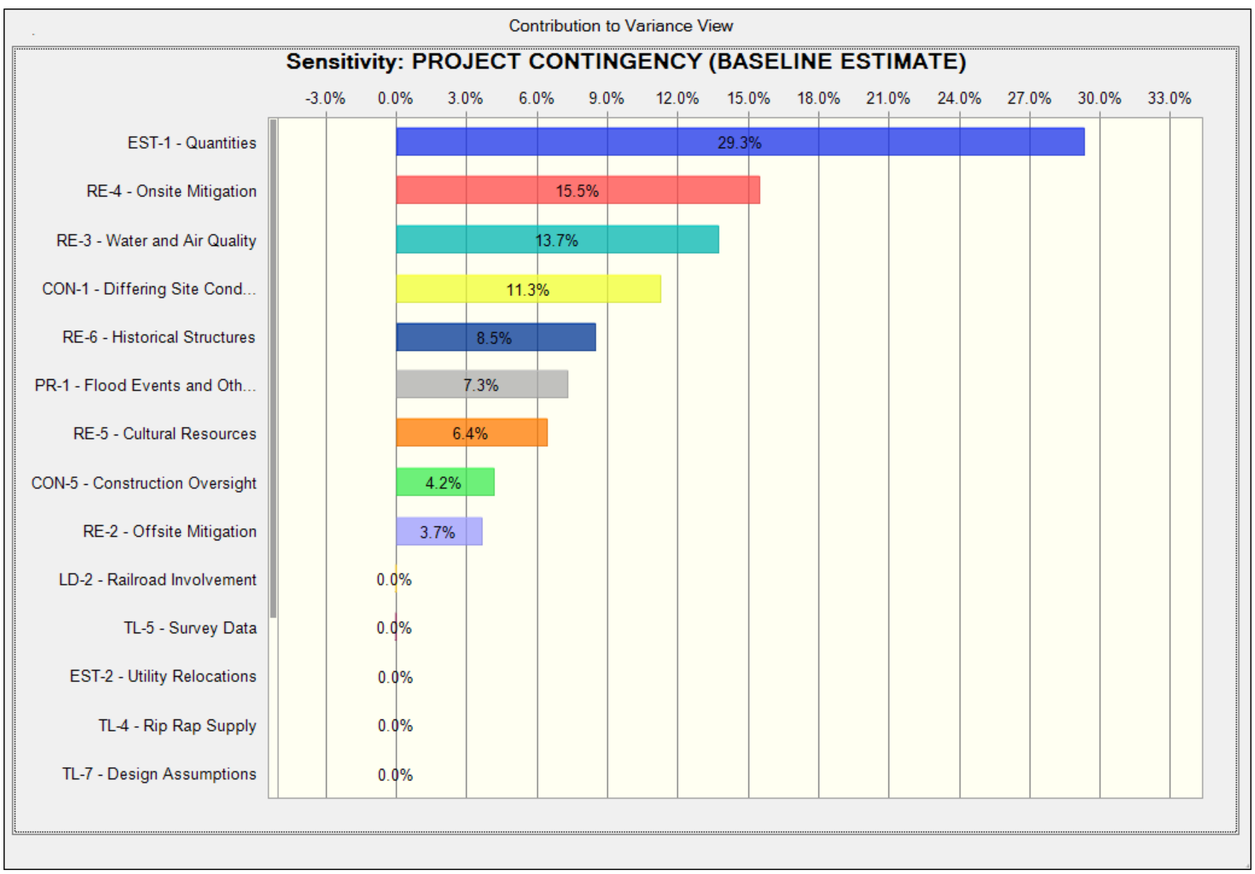
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule and Contingency Risk Analysis

The Sacramento River Bank Protection Project (SRBPP) consists of multiple separate sites with most if not all taking one construction season or less to complete. Individual sites will be addressed as issues arise and delays at any one site will not impact overall project completion schedule, therefore Schedule Risk Analysis becomes somewhat irrelevant for this project.

7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost summaries are provided in Table 2. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on 8 April 2014. It quickly became evident that the team understands the project, the experienced risks and those risks already incorporated into the current designs and estimated costs (i.e., the major risks have already been experienced and mitigated through various means). The key risk drivers identified through sensitivity analysis suggest an 80% confidence level total contingency of $8.1M. Findings indicate no schedule risks that would result in any substantial cost impacts or resulting contingencies.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- <u>EST-1: Quantities</u> - During design or awarded it could be determined additional erosion has occurred and quantities will increase.
- <u>RE-4: Onsite Mitigation</u> - Resource agencies requirements for onsite mitigation continue to evolve, resulting in additional onsite mitigation requirements. ESA consultations have yet to occur. Until consultations occur, restoration ratios have not been established.

Moderate risks, when combined, can also become a cost impact; though no major contributors were noted other than Water and Air Quality, Differing Site Conditions, Offsite Mitigation and Construction Oversight.

Schedule Risks: All schedule risk drivers where either outside the scope of this risk analysis and therefore not modeled or will be resolved prior to schedule impacts being realized. Specific schedule risks identified included:

- PPM-3: Internal Red Tape – Discussions on Economic Justification have delayed schedules. Economically disadvantaged sites are some 5 years or more from implementation, allowing for sufficient time for resolution prior to site implementation. This issue is not a Risk for Economically Justified Sites so will not be considered for this evaluation.
- PPM-4: Project Partnership Agreement Signature – PPA signature is due within the next year and must be signed for project to continue. USACE HQ and State sponsor are currently at an impasse on signature of the PPA due to current ETL policy (levee vegetation requirements). If PPA is not signed, project funding will cease and project schedule will slip. Given the potential huge project impact if PPA is not achieved, modeling this risk is outside scope of this risk analysis and will not be included.
- PR-2: Design Criteria Agreement – Sponsor and USACE agreements on Levee Vegetation. While the sponsor and USACE have managed to work around this issue in the past, it is possible this issue will come to a head; requiring either resolution or termination of this project. That discussion is outside the scope of this risk analysis and will not be modeled here.

Table 2. Project Cost Comparison Summary (Uncertainty Analysis)

Most Likely Cost Estimate	$25,754,000		
Confidence Level	**Project Cost**	**Contingency**	**Contingency %**
0%	**$22,663,520**	**($3,090,480.00)**	**-12.00%**
5%	**$26,784,160**	**$1,030,160.00**	**4.00%**
10%	**$27,556,780**	**$1,802,780.00**	**7.00%**
15%	**$28,071,860**	**$2,317,860.00**	**9.00%**
20%	**$28,329,400**	**$2,575,400.00**	**10.00%**
25%	**$28,844,480**	**$3,090,480.00**	**12.00%**
30%	**$29,102,020**	**$3,348,020.00**	**13.00%**
35%	**$29,359,560**	**$3,605,560.00**	**14.00%**
40%	**$29,617,100**	**$3,863,100.00**	**15.00%**
45%	**$29,874,640**	**$4,120,640.00**	**16.00%**
50%	**$30,132,180**	**$4,378,180.00**	**17.00%**
55%	**$30,647,260**	**$4,893,260.00**	**19.00%**
60%	**$30,904,800**	**$5,150,800.00**	**20.00%**
65%	**$31,162,340**	**$5,408,340.00**	**21.00%**
70%	**$31,419,880**	**$5,665,880.00**	**22.00%**
75%	**$31,677,420**	**$5,923,420.00**	**23.00%**
80%	**$32,192,500**	**$6,438,500.00**	**25.00%**
85%	**$32,707,580**	**$6,953,580.00**	**27.00%**
90%	**$33,222,660**	**$7,468,660.00**	**29.00%**
95%	**$33,995,280**	**$8,241,280.00**	**32.00%**
100%	**$38,373,460**	**$12,619,460.00**	**49.00%**

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

Project Specific: Funding and bidding competition must be periodically re-evaluated to ensure sufficient budget is available to perform the work objectives as authorized. .

APPENDIX A – RISK REGISTER

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)					
	PROJECT & PROGRAM MGMT				
PPM-1	Scope Definition	Questions remain unsettled about controlling criteria. Project is authorized for additional 80,000 LF yet recent HQ guidance now requires additional bank protection to comply with Corps planning policy (i.e. B/C ratios etc).	District has agreed to perform B/C economic analysis for all sites deemed critical. Estimate is based on 106 representative sites, of which some 12,000LF have economic justification. In the future, sites may change but project costs and risks will be based on 80,000 LF. Given the potential huge project changes if economic justification is required, modeling this risk is outside scope of this risk analysis and will not be modeled.	HIGH	LOW
PPM-2	Project Priorities	Given the long project duration with undefined critical path and conflicts with District priorities; project has received intermittent support. Only after emergency events does this project receive priority status.	Limited resources and project staffing turnover affect continuity, lost efficiencies and schedule. Districts historical averages have been used for the estimate, it is possible design costs could increase but only marginally at most.	LOW	LOW
PPM-3	Internal Red Tape	Internal decision making process has delayed project.	Discussions on Economic Justification have delayed schedules. Economically disadvantaged sites are some 5 years or more from implementation, allowing for sufficient time for resolution prior to site implementation. Not a Risk for Economically Justified Sites so will not be considered for this evaluation.	LOW	MODERATE
PPM-4	Project Partnership Agreement Signature	PPA signature is due within the next year and must be signed for project to continue.	USACE HQ and State sponsor are currently at an impasse on signature of the PPA due to current ETL policy (levee vegetation requirements). If PPA is not signed, project funding will cease and project schedule will slip. Given the potential huge project impact if PPA is not achieved, modeling this risk is outside scope of this risk analysis and will not be included.	LOW	HIGH

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost	Schedule
				Risk Level*	Risk Level*
	CONTRACT ACQUISITION RISKS				
CA-1	Small Business vs. Full and Open	Potential for Small Business Contracts	Much of this work is conducive for small business contracts. The estimate currently assumes full and open contracts. If individual sites are advertised via Small Business, 8(a) contractors, anticipate additional contract acquisition costs, construction costs and district resources for oversight and administration.	HIGH	LOW
CA-2	Numerous Contracts	Contracts will attempt to group sites by Fiscal Year wherever practical to minimize the number of individual contracts.	Multiple sites could be awarded fifty miles or more apart limiting the number of small contractors able to perform the work and potentially lends to more full and open large business contracts.	LOW	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	TECHNICAL RISKS				
TL-1	HTRW	HTRW could be encountered during site excavation and construction.	Borings will be done in a proactive attempt to locate any HTRW. Estimate currently assumes no HTRW is located. It is likely HTRW will be encountered, with marginal cost impacts anticipated. When HTRW is encountered it is possible individual sites schedule may slip but overall project schedule will not slip.	MODERATE	LOW
TL-2	Exploratory Borings	Limited exploratory borings have been taken. Additional geotechnical investigation will be required especially in areas of levee realignment.	Depending on exploratory results, site specific design could change. Design changes are anticipated to be marginal.	MODERATE	LOW
TL-3	Borrow/Fill Sources	Borrow sources have not been located. It is typically the contracts responsibility to procure borrow material.	Estimate assumes purchased material. For large fill volumes this could be impossible. Haul distances or commercial prices could increase significantly.	HIGH	LOW
TL-4	Rip Rap Supply	Rock quarry availability over time.	Rock placement has been ongoing since 1960's and will be required for another 40years. Availability of suitable rip rap at current haul distances may not be possible.	MODERATE	LOW
TL-5	Survey Data	Delayed survey data.	For previous project locations obtaining temporary site access has been delayed postponing survey data consequently postponing design and resulting in compressed schedules or construction schedules slipping to next FY. Risk does not necessarily cause overall program schedule impacts but does result in increased PED costs.	MODERATE	LOW
TL-6	Design Criteria	Delays in procurement have resulted in need to update designs for revised criteria.	Design criteria changes have lead to changes for projects put "on the shelf". When projects are awarded additional design updates are required with marginal construction cost increases.	MODERATE	LOW
TL-7	Design Assumptions	Current construction and design are all based on certain core design assumptions and principals. Changes to those assumptions would result in significant design re-work.	Many sites have been constructed. If inspections of constructed sites show current design methodology is not performing as expected designs could change resulting in significant design re-work.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	LANDS AND DAMAGES RISKS				
LD-1	Real Estate Acquisition	Large portions of the existing levee (majority) are still privately owned. Design may require acquisition of new real estate to enable repair requirements.	Almost all areas will require real estate actions; ranging from letters to State asking for easements on State land to acquisition of private property. Real Estate costs have been developed for the representative 106 sites, a majority of which required real estate actions. Any variation in sites will probably experience similar real estate costs. Current design features sections of riverside erosion control that could instead be replaced with landside setback levees requiring additional real estate acquisition with significant cost impacts. Real Estate acquisition is critical driver for all project sites. For Risk Mitigation purposes, site selection is flexible. If Real Estate acquisition is difficult, different sites can be selected. Project is scheduled for 40 years, allowing time for flexible real estate acquisitions. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	HIGH	LOW
LD-2	Railroad Involvement	Interactions with railroad have been problematic.	Every effort will be made to work outside railroad properties, but there are areas where the railroad is located on the levee. Given the 40 year project duration, PDT is being proactive and pursuing difficult acquisitions with sufficient lead time to address issues prior to fixes at sites. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	MODERATE	LOW
LD-3	Environmental Mitigation - Real Estate	Real Estate acquisitions for environmental acquisitions can be both on and off site.	Estimate captures cost/scope for environmental mitigation acquisition requirements. It is possible additional real estate will be required. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	HIGH	LOW
LD-4	Utility Relocations	Large number and variety of requirements for utility relocations.	Variable nature of relocation requirements is difficult to quantify. Real Estate estimates do well in capturing most known utility requirements, but potential unknown utilities remain. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	REGULATORY AND ENVIRONMENTAL RISKS				
RE-1	Endangered Species Act	Additional species could be added to ESA.	Additional species could result in additional mitigation costs or design adaptations and changes. It is unlikely to impact cost and no impacts to schedule would be anticipated.	LOW	LOW
RE-2	Offsite Mitigation	Additional offsite mitigation could be required.	As sites information is further refined, it could be discovered additional offsite mitigation efforts will be required to offset impacts. Additional offsite mitigation shouldn't impact schedule.	HIGH	LOW
RE-3	Water and Air Quality	Construction could require air quality credits. Air quality is legislated by local California Resource Board by county and program will overlap multiple regions. Construction could be halted or limited due to water quality impacts.	Baseline Estimate includes costs for monitoring. Marginal additional construction cost impacts should be encountered.	MODERATE	LOW
RE-4	Onsite Mitigation	Depending on Agencies, additional onsite mitigation could be required.	Resource agencies requirements for onsite mitigation continue to evolve, resulting in additional onsite mitigation requirements. ESA consultations have yet to occur. Until consultations occur, restoration ratios have not been established. Additional setback levees in place of riverside repairs may be required.	HIGH	LOW
RE-5	Cultural Resources	It is possible cultural resources could be encountered.	Estimate includes costs for cultural investigations but no costs for mitigations. Cost need to be added for some mitigation for discovery of cultural sites; typically coordinating with local tribes and not removing but protecting resource on site.	MODERATE	LOW
RE-6	Historical Structures	Consultation with State SHIPO has yet to occur.	Additional costs may be necessary for historic documentation of existing levee.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	CONSTRUCTION RISKS				
CON-1	Differing Site Conditions	Heavily dependent on geotechnical design solutions.	Inherent with any geotechnical design comes the possibility of differing site conditions. Given the nature of design solutions (either build new setback levee or overlay existing levees) institute conditions will not be exposed as much as on other typical levee projects. Anticipate lower risks with this item.	MODERATE	LOW
CON-2	Unknown Utilities	Based on previous experience in the project, unknown utilities have rarely been discovered.	For setback levees, it is likely unknown utilities will be encountered, for all other fixes unknown utility impacts are not anticipated.	LOW	LOW
CON-3	Site Access	While access may be remote or round-about for some sites, site and maintenance access is well established.	Minimal Risk is anticipated.	LOW	LOW
CON-4	Construction Windows	All in water work must be completed between April 15 to Nov 30. Depending on contract award dates, durations, and inefficient contractors some contracts could be limited or delayed to the following construction season.	In general this has been a minimal risk, with worst case a one season schedule slip may occur, impacting local contract schedule but not does not impact overall project schedule.	LOW	LOW
CON-5	Construction Oversight	Given the large number of potential sites/contracts per year, submittal turn around times and construction oversight could be an issue.	Based on previous expense, mods and claims have been experienced leading to cost increases.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	ESTIMATE AND SCHEDULE RISKS				
EST-1	Quantities	Differences in quantities.	During design or awarded it could be determined additional erosion has occurred and quantities will increase.	HIGH	LOW
EST-2	Utility Relocations	Large number and variety of requirements for utility relocations.	Variable nature of relocation requirements is difficult to quantify. Potential unknown utilities remain.	MODERATE	LOW
EST-3	Estimate Assumptions and Quantities	Estimate is based on "typical" fixes per reach. A survey has been performed for the project, but has only established a single cross section per length of fix. Specific designs, quantity takeoffs and estimates have not been developed.	Feasibility level estimates have been developed. Quantities could vary marginally.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	ECONOMIC RISKS				
FL-1	Funding Stream	Federal and Sponsor Funding has been sufficient.	Historically project has been funded $5 to $15 M per year which would be sufficient to maintain projected construction schedule assumptions.	LOW	LOW
	Programmatic Risks		(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)		
PR-1	Flood Events and Other Acts of God	Weather events could impact in water construction.	It is possible construction seasons could be delayed or postponed with storm or other weather events resulting in additional construction costs but minimal overall project schedule impacts.	MODERATE	LOW
PR-2	Design Criteria Agreement	Sponsor and USACE agreements on Levee Vegetation	While the sponsor and USACE have managed to work around this issue in the past, it is possible this issue will come to a head; requiring either resolution or termination of this project. That discussion is outside the scope of this risk analysis and will not be modeled here.	HIGH	HIGH

WALLA WALLA COST ENGINEERING
MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

For Project No. 105606

SPK – Sacramento River Bank Protection
Seven Economically Feasible Sub-Basins (~8,000LF)

The Sacramento River Bank Protection Project presented by Sacramento District represents an approximate 8,000 linear feet of protection deemed as the economically justified portion of the authorization. It has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of December 19, 2014, the Cost MCX certifies the estimated total project cost:

FY 2015 Price Level: $39,460,000
Fully Funded Amount: $42,955,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management throughout the life of the project.

For Kim C. Callan, PE, CCE, PM
Chief, Cost Engineering MCX
Walla Walla District

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Sacramento River Bank Protection Project**
PROJECT NO: P2 105606
LOCATION: Seven Economically Feasible Sub-Basins

DISTRICT: SPK Sacramento District PREPARED: 12/3/2014
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Post Authorization Change Report - July 2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2015 Effective Price Level Date: 1 OCT 14				Spent Thru:					
WBS NUMBER *A*	Civil Works Feature & Sub-Feature Description *B*	COST ($K) *C*	CNTG ($K) *D*	CNTG (%) *E*	TOTAL ($K) *F*	ESC (%) *G*	COST ($K) *H*	CNTG ($K) *I*	**TOTAL ($K)** *J*	**10/1/2013** ($K)	**TOTAL FIRST COST** ($K)	ESC (%)	COST ($K) *M*	CNTG ($K) *N*	FULL ($K) *O*
02	RELOCATIONS	$304	$76	25%	$380	1.6%	$309	$77	$386	$0	$386	9.2%	$337	$84	$422
06	FISH & WILDLIFE FACILITIES	$1,158	$290	25%	$1,448	1.9%	$1,181	$295	$1,476	$0	$1,476	6.6%	$1,259	$315	$1,574
11	LEVEES & FLOODWALLS	$1,984	$496	25%	$2,480	1.5%	$2,013	$503	$2,516	$0	$2,516	9.2%	$2,197	$549	$2,747
16	BANK STABILIZATION	$15,102	$3,776	25%	$18,878	1.8%	$15,381	$3,845	$19,226	$0	$19,226	7.8%	$16,581	$4,145	$20,727
	CONSTRUCTION ESTIMATE TOTALS:	$18,548	$4,637		$23,185	1.8%	$18,884	$4,721	$23,605	$0	$23,605	7.9%	$20,375	$5,094	$25,469
01	LANDS AND DAMAGES	$4,970	$1,740	35%	$6,710	1.6%	$5,052	$1,768	$6,820	$0	$6,820	6.0%	$5,355	$1,874	$7,230
30	PLANNING, ENGINEERING & DESIGN	$4,271	$1,068	25%	$5,339	2.2%	$4,363	$1,091	$5,454	$0	$5,454	12.3%	$4,899	$1,225	$6,124
31	CONSTRUCTION MANAGEMENT	$2,691	$673	25%	$3,364	2.2%	$2,749	$687	$3,436	$0	$3,436	15.7%	$3,181	$795	$3,976
18	CULTURAL RESOURCE PRESERVATION	$114	$28	25%	$142	1.8%	$116	$29	$145	$0	$145	7.5%	$124	$31	$156
	PROJECT COST TOTALS:	$30,594	$8,145	27%	$38,739		$31,164	$8,296	**$39,460**	$0	**$39,460**	8.9%	$33,935	$9,019	$42,955

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Steve Osgood

CHIEF, REAL ESTATE, Sharon Caine

CHIEF, ENGINEERING, Rick Poeppelman

ESTIMATED FEDERAL COST:	**65%**	**$27,921**
ESTIMATED NON-FEDERAL COST:	**35%**	**$15,034**
ESTIMATED TOTAL PROJECT COST:		**$42,955**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project
LOCATION: Seven Economically Feasible Sub-Basins
This Estimate reflects the scope and schedule in report; Post Authorization Change Report - July 2014

DISTRICT: SPK Sacramento District PREPARED: 12/3/2014
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 6/2/2014				Program Year (Budget EC): 2015								
			Effective Price Level: 10/1/2013				Effective Price Level Date: 1 OCT 14								
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	CONTRACT 1														
16	BANK STABILIZATION	Butte Basin, Sacramento River 152.8 L	$891	$223	25%	$1,114	1.8%	$907	$227	$1,134	2017Q3	4.9%	$952	$238	$1,190
16	BANK STABILIZATION	Butte Basin, Sacramento River 163 L	$1,307	$327	25%	$1,634	1.8%	$1,331	$333	$1,664	2017Q3	4.9%	$1,397	$349	$1,746
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 152.8 L	$77	$19	25%	$96	1.9%	$78	$20	$98	2017Q3	4.9%	$82	$21	$103
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 163 L	$308	$77	25%	$385	1.9%	$314	$78	$392	2017Q3	4.9%	$329	$82	$412
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$2,583	$646	25%	**$3,229**		$2,631	$658	$3,289			$2,760	$690	$3,450
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 152.8 L	$142	$50	35%	$192	1.6%	$144	$51	$195	2016Q3	2.8%	$148	$52	$200
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 163 L	$568	$199	35%	$767	1.6%	$577	$202	$779	2016Q3	2.8%	$594	$208	$802
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$65	$16	25%	$81	2.2%	$66	$17	$83	2016Q3	5.4%	$70	$18	$88
2.0%	Planning & Environmental Compliance		$52	$13	25%	$65	2.2%	$53	$13	$66	2016Q3	5.4%	$56	$14	$70
8.5%	Engineering & Design		$220	$55	25%	$275	2.2%	$225	$56	$281	2016Q3	5.4%	$237	$59	$296
0.5%	Reviews, ATRs, IEPRs, VE		$13	$3	25%	$16	2.2%	$13	$3	$17	2016Q3	5.4%	$14	$4	$18
0.5%	Life Cycle Updates (cost, schedule, risks)		$13	$3	25%	$16	2.2%	$13	$3	$17	2016Q3	5.4%	$14	$4	$18
2.0%	Contracting & Reprographics		$52	$13	25%	$65	2.2%	$53	$13	$66	2016Q3	5.4%	$56	$14	$70
3.0%	Engineering During Construction		$77	$19	25%	$96	2.2%	$79	$20	$98	2017Q3	9.5%	$86	$22	$108
2.0%	Planning During Construction		$52	$13	25%	$65	2.2%	$53	$13	$66	2017Q3	9.5%	$58	$15	$73
2.0%	Project Operations		$52	$13	25%	$65	2.2%	$53	$13	$66	2016Q3	5.4%	$56	$14	$70
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$258	$65	25%	$323	2.2%	$264	$66	$329	2017Q3	9.5%	$289	$72	$361
2.0%	Project Operation:		$52	$13	25%	$65	2.2%	$53	$13	$66	2017Q3	9.5%	$58	$15	$73
2.5%	Project Management		$65	$16	25%	$81	2.2%	$66	$17	$83	2017Q3	9.5%	$73	$18	$91
18	CULTURAL RESOURCE PRESERVATION		$34	$9	25%	$43	1.8%	$35	$9	$43	2017Q3	4.9%	$36	$9	$46
	CONTRACT COST TOTALS:		$4,298	$1,146		**$5,444**		$4,380	$1,167	$5,547			$4,606	$1,226	**$5,832**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project
LOCATION: Seven Economically Feasible Sub-Basins
This Estimate reflects the scope and schedule in report; Post Authorization Change Report - July 2014

DISTRICT: SPK Sacramento District PREPARED: 12/3/2014
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: / Effective Price Level:			6/2/2014 / 10/1/2013	Program Year (Budget EC): / Effective Price Level Date:			2015 / 1 OCT 14					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 2														
16	BANK STABILIZATION	Butte Basin, Sacramento River 168.3 L	$1,177	$294	25%	$1,471	1.8%	$1,199	$300	$1,498	2018Q3	7.0%	$1,283	$321	$1,604
16	BANK STABILIZATION	Butte Basin, Sacramento River 172.0 L	$631	$158	25%	$789	1.8%	$643	$161	$803	2018Q3	7.0%	$688	$172	$860
16	BANK STABILIZATION	Natomas, Sacramento River 78.3 L	$1,075	$269	25%	$1,344	1.8%	$1,095	$274	$1,369	2018Q3	7.0%	$1,172	$293	$1,465
16	BANK STABILIZATION	Sacramento, Sacramento River 56.6 L	$390	$98	25%	$488	1.8%	$397	$99	$497	2018Q3	7.0%	$425	$106	$531
16	BANK STABILIZATION	Southport, Sacramento River 56.5 R	$1,511	$378	25%	$1,889	1.8%	$1,539	$385	$1,924	2018Q3	7.0%	$1,647	$412	$2,059
16	BANK STABILIZATION	Southport, Sacramento River 56.7 R	$3,892	$973	25%	$4,865	1.8%	$3,964	$991	$4,955	2018Q3	7.0%	$4,242	$1,060	$5,302
06	FISH & WILDLIFE FACILITIES	Natomas, Sacramento River 78.3 L	$275	$69	25%	$344	1.9%	$280	$70	$350	2018Q3	7.0%	$300	$75	$375
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 168.3 L	$176	$44	25%	$220	1.9%	$179	$45	$224	2018Q3	7.0%	$192	$48	$240
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 172.0 L	$81	$20	25%	$101	1.9%	$83	$21	$103	2018Q3	7.0%	$88	$22	$110
06	FISH & WILDLIFE FACILITIES	Sacramento, Sacramento River 56.6 L	$8	$2	25%	$10	1.9%	$8	$2	$10	2018Q3	7.0%	$9	$2	$11
06	FISH & WILDLIFE FACILITIES	Southport, Sacramento River 56.5 R	$37	$9	25%	$46	1.9%	$38	$9	$47	2018Q3	7.0%	$40	$10	$50
06	FISH & WILDLIFE FACILITIES	Southport, Sacramento River 56.7 R	$96	$24	25%	$120	1.9%	$98	$24	$122	2018Q3	7.0%	$105	$26	$131
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$9,349	$2,337	25%	**$11,686**		$9,522	$2,381	$11,903			$10,190	$2,548	$12,738
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 168.3 L	$284	$99	35%	$383	1.6%	$289	$101	$390	2017Q3	4.9%	$303	$106	$409
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 172.0 L	$568	$199	35%	$767	1.6%	$577	$202	$779	2017Q3	4.9%	$606	$212	$818
01	LANDS AND DAMAGES	Natomas, Sacramento River 78.3 L	$142	$50	35%	$192	1.6%	$144	$51	$195	2017Q3	4.9%	$151	$53	$204
01	LANDS AND DAMAGES	Sacramento, Sacramento River 56.6 L	$426	$149	35%	$575	1.6%	$433	$152	$585	2017Q3	4.9%	$454	$159	$613
01	LANDS AND DAMAGES	Southport, Sacramento River 56.5 R	$426	$149	35%	$575	1.6%	$433	$152	$585	2017Q3	4.9%	$454	$159	$613
01	LANDS AND DAMAGES	Southport, Sacramento River 56.7 R	$284	$99	35%	$383	1.6%	$289	$101	$390	2017Q3	4.9%	$303	$106	$409
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$234	$59	25%	$293	2.2%	$239	$60	$299	2017Q3	9.5%	$262	$65	$327
2.0%	Planning & Environmental Compliance		$187	$47	25%	$234	2.2%	$191	$48	$239	2017Q3	9.5%	$209	$52	$262
8.5%	Engineering & Design		$795	$199	25%	$994	2.2%	$812	$203	$1,015	2017Q3	9.5%	$890	$222	$1,112
0.5%	Reviews, ATRs, IEPRs, VE		$47	$12	25%	$59	2.2%	$48	$12	$60	2017Q3	9.5%	$53	$13	$66
0.5%	Life Cycle Updates (cost, schedule, risks)		$47	$12	25%	$59	2.2%	$48	$12	$60	2017Q3	9.5%	$53	$13	$66
2.0%	Contracting & Reprographics		$187	$47	25%	$234	2.2%	$191	$48	$239	2017Q3	9.5%	$209	$52	$262
3.0%	Engineering During Construction		$280	$70	25%	$350	2.2%	$286	$72	$358	2018Q3	13.8%	$326	$81	$407
2.0%	Planning During Construction		$187	$47	25%	$234	2.2%	$191	$48	$239	2018Q3	13.8%	$217	$54	$272
2.0%	Project Operations		$187	$47	25%	$234	2.2%	$191	$48	$239	2017Q3	9.5%	$209	$52	$262
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$935	$234	25%	$1,169	2.2%	$955	$239	$1,194	2018Q3	13.8%	$1,087	$272	$1,359
2.0%	Project Operation:		$187	$47	25%	$234	2.2%	$191	$48	$239	2018Q3	13.8%	$217	$54	$272
2.5%	Project Management		$234	$59	25%	$293	2.2%	$239	$60	$299	2018Q3	13.8%	$272	$68	$340
18	CULTURAL RESOURCE PRESERVATION		$43	$11	25%	$54	1.8%	$44	$11	$54	2018Q3	7.0%	$47	$12	$58
	CONTRACT COST TOTALS:		$15,029	$3,970		**$18,999**		$15,314	$4,045	$19,359			$16,512	$4,355	**$20,867**

****** TOTAL PROJECT COST SUMMARY ******

****** CONTRACT COST SUMMARY ******

PROJECT: Sacramento River Bank Protection Project
LOCATION: Seven Economically Feasible Sub-Basins
This Estimate reflects the scope and schedule in report; Post Authorization Change Report - July 2014

DISTRICT: SPK Sacramento District PREPARED: 12/3/2014
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: Effective Price Level:			6/2/2014 10/1/2013	Program Year (Budget EC): Effective Price Level Date:			2015 1 OCT 14					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 3														
02	RELOCATIONS	Yolo, Cache Creek 3.9 L	$304	$76	25%	$380	1.6%	$309	$77	$386	2019Q3	9.2%	$337	$84	$422
06	FISH & WILDLIFE FACILITIES	West Sacramento, Sacramento River 62.9 R	$13	$3	25%	$16	1.9%	$13	$3	$17	2019Q3	9.2%	$14	$4	$18
06	FISH & WILDLIFE FACILITIES	West Sacramento, Sacramento River 63.0 R	$7	$2	25%	$9	1.9%	$7	$2	$9	2019Q3	9.2%	$8	$2	$10
11	LEVEES & FLOODWALLS	Yolo, Cache Creek 3.9 L	$1,984	$496	25%	$2,480	1.5%	$2,013	$503	$2,516	2019Q3	9.2%	$2,197	$549	$2,747
16	BANK STABILIZATION	West Sacramento, Sacramento River 63.0 R	$327	$82	25%	$409	1.8%	$333	$83	$416	2019Q3	9.2%	$364	$91	$454
16	BANK STABILIZATION	West Sacramento, Sacramento River 62.9 R	$453	$113	25%	$566	1.8%	$461	$115	$577	2019Q3	9.2%	$504	$126	$629
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$3,088	$772	25%	**$3,860**		$3,137	$784	$3,921			$3,424	$856	$4,280
01	LANDS AND DAMAGES	West Sacramento, Sacramento River 62.9 R	$284	$99	35%	$383	1.6%	$289	$101	$390	2018Q3	7.0%	$309	$108	$417
01	LANDS AND DAMAGES	West Sacramento, Sacramento River 63.0 R	$284	$99	35%	$383	1.6%	$289	$101	$390	2018Q3	7.0%	$309	$108	$417
01	LANDS AND DAMAGES	Yolo, Cache Creek 3.9 L	$426	$149	35%	$575	1.6%	$433	$152	$585	2018Q3	7.0%	$463	$162	$626
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$77	$19	25%	$96	2.2%	$79	$20	$98	2018Q3	13.8%	$90	$22	$112
2.0%	Planning & Environmental Compliance		$62	$16	25%	$78	2.2%	$63	$16	$79	2018Q3	13.8%	$72	$18	$90
8.5%	Engineering & Design		$262	$66	25%	$328	2.2%	$268	$67	$335	2018Q3	13.8%	$305	$76	$381
0.5%	Reviews, ATRs, IEPRs, VE		$15	$4	25%	$19	2.2%	$15	$4	$19	2018Q3	13.8%	$17	$4	$22
0.5%	Life Cycle Updates (cost, schedule, risks)		$15	$4	25%	$19	2.2%	$15	$4	$19	2018Q3	13.8%	$17	$4	$22
2.0%	Contracting & Reprographics		$62	$16	25%	$78	2.2%	$63	$16	$79	2018Q3	13.8%	$72	$18	$90
3.0%	Engineering During Construction		$93	$23	25%	$116	2.2%	$95	$24	$119	2019Q3	18.3%	$112	$28	$140
2.0%	Planning During Construction		$62	$16	25%	$78	2.2%	$63	$16	$79	2019Q3	18.3%	$75	$19	$94
2.0%	Project Operations		$62	$16	25%	$78	2.2%	$63	$16	$79	2018Q3	13.8%	$72	$18	$90
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$309	$77	25%	$386	2.2%	$316	$79	$395	2019Q3	18.3%	$373	$93	$467
2.0%	Project Operation:		$62	$16	25%	$78	2.2%	$63	$16	$79	2019Q3	18.3%	$75	$19	$94
2.5%	Project Management		$77	$19	25%	$96	2.2%	$79	$20	$98	2019Q3	18.3%	$93	$23	$116
18	CULTURAL RESOURCE PRESERVATION		$17	$4	25%	$22	1.8%	$18	$4	$22	2019Q3	9.2%	$19	$5	$24
	CONTRACT COST TOTALS:		$5,257	$1,414		**$6,671**		$5,348	$1,438	$6,786			$5,898	$1,583	**$7,481**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project
LOCATION: Seven Economically Feasible Sub-Basins
This Estimate reflects the scope and schedule in report; Post Authorization Change Report - July 2014

DISTRICT: SPK Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 12/3/2014

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			6/2/2014	Program Year (Budget EC):			2015	FULLY FUNDED PROJECT ESTIMATE				
			Effective Price Level:			10/1/2013	Effective Price Level Date:			1 OCT 14					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 4														
16	BANK STABILIZATION	Yolo, Knights Landing Ridge Cut 0.2 R	$102	$26	25%	$128	1.8%	$104	$26	$130	2020Q3	11.3%	$116	$29	$145
16	BANK STABILIZATION	Rio Oso, Bear River 0.8 L	$520	$130	25%	$650	1.8%	$530	$132	$662	2020Q3	11.3%	$590	$147	$737
16	BANK STABILIZATION	Rio Oso, Feather River 0.6 L	$836	$209	25%	$1,045	1.8%	$851	$213	$1,064	2020Q3	11.3%	$948	$237	$1,185
16	BANK STABILIZATION	Rio Oso, Feather River 5.0 L	$1,990	$498	25%	$2,488	1.8%	$2,027	$507	$2,533	2020Q3	11.3%	$2,256	$564	$2,821
06	FISH & WILDLIFE FACILITIES	Yolo, Knights Landing Ridge Cut 0.2 R	$80	$20	25%	$100	1.9%	$82	$20	$102	2020Q3	11.3%	$91	$23	$114
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$3,528	$882	25%	**$4,410**		$3,593	$898	$4,492			$4,001	$1,000	$5,001
01	LANDS AND DAMAGES	Yolo, Knights Landing Ridge Cut 0.2 R	$426	$149	35%	$575	1.6%	$433	$152	$585	2019Q3	9.2%	$473	$165	$638
01	LANDS AND DAMAGES	Rio Oso, Bear River 0.8 L	$142	$50	35%	$192	1.6%	$144	$51	$195	2019Q3	9.2%	$158	$55	$213
01	LANDS AND DAMAGES	Rio Oso, Feather River 0.6 L	$284	$99	35%	$383	1.6%	$289	$101	$390	2019Q3	9.2%	$315	$110	$425
01	LANDS AND DAMAGES	Rio Oso, Feather River 5.0 L	$284	$99	35%	$383	1.6%	$289	$101	$390	2019Q3	9.2%	$315	$110	$425
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$88	$22	25%	$110	2.2%	$90	$22	$112	2019Q3	18.3%	$106	$27	$133
2.0%	Planning & Environmental Compliance		$71	$18	25%	$89	2.2%	$73	$18	$91	2019Q3	18.3%	$86	$21	$107
8.5%	Engineering & Design		$300	$75	25%	$375	2.2%	$306	$77	$383	2019Q3	18.3%	$363	$91	$453
0.5%	Reviews, ATRs, IEPRs, VE		$18	$5	25%	$23	2.2%	$18	$5	$23	2019Q3	18.3%	$22	$5	$27
0.5%	Life Cycle Updates (cost, schedule, risks)		$18	$5	25%	$23	2.2%	$18	$5	$23	2019Q3	18.3%	$22	$5	$27
2.0%	Contracting & Reprographics		$71	$18	25%	$89	2.2%	$73	$18	$91	2019Q3	18.3%	$86	$21	$107
3.0%	Engineering During Construction		$106	$27	25%	$133	2.2%	$108	$27	$135	2020Q3	23.0%	$133	$33	$166
2.0%	Planning During Construction		$71	$18	25%	$89	2.2%	$73	$18	$91	2020Q3	23.0%	$89	$22	$112
2.0%	Project Operations		$71	$18	25%	$89	2.2%	$73	$18	$91	2019Q3	18.3%	$86	$21	$107
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$353	$88	25%	$441	2.2%	$361	$90	$451	2020Q3	23.0%	$444	$111	$554
2.0%	Project Operation:		$71	$18	25%	$89	2.2%	$73	$18	$91	2020Q3	23.0%	$89	$22	$112
2.5%	Project Management		$88	$22	25%	$110	2.2%	$90	$22	$112	2020Q3	23.0%	$111	$28	$138
18	CULTURAL RESOURCE PRESERVATION		$20	$5	25%	$25	1.8%	$20	$5	$25	2020Q3	11.3%	$22	$6	$28
	CONTRACT COST TOTALS:		$6,010	$1,616		**$7,626**		$6,123	$1,646	$7,769			$6,919	$1,856	**$8,775**

Comment Report: All Comments
Project: Sac Bank ATR - PACR, Engr Appx, EIS/EIR - Phase II 80K LF, Sacramento River Bank Protection Project (SRBPP), California (P2# 105606)
Review: ATR PACR Cost Est REVISED (11-25 Aug 2014)
Displaying 24 comments for the criteria specified in this report.

Id	Discipline	DocType	Spec	Sheet	Detail
5788254	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

1. CONCERN: Please provide a reasonably complete statement indicating the purpose of this review, how the cost documents will be used going forward, and indicate if a cost certification is being requested. Will the documents be used to secure funding or authorization? Will the documents be used in an economic analysis? Will the documents be submitted to HQ or to the Division?
BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements
SIGNIFICANCE: Medium
RESOLUTION: Respond to the concern and adjust the cited documents as indicated.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 05 2014

1-0 Evaluation **Concurred**

Please provide a reasonably complete statement indicating the purpose of this review: The purpose of this review is an un-certified ATR aligned with the Acquisition Life Cycle as it relates to the ATR prior to the AGENCY DECISION MILESTONE.

how the cost documents will be used going forward: This estimate should be considered as programmatic. The sites selected in the estimate are based on the 2007 priority site inventory. These were sites determined to need erosion repair based on engineering criteria. The sites selected are a representative sample of the majority of sites and the various types of fixes that will be done in the implementation of the 80,000 LF bank protection program. The actual repair sites will be determined and developed on a roughly 3-5 year basis using the site selection process outlined in the Appendix B of the PACR, and based on funding received, these site locations will go through the certified ATR process.

Will the documents be used to secure funding or authorization? This project was authorized in WRDA 2007 for the repair of 80,000 LF and is not tied to a specific dollar value. The documents will be used for funding purposes.

Will the documents be used in an economic analysis? Yes, they have been used in the economic analysis of this PACR.

Will the documents be submitted to HQ or to the Division? The documents will be submitted to South Pacific Division for approval.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 19 2014

1-1 Backcheck Recommendation **Close Comment**
Back Check: Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Oct 23 2014
Current Comment Status: **Comment Closed**

5788256	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

2. CONCERN: Observation: Some of the comments are based my observation of cost and schedule documents that are in conformance with the cost and schedule requirements. The purpose of these comments is to record the aspects of the cost and schedule documents that have been considered in the review. Your evaluation can be: concur. An evaluation is required in order for the reviewer to close the comment.
BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements
SIGNIFICANCE: Medium
RESOLUTION: Observation Comment. No Resolution Required.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 05 2014

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 18 2014

1-1 Backcheck Recommendation **Close Comment**
Back Check: Observation Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Oct 23 2014
Current Comment Status: **Comment Closed**

5788260	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

3. CONCERN: Files provided for this review are listed below. These are all cost engineering files. Please provide files to define the scope of work.
BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements
SIGNIFICANCE: Medium
RESOLUTION: Respond to the concern and adjust the cited documents as indicated.

Sac Bank Schedule dated 8 5 14.mpp
Cost Appendix.docx
JR CONSTRUCTION CONTRACT COMMENTS RESPONSES2.docx
SAC BANK PROJECT NOTES (Construction Contract).docx
Variable notes.docx
SacBank-NWW-FeasOnly.mlp
SacBank-SPK-FeasOnly 31Jul2014.mlp
2014_03_31_Sac_Bank_Schedule_PhaseII.PDF
CSRA Report - SPK Sacramento Bank 2014_06_19.pdf
SacBank-NWW-FeasOnly.ldb
SacBank-SPK-FeasOnly 31Jul2014.ldb
HAUL CYCLES.xls
SAC_BANK_Quantity Development_CC#1xlsx 3 07 14_Imp_ScheduleBEN.xlsx
SacBank TPCS - Feas Only 07172014 without Sutter.xlsx
SPK - Sacramento Bank - CSRA 2014-06-19.xlsx

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 05 2014

1-0 Evaluation **Concurred**

The following documents have been provided for review:

- Sac_Bank_PACR_pre-Final_Draft
- AppendixA-EngineeringMain Report-10Jul2014
- EA Appendix 2 Civil Design with Cost Estimates - July 10 - for COE rev

These documents in of themselves may not completely address this comment and may need further definition.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 18 2014

1-1 Backcheck Recommendation **Close Comment**

Back Check: Documents provided are sufficient. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Oct 23 2014

Current Comment Status: **Comment Closed**

5788263	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

4. CONCERN: Two MII files have been provided, filenames SacBank-SPK-FeasOnly 31Jul2014.mlp = 8,345,073.39 and SacBank-NWW-FeasOnly.mlp = 6,645,636.50. Parts of both estimates appear to be applied to the TPCS filename SacBank TPCS - Feas Only 07172014 without Sutter.xlsx = $20,561,000. Please explain how the MII estimates are applied to the TPCS file because the MII files do not add up to the TPCS file.
BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements
SIGNIFICANCE: Medium

RESOLUTION: Respond to the concern and adjust the cited documents as indicated.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 05 2014

1-0 Evaluation **Concurred**
This comment will be addressed when comment 5788265 is resolved since it has the capacity to change all the numbers in the TPCS.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 19 2014

1-1 Backcheck Recommendation **Open Comment**
Back Check: Comment remains open until comment 5788265 is resolved. Comment remains open

Submitted By: Gary Smith (651 260 1819) Submitted On: Oct 23 2014

2-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Oct 31 2014

2-1 Backcheck Recommendation **Close Comment**
Revised documents address the concern. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Nov 14 2014
Current Comment Status: **Comment Closed**

5788265	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

5. CONCERN: Two MII files have been provided, filenames SacBank-SPK-FeasOnly 31Jul2014.mlp = 8,345,073.39 and SacBank-NWW-FeasOnly.mlp = 6,645,636.50. These estimates appear to have been prepared by different groups. If these estimated costs are to represent the project cost, the two estimates should be consistent in pricing and contractor markups. Prime contractor JOOH = 15%, 12%, Prime Contractor HOOH = 7%, 8%, Prime Contractor Profit = 5.65%, 9.10%. Suggest that these 2 estimates be combined into 1 estimate and that the contractor markups be adjusted to match the acquisition strategy. Also the detail items should be similar.
BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements
SIGNIFICANCE: Medium
RESOLUTION: Respond to the concern and adjust the cited documents as indicated.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 05 2014

1-0 Evaluation **Concurred**

In the process of forwarding the ATR package, there is one MII file that was not submitted. This was for the Service Contract items NWW created. After re-review, it appears that this file has a total mark up of approximately 16%. HOOH will be raised from 6% to 10% which will produce a total mark up of 20% which is reasonable since this type of contract typically does not have as much JOOH for growing, installing and maintaining plants for the maintenance period. This file will be submitted with the other two files after all modifications are completed.

The total markup for JOOH, HOOH & Profit originally resulted in 27.65% for estimates provided by NWW and 29.1% for estimates provided by SPK. Markups for NWW products will be adjusted to mimic the SPK products to account for the 1.45% in overall difference and make them the same (JOOH, HOOH, Profit).

It is the intention of SPK not to combine the MII files into one. The estimate has been divided into economic regions (sub-basins) to aid in determining economic benefits. Due to the project covering over 100 river miles, haul distances and material sources for all the sites are not the same. By keeping the economic sub-basins intact, it will be easier in the future when we will need to do the required cost updates per ER 110-2-1302. The contracts are assembled using the priority site inventory, starting with those sites that are the most critical. When the actual sites are determined, we will be using the latest inventory to re-determine which sites will be addressed and confirm that there is still a positive BCR for those regions with the sites chosen.

Please confirm whether this path forward will be acceptable and files will be modified and submitted.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 19 2014

1-1 Backcheck Recommendation **Open Comment**

Back Check: This path forward is acceptable. Comment will remain open until modified files are submitted. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Oct 23 2014

2-0 Evaluation **Concurred**

Per Evaluation 1 above, HOOH has been raised to 20% for the service contract in MII file "SacBank-NWWService 31Oct2014"

JOOH, HOOH & profit are now the same in the other 2 MII files that contain construction cost only so that the overall mark ups are the same. Files have been submitted via AMERDC for review.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Oct 31 2014

2-1 Backcheck Recommendation **Close Comment**

Revised documents address the concern. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Nov 14 2014

Current Comment Status: **Comment Closed**

5788267	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

6. CONCERN: TPCS filename SacBank TPCS - Feas Only 07172014 without Sutter.xlsx = $20,561,000 is divided into 4 contracts. When the 2 MII files are combined, the work should be divided up in the MII file by the same contracts as found in the TPCS file.
BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements
SIGNIFICANCE: Medium
RESOLUTION: Respond to the concern and adjust the cited documents as indicated.

Submitted By: Gary Smith (651 260 1819). Submitted On: Sep 05 2014

1-0 Evaluation **Concurred**

Similar to comment 5788265, it is the intention of SPK not to combine the MII files into one file. The estimate has been divided into economic regions to aid in determining economic benefits. Due to the project covering over 100 river miles, haul distances and material sources for all the sites are not the same. By keeping the economic sub-basins intact, it will be easier in the future when we will need to do the required cost updates per ER 110-2-1302. The contracts are assembled using the priority site inventory, starting with those sites that are the most critical. When the actual sites are determined, we will be using the latest inventory to re-determine which sites will be addressed and confirm that there is still a positive BCR for those regions with the sites chosen.

Please keep in mind that this project will be ongoing for 20+ years to reach the authorized 80,000 LF of repair. It is our desire to leave the estimate in the most intact and usable form due to this reason.

Also note that among the 3 files that there is not any duplication or overlap of locations or construction and service contracts.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Sep 19 2014

1-1 Backcheck Recommendation **Close Comment**

Back Check: Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Oct 23 2014

Current Comment Status: **Comment Closed**

5861925	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

1. CONCERN: Observation: Some of the comments are based my observation of cost and schedule documents that are in conformance with the cost and schedule requirements. The purpose of these comments is to record the aspects of the cost and schedule documents that have been considered in the review. Your evaluation can be: concur. An evaluation is required in order for the reviewer to

close the comment.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 02 2014

1-1 Backcheck Recommendation **Close Comment**
Observation Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861928	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

2. CONCERN: Observation: Estimate Structure

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

2.1. Estimate Structure
4,756,174 33% Direct Construction Labor $4,756,174, 33.05% of Direct Construction Cost
2,856,410 20% Direct Construction Equipment $2,856,410, 19.85% of Direct Construction Cost
7,612,583 53% Direct Construction Labor + Equipment $7,612,583, 52.9% of Direct Construction Cost
6,183,992 43% Direct Construction Matl $6,183,992, 42.97% of Direct Construction Cost
593,695 4% Direct Construction Sub Bid $593,695, 4.13% of Direct Construction Cost
0 0% Direct Construction User $, 0% of Direct Construction Cost
14,390,271 100% Direct Construction Cost

2.2. Direct Cost Overrides
8 *M*

5 *E*
54 *O*
5 *L*
55 *Sb*
119 total overrides

2.3. Notes and Folders
874 Notes
170 Unique
1087 detail
131 upper folder
359 lower folder

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 14 2014

1-1 Backcheck Recommendation **Close Comment**
Observation Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861933	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

1. CONCERN: Observation: Some of the comments are based my observation of cost and schedule documents that are in conformance with the cost and schedule requirements. The purpose of these comments is to record the aspects of the cost and schedule documents that have been considered in the review. Your evaluation can be: concur. An evaluation is required in order for the reviewer to close the comment.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 14 2014

1-1 Backcheck Recommendation **Close Comment**
Observation Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861935	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

2. CONCERN: Observation: Estimate Structure

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

2.1. Estimate Structure
4,756,174 33% Direct Construction Labor $4,756,174, 33.05% of Direct Construction Cost
2,856,410 20% Direct Construction Equipment $2,856,410, 19.85% of Direct Construction Cost
7,612,583 53% Direct Construction Labor + Equipment $7,612,583, 52.9% of Direct Construction Cost
6,183,992 43% Direct Construction Matl $6,183,992, 42.97% of Direct Construction Cost
593,695 4% Direct Construction Sub Bid $593,695, 4.13% of Direct Construction Cost
0 0% Direct Construction User $, 0% of Direct Construction Cost
14,390,271 100% Direct Construction Cost

2.2. Direct Cost Overrides
8 *M*
5 *E*
54 *O*
5 *L*
55 *Sb*
119 total overrides

2.3. Notes and Folders
874 Notes
170 Unique
1087 detail
131 upper folder
359 lower folder

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 14 2014

1-1 Backcheck Recommendation **Close Comment**
Observation Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861942	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

3. CONCERN: Significant Detail Items. The following detail items are based on a crew and a developed time to complete the task. The time development is referenced in the notes "See production spreadsheet for duration and quantities". The production worksheets are filename "Sac Bank 80k LF - ProdQuant WORKSHEETS 2014v2.xls" and filename "HAUL CYCLES.xls". Please verify that the calculations are accurate and complete and have been applied in the MII estimate correctly.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

3.1. detail Quarry Stone - Hauling (Quarry to Site) , 13,730 HR @ $114 per HR = $1,567,757, 11% of the estimated direct construction cost, used 8 times in the estimate, overrides = N

3.2. detail Soil-Filled Quarry Stone - Hauling (Quarry to Site) , 8,485 HR @ $115 per HR = $972,821, 7% of the estimated direct construction cost, used 9 times in the estimate, overrides = N

3.3. detail Embankment Fill - Hauling (Borrow to Site) , 7,245 HR @ $114 per HR = $826,163, 6% of the estimated direct construction cost, used 1 times in the estimate, overrides = N
3.4. detail Embankment Fill - Placement , 1,590 HR @ $307 per HR = $487,710, 3% of the estimated direct construction cost, used 1 times in the estimate, overrides = N

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**

Spot checking of hours in spreadsheets with hours in estimate indicate that the the hours have been transfered reasonably well. By this, I mean that the calculations may indicate 2198 hours but 2200 hours have been used in the estimate. Off by only minor rounding of numbers. The spreadsheets appear to have addressed the various sites and their corresponding haul distances and times.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 02 2014

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014

Current Comment Status: **Comment Closed**

5861948	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

4. CONCERN: The following detail items represent a significant % of the estimated direct construction. The following detail items are based on a crew and a developed time to complete the task. The production worksheets are filename "Sac Bank 80k LF - ProdQuant WORKSHEETS 2014v2.xls" and filename "HAUL CYCLES.xls". Please verify that the calculations are accurate and complete and have been applied in the MII estimate correctly.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

4.1. detail Barge Haul , 1,650 HR @ $267 per HR = $441,081, 3% of the estimated direct construction cost, used 8 times in the estimate, overrides = N

4.2. detail Semi-End Dumps Trucking Service , 3,833 HR @ $100 per HR = $383,300, 3% of the estimated direct construction cost, used 41 times in the estimate, overrides = N

4.3. detail Place Material from Barge , 210 HR @ $1,387.39 per HR = $291,352, 4% of the estimated direct Labor and Equipment Construction Cost, 2% of the estimated total direct construction cost, used 4 times in the estimate, overrides = N

4.4. detail Tug Mob or Demob , 768 HR @ $350.72 per HR = $269,355, 4% of the estimated direct Labor and Equipment Construction Cost, 2% of the estimated total direct construction cost, used 4 times in the estimate, overrides = N

4.5. detail Load to Barge , 240 HR @ $721.08 per HR = $173,060, 2% of the estimated direct Labor and Equipment Construction Cost, 1% of the estimated total direct construction cost, used 4 times in the estimate, overrides = N

4.6. detail Laborers, (Semi-Skilled) , 2,560 HR @ $56.77 per HR = $145,320, 2% of the estimated direct Labor and Equipment Construction Cost, 1% of the estimated total direct construction cost, used 20 times in the estimate, overrides = N

4.7. detail Soil Cover - Hauling (Borrow to Site) , 1,125 HR @ $114.47 per HR = $128,783, 2% of the estimated direct Labor and Equipment Construction Cost, 1% of the est

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
The calculations have been reviewed and appear reasonable.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014
Current Comment Status: **Comment Closed**

5861950	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

5. Concern: detail Quarry Stone - Placement , 705 HR @ $200 per HR = $140,942, 1% of the estimated direct construction cost, used 8 times in the estimate, overrides = N Verify if the material cost should be removed from this detail item.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
It should be removed as shown. It is included in the "Buy Materials" subfolder.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014
Current Comment Status: **Comment Closed**

5861951	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

6. Concern: Observation: Excellent notes documenting material cost quotes.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

6.1. detail Quarry Stone - Material , 91,510 TON @ $21.33 per TON = $1,951,474, 32% of the estimated direct Material Construction Cost, 14% of the estimated total Direct Construction Cost, used 8 times in the estimate, overrides = N

6.2. detail Soil-Filled Quarry Stone - Material , 61,648 TON @ $17.82 per TON = $1,098,441, 18% of the estimated direct Material Construction Cost, 8% of the estimated total Direct Construction Cost, used 9 times in the estimate, overrides = N

6.3. detail In-Stream Wood (Dead Trees w/ Roots) , 1,069 EA @ $270.63 per EA = $289,298, 5% of the estimated direct Material Construction Cost, 2% of the estimated total Direct Construction Cost, used 9 times in the estimate, overrides = N

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 17 2014

1-1 Backcheck Recommendation **Close Comment**
Observation Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861954	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

7. Concern: detail Rip Rap , 48,771 TON @ $37.89 per TON = $1,847,823, 30% of the estimated direct Material Construction Cost, 13% of the estimated total Direct Construction Cost, used 4 times in the estimate, overrides = N Quote documentation note reads :"Price from San Rafael Quarry". This note should be expanded to include quote date and source

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Price from San Rafael Quarry "1-2-2013, Dutra Materials Price List" add to items that where water side placement.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014
Current Comment Status: **Comment Closed**

5861956	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

8. CONCERN: From filename SacBank-NWW-FeasOnly 31Oct2014 ACQUISITION PLAN - The prime contractor is expected to be an earthwork contractor responsible for general site work. Subcontractors are provided for clearing, tree removal, erosion control seeding, landscaping and paving. Hauling subcontractors previously used in the estimate have been substituted with sub-bid costs based on local hauling rates for trucking 'brokers" in the Sacramento area. Please explain why the acquisition plan does not appear to match the contractor sub contractor set up

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**

In this area (location of project) most trucking is obtained from "brokers". A couple of things come into play here. The current rate for trucking is based on an hourly rate which is representative of the costs in the estimate. The brokers negociate a price from the sub-haulers and there is not a set profit by either subhauler or broker, but the consistant part is the hourly rate to the contractor. Contractor only adds their mark up. The vast majority of rock/soils will come from a commercial pit, and since the it is not government owned, and the drivers are only delivering materials and not performing any other work, they are not paid prevailing wages which is also why the pricing is consistent. Markups are reasonable.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 21 2014

Backcheck not conducted

2-0 Evaluation **Concurred**

Detail items have been changed so that all occurrences of the haul are now identified in the "sub-bid" item and the markup has now been changed to "Prime Contractor". Subcontractor Tab has also been modified to not include this subcontractor markup option.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 02 2014

2-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861957 Cost Engineering Cost Estimate n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

9. CONCERN: Sac Bank-NWW-SERVICE_CONTRACT - 31Oct2014. Verify the correct sales tax, 7.75 in this contract and 8.25 in the other 2 contracts.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
concur. tax has been adjusted.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014
Current Comment Status: **Comment Closed**

5861963 Cost Engineering Cost Estimate n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

10. CONCERN: Verify the applied markups as indicated below. Explain why the MII Profit Guidelines and bond table are not used for all 3 contracts,

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

10.1. SacBank-NWW-FeasOnly 31Oct2014
JOOH Running % 12.00 8.00
HOOH Running % 8.00 8.00
Profit Running % 9.10 9.10
Bond Running % 0.97 0.97

10.2. Sac Bank-NWW-SERVICE_CONTRACT - 31Oct2014
HOOH Running % 6.00 6.00
JOOH Running % 2.00 2.00
Profit Running % 8.00 8.00

10.3. SacBank-SPK-FeasOnly 31Oct2014
JOOH (Calc) (Small Tools) % of Labor 2.00 0.00
JOOH (Calc) Overhead Calc 0.00 0.00
JOOH Running % 10.00 8.00
HOOH Running % 8.00 8.00
Profit Guideline Profit 9.10 9.10
Bond Bond Table 0.97 0.97

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**

The mark ups are essentially the same.

Profit for 10.1 is the same as the profit for 10.3 which was created using the PWG. The same can be said for the bond rate. There are other risk items that have a significantly bigger impact on the total cost.

10.2 is a different animal all together. The service contract, for the most part plantings and maintenance of the plant material requires significantly less HOOH and JOOH which is represented.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 21 2014

1-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014

2-0 Evaluation **Concurred**
Bond cost of 1.5% was added to the service contract.
Prime Contractor changed so both construction cost estimates reflect the same percent.
Profit was figured using PWG for one estimate and resulting % was used for the other.
JOOH 12% & 8%
HOOH 8% & 8%
Profit: 9.1% & 9.1%
Bond: 1% & 1%

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 02 2014
Backcheck not conducted
Current Comment Status: **Comment Closed**

5861964	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

11. CONCERN Filename "SPK - Sacramento Bank - CSRA 2014-06-19.xlsm" WBS Costs tab indicates baseline cost = Construction $26,457,000 + Non construction $16,426,000 = $42,883,000. This is considerably different than the total of the MII estimates filename "SacBank-SPK-FeasOnly 31Oct2014.mlp" 11,871,942 , "Sac Bank-NWW-SERVICE_CONTRACT - 31Oct2014.mlp" 581,204 "SacBank-NWW-FeasOnly 31Oct2014.mlp" 6,645,637 , total = 19,098,783 construction cost and filename SacBank TPCS - Feas Only 31Oct2014.xlsx = $19,095,000 construction and non construction cost t $12,350,000 = $31,445,000. It looks like the CSRA is based on incorrect estimated amounts and the developed contingency % is applied in the tpcs. The CSRA needs to be redeveloped based on the actual estimated amounts.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**

PLease review updated documents supplied. Revised TPCS has been suppied.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**

CSRA TPCS and MII match up. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014

Current Comment Status: **Comment Closed**

5861965	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

11. CONCERN Filename "SPK - Sacramento Bank - CSRA 2014-06-19.xlsm" WBS Costs tab indicates baseline cost = Construction $26,457,000 + Non construction $16,426,000 = $42,883,000. This is considerably different than the total of the MII estimates filename "SacBank-SPK-FeasOnly 31Oct2014.mlp" 11,871,942 , "Sac Bank-NWW-SERVICE_CONTRACT - 31Oct2014.mlp" 581,204 "SacBank-NWW-FeasOnly 31Oct2014.mlp" 6,645,637 , total = 19,098,783 construction cost and filename SacBank TPCS - Feas Only 31Oct2014.xlsx = $19,095,000 construction and non construction cost t $12,350,000 = $31,445,000. It looks like the CSRA is based on incorrect estimated amounts and the developed contingency % is applied in the tpcs. The CSRA needs to be redeveloped based on the actual estimated amounts.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**

Please review updated documents supplied. This concerned has been updated.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**
TPCS CSRA and MII match. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014
Current Comment Status: **Comment Closed**

5861967	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

12. CONCERN: Filename "SPK - Sacramento Bank - CSRA 2014-06-19.xlsm". Please expand the discussion to support the following worst case
TL-3 Borrow/Fill Sources basis for 10%
TL-4 Rip Rap Supply Basis for 10%

I generally believe that the worst cases are based on what could be expected instead of what is the worst that could be expected and are not high enough. Please reconsider the worst case based on what is the worst that could happen, not what is likely to happen.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Please review the current CSRA. It has been redone from this last review.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**
Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014
Current Comment Status: **Comment Closed**

5861969	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

13. CONCERN: Filename "SPK - Sacramento Bank - CSRA 2014-06-19.xlsm". The following items include contingencies developed elsewhere. Verify that the CSRA excludes these amounts from all risk analysis.

LD-1 Real Estate Acquisition verify not included in $

LD-4 Utility Relocations verify not included in $

RE-2 Offsite Mitigation basis for 50%

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: In the comment evaluations, please provide a detailed explanation of what has been changed to the cost and schedule documents in response to the comment, including the location of the change. Explain why the comment does not require a change to the documents if no change is made. Address each statement or concern in the comment. In most cases, the comment is intended clarify a concern and the clarification must be included in the documents, not just in the evaluation. This will help to expedite the backcheck process in order to close comments as soon as possible. Note that ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the documents.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**

Since the June/2014 CSRA, the CSRA has been refined ans does not include these in the risk register.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 10 2014

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014

Current Comment Status: **Comment Closed**

5861970	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

14. CONCERN: Observation. Except as noted above, the estimate documents are complete. Reliable DQC, Adequate Scoping Documents, Complete Cost Engineering Appendix discussing basis of the estimate and uncertainties associated with major cost items, Project Acquisition plan, Project Notes, Quantity Development, Basis and development of TPC, Development of Contractor

and Subcontractor Markup, HOOH, JOOH, Profit, and Bond.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 14 2014

1-1 Backcheck Recommendation **Close Comment**
Observation Comment Closed

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 10 2014
Current Comment Status: **Comment Closed**

5861975	Cost Engineering	Cost Estimate	n/a	n/a	n/a

Comment Classification: **For Official Use Only (FOUO)**

15. CONCERN: Observation: TPCS will have a final review upon completion of other documents.

BASIS: ETL 1110-2-573 Construction Cost Estimating Guide for Civil Works, ER 1110-2-1302 Civil Works Cost Engineering, ER 1110-1-1300 Cost Engineering Policy and General Requirements

SIGNIFICANCE: Medium

RESOLUTION: Observation Comment. No Resolution Required.

Submitted By: Gary Smith (651 260 1819). Submitted On: Nov 14 2014

1-0 Evaluation **Concurred**
Concur

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Nov 14 2014
Backcheck not conducted

2-0 Evaluation **Concurred**

Current TPCS has been submitted for review so that other comments can be closed (total of 3 MII estimates equal the construction costs in the TPCS). This same TPCS has been forwarded to Bill Bolte so that he can rerun the CSRA based on the economically justified basins. I will forward a revised TPCS with the correct contingency when available.

Submitted By: Joe Reynolds ((916) 557-7573) Submitted On: Dec 02 2014

2-1 Backcheck Recommendation **Close Comment**

Documents received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Dec 11 2014

Current Comment Status: **Comment Closed**

US Army Corps of Engineers®

Sacramento River Bank Protection Project (SRBPP)

Project Cost and Schedule Risk Analysis Report

Prepared for:

U.S. Army Corps of Engineers,
Sacramento District

Prepared by:

U.S. Army Corps of Engineers
Cost Engineering Mandatory Center of Expertise, Walla Walla

June 19, 2014

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EXECUTIVE SUMMARY

The US Army Corps of Engineers (USACE), Sacramento District, presents this cost and schedule risk analysis (CSRA) report regarding the risk findings and recommended contingencies for the Sacramento River Bank Protection Project (SRBPP) Limited Reevaluation Report (LRR). In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a formal risk analysis, *Monte-Carlo* based-study was conducted by the Project Development Team (PDT) on remaining costs. The purpose of this risk analysis study is to present the cost and schedule risks considered, those determined and respective project contingencies at a recommended 80% confidence level of successful execution to project completion.

The SRBPP is a long-range construction project to identify significant erosion problems, prioritize sites, and design and construct bank protection. Corrective measures are applied only to affected banks and levees that are part of the Federal Sacramento River Flood Control Project (SRFCP). Per Section 3031 of the Water Resources Development Act of 2007 (WRDA 2007), an additional 80,000 LF of bank protection was added to the original SRBPP Phase II project authorization. The portion included in this analysis is for some 16 sites with approximately 7,865 LF.

Cost estimates fluctuate over time. During this period of study, minor cost fluctuations can and have occurred. For this reason, contingency reporting is based in cost and per cent values. Should cost vary to a slight degree with similar scope and risks, contingency per cent values will be reported, cost values rounded

Table ES-1. Project Contingency Results

Base Case Project Cost Estimate (Excluding Real Estate)	**$36,869,000**	
Confidence Level	**Project Value ($$)**	**Contingency (%)**
5%	$1,106,000	3%
50%	$5,530,000	15%
80%	**$8,111,000**	**22%**
95%	$10,323,000	28%

KEY FINDINGS/OBSERVATIONS RECOMMENDATIONS

The PDT worked through the risk register on 8 April 2014. It quickly became evident that the team understands the project, the experienced risks and those risks already incorporated into the current designs and estimated costs (i.e., the major risks have already been experienced and mitigated through various means). The key risk drivers identified through sensitivity analysis suggest an 80% confidence level total contingency of $8.1M. Findings indicate no schedule risks that would result in any substantial cost impacts or resulting contingencies.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- EST-1: Quantities - During design or awarded it could be determined additional erosion has occurred and quantities will increase.
- RE-4: Onsite Mitigation - Resource agencies requirements for onsite mitigation continue to evolve, resulting in additional onsite mitigation requirements. ESA consultations have yet to occur. Until consultations occur, restoration ratios have not been established.

Moderate risks, when combined, can also become a cost impact; though no major contributors were noted other than Water and Air Quality, Differing Site Conditions, Offsite Mitigation and Construction Oversight.

Schedule Risks: All schedule risk drivers where either outside the scope of this risk analysis and therefore not modeled or will be resolved prior to schedule impacts being realized. Specific schedule risks identified included:

- PPM-3: Internal Red Tape – Discussions on Economic Justification have delayed schedules. Economically disadvantaged sites are some 5 years or more from implementation, allowing   for sufficient time for resolution prior to site implementation. This issue is not a Risk for Economically Justified Sites so will not be considered for this evaluation.
- PPM-4: Project Partnership Agreement Signature – PPA signature is due within the next year and must be signed for project to continue. USACE HQ and State sponsor are currently at an impasse on signature of the PPA due to current ETL policy (levee vegetation requirements). If PPA is not signed, project funding will cease and project schedule will slip. Given the potential huge project impact if PPA is not achieved, modeling this risk is outside scope of this risk analysis and will not be included.
- PR-2: Design Criteria Agreement – Sponsor and USACE agreements on Levee Vegetation. While the sponsor and USACE have managed to work around this issue in the past, it is possible this issue will come to a head; requiring either resolution or termination of this project. That discussion is outside the scope of this risk analysis and will not be modeled here.

MAIN REPORT

1.0 PURPOSE

Under the authority of the US Army Corps of Engineers (USACE), Sacramento District presents this cost and schedule risk analysis, identified major risks and recommendations for the total project cost and schedule contingencies for the Sacramento River Bank Protection Project (SRBPP).

2.0 BACKGROUND

The SRBPP is a long-range construction project to identify significant erosion problems, prioritize sites, and design and construct bank protection. Corrective measures are applied only to affected banks and levees that are part of the Federal Sacramento River Flood Control Project (SRFCP). Per Section 3031 of the Water Resources Development Act of 2007 (WRDA 2007), an additional 80,000 LF of bank protection was added to the original SRBPP Phase II project authorization. The portion included in this analysis is for some 16 sites with approximately 7,865 LF.

3.0 REPORT SCOPE

The scope of the risk analysis report is to identify cost and schedule risks with a resulting recommendation for contingencies at the 80 percent confidence level using the risk analysis processes, as mandated by U.S. Army Corps of Engineers (USACE) Engineer Regulation (ER) 1110-2-1150, Engineering and Design for Civil Works, ER 1110-2-1302, Civil Works Cost Engineering, and Engineer Technical Letter 1110-2-573, Construction Cost Estimating Guide for Civil Works. The report presents the contingency results for cost risks for construction features. The CSRA excludes Real Estate costs and does not include consideration for life cycle costs.

3.1 Project Scope

The formal process included extensive involvement of the PDT for risk identification and the development of the risk register. The analysis process evaluated the Micro Computer Aided Cost Estimating System (MCACES) cost estimate, project schedule, and funding profiles using Crystal Ball software to conduct a *Monte Carlo* simulation and statistical sensitivity analysis, per the guidance in Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

The project technical scope, estimates and schedules were developed and presented by the Sacramento District. Consequently, these documents serve as the basis for the risk analysis.

The scope of this study addresses the identification of concerns, needs, opportunities and potential solutions that are viable from an economic, environmental, and engineering viewpoint.

3.2 USACE Risk Analysis Process

The risk analysis process for this study follows the USACE Headquarters requirements as well as the guidance provided by the Cost Engineering MCX. The risk analysis process reflected within this report uses probabilistic cost and schedule risk analysis methods within the framework of the Crystal Ball software. Furthermore, the scope of the report includes the identification and communication of important steps, logic, key assumptions, limitations, and decisions to help ensure that risk analysis results can be appropriately interpreted.

Risk analysis results are also intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as the project progresses through planning and implementation. To fully recognize its benefits, cost and schedule risk analysis should be considered as an ongoing process conducted concurrent to, and iteratively with, other important project processes such as scope and execution plan development, resource planning, procurement planning, cost estimating, budgeting and scheduling.

In addition to broadly defined risk analysis standards and recommended practices, this risk analysis was performed to meet the requirements and recommendations of the following documents and sources:

- Cost and Schedule Risk Analysis Process guidance prepared by the USACE Cost Engineering MCX.

- Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008.

- Engineer Technical Letter (ETL) CONSTRUCTION COST ESTIMATING GUIDE FOR CIVIL WORKS, dated September 30, 2008.

4.0 METHODOLOGY / PROCESS

The Cost Engineering MCX performed the Cost and Schedule Risk Analysis, relying on local Sacramento District staff to provide expertise and information gathering. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis. Follow on meetings updated project development and refined risk modeling. Participants in the risk identification meeting included:

Risk Register Development Meeting

Tuesday, April 8, 2014

Attendance	Name	Representing
Civil Design	Hans Carota	Sacramento District
Civil Design – Tech Lead	Pamlyn Hill	Sacramento District
Planning	Karin Lee	Sacramento District
Cost Engineer	Joe Reynolds	Sacramento District
Real Estate	Greg Garner	DWR
Environmental	Kip Young	DWR
Planner	Thomas Adams	HDR
Cost Engineer	Robert Vrchoticky	Sacramento District
Real Estate	Kelly Boyd	Sacramento District
Cost Engineer	Tri Duong	Sacramento District
Project Manager	Cynthia Brooks	Sacramento District
Risk Analyst	William Bolte	Cost Engineering MCX

The risk analysis process for this study is intended to determine the probability of various cost outcomes and quantify the required contingency needed in the cost estimate to achieve the desired level of cost confidence. Per regulation and guidance, the P80 confidence level (80% confidence level) is the normal and accepted cost confidence level. District Management has the prerogative to select different confidence levels, pending approval from Headquarters, USACE.

In simple terms, contingency is an amount added to an estimate to allow for items, conditions or events for which the occurrence or impact is uncertain and that experience suggests will likely result in additional costs being incurred or additional time being required. The amount of contingency included in project control plans depends, at least in part, on the project leadership's willingness to accept risk of project overruns. The less risk that project leadership is willing to accept the more contingency should be applied in the project control plans. The risk of overrun is expressed, in a probabilistic context, using confidence levels.

The Cost MCX guidance for cost and schedule risk analysis generally focuses on the 80-percent level of confidence (P80) for cost contingency calculation. It should be noted that use of P80 as a decision criteria is a risk averse approach (whereas the use of P50 would be a risk neutral approach, and use of levels less than 50 percent would be risk seeking). Thus, a P80 confidence level results in greater contingency as compared to a P50 confidence level. The selection of contingency at a particular confidence level is ultimately the decision and responsibility of the project's District and/or Division management.

The risk analysis process uses *Monte Carlo* techniques to determine probabilities and contingency. The *Monte Carlo* techniques are facilitated computationally by a commercially available risk analysis software package (Crystal Ball) that is an add-in to Microsoft Excel. Cost estimates are packaged into an Excel format and used directly for cost risk analysis purposes. The level of detail recreated in the Excel-format schedule is sufficient for risk analysis purposes that reflect the established risk register, but generally less than that of the native format.

The primary steps, in functional terms, of the risk analysis process are described in the following subsections. Risk analysis results are provided in Section 6.

4.1 Identify and Assess Risk Factors

Identifying the risk factors via the PDT is considered a qualitative process that results in establishing a risk register that serves as the document for the quantitative study using the Crystal Ball risk software. Risk factors are events and conditions that may influence or drive uncertainty in project performance. They may be inherent characteristics or conditions of the project or external influences, events, or conditions such as weather or economic conditions. Risk factors may have either favorable or unfavorable impacts on project cost and schedule.

A formal PDT meeting held 8 April 2014 included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, and real estate

The initial formal meetings focused primarily on risk factor identification using brainstorming techniques, but also included some facilitated discussions based on risk factors common to projects of similar scope and geographic location. Additionally, conference calls and informal meetings were conducted throughout the risk analysis process on an as-needed basis to further facilitate risk factor identification, market analysis, and risk assessment.

4.2 Quantify Risk Factor Impacts

The quantitative impacts (putting it to numbers of cost and time) of risk factors on project plans were analyzed using a combination of professional judgment, empirical data and analytical techniques. Risk factor impacts were quantified using probability distributions (density functions) because risk factors are entered into the Crystal Ball software in the form of probability density functions.

Similar to the identification and assessment process, risk factor quantification involved multiple project team disciplines and functions. However, the quantification process relied more extensively on collaboration between cost engineering and risk analysis team members with lesser inputs from other functions and disciplines. This process used an iterative approach to estimate the following elements of each risk factor:

- Maximum possible value for the risk factor
- Minimum possible value for the risk factor
- Most likely value (the statistical mode), if applicable
- Nature of the probability density function used to approximate risk factor uncertainty
- Mathematical correlations between risk factors
- Affected cost estimate and schedule elements

The resulting product from the PDT discussions is captured within a risk register as presented in Appendix A for both cost and schedule risk concerns. Note that the risk register records the PDT's risk concerns, discussions related to those concerns, and potential impacts to the current cost and schedule estimates. The concerns and discussions support the team's decisions related to event likelihood, impact, and the resulting risk levels for each risk event.

4.3 Analyze Cost Estimate and Schedule Contingency

Contingency is analyzed using the Crystal Ball software, an add-in to the Microsoft Excel format of the cost estimate and schedule. *Monte Carlo* simulations are performed by applying the risk factors (quantified as probability density functions) to the appropriate estimated cost and schedule elements identified by the PDT. Contingencies are calculated by applying only the moderate and high level risks identified for each option (i.e., low-level risks are typically not considered, but remain within the risk register to serve historical purposes as well as support follow-on risk studies as the project and risks evolve).

For the cost estimate, the contingency is calculated as the difference between the P80 cost forecast and the baseline cost estimate. Each option-specific contingency is then allocated on a civil works feature level based on the dollar-weighted relative risk of each feature as quantified by *Monte Carlo* simulation. Standard deviation is used as the feature-specific measure of risk for contingency allocation purposes. This approach results in a relatively larger portion of all the project feature cost contingency being allocated to features with relatively higher estimated cost uncertainty.

5.0 PROJECT ASSUMPTIONS

The following data sources and assumptions were used in determining the cost and schedule risks.

a. The Sacramento District provided a 2 June 2014 Total Project Cost Summary Excel Spreadsheet file electronically. The CSRA was performed on the final TPCS Project Costs (excluding Real Estate).

b. The cost comparisons and risk analyses performed and reflected within this report are based on project experience related to previous Phase 1 projects. The project scoping is well understood, the bulk of risks have been incorporated into more recent design and estimated construction costs. The contingency outcome of 20-25% was expected to be lower than a standard Feasibility Report of 25-35%.

c. The Cost Engineering MCX guidance generally focuses on the eighty-percent level of confidence (P80) for cost contingency calculation. For this risk analysis, the eighty-percent level of confidence (P80) was used. It should be noted that the use of P80 as a decision criteria is a moderately risk averse approach, generally resulting in higher cost contingencies. However, the P80 level of confidence also assumes a small degree of risk that the recommended contingencies may be inadequate to capture actual project costs.

d. Only high and moderate risk level impacts, as identified in the risk register, were considered for the purposes of calculating cost contingency. Low level risk impacts should be maintained in project management documentation, and reviewed at each project milestone to determine if they should be placed on the risk “watch list”.

6.0 RESULTS

The cost and schedule risk analysis results are provided in the following sections. In addition to contingency calculation results, sensitivity analyses are presented to provide decision makers with an understanding of variability and the key contributors to the cause of this variability.

6.1 Risk Register

A risk register is a tool commonly used in project planning and risk analysis. The actual risk register is provided in Appendix A. The complete risk register includes low level risks, as well as additional information regarding the nature and impacts of each risk.

It is important to note that a risk register can be an effective tool for managing identified risks throughout the project life cycle. As such, it is generally recommended that risk registers be updated as the designs, cost estimates, and schedule are further refined, especially on large projects with extended schedules. Recommended uses of the risk register going forward include:

- Documenting risk mitigation strategies being pursued in response to the identified risks and their assessment in terms of probability and impact.
- Providing project sponsors, stakeholders, and leadership/management with a

documented framework from which risk status can be reported in the context of project controls.

- Communicating risk management issues.
- Providing a mechanism for eliciting feedback and project control input.
- Identifying risk transfer, elimination, or mitigation actions required for implementation of risk management plans.

6.2 Cost Contingency and Sensitivity Analysis

The result of risk or uncertainty analysis is quantification of the cumulative impact of all analyzed risks or uncertainties as compared to probability of occurrence. These results, as applied to the analysis herein, depict the overall project cost at intervals of confidence (probability).

Table 1 provides the construction cost contingencies calculated for the P80 confidence level and rounded to the nearest thousand. The project cost contingencies for the P5, P50, P80 and P95 confidence levels are also provided for illustrative purposes only.

Contingency was quantified as approximately $8.1 Million at the P80 confidence level (22% of the baseline cost estimate). For comparison, the cost contingency at the P50 and P95 confidence levels was quantified as 15% and 28% of the baseline cost estimate, respectively.

Table 1. Project Cost Contingency Summary

Base Case Project Cost Estimate (Excluding Real Estate)	**$36,869,000**	
Confidence Level	**Project Value ($$)**	**Contingency (%)**
5%	$1,106,000	3%
50%	$5,530,000	15%
80%	**$8,111,000**	**22%**
95%	$10,323,000	28%

6.2.1 Sensitivity Analysis

Sensitivity analysis generally ranks the relative impact of each risk/opportunity as a percentage of total cost uncertainty. The Crystal Ball software uses a statistical measure (contribution to variance) that approximates the impact of each risk/opportunity contributing to variability of cost outcomes during *Monte Carlo* simulation.

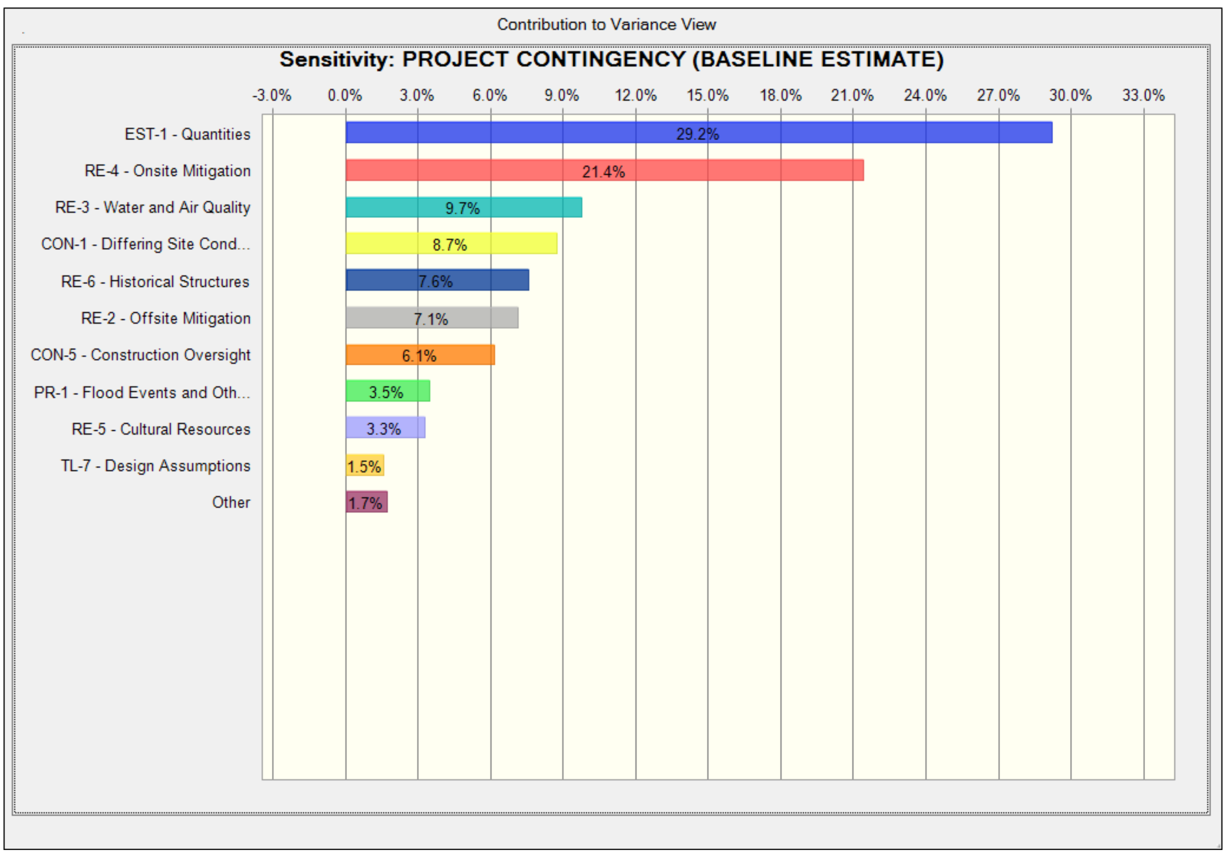
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used to support development of strategies to eliminate, mitigate, accept or transfer key risks.

6.2.2 Sensitivity Analysis Results

The risks/opportunities considered as key or primary cost drivers and the respective value variance are ranked in order of importance in contribution to variance bar charts. Opportunities that have a potential to reduce project cost and are shown with a negative sign; risks are shown with a positive sign to reflect the potential to increase project cost. A longer bar in the sensitivity analysis chart represents a greater potential impact to project cost.

Figure 1 presents a sensitivity analysis for cost growth risk from the high level cost risks identified in the risk register. Likewise, Figure 2 presents a sensitivity analysis for schedule growth risk from the high level schedule risks identified in the risk register.

Figure 1. Cost Sensitivity Analysis



6.3 Schedule and Contingency Risk Analysis

The Sacramento River Bank Protection Project (SRBPP) consists of multiple separate sites with most if not all taking one construction season or less to complete. Individual sites will be addressed as issues arise and delays at any one site will not impact overall project completion schedule, therefore Schedule Risk Analysis becomes somewhat irrelevant for this project.

7.0 MAJOR FINDINGS/OBSERVATIONS/RECOMMENDATIONS

This section provides a summary of significant risk analysis results that are identified in the preceding sections of the report. Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes, as well as to provide tools to support decision making and risk management as projects progress through planning and implementation. Because of the potential for use of risk analysis results for such diverse purposes, this section also reiterates and highlights important steps, logic, key assumptions, limitations, and decisions to help ensure that the risk analysis results are appropriately interpreted.

7.1 Major Findings/Observations

Project cost summaries are provided in Table 2. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register on 8 April 2014. It quickly became evident that the team understands the project, the experienced risks and those risks already incorporated into the current designs and estimated costs (i.e., the major risks have already been experienced and mitigated through various means). The key risk drivers identified through sensitivity analysis suggest an 80% confidence level total contingency of $8.1M. Findings indicate no schedule risks that would result in any substantial cost impacts or resulting contingencies.

Cost Risks: From the CSRA, the key or greater Cost Risk items of include:

- <u>EST-1: Quantities</u> - During design or awarded it could be determined additional erosion has occurred and quantities will increase.
- <u>RE-4: Onsite Mitigation</u> - Resource agencies requirements for onsite mitigation continue to evolve, resulting in additional onsite mitigation requirements. ESA consultations have yet to occur. Until consultations occur, restoration ratios have not been established.

Moderate risks, when combined, can also become a cost impact; though no major contributors were noted other than Water and Air Quality, Differing Site Conditions, Offsite Mitigation and Construction Oversight.

Schedule Risks: All schedule risk drivers where either outside the scope of this risk analysis and therefore not modeled or will be resolved prior to schedule impacts being realized. Specific schedule risks identified included:

- PPM-3: Internal Red Tape – Discussions on Economic Justification have delayed schedules. Economically disadvantaged sites are some 5 years or more from implementation, allowing for sufficient time for resolution prior to site implementation. This issue is not a Risk for Economically Justified Sites so will not be considered for this evaluation.
- PPM-4: Project Partnership Agreement Signature – PPA signature is due within the next year and must be signed for project to continue. USACE HQ and State sponsor are currently at an impasse on signature of the PPA due to current ETL policy (levee vegetation requirements). If PPA is not signed, project funding will cease and project schedule will slip. Given the potential huge project impact if PPA is not achieved, modeling this risk is outside scope of this risk analysis and will not be included.
- PR-2: Design Criteria Agreement – Sponsor and USACE agreements on Levee Vegetation. While the sponsor and USACE have managed to work around this issue in the past, it is possible this issue will come to a head; requiring either resolution or termination of this project. That discussion is outside the scope of this risk analysis and will not be modeled here.

Table 2. Project Cost Comparison Summary (Uncertainty Analysis)

Most Likely Cost Estimate	$36,869,000		
Confidence Level	Project Cost	Contingency	Contingency %
0%	**$33,919,480**	**($2,949,520)**	**-8.00%**
5%	**$37,975,070**	**$1,106,070**	**3.00%**
10%	**$38,712,450**	**$1,843,450**	**5.00%**
15%	**$39,081,140**	**$2,212,140**	**6.00%**
20%	**$39,818,520**	**$2,949,520**	**8.00%**
25%	**$40,187,210**	**$3,318,210**	**9.00%**
30%	**$40,924,590**	**$4,055,590**	**11.00%**
35%	**$41,293,280**	**$4,424,280**	**12.00%**
40%	**$41,661,970**	**$4,792,970**	**13.00%**
45%	**$42,030,660**	**$5,161,660**	**14.00%**
50%	**$42,399,350**	**$5,530,350**	**15.00%**
55%	**$42,768,040**	**$5,899,040**	**16.00%**
60%	**$43,136,730**	**$6,267,730**	**17.00%**
65%	**$43,505,420**	**$6,636,420**	**18.00%**
70%	**$43,874,110**	**$7,005,110**	**19.00%**
75%	**$44,242,800**	**$7,373,800**	**20.00%**
80%	**$44,980,180**	**$8,111,180**	**22.00%**
85%	**$45,717,560**	**$8,848,560**	**24.00%**
90%	**$46,454,940**	**$9,585,940**	**26.00%**
95%	**$47,192,320**	**$10,323,320**	**28.00%**
100%	**$51,985,290**	**$15,116,290**	**41.00%**

7.2 Recommendations

Risk Management is an all-encompassing, iterative, and life-cycle process of project management. The Project Management Institute's (PMI) *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)*, *4th edition*, states that "project risk management includes the processes concerned with conducting risk management planning, identification, analysis, responses, and monitoring and control on a project." Risk identification and analysis are processes within the knowledge area of risk management. Its outputs pertinent to this effort include the risk register, risk quantification (risk analysis model), contingency report, and the sensitivity analysis.

The intended use of these outputs is implementation by the project leadership with respect to risk responses (such as mitigation) and risk monitoring and control. In short, the effectiveness of the project risk management effort requires that the proactive management of risks not conclude with the study completed in this report.

The Cost and Schedule Risk Analysis (CSRA) produced by the PDT identifies issues that require the development of subsequent risk response and mitigation plans. This section provides a list of recommendations for continued management of the risks identified and analyzed in this study. Note that this list is not all inclusive and should not substitute a formal risk management and response plan.

Risk Management: Project leadership should use of the outputs created during the risk analysis effort as tools in future risk management processes. The risk register should be updated at each major project milestone. The results of the sensitivity analysis may also be used for response planning strategy and development. These tools should be used in conjunction with regular risk review meetings.

Risk Analysis Updates: Project leadership should review risk items identified in the original risk register and add others, as required, throughout the project life-cycle. Risks should be reviewed for status and reevaluation (using qualitative measure, at a minimum) and placed on risk management watch lists if any risk's likelihood or impact significantly increases. Project leadership should also be mindful of the potential for secondary (new risks created specifically by the response to an original risk) and residual risks (risks that remain and have unintended impact following response).

Project Specific: Funding and bidding competition must be periodically re-evaluated to ensure sufficient budget is available to perform the work objectives as authorized. .

APPENDIX A – RISK REGISTER

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost	Schedule
				Risk Level*	Risk Level*
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)					
	PROJECT & PROGRAM MGMT				
PPM-1	Scope Definition	Questions remain unsettled about controlling criteria. Project is authorized for additional 80,000 LF yet recent HQ guidance now requires additional bank protection to comply with Corps planning policy (i.e. B/C ratios etc).	District has agreed to perform B/C economic analysis for all sites deemed critical. Estimate is based on 106 representative sites, of which some 12,000LF have economic justification. In the future, sites may change but project costs and risks will be based on 80,000 LF. Given the potential huge project changes if economic justification is required, modeling this risk is outside scope of this risk analysis and will not be modeled.	HIGH	LOW
PPM-2	Project Priorities	Given the long project duration with undefined critical path and conflicts with District priorities; project has received intermittent support. Only after emergency events does this project receive priority status.	Limited resources and project staffing turnover affect continuity, lost efficiencies and schedule. Districts historical averages have been used for the estimate, it is possible design costs could increase but only marginally at most.	LOW	LOW
PPM-3	Internal Red Tape	Internal decision making process has delayed project.	Discussions on Economic Justification have delayed schedules. Economically disadvantaged sites are some 5 years or more from implementation, allowing for sufficient time for resolution prior to site implementation. Not a Risk for Economically Justified Sites so will not be considered for this evaluation.	LOW	MODERATE
PPM-4	Project Partnership Agreement Signature	PPA signature is due within the next year and must be signed for project to continue.	USACE HQ and State sponsor are currently at an impasse on signature of the PPA due to current ETL policy (levee vegetation requirements). If PPA is not signed, project funding will cease and project schedule will slip. Given the potential huge project impact if PPA is not achieved, modeling this risk is outside scope of this risk analysis and will not be included.	LOW	HIGH

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	CONTRACT ACQUISITION RISKS				
CA-1	Small Business vs. Full and Open	Potential for Small Business Contracts	Much of this work is conducive for small business contracts. The estimate currently assumes full and open contracts. If individual sites are advertised via Small Business, 8(a) contractors, anticipate additional contract acquisition costs, construction costs and district resources for oversight and administration.	HIGH	LOW
CA-2	Numerous Contracts	Contracts will attempt to group sites by Fiscal Year wherever practical to minimize the number of individual contracts.	Multiple sites could be awarded fifty miles or more apart limiting the number of small contractors able to perform the work and potentially lends to more full and open large business contracts.	LOW	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	TECHNICAL RISKS				
TL-1	HTRW	HTRW could be encountered during site excavation and construction.	Borings will be done in a proactive attempt to locate any HTRW. Estimate currently assumes no HTRW is located. It is likely HTRW will be encountered, with marginal cost impacts anticipated. When HTRW is encountered it is possible individual sites schedule may slip but overall project schedule will not slip.	MODERATE	LOW
TL-2	Exploratory Borings	Limited exploratory borings have been taken. Additional geotechnical investigation will be required especially in areas of levee realignment.	Depending on exploratory results, site specific design could change. Design changes are anticipated to be marginal.	MODERATE	LOW
TL-3	Borrow/Fill Sources	Borrow sources have not been located. It is typically the contracts responsibility to procure borrow material.	Estimate assumes purchased material. For large fill volumes this could be impossible. Haul distances or commercial prices could increase significantly.	HIGH	LOW
TL-4	Rip Rap Supply	Rock quarry availability over time.	Rock placement has been ongoing since 1960's and will be required for another 40years. Availability of suitable rip rap at current haul distances may not be possible.	MODERATE	LOW
TL-5	Survey Data	Delayed survey data.	For previous project locations obtaining temporary site access has been delayed postponing survey data consequently postponing design and resulting in compressed schedules or construction schedules slipping to next FY. Risk does not necessarily cause overall program schedule impacts but does result in increased PED costs.	MODERATE	LOW
TL-6	Design Criteria	Delays in procurement have resulted in need to update designs for revised criteria.	Design criteria changes have lead to changes for projects put "on the shelf". When projects are awarded additional design updates are required with marginal construction cost increases.	MODERATE	LOW
TL-7	Design Assumptions	Current construction and design are all based on certain core design assumptions and principals. Changes to those assumptions would result in significant design re-work.	Many sites have been constructed. If inspections of constructed sites show current design methodology is not performing as expected designs could change resulting in significant design re-work.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	LANDS AND DAMAGES RISKS				
LD-1	Real Estate Acquisition	Large portions of the existing levee (majority) are still privately owned. Design may require acquisition of new real estate to enable repair requirements.	Almost all areas will require real estate actions; ranging from letters to State asking for easements on State land to acquisition of private property. Real Estate costs have been developed for the representative 106 sites, a majority of which required real estate actions. Any variation in sites will probably experience similar real estate costs. Current design features sections of riverside erosion control that could instead be replaced with landside setback levees requiring additional real estate acquisition with significant cost impacts. Real Estate acquisition is critical driver for all project sites. For Risk Mitigation purposes, site selection is flexible. If Real Estate acquisition is difficult, different sites can be selected. Project is scheduled for 40 years, allowing time for flexible real estate acquisitions. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	HIGH	LOW
LD-2	Railroad Involvement	Interactions with railroad have been problematic.	Every effort will be made to work outside railroad properties, but there are areas where the railroad is located on the levee. Given the 40 year project duration, PDT is being proactive and pursuing difficult acquisitions with sufficient lead time to address issues prior to fixes at sites. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	MODERATE	LOW
LD-3	Environmental Mitigation - Real Estate	Real Estate acquisitions for environmental acquisitions can be both on and off site.	Estimate captures cost/scope for environmental mitigation acquisition requirements. It is possible additional real estate will be required. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	HIGH	LOW
LD-4	Utility Relocations	Large number and variety of requirements for utility relocations.	Variable nature of relocation requirements is difficult to quantify. Real Estate estimates do well in capturing most known utility requirements, but potential unknown utilities remain. REAL ESTATE CONTINGENCY HAS BEEN DEVELOPED INDEPENDENTLY AND WILL NOT BE INCLUDED IN THIS EVALUATION.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	REGULATORY AND ENVIRONMENTAL RISKS				
RE-1	Endangered Species Act	Additional species could be added to ESA.	Additional species could result in additional mitigation costs or design adaptations and changes. It is unlikely to impact cost and no impacts to schedule would be anticipated.	LOW	LOW
RE-2	Offsite Mitigation	Additional offsite mitigation could be required.	As sites information is further refined, it could be discovered additional offsite mitigation efforts will be required to offset impacts. Additional offsite mitigation shouldn't impact schedule.	HIGH	LOW
RE-3	Water and Air Quality	Construction could require air quality credits. Air quality is legislated by local California Resource Board by county and program will overlap multiple regions. Construction could be halted or limited due to water quality impacts.	Baseline Estimate includes costs for monitoring. Marginal additional construction cost impacts should be encountered.	MODERATE	LOW
RE-4	Onsite Mitigation	Depending on Agencies, additional onsite mitigation could be required.	Resource agencies requirements for onsite mitigation continue to evolve, resulting in additional onsite mitigation requirements. ESA consultations have yet to occur. Until consultations occur, restoration ratios have not been established. Additional setback levees in place of riverside repairs may be required.	HIGH	LOW
RE-5	Cultural Resources	It is possible cultural resources could be encountered.	Estimate includes costs for cultural investigations but no costs for mitigations. Cost need to be added for some mitigation for discovery of cultural sites; typically coordinating with local tribes and not removing but protecting resource on site.	MODERATE	LOW
RE-6	Historical Structures	Consultation with State SHIPO has yet to occur.	Additional costs may be necessary for historic documentation of existing levee.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	CONSTRUCTION RISKS				
CON-1	Differing Site Conditions	Heavily dependent on geotechnical design solutions.	Inherent with any geotechnical design comes the possibility of differing site conditions. Given the nature of design solutions (either build new setback levee or overlay existing levees) institute conditions will not be exposed as much as on other typical levee projects. Anticipate lower risks with this item.	MODERATE	LOW
CON-2	Unknown Utilities	Based on previous experience in the project, unknown utilities have rarely been discovered.	For setback levees, it is likely unknown utilities will be encountered, for all other fixes unknown utility impacts are not anticipated.	LOW	LOW
CON-3	Site Access	While access may be remote or round-about for some sites, site and maintenance access is well established.	Minimal Risk is anticipated.	LOW	LOW
CON-4	Construction Windows	All in water work must be completed between April 15 to Nov 30. Depending on contract award dates, durations, and inefficient contractors some contracts could be limited or delayed to the following construction season.	In general this has been a minimal risk, with worst case a one season schedule slip may occur, impacting local contract schedule but not does not impact overall project schedule.	LOW	LOW
CON-5	Construction Oversight	Given the large number of potential sites/contracts per year, submittal turn around times and construction oversight could be an issue.	Based on previous expense, mods and claims have been experienced leading to cost increases.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
	ESTIMATE AND SCHEDULE RISKS				
EST-1	Quantities	Differences in quantities.	During design or awarded it could be determined additional erosion has occurred and quantities will increase.	HIGH	LOW
EST-2	Utility Relocations	Large number and variety of requirements for utility relocations.	Variable nature of relocation requirements is difficult to quantify. Potential unknown utilities remain.	MODERATE	LOW
EST-3	Estimate Assumptions and Quantities	Estimate is based on "typical" fixes per reach. A survey has been performed for the project, but has only established a single cross section per length of fix. Specific designs, quantity takeoffs and estimates have not been developed.	Feasibility level estimates have been developed. Quantities could vary marginally.	MODERATE	LOW

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost Risk Level*	Schedule Risk Level*
ECONOMIC RISKS					
FL-1	Funding Stream	Federal and Sponsor Funding has been sufficient.	Historically project has been funded $5 to $15 M per year which would be sufficient to maintain projected construction schedule assumptions.	LOW	LOW
Programmatic Risks		(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)			
PR-1	Flood Events and Other Acts of God	Weather events could impact in water construction.	It is possible construction seasons could be delayed or postponed with storm or other weather events resulting in additional construction costs but minimal overall project schedule impacts.	MODERATE	LOW
PR-2	Design Criteria Agreement	Sponsor and USACE agreements on Levee Vegetation	While the sponsor and USACE have managed to work around this issue in the past, it is possible this issue will come to a head; requiring either resolution or termination of this project. That discussion is outside the scope of this risk analysis and will not be modeled here.	HIGH	HIGH

QUANTITIES

Folder level quantities obtained from Planning. See spreadsheet for values and locations.

PROJECT SCOPE

This baseline estimate is for the construction contract portion of the Sacramento Levee repair which has been authorized for 80,000 LF. Approximately 94 preliminary sites have been selected. Assumed construction contract items were obtained from the previous project shown below:

Sacramento River Bank Protection
FY 12 Erosion Repair Sites
Sacramento River RM 71.3R and 157.7R
Contract 6
90% CWE based on 95% P&S Submittals
Drawing No. 50-04-6329
Specification No. 1861

The included scope of work is as shown below:

- ☐ Mobilization / Demobilization
- ☐ Construction of temporary site access to permit trucks to place materials near water
- ☐ Clearing and grubbing
- ☐ Striping of top 2" of topsoil
- ☐ Elderberry bush transplantation
- ☐ SWPPP:
    - o Stabilized access pad for each site
    - o 3' silt fence along site bank
    - o 3 rows of straw wattles
- ☐ Placement of quarry stone - Placed below summer mean water surface elevation (SMWSE)
- ☐ Soil filled quarry stone (30% soil, 70% quarry stone by VOL) - Placed above SMWSE
- ☐ Placement of in-stream wood [appears as dead trees w/ roots placed at waterline]
- ☐ Placement of fascines [12 willow cuttings bundled together. Length ~ 6'. Placed near in-stream wood]
- ☐ Placement of 6" of soil cover - Placed above SMWSE
- ☐ Erosion control seeding [hydro seed area]
- ☐ Placement of a beaver barrier fence [placed above in-stream wood/fascines to protect vegetation placed under service contract portion of contract from swimming beavers].
- ☐ On -Site signage to discourage human disruption of re-vegetated area and warn of fine/prison penalties.

BASIS OF DESIGN

The previous bank protection project listed above in italics. New quantities were provided by Planning.

HAULING

Nordic Industries in Olivehurst, CA, Teichert Aggregates near Cool, CA, George Reed, Inc near Ione, CA and Dutra Materials in San Rafael, CA were the identified as potential sources of rip rap/quarry stone material. Material would be delivered by barge from Dutra Materials and by truck from other potential suppliers. Distances from the source to site were determined using GIS data. An analysis was conducted to determine the most cost efficient source for each site. It was found that north of Sacramento River RM

60.0 it was more cost efficient to haul rip rap. In general, sites south of Sacramento River RM 60.0 would obtain rip rap from Dutra Materials via barge. For certain very short reaches or those with very shallow draft, it is more economical to truck the stone in. Haul distances for each site are noted within the estimate.

CONSTRUCTION WINDOWS

To be determined. It is assumed that each of the preliminary sites will have its own construction and service contract.

OVERTIME

This estimate now assumes overtime (10-hr days, 6 days per week) as it is anticipated that several sites may be gathered into single contracts.

ACQUISITION PLAN

The prime contractor is expected to be an earthwork contractor responsible for general site work. Subcontractors are provided for clearing, tree removal, erosion control seeding, landscaping and paving. Hauling subcontractors previously used in the estimate have been substituted with sub-bid costs based on local hauling rates for trucking ‘brokers” in the Sacramento area.

SITE ACCESS

This depends on each individual site. Often service roads are present and can be used for access. In some sites, road improvement and/or creation will be needed. In other sites, access will be obtained through the usage of barge platforms.

CONSTRUCTION METHODOLOGY

Standard earthwork methodology.

UNUSUAL CONDITIONS

None.

UNIQUE TECHNIQUES OF CONSTRUCTION

None.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED

This estimate meets Davis Bacon wage rates for Davis Bacon wage determinations for the Sacramento County, General Decision Numbers CA 140009 as of 1/17/2014 and Wage Determination 2005-2056 06/19/2013. Equipment unit costs are obtained from the 2011 MCACES Equipment Library. Material prices were obtained from quotes or pricelists obtained since January 2013, previous similar estimates and the MCACES Cost Book. Sales tax is applied at 8.25%.

ENVIRONMENTAL CONCERNS

Costs for implementation of the SWPPP are included in the estimate. Costs for preparation are assumed to be part of JOOH.

EQUIPMENT, LABOR RATES, MATERIAL AND OTHER COSTS

Labor rates utilized from LLS2014 (*Local Labor Library - Sacramento 2014*). Equipment prices obtained from the MII 2011 Region 7 Manual. Material prices based off of prices found online.

SACRAMENTO RIVER BANK PROTECTION PROJECT

Hydraulics Evaluation Technical Memo ***March, 2011***

The purpose of this technical memorandum (TM) is to provide hydraulics information for the Sacramento River Bank Protection Project. No hydraulic modeling was requested at this time; therefore, best available hydraulic modeling information from the US Army Corps of Engineers (USACE) Comprehensive Study dated 2002 was used for this evaluation. HEC-RAS models for the Sacramento and San Joaquin Rivers, obtained by conversion from the Comprehensive Study UNET models, were provided to HDR by the California Department of Water Resources (DWR) for use with the Central Valley Floodplain Evaluation and Delineation project. The Sacramento River HEC-RAS model based on the NGVD 29 vertical datum was used to obtain hydraulic modeling information from approximately half a mile upstream to approximately half a mile downstream of each of the following river mile (RM) locations:

- Cache Slough - RM 15.9, RN 23.6
- Georgiana Slough - RM 3.6, RM 3.7, RM 4.0
- Sacramento River - RM 21.5, RM 22.5, RM 22.7, 23.2

Table 1 provides the HEC-RAS stationing information and variations in water surface elevations and channel velocities for the 100-year storm event at these locations obtained from the Comprehensive Study.

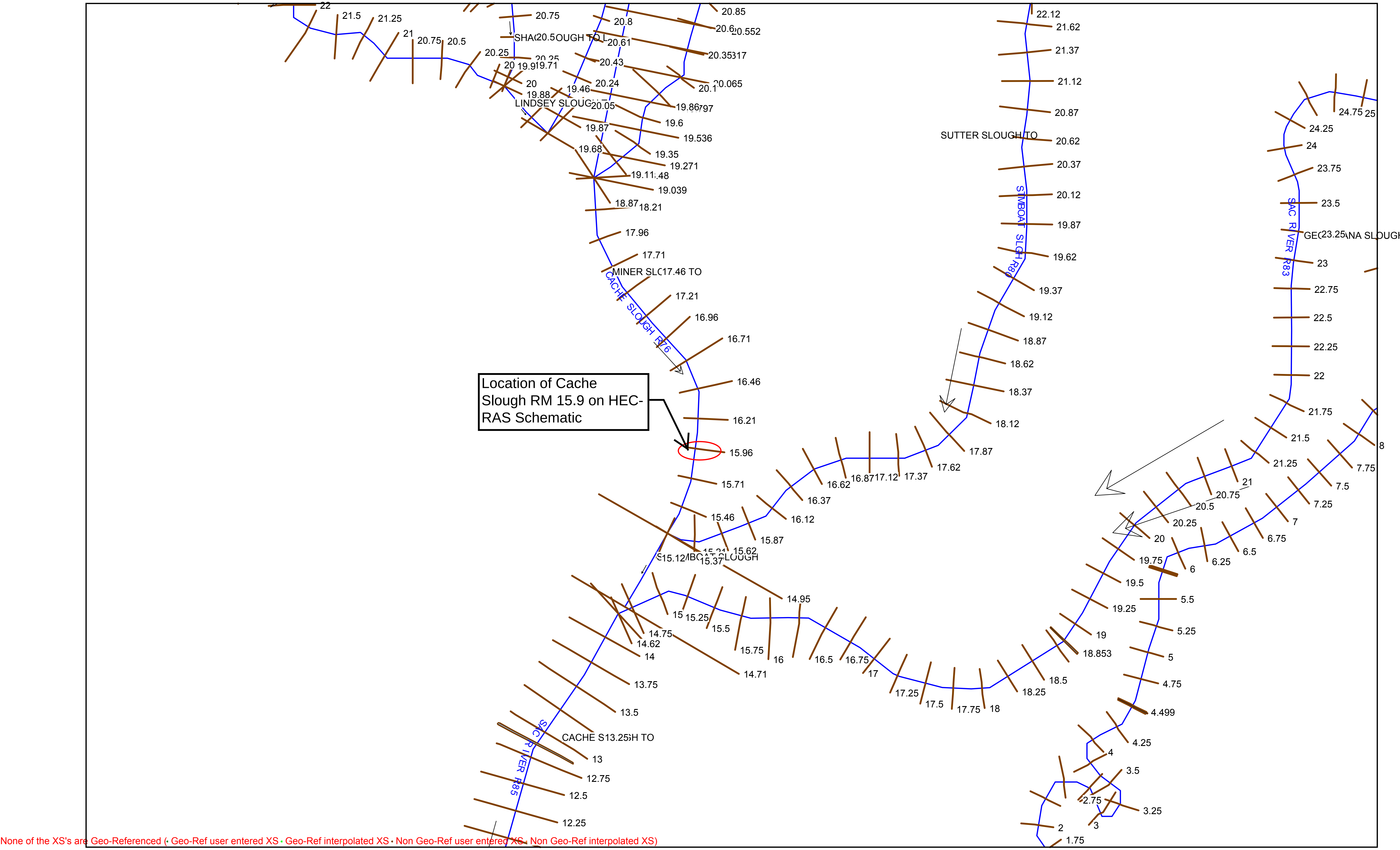
Table 1: Hydraulic Modeling Information from the 2002 Comprehensive Study

River Mile Location	Start and End HEC-RAS Stationing for Reach*	Variation in Water Surface Elevation for Reach (ft, NGVD 29)	Variation in Channel Velocity for Reach (ft/s)
Cache Slough RM 15.9	RM 15.46 - RM 16.46	13.2 to 16.0	6 to 11
Cache Slough RM 23.6	RM 23 - RM 24.25	21.3**	0.04 to 0.35
Georgiana Slough RM 3.6	RM 3.0 to RM 4.0	9.8 to 10.8	3.5 to 4.3
Georgiana Slough RM 3.7	RM 3.25 to RM 4.25	10.0 to 11.0	3.5 to 4.3
Georgiana Slough RM 4.0	RM 3.5 to RM 4.499	10.2 to 11.2	3.5 to 4.3
Sacramento River RM 21.5	RM 21.0 to 22.0	14.7 to 15.1	4.2 to 4.6
Sacramento River RM 22.5	RM 22.0 to 23.0	15.1 to 15.5	4.2 to 4.7
Sacramento River RM 22.7	RM 22.25 to RM 23.25	15.2 to 15.6	4.1 to 4.7
Sacramento River RM 23.2	RM 22.75 to RM 23.75	15.4 to 15.8	4.1 to 4.7

Notes: *The reach considered for each river mile location extends from approximately half a mile upstream to approximately half a mile downstream of that location.

**For the reach from RM 23 to RM 24.25, the channel does not have adequate capacity to contain the 100-year flood.

The attachments to this TM include the following information for each of the RM locations: HEC-RAS schematic showing the location, output profile figures from HEC-RAS for each reach, and HEC-RAS plots for all cross sections within that reach. Water surface elevations and channel velocities for the 100-year storm event at each HEC-RAS cross section are provided in the output profile figures.


Location of Cache Slough RM 15.9 on HEC-RAS Schematic
CACHE SLOUGH R76
STMBOAT SLGH R80
SAC RIVER R83
SAC RIVER R85
SUTTER SLOUGH TO
MINER SLO
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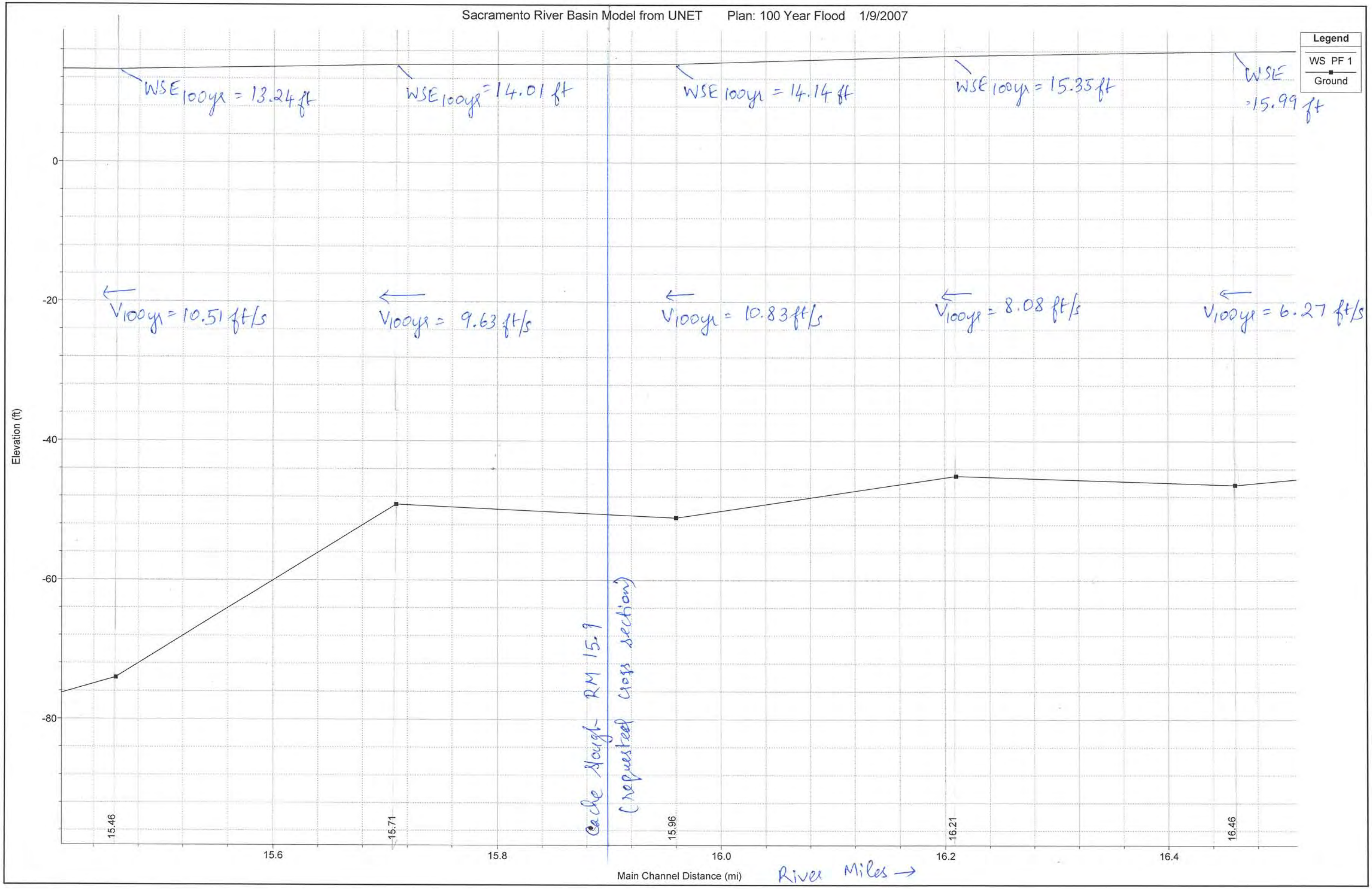
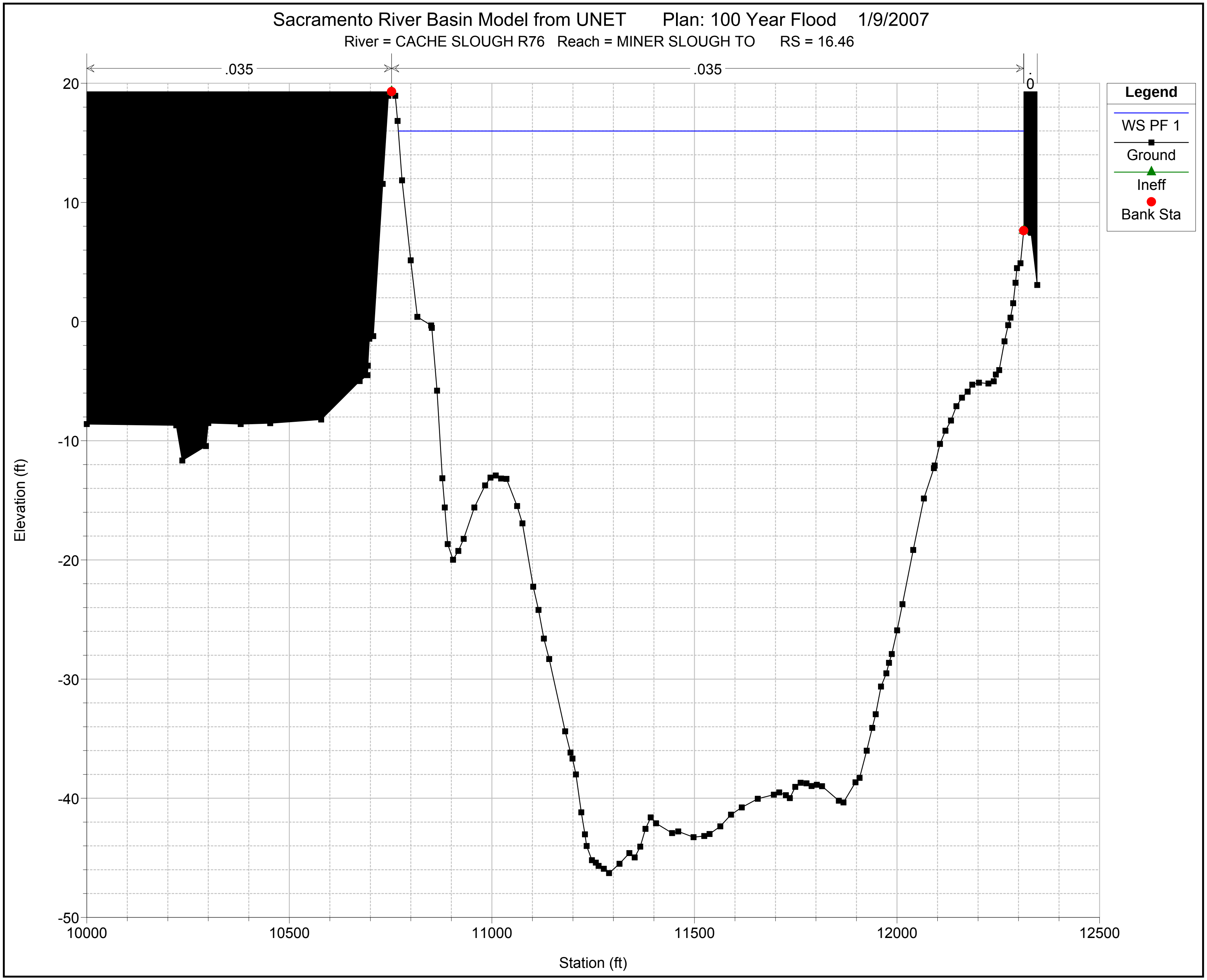
CACHE S
GEORGIANA SLOUGH
None of the XS's are Geo-Referenced (Geo-Ref user entered XS · Geo-Ref interpolated XS · Non Geo-Ref user entered XS · Non Geo-Ref interpolated XS)

HEC-RAS Profile Drawing for Cache Slough RM 15.9





Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = CACHE SLOUGH R76 Reach = MINER SLOUGH TO RS = 16.46
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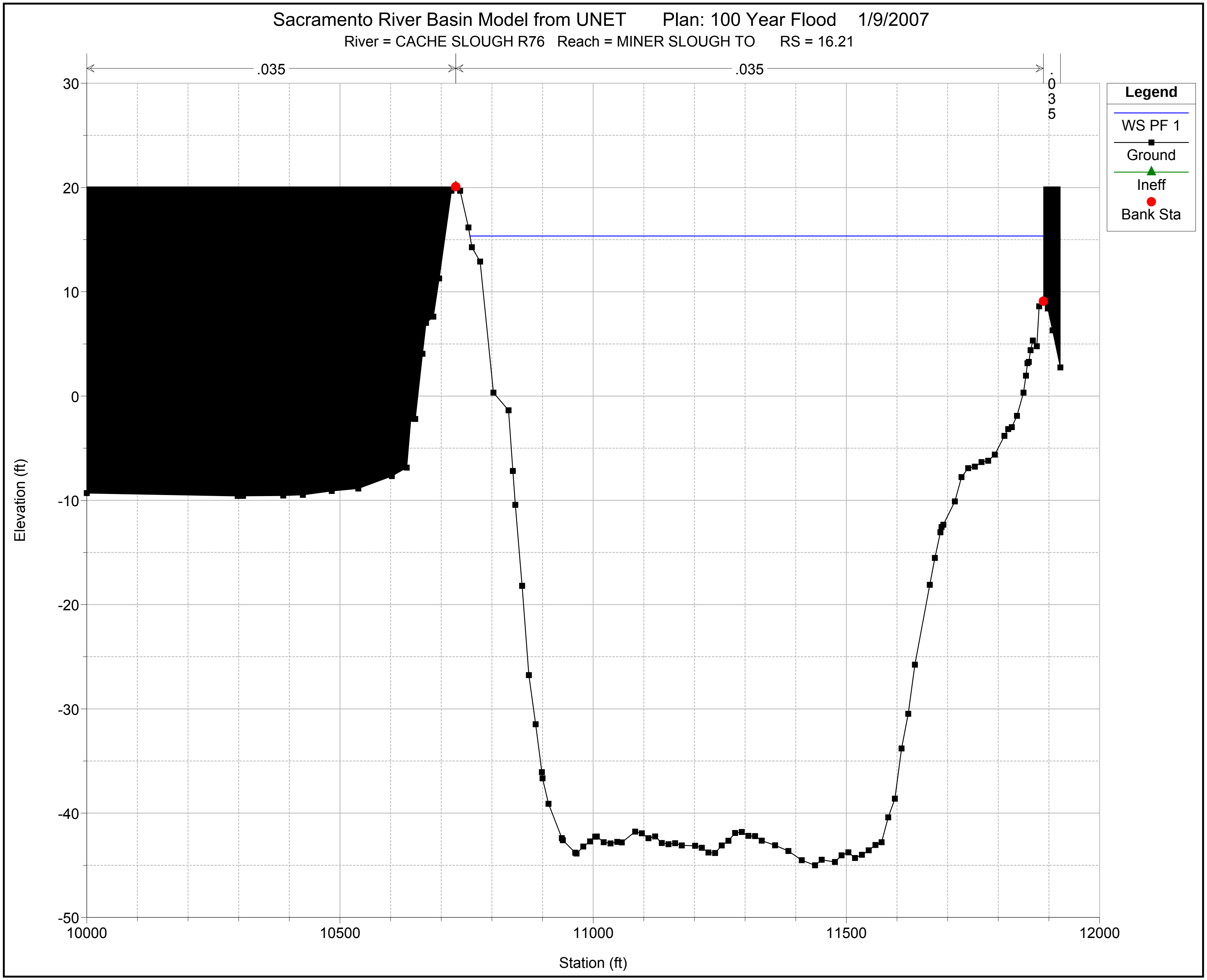

Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
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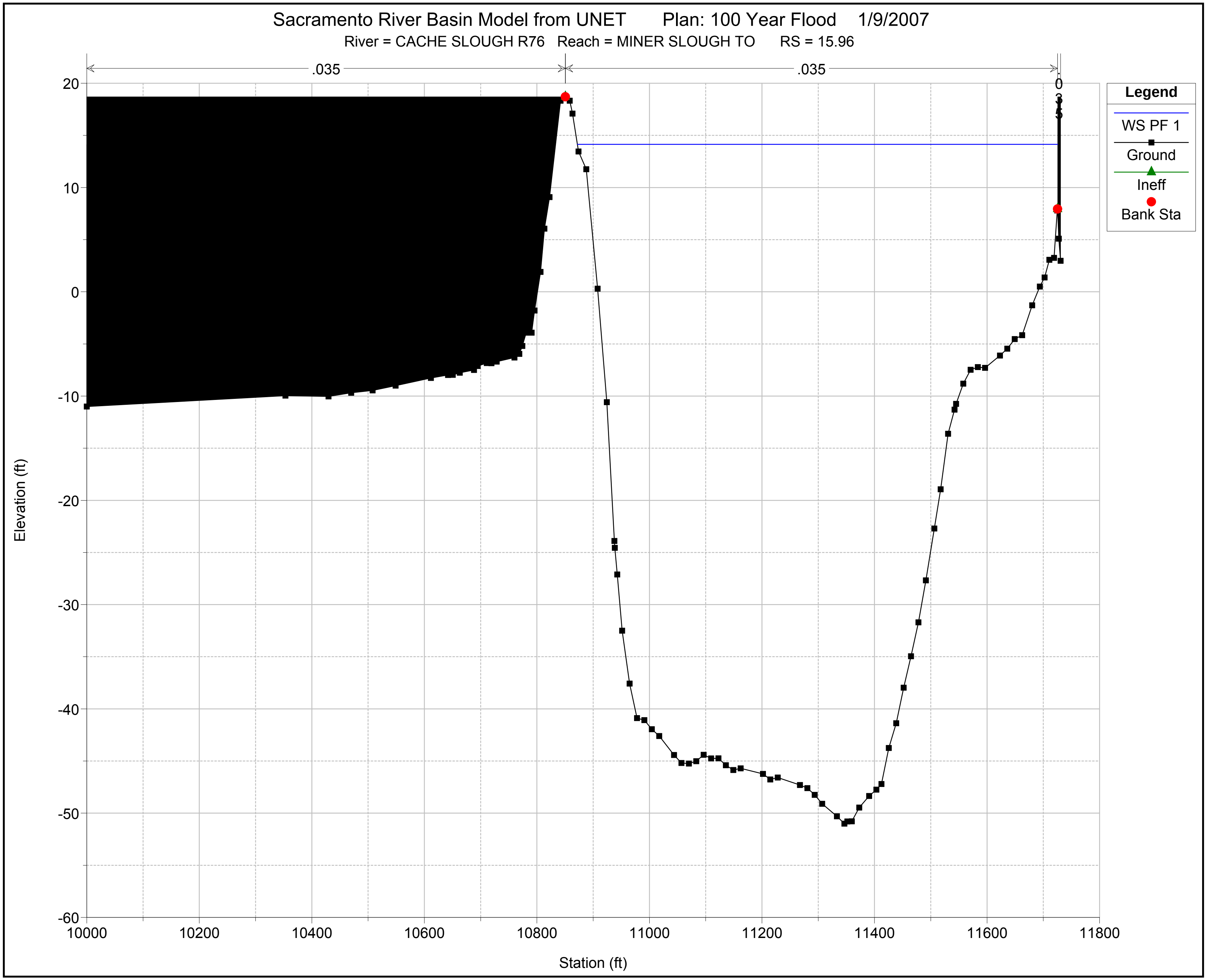

Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
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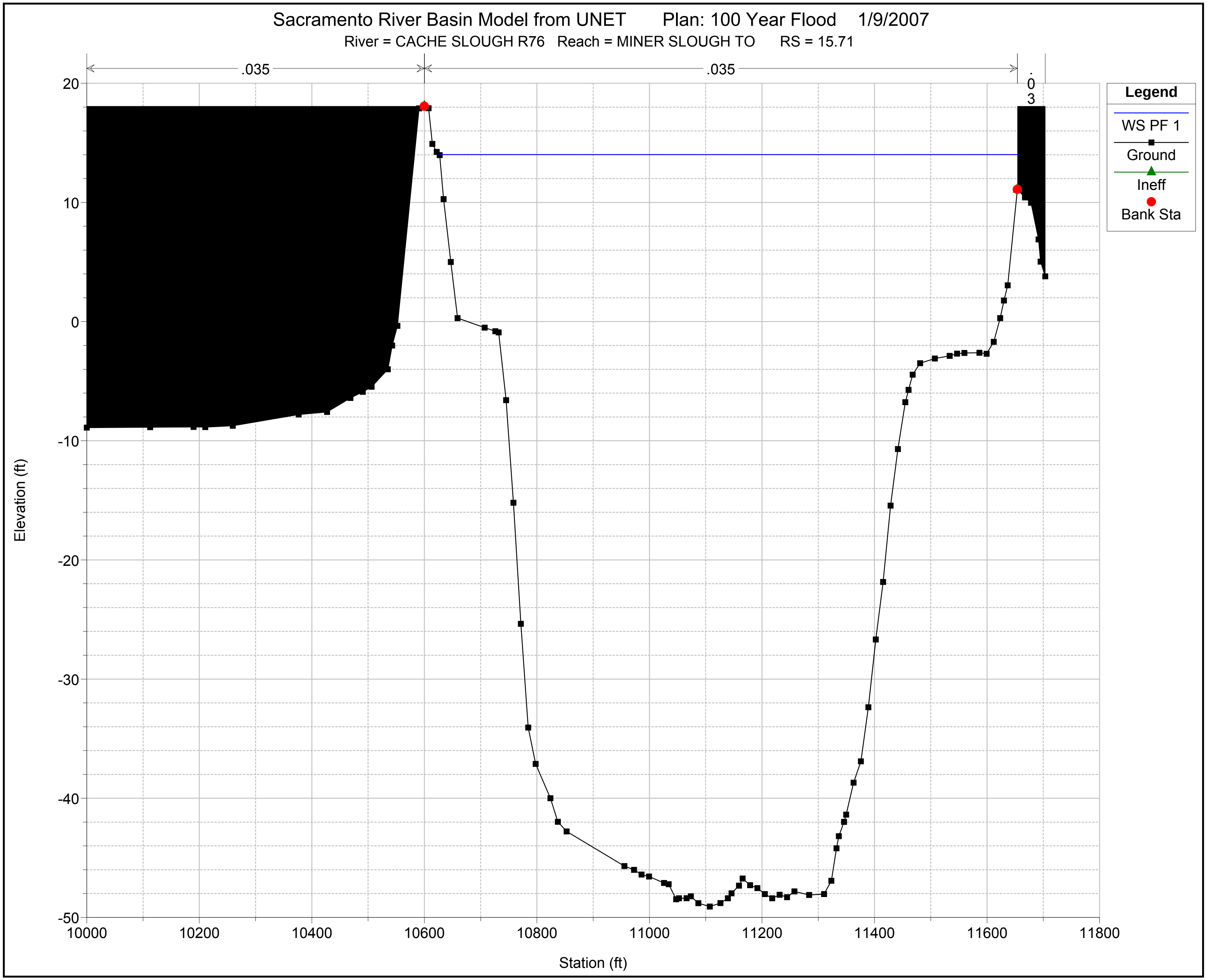

Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
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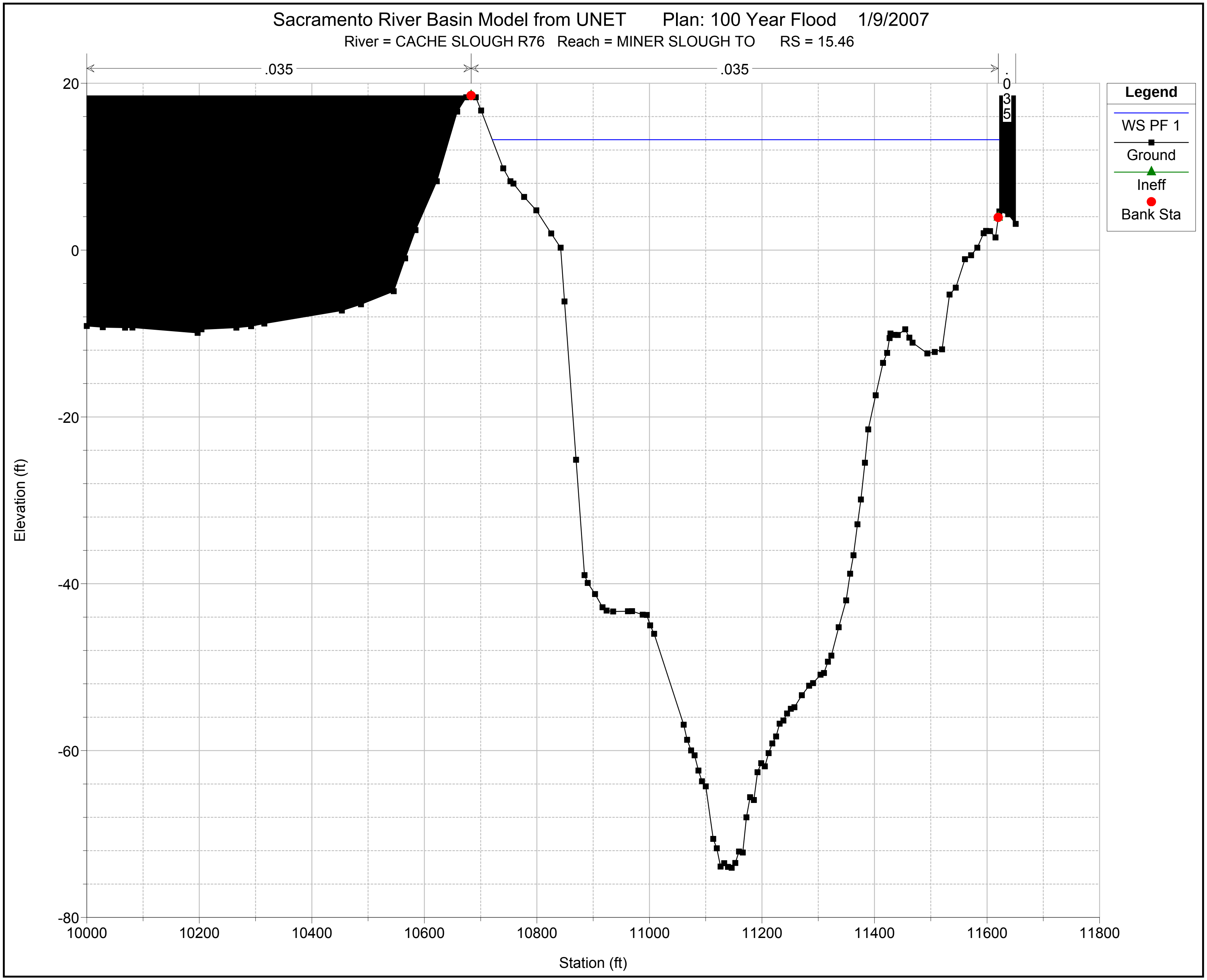
Station (ft)



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = CACHE SLOUGH R76 Reach = MINER SLOUGH TO RS = 15.46
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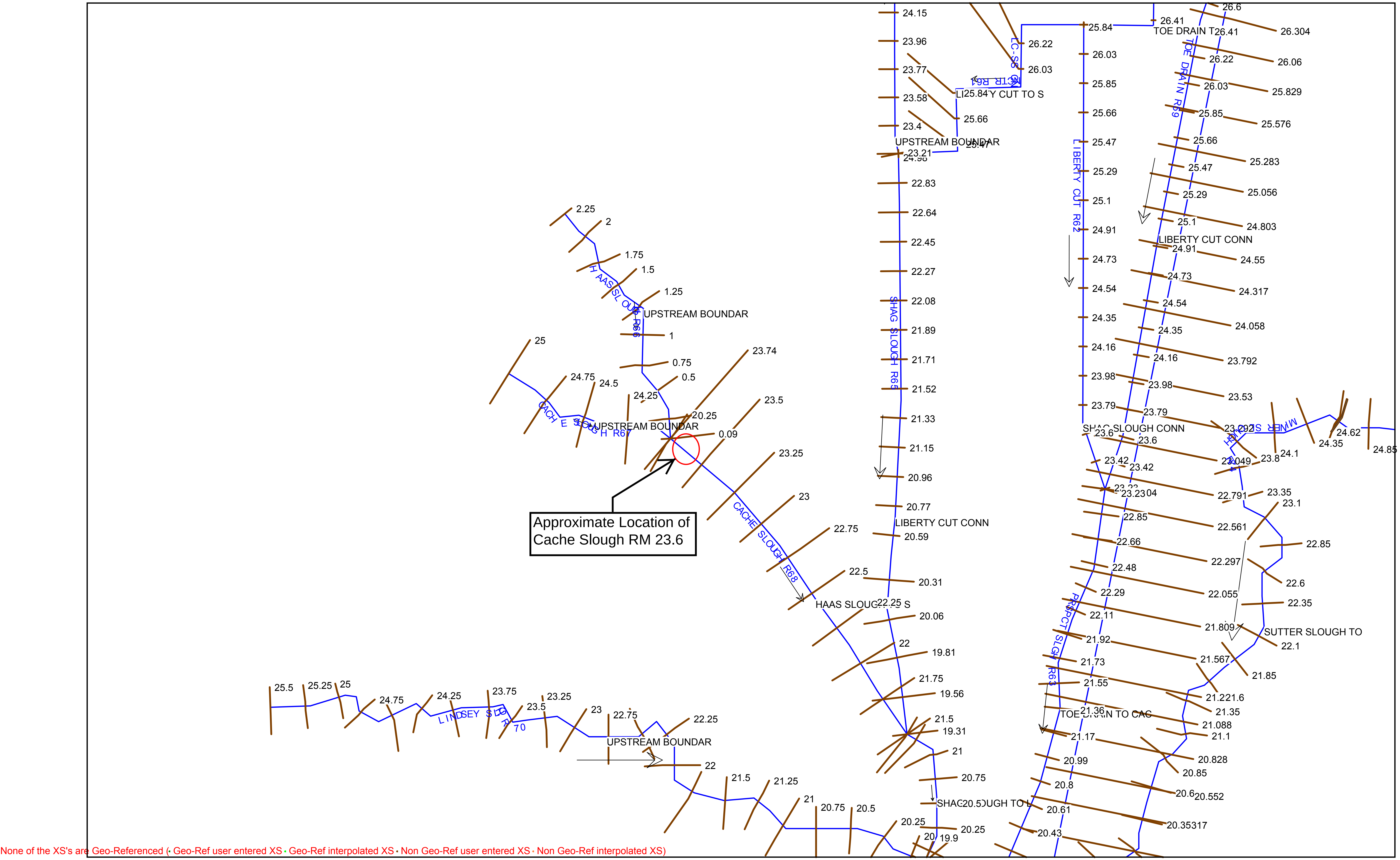
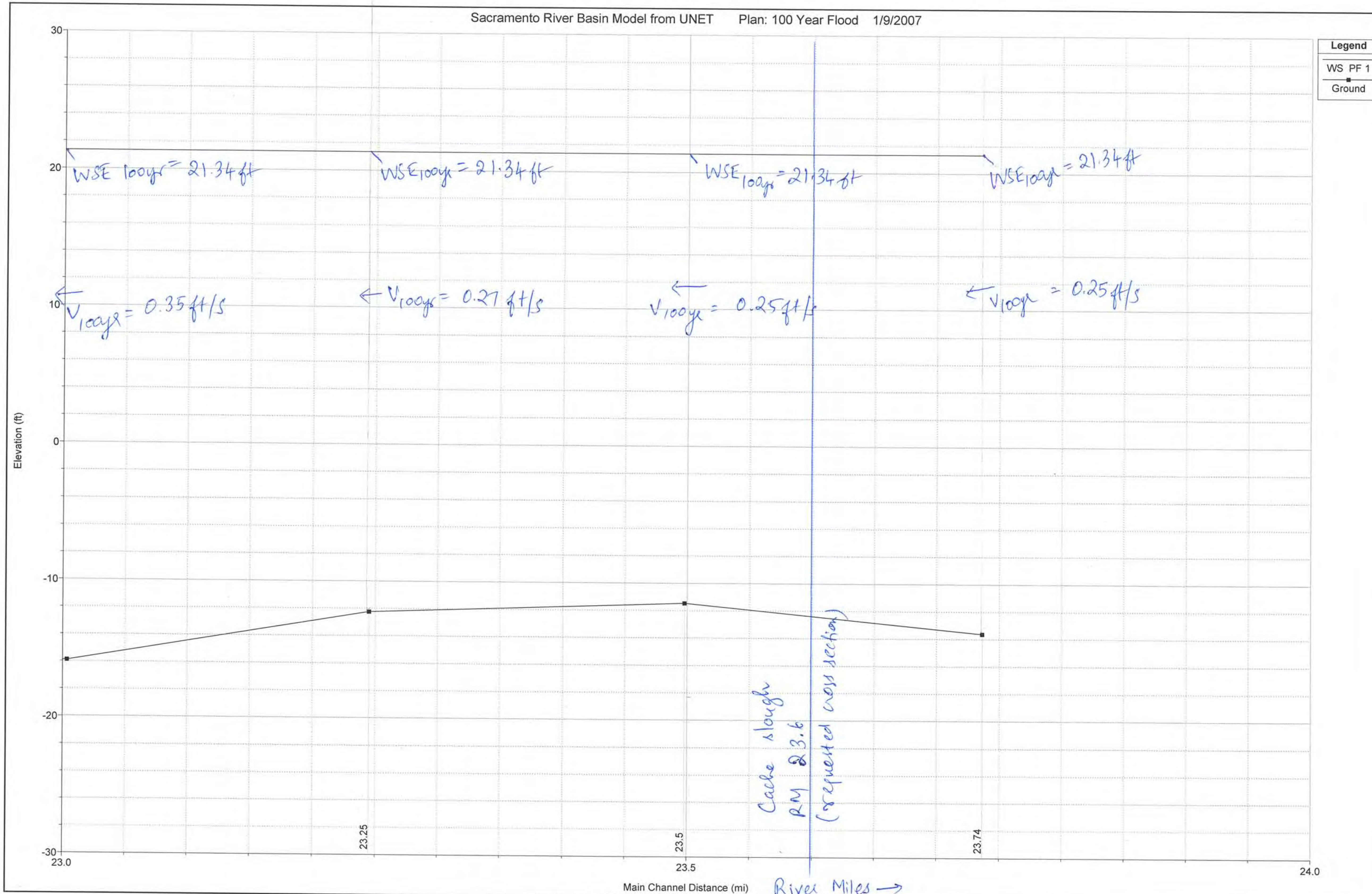
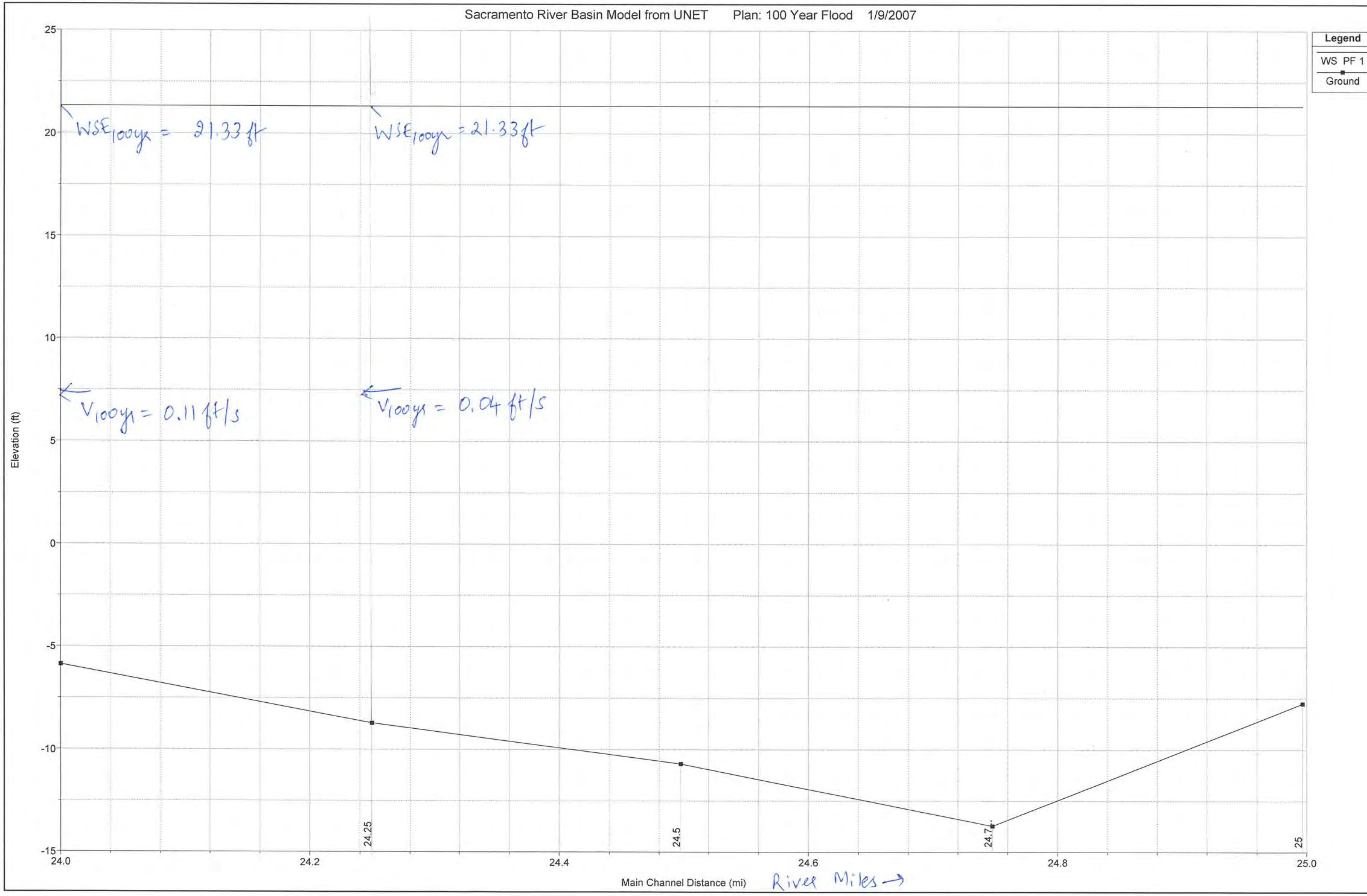
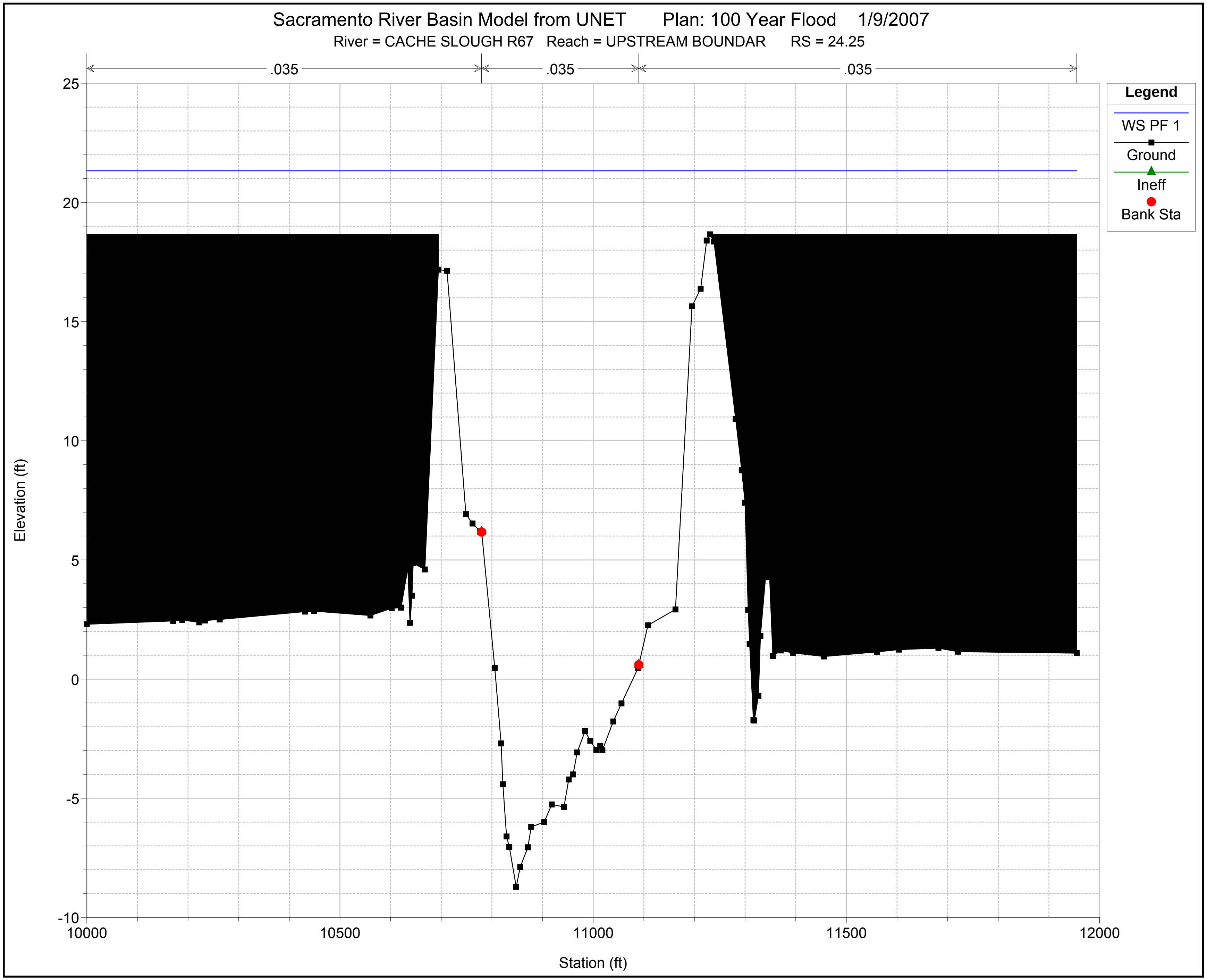

Approximate Location of
Cache Slough RM 23.6
CACHE SLOUGH R68
CACHE SLOUGH R67
HAAS SLOUGH R66
SHAG SLOUGH R65
LIBERTY CUT R62
TOE DRAIN R69
PROSPECT SLGH R63
LINDSEY SLGH R70
UPSTREAM BOUNDAR
LIBERTY CUT CONN
SHAG SLOUGH CONN
HAAS SLOUGH
SUTTER SLOUGH TO
TOE DRAIN TO CAC
SHAG SLOUGH TO
None of the XS's are Geo-Referenced (Geo-Ref user entered XS · Geo-Ref interpolated XS · Non Geo-Ref user entered XS · Non Geo-Ref interpolated XS)

HEC-RAS Profile Drawing for Cache Slough RM 23.6 Sheet 1

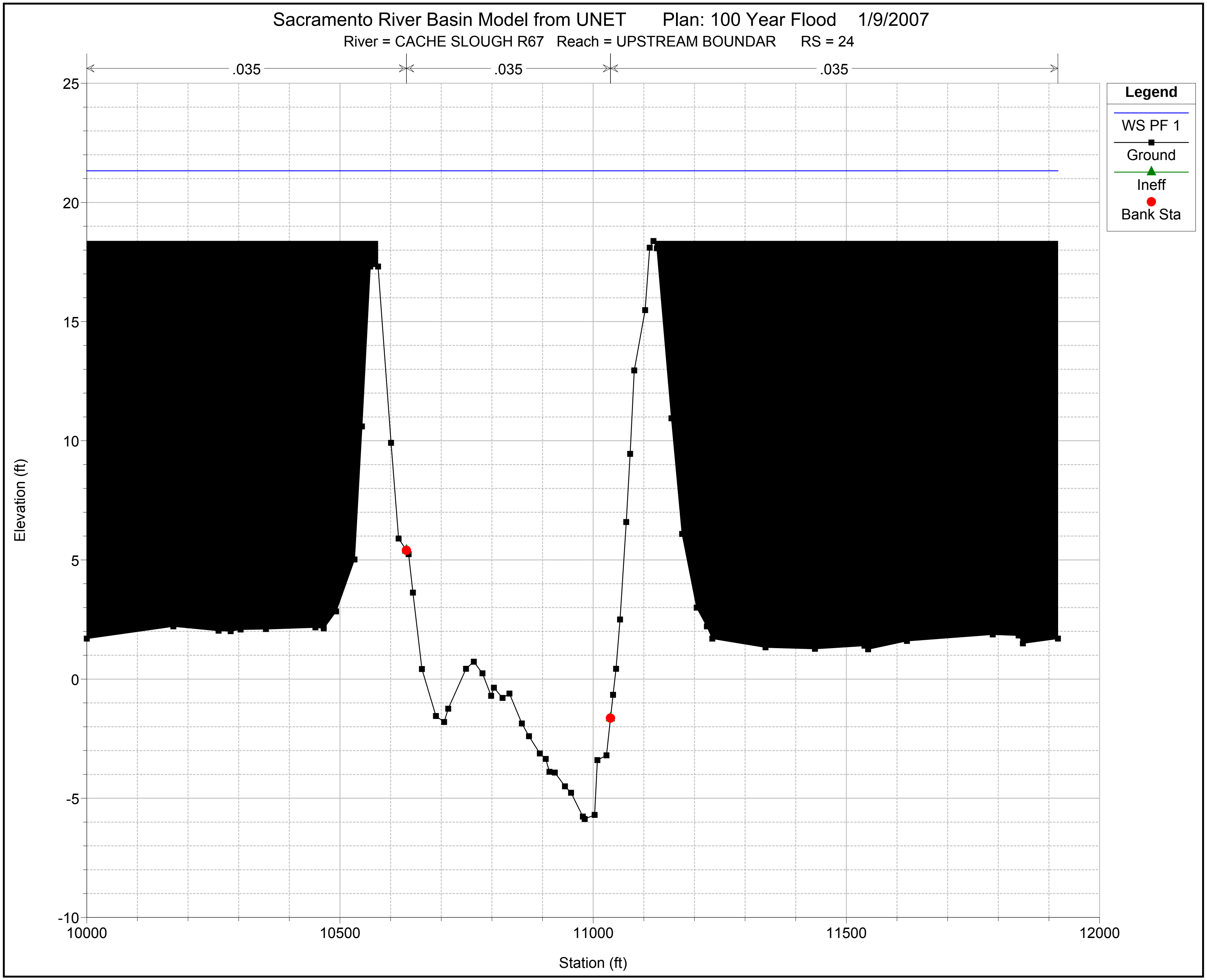


HEC-RAS Profile Drawing for Cache Slough RM 23.6 Sheet 2

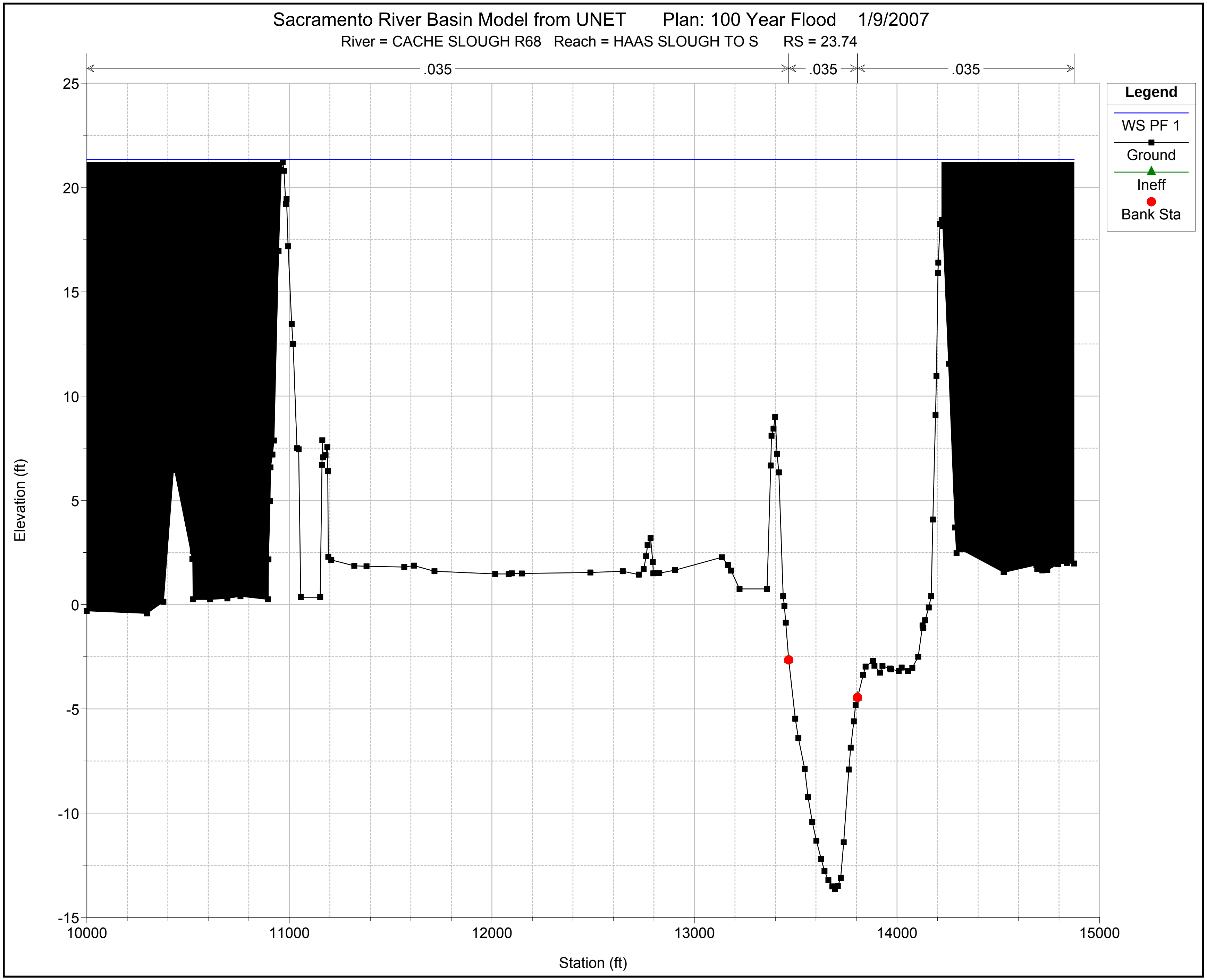




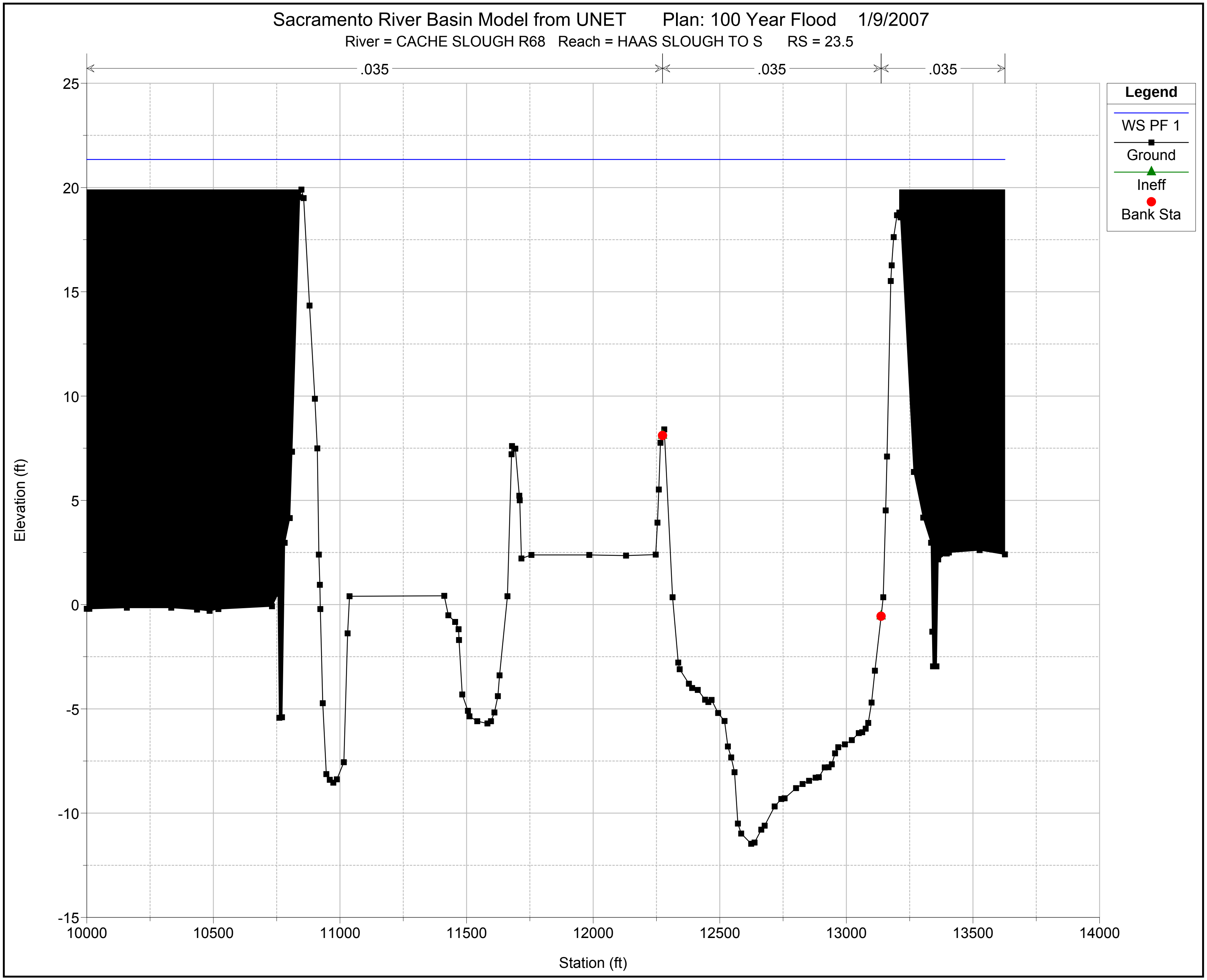
Note: The channel does not have adequate capacity at this location to contain the 100-year flood.



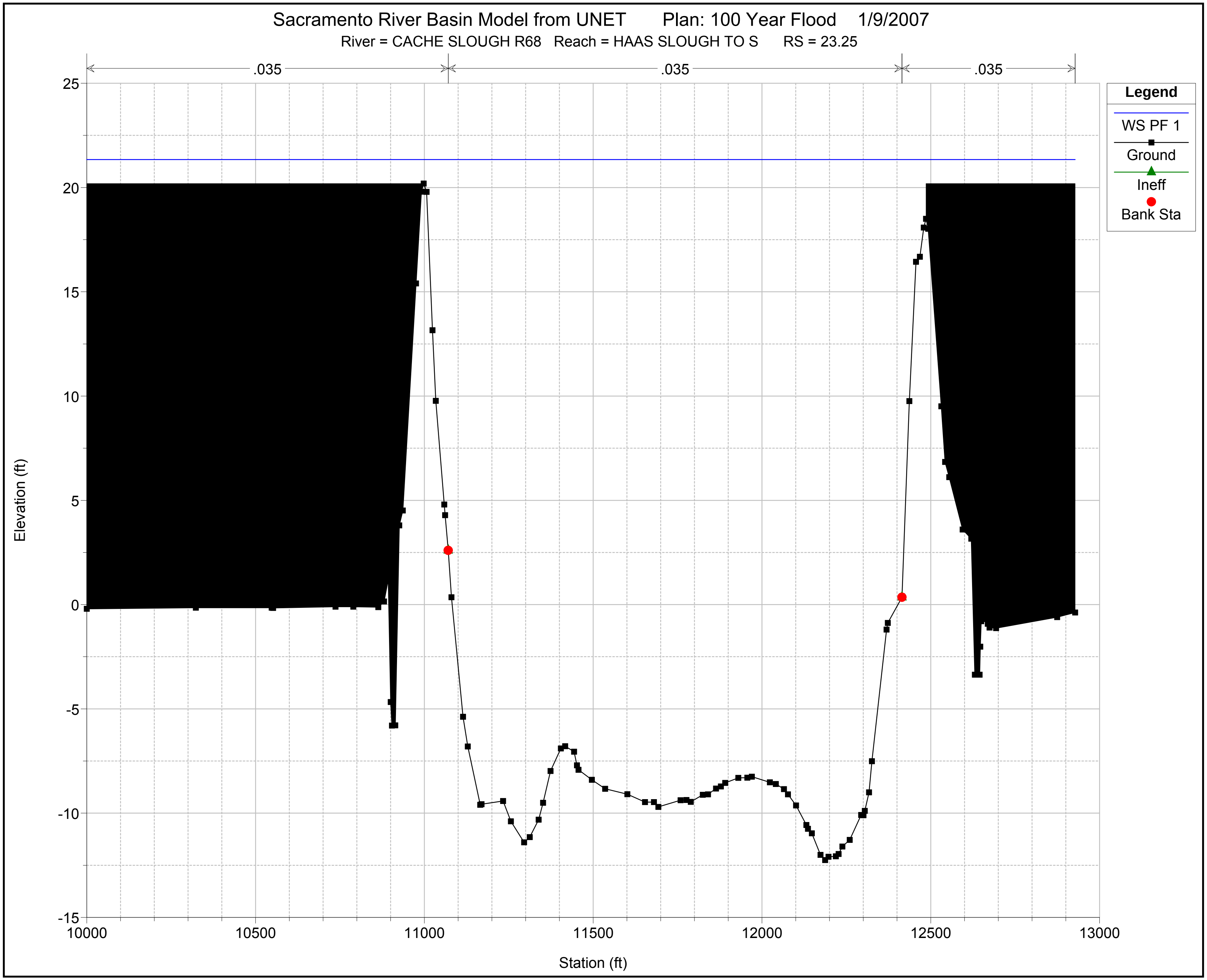
Note: The channel does not have adequate capacity at this location to contain the 100-year flood.



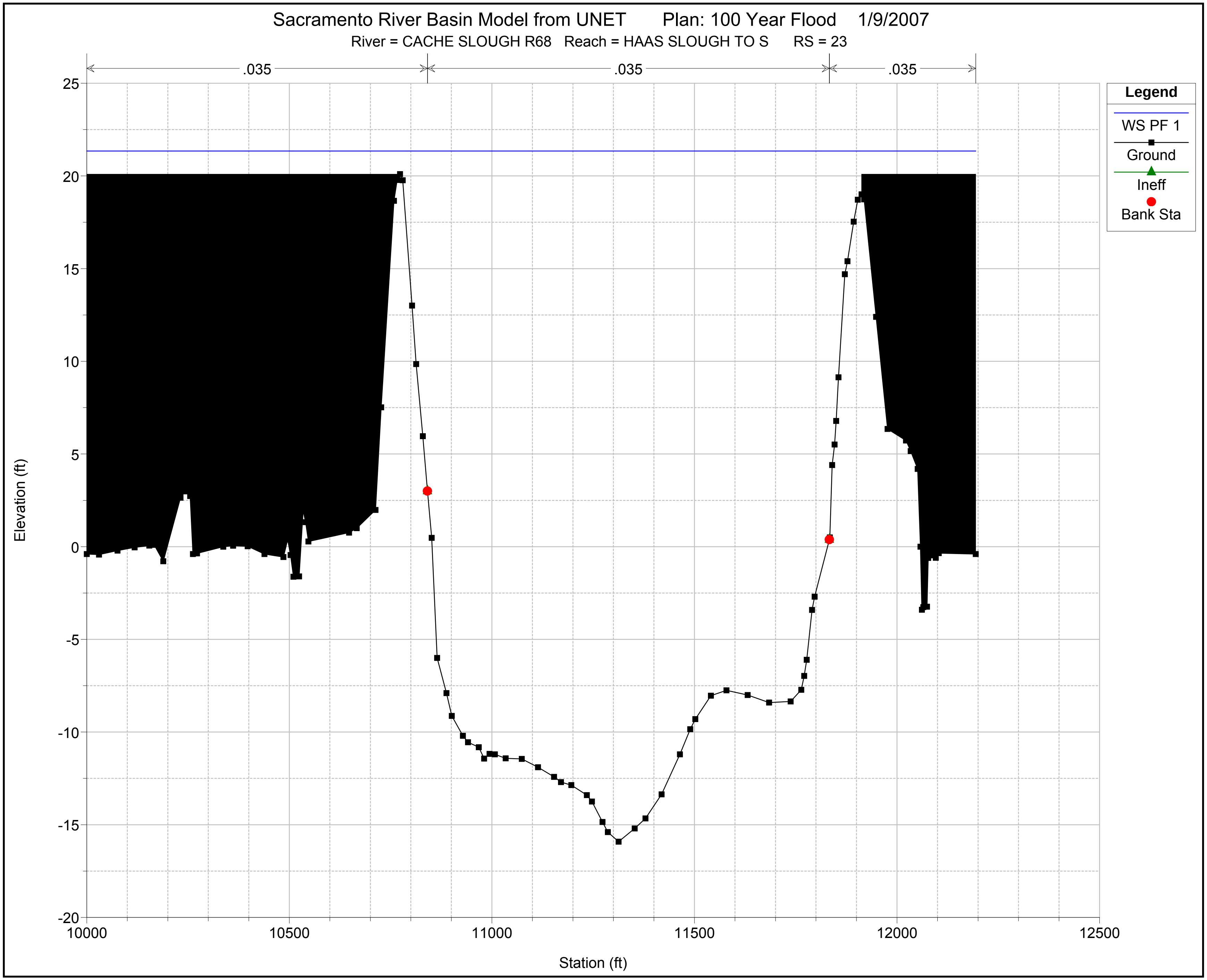
Note: The channel does not have adequate capacity at this location to contain the 100-year flood.



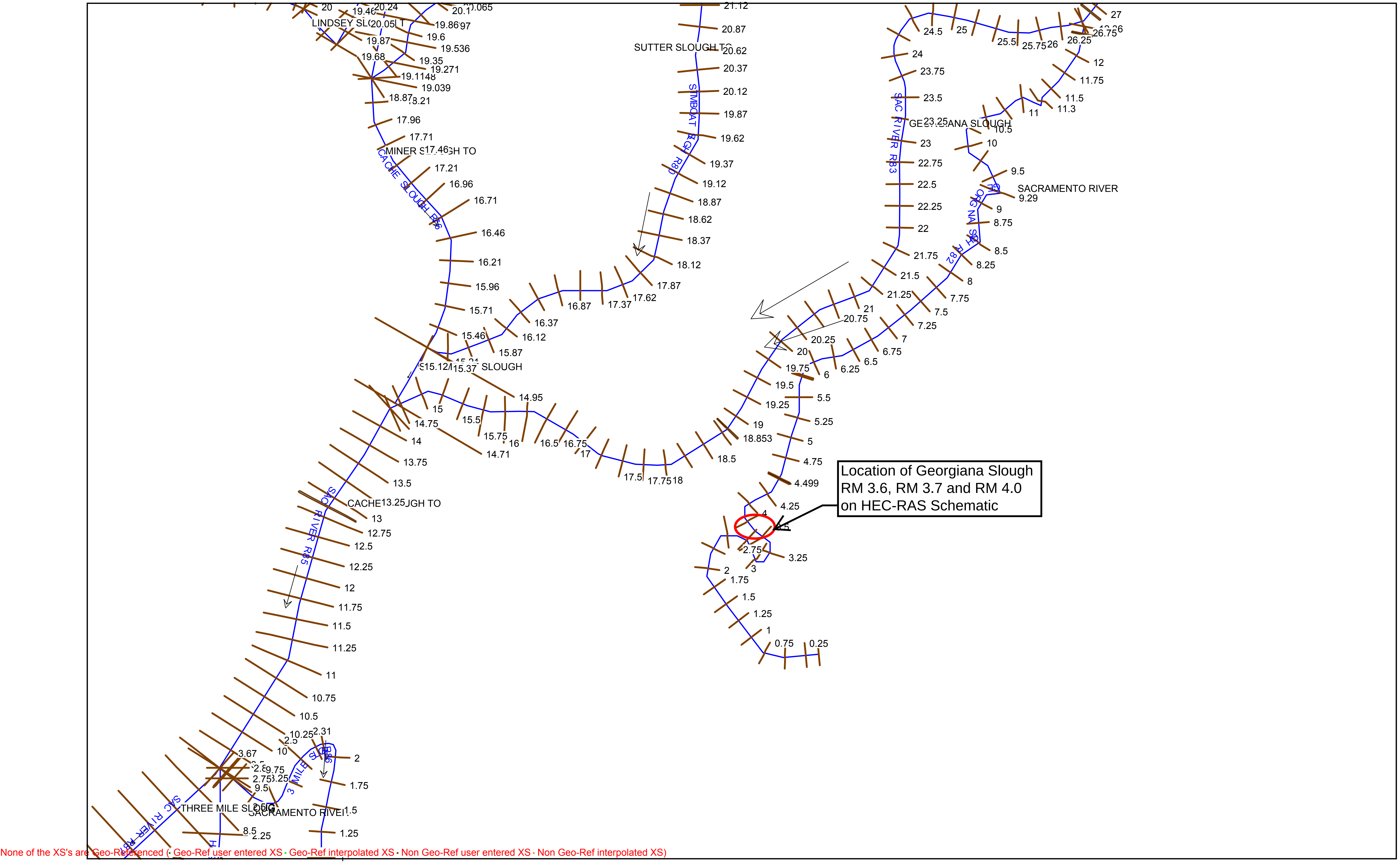
Note: The channel does not have adequate capacity at this location to contain the 100-year flood.



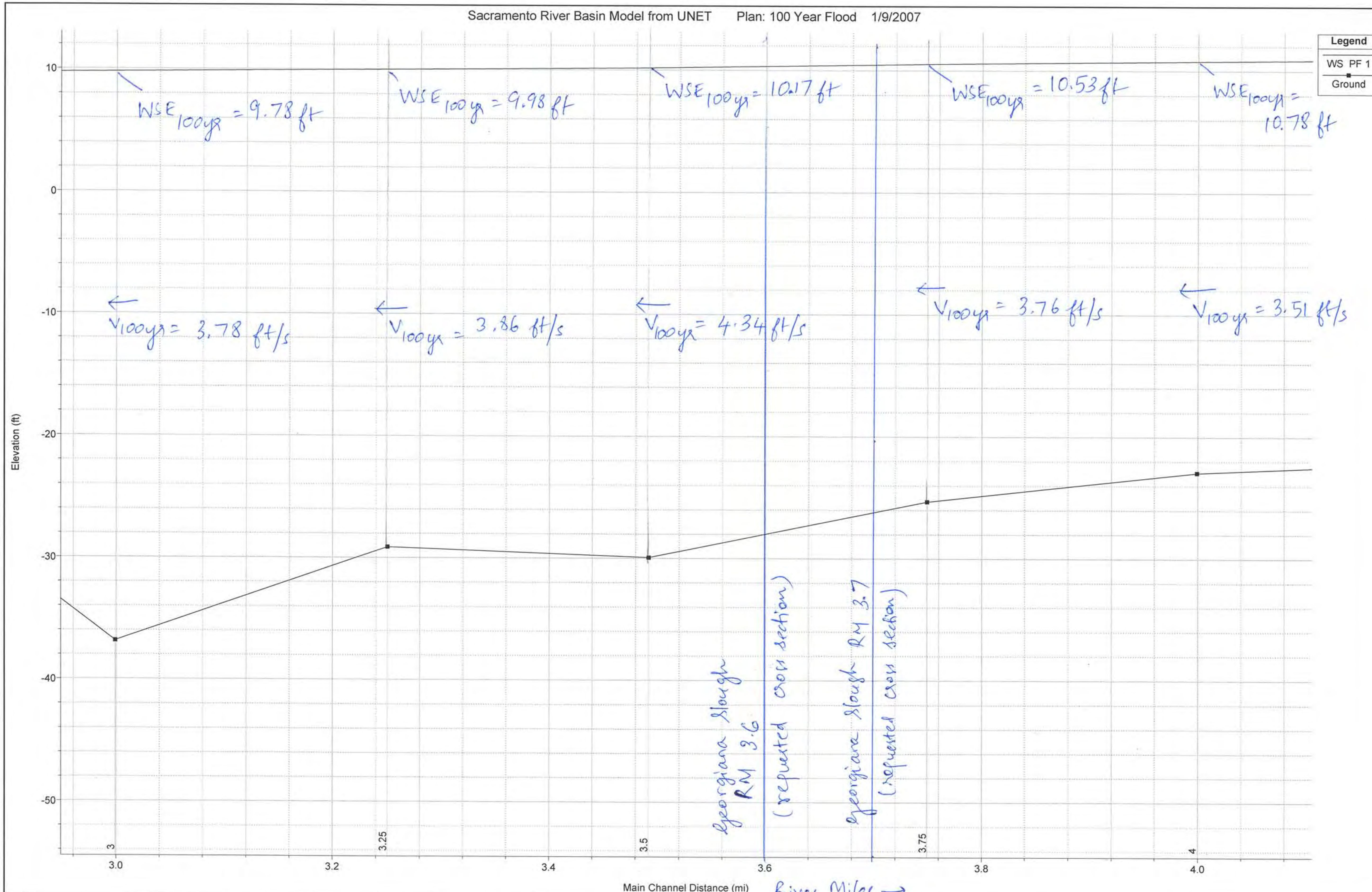
Note: The channel does not have adequate capacity at this location to contain the 100-year flood.



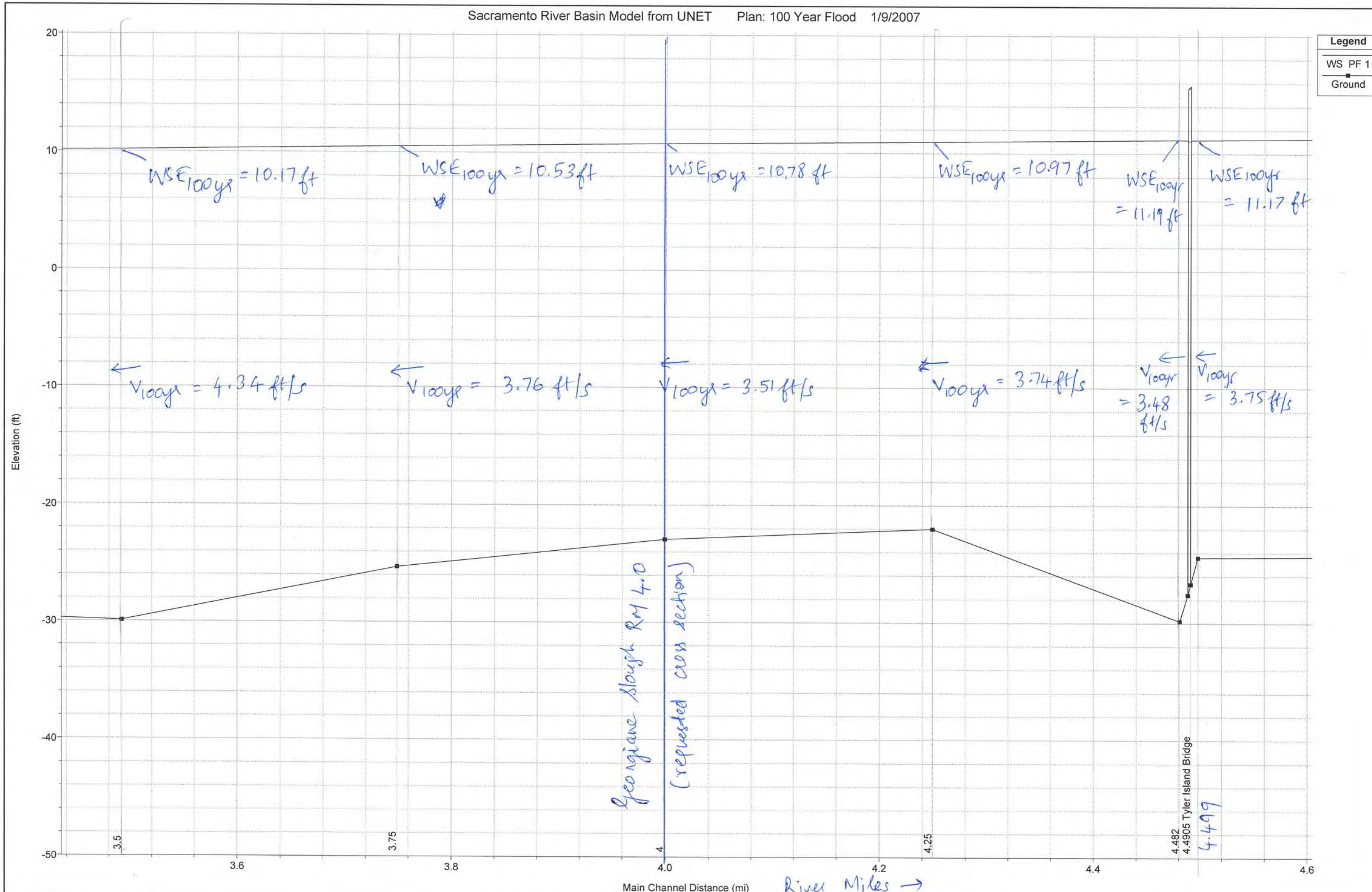
Note: The channel does not have adequate capacity at this location to contain the 100-year flood.

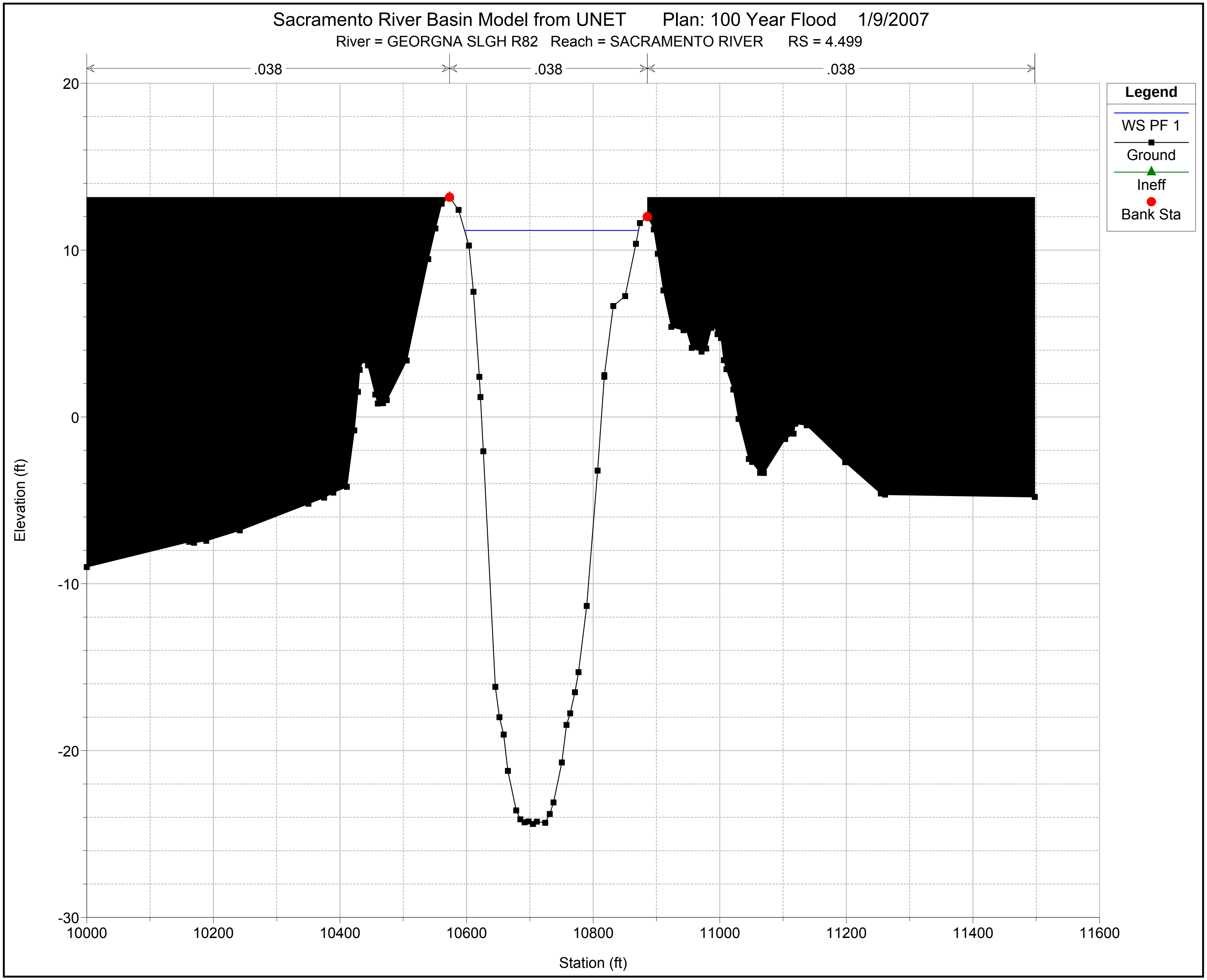

Location of Georgiana Slough
RM 3.6, RM 3.7 and RM 4.0
on HEC-RAS Schematic
SUTTER SLOUGH
LINDSEY SL
CACHE SLOUGH R86
SAC RIVER R83
SACRAMENTO RIVER
SAC RIVER R85
THREE MILE SL
3 MILE SL
None of the XS's are Geo-Referenced (Geo-Ref user entered XS · Geo-Ref interpolated XS · Non Geo-Ref user entered XS · Non Geo-Ref interpolated XS)

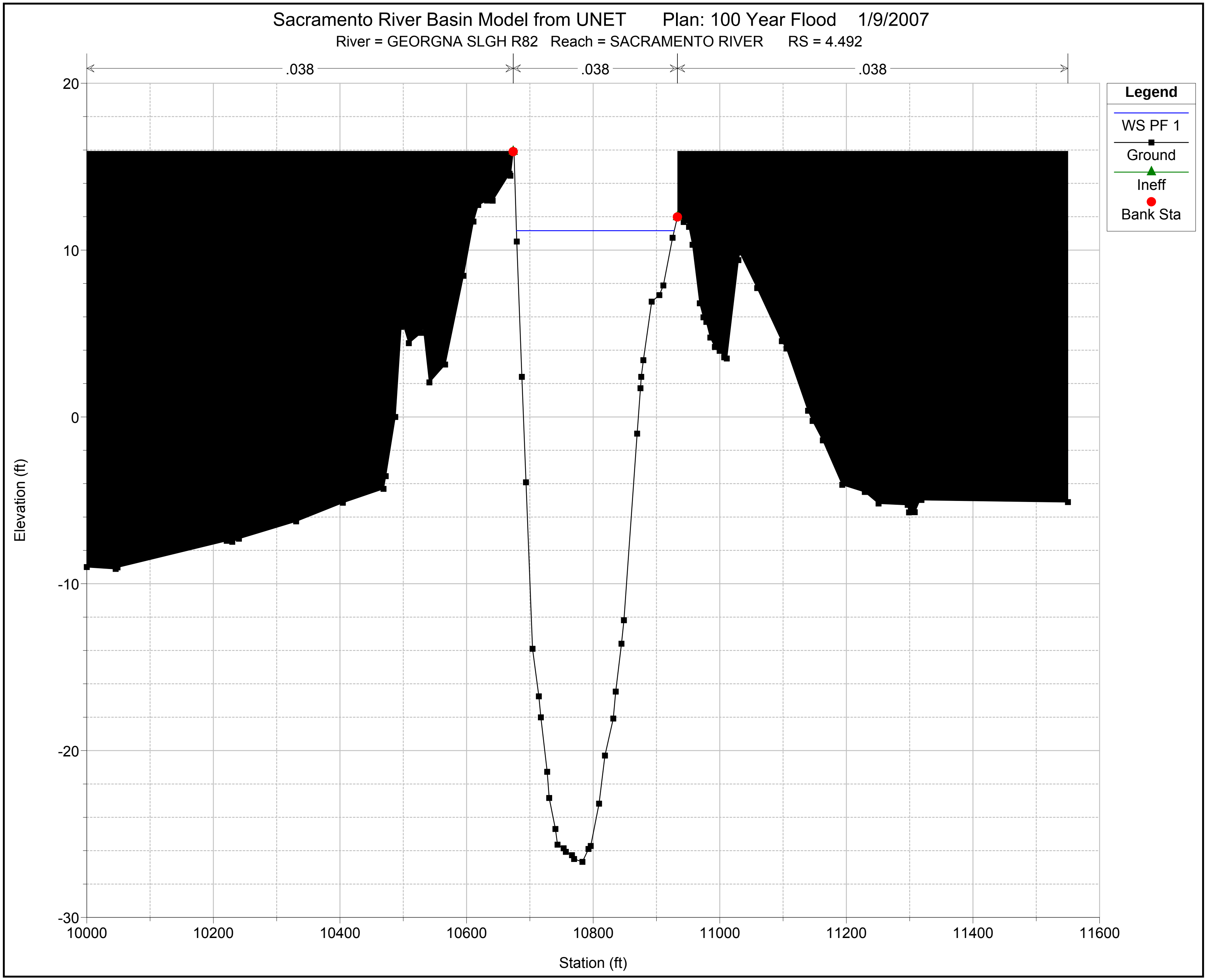
HEC-RAS Profile Drawing for Georgiana Slough RM 3.6 and 3.7



HEC-RAS Profile Drawing for Georgiana Slough RM 4.0




Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.499
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
20
10
0
-10
-20
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
Station (ft)


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.492
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
20
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-10
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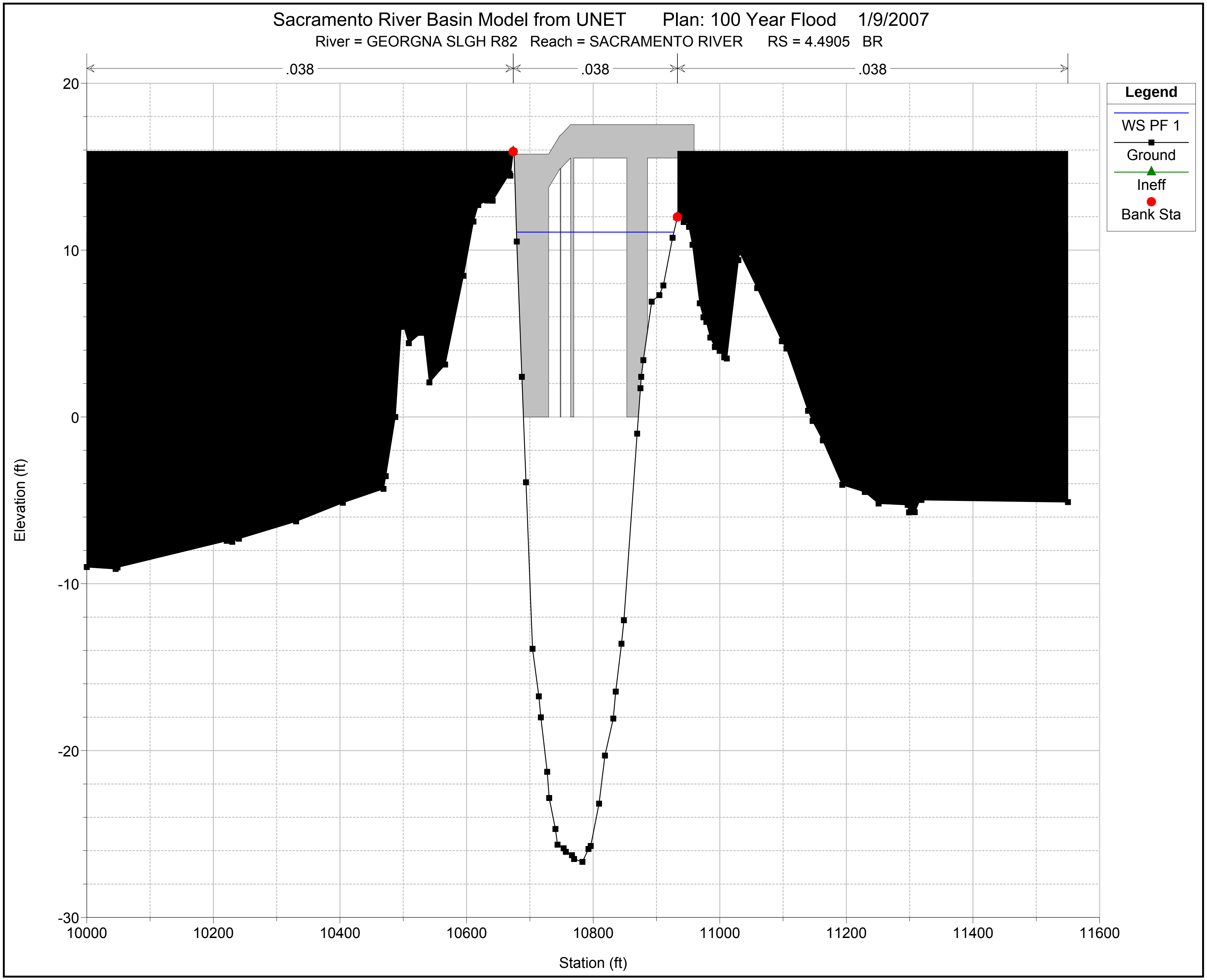
10000
10200
10400
10600
10800
11000
11200
11400
11600
Station (ft)


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.4905 BR
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
20
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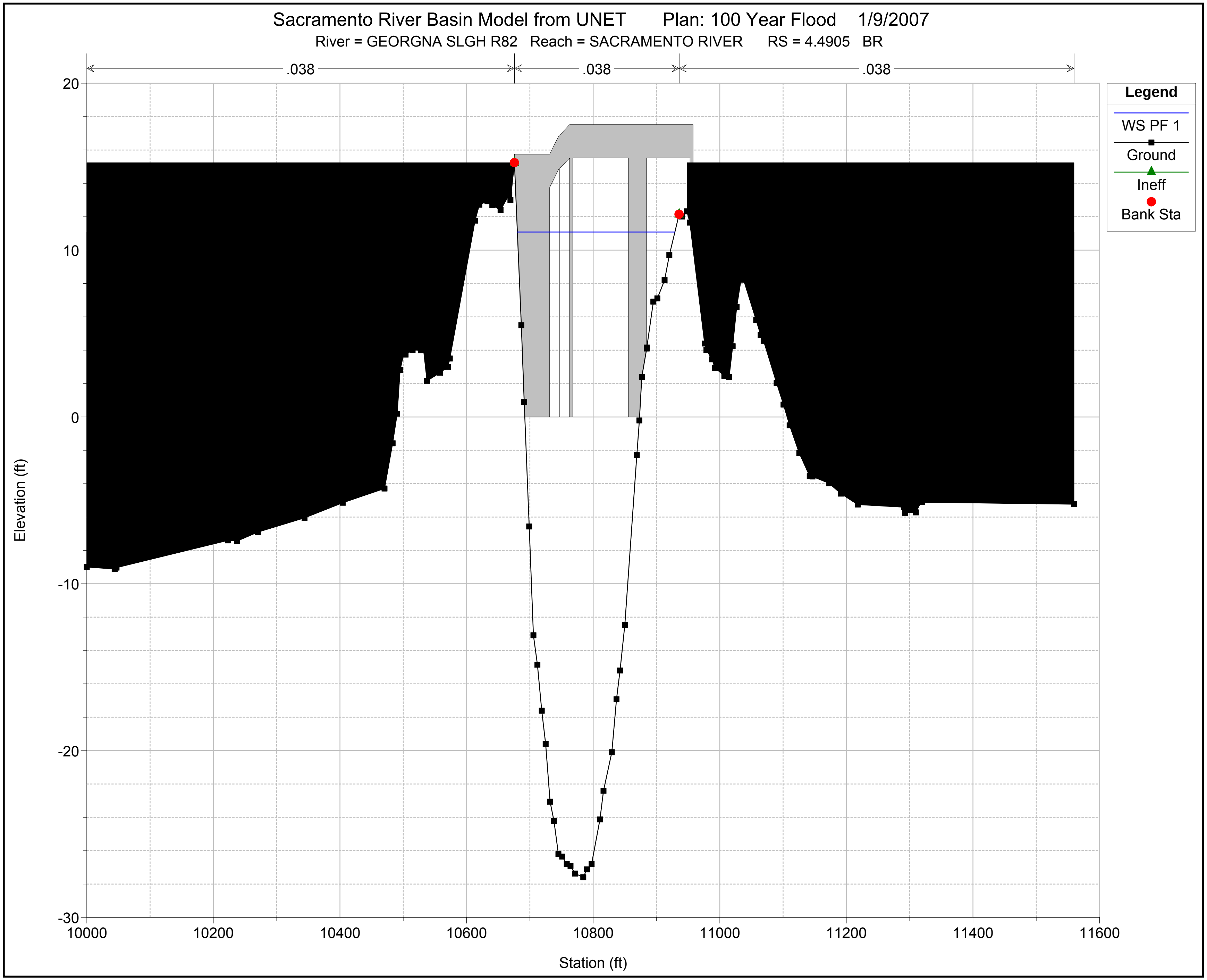
0
-10
-20
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
Station (ft)


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.4905 BR
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
20
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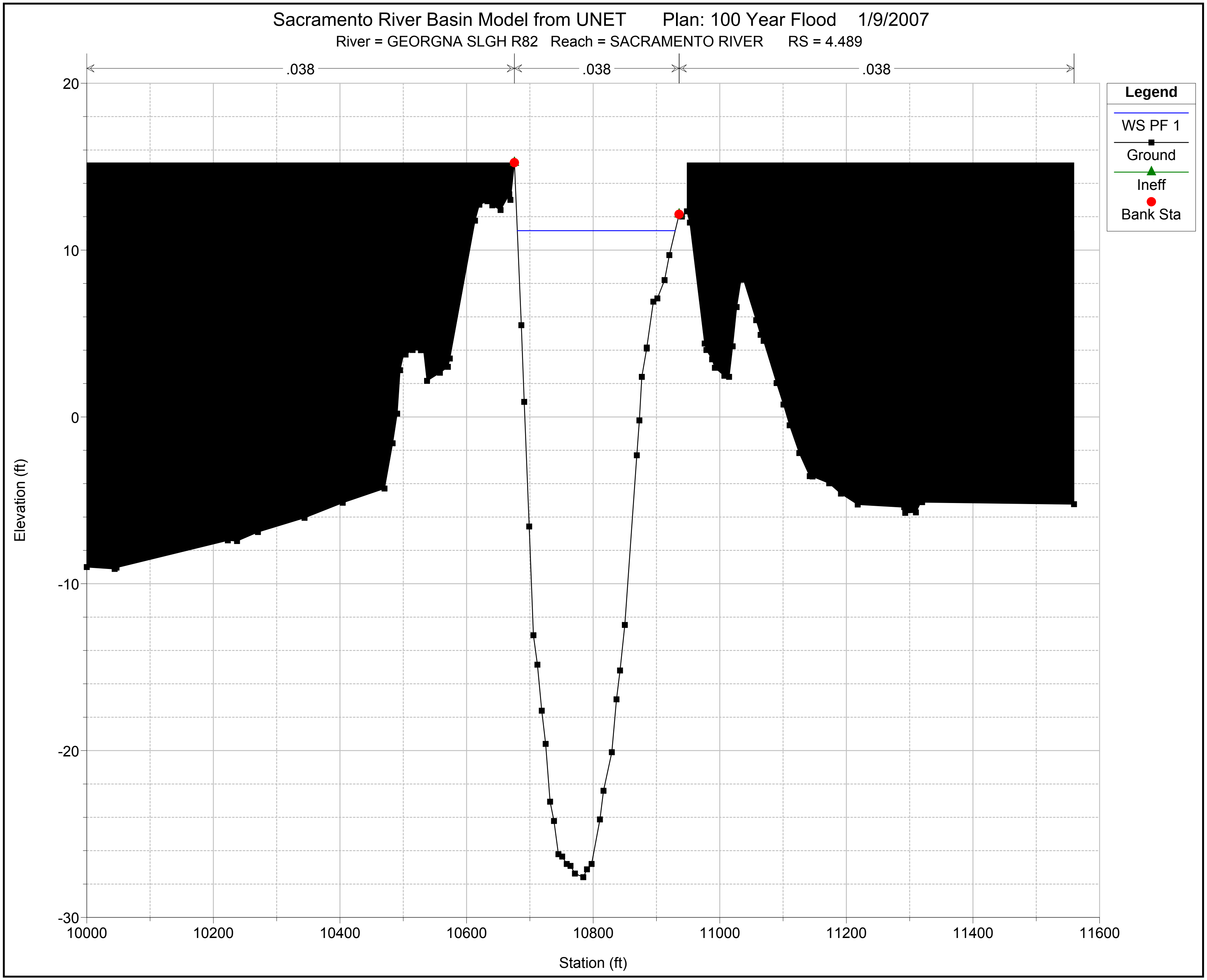
0
-10
-20
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
Station (ft)



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.489
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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10
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-10
-20
-30
10000
10200
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10600
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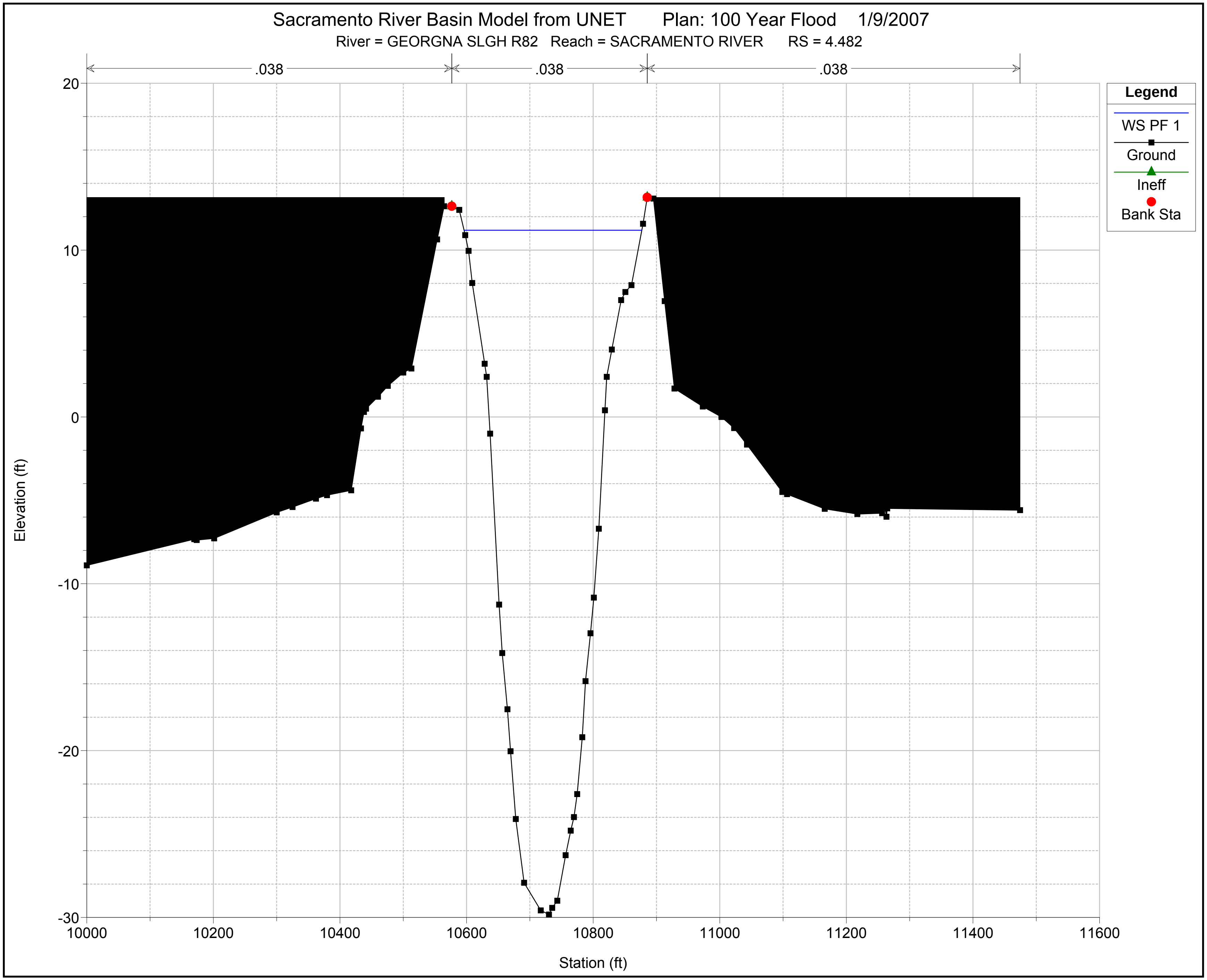
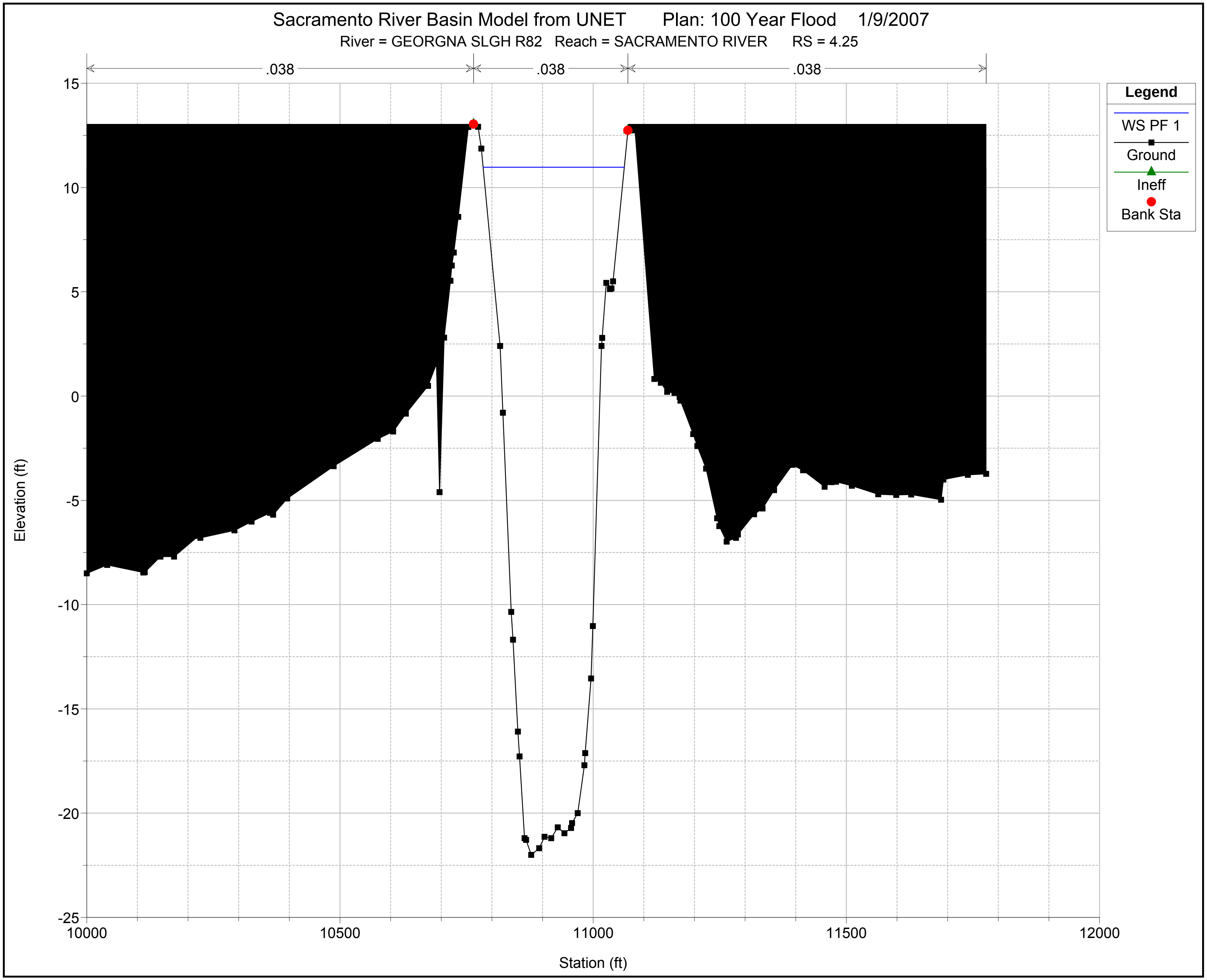
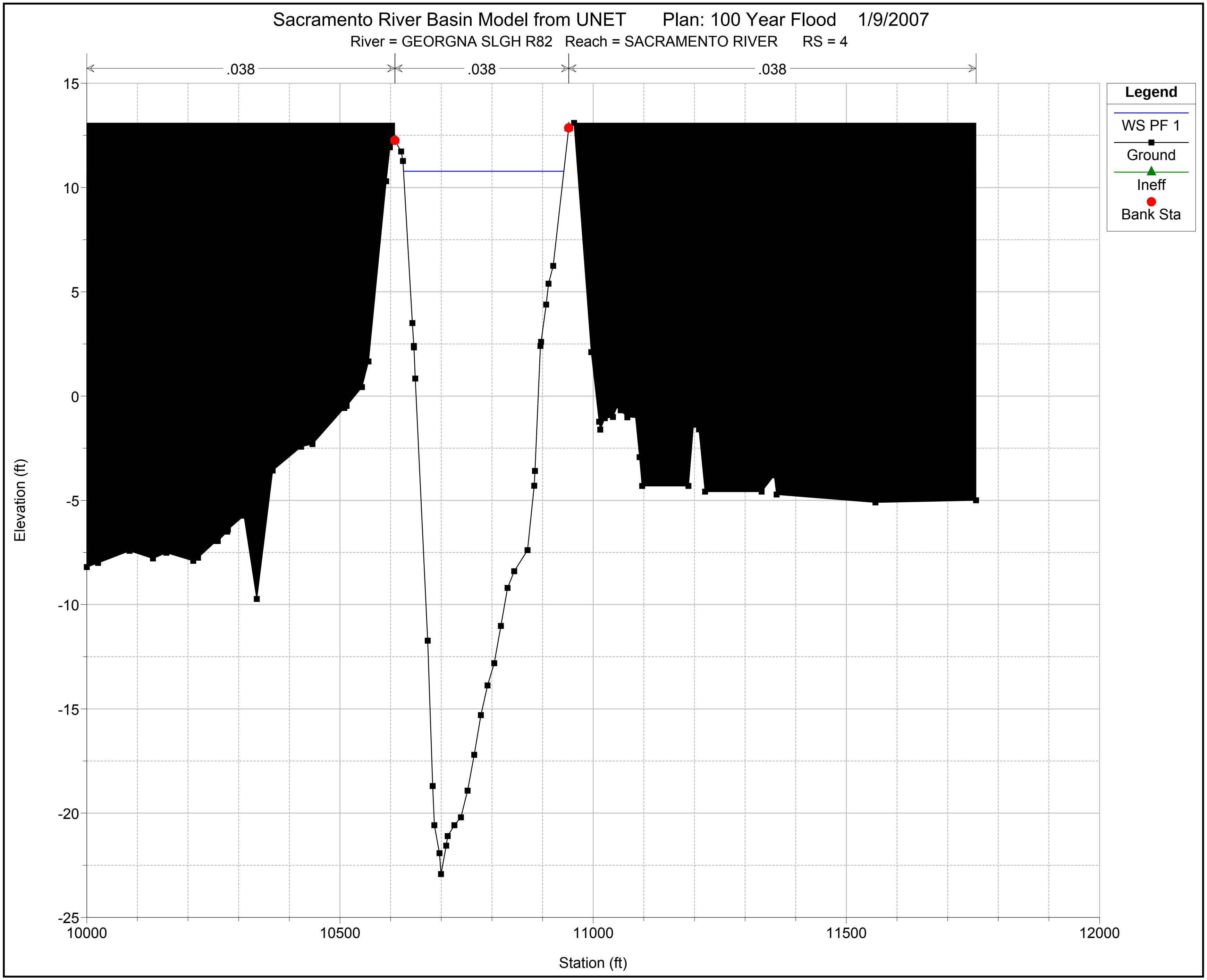
11200
11400
11600

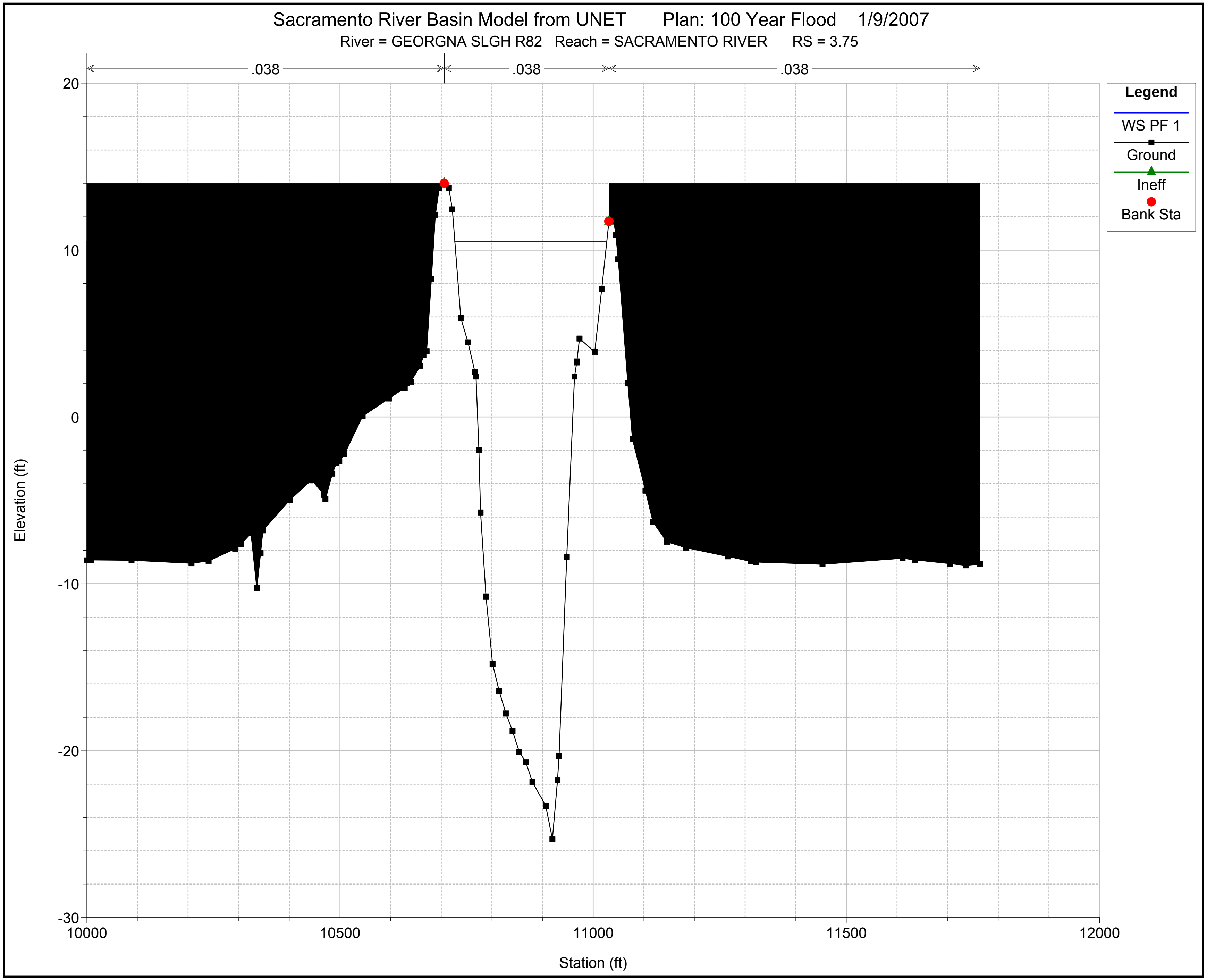


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.482
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
20
10
0
-10
-20
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
Station (ft)

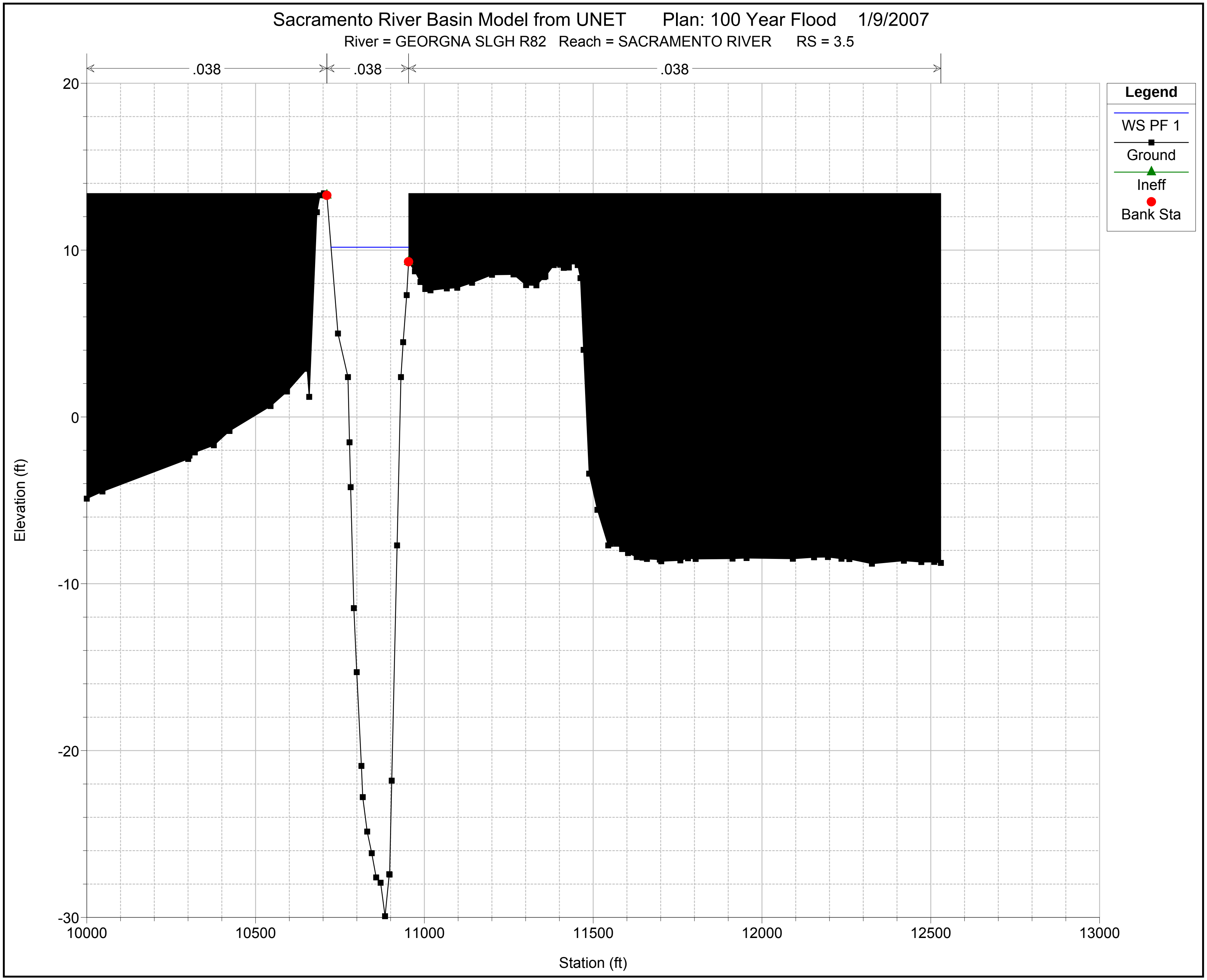


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4.25
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
15
10
5
0
-5
-10
-15
-20
-25
10000
10500
11000
11500
12000

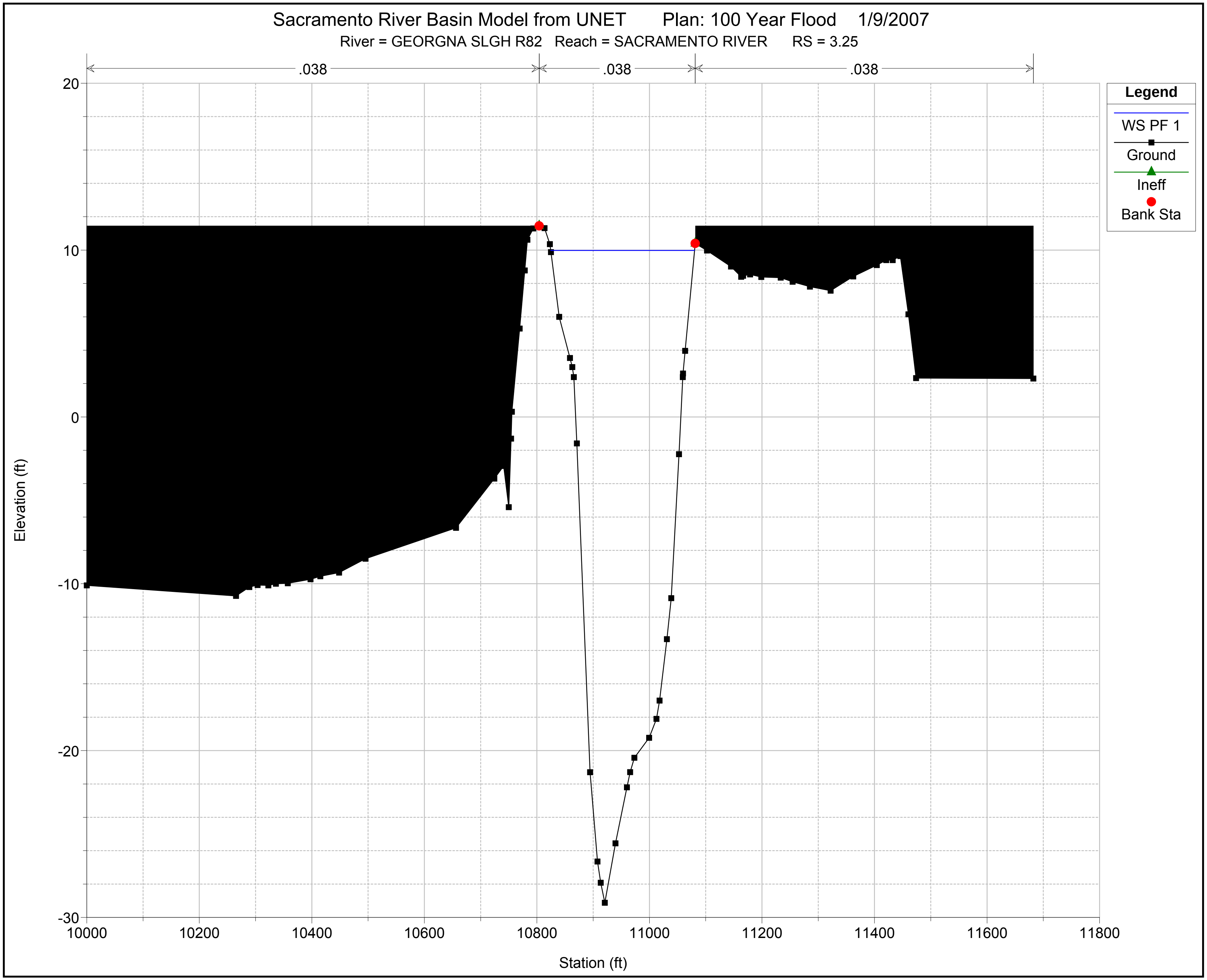

Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 4
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
15
10
5
0
-5
-10
-15
-20
-25
10000
10500
11000
11500
12000



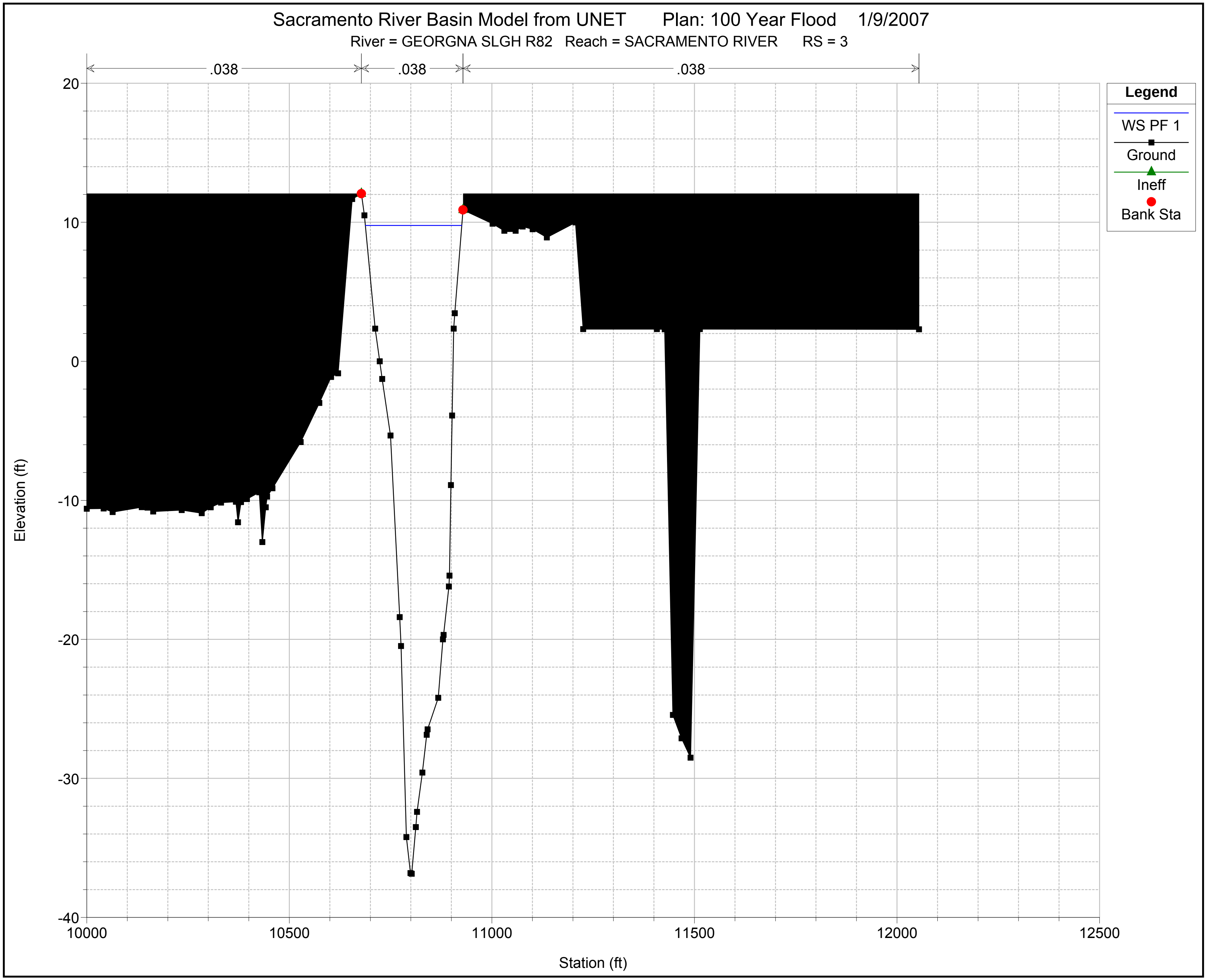
Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 3.75
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
20
10
0
-10
-20
-30
10000
10500
11000
11500
12000



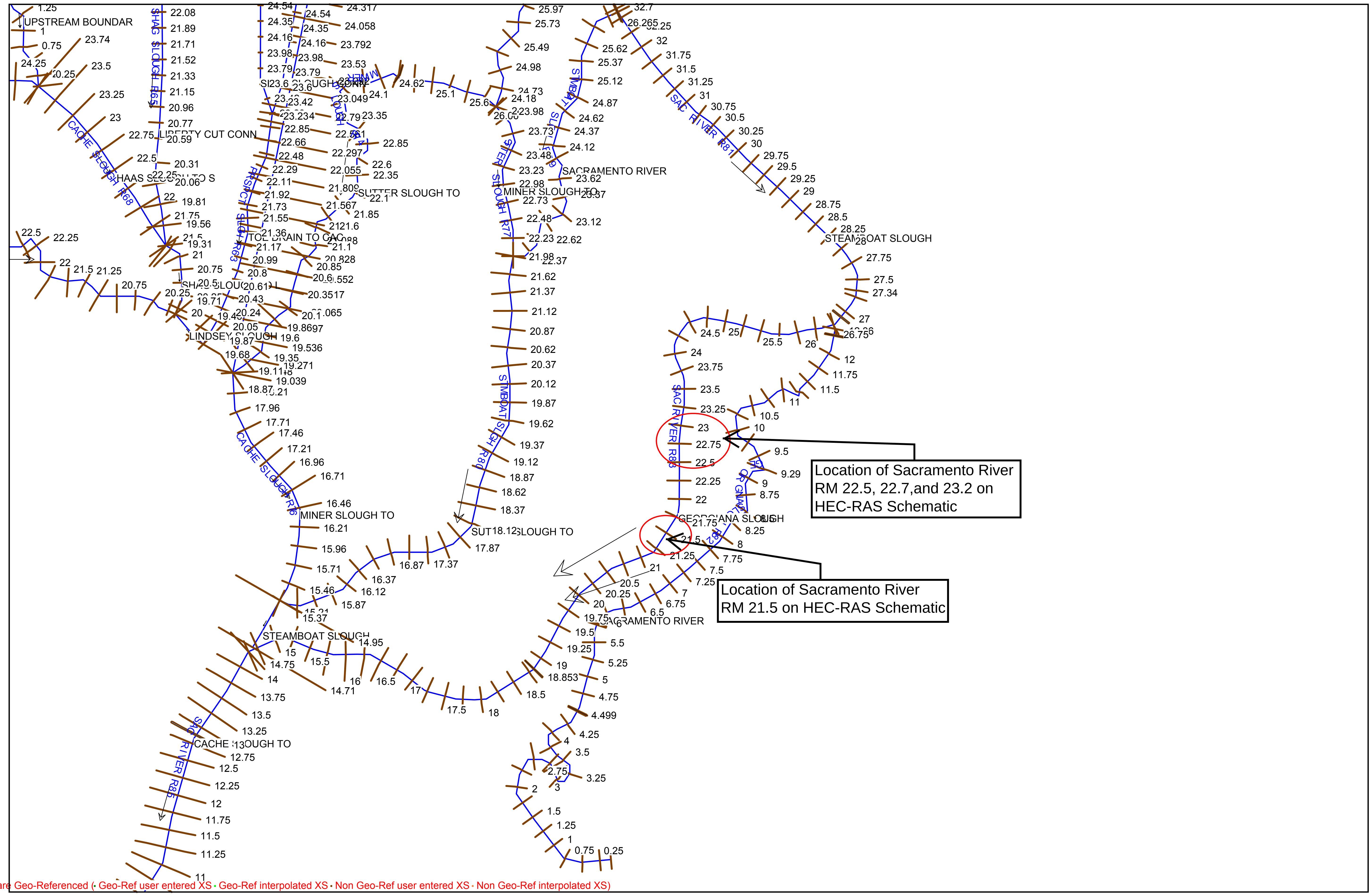
Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 3.5
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
20
10
0
-10
-20
-30
10000
10500
11000
11500
12000
12500
13000



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 3.25
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
20
10
0
-10
-20
-30
Elevation (ft)
10000
10200
10400
10600
10800
11000
11200
11400
11600
11800
Station (ft)

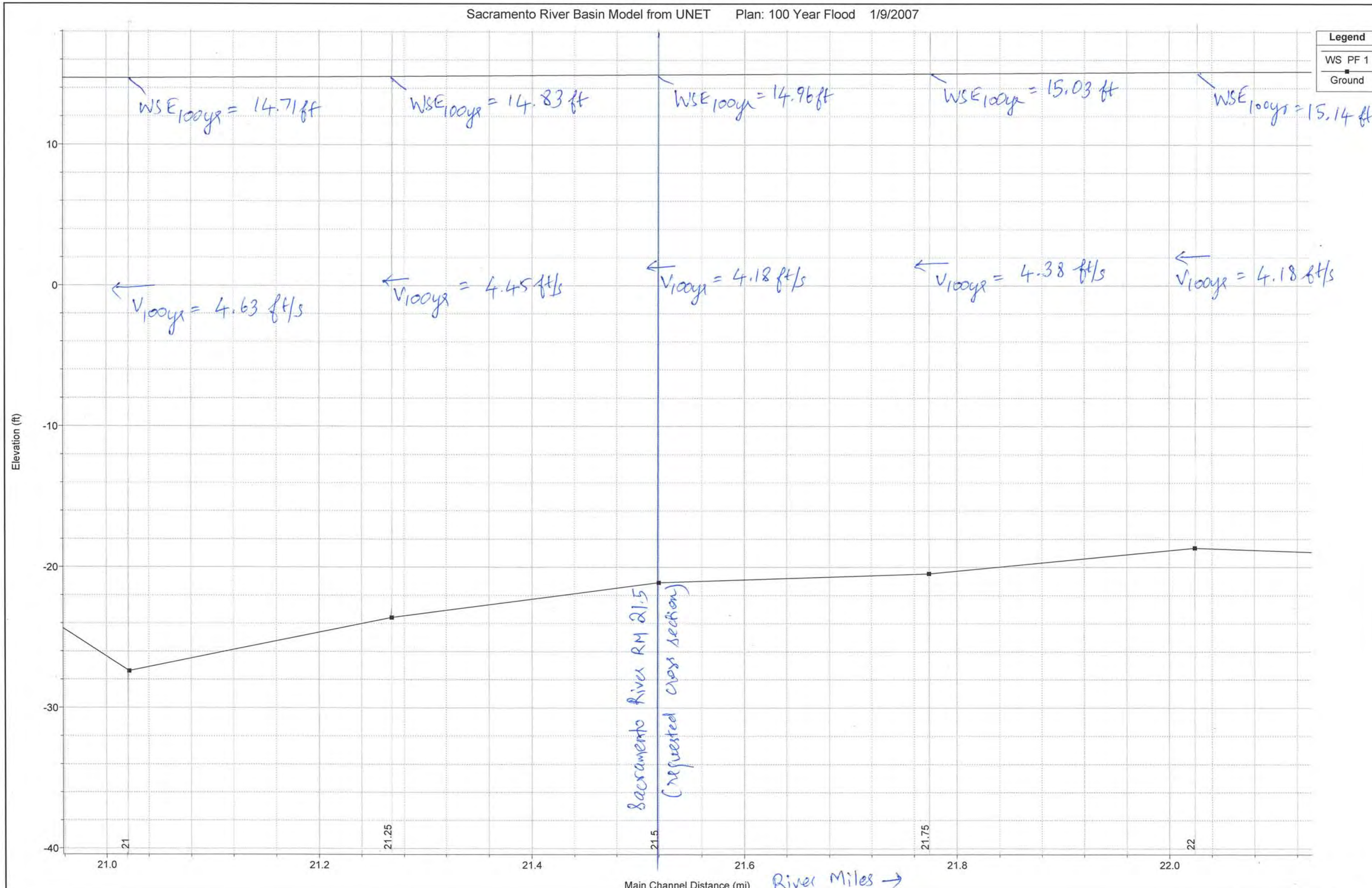


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = GEORGNA SLGH R82 Reach = SACRAMENTO RIVER RS = 3
.038
.038
.038
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
20
10
0
-10
-20
-30
-40
10000
10500
11000
11500
12000
12500

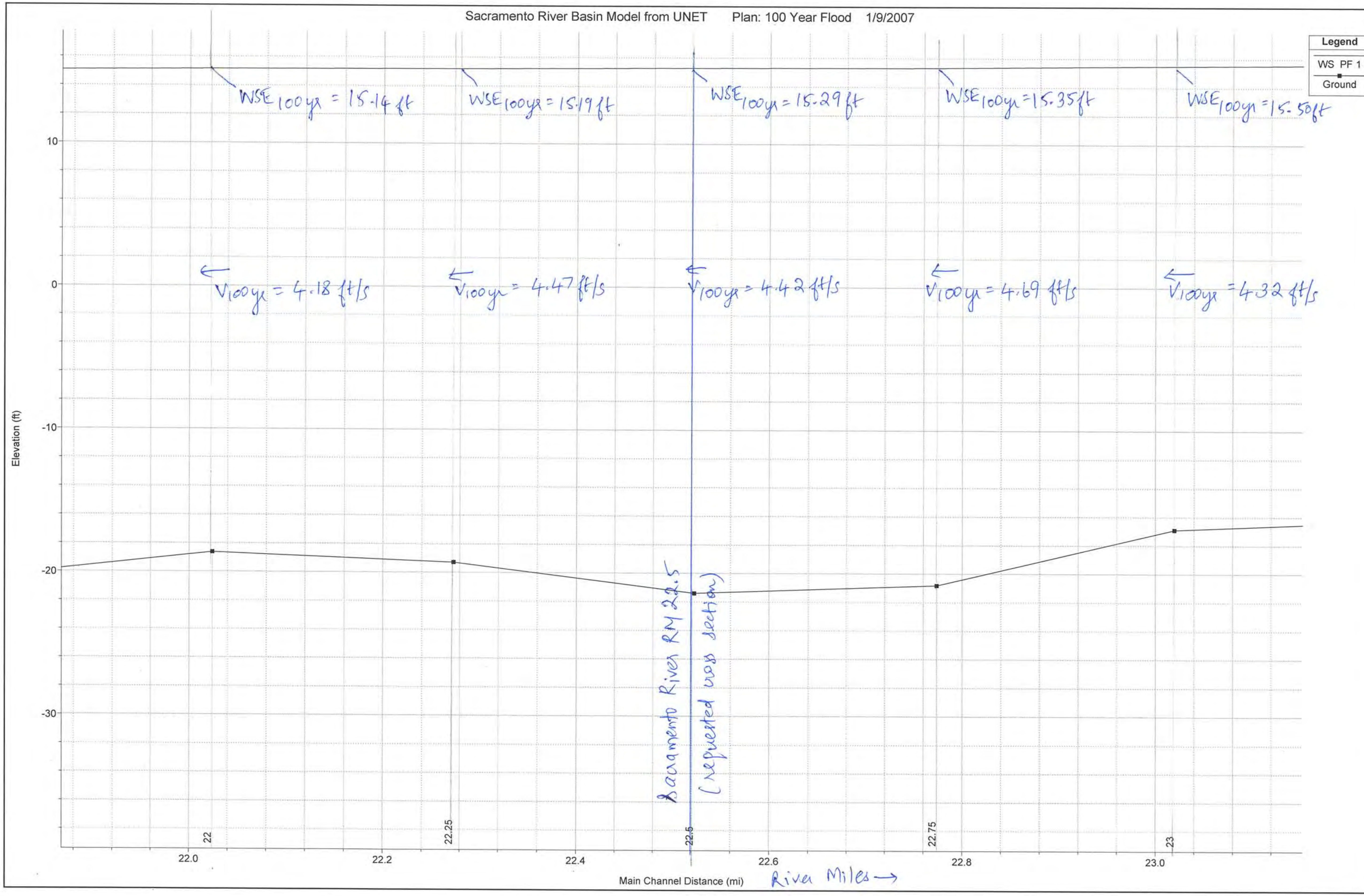


Location of Sacramento River RM 22.5, 22.7,and 23.2 on HEC-RAS Schematic
Location of Sacramento River RM 21.5 on HEC-RAS Schematic
UPSTREAM BOUNDAR
LIBERTY CUT CONN
HAAS SLOUGH TO S
SUTTER SLOUGH TO
SACRAMENTO RIVER
MINER SLOUGH TO
STEAMBOAT SLOUGH
LINDSEY SLOUGH
GEORGIANA SLOUGH
CACHE SLOUGH TO
None of the XS's are Geo-Referenced (· Geo-Ref user entered XS · Geo-Ref interpolated XS · Non Geo-Ref user entered XS · Non Geo-Ref interpolated XS)

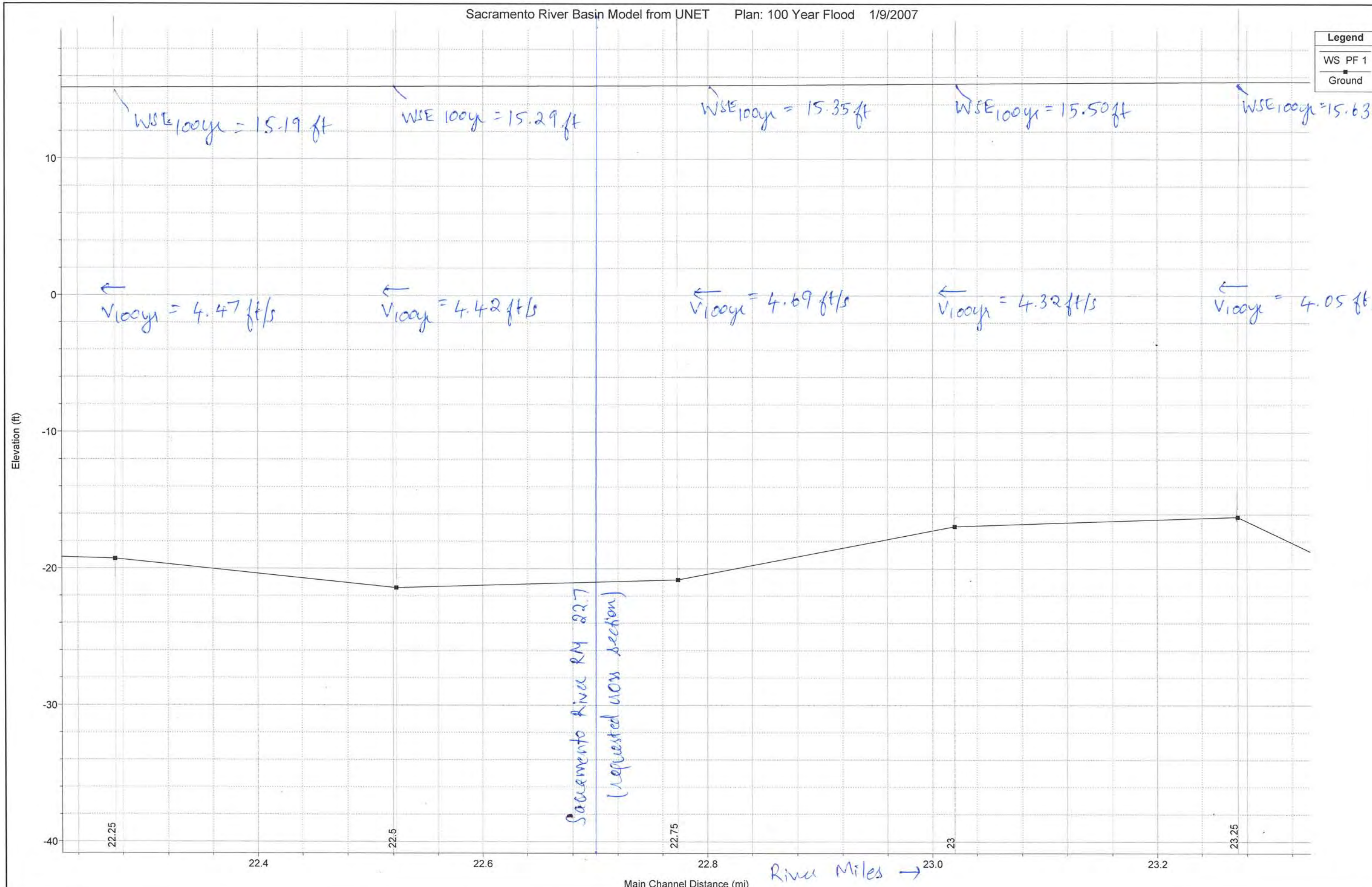
HEC-RAS Profile Drawing for Sacramento River RM 21.5



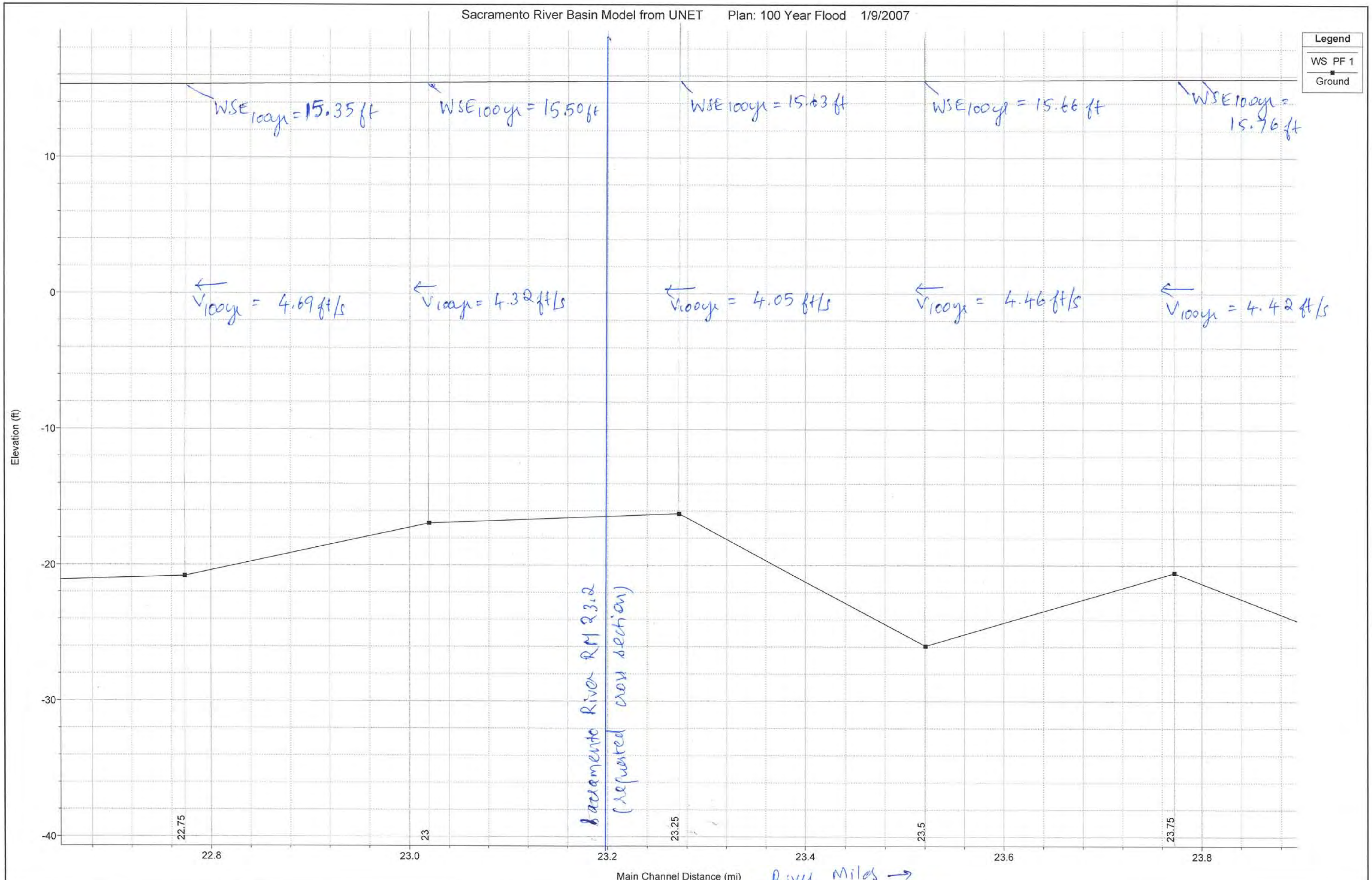
HEC-RAS Profile Drawing for Sacramento River RM 22.5

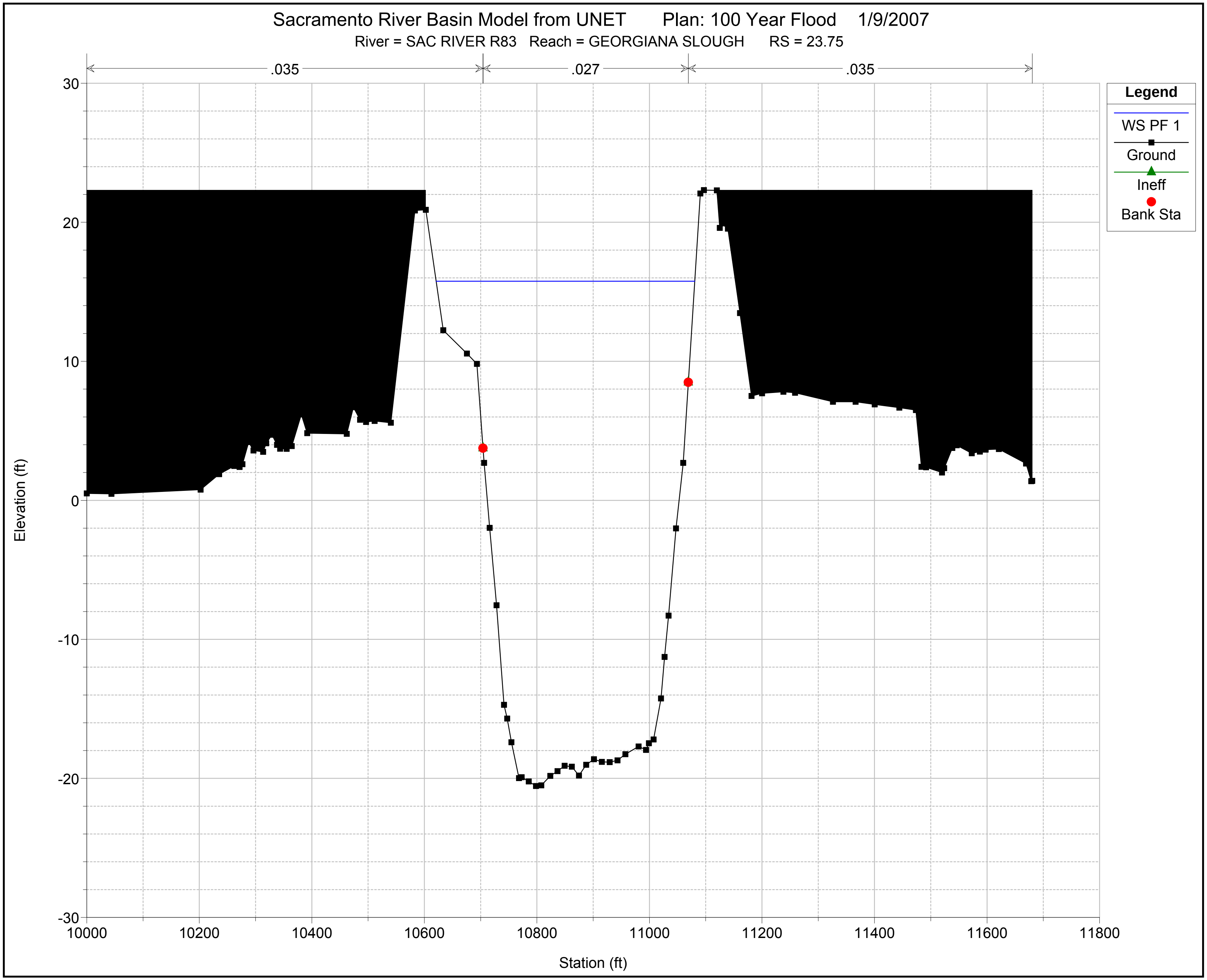


HEC-RAS Profile Drawing for Sacramento River RM 22.7

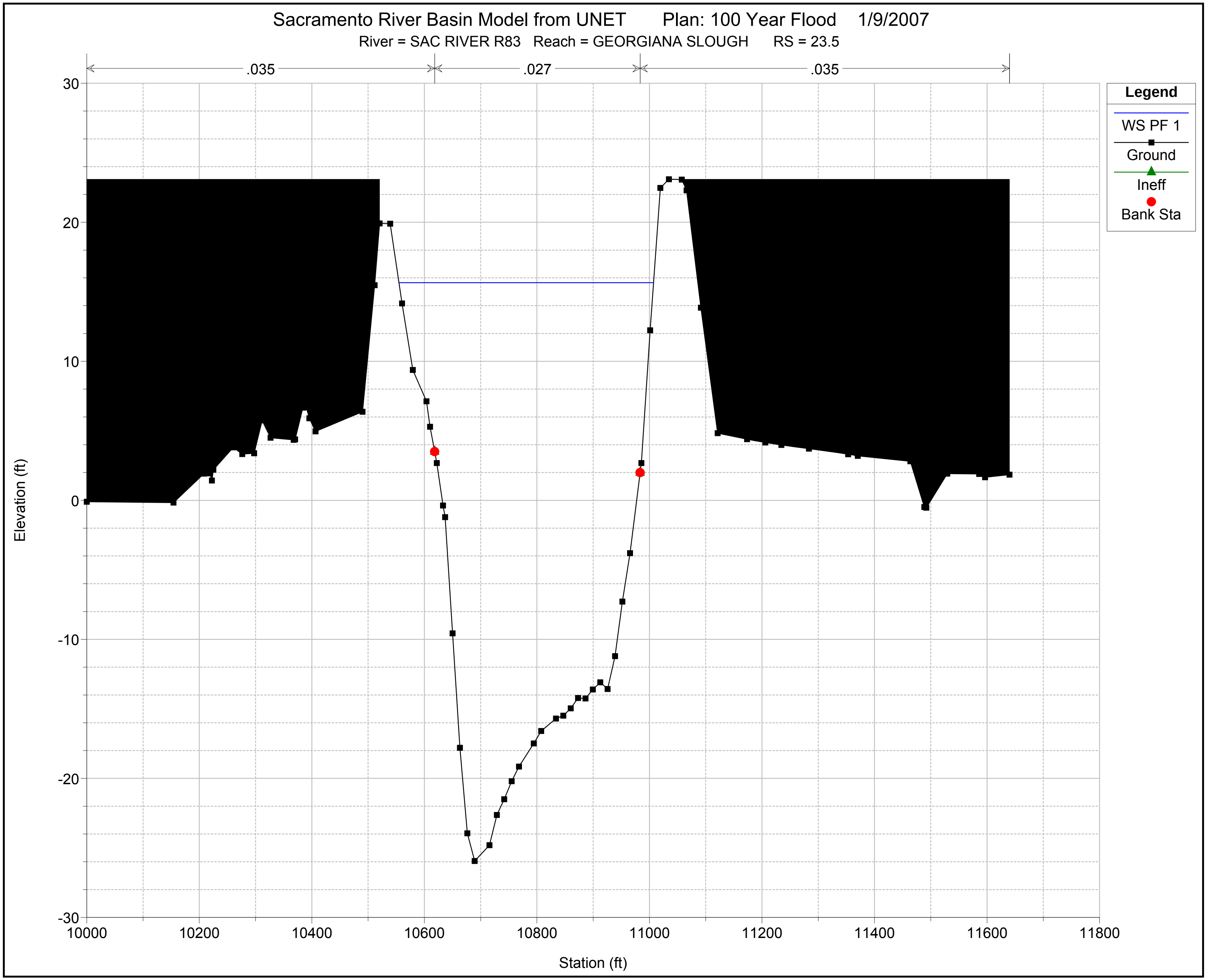


HEC-RAS Profile Drawing for Sacramento River RM 23.2





Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 23.75
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
30
20
10
0
-10
-20
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
11800



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 23.5
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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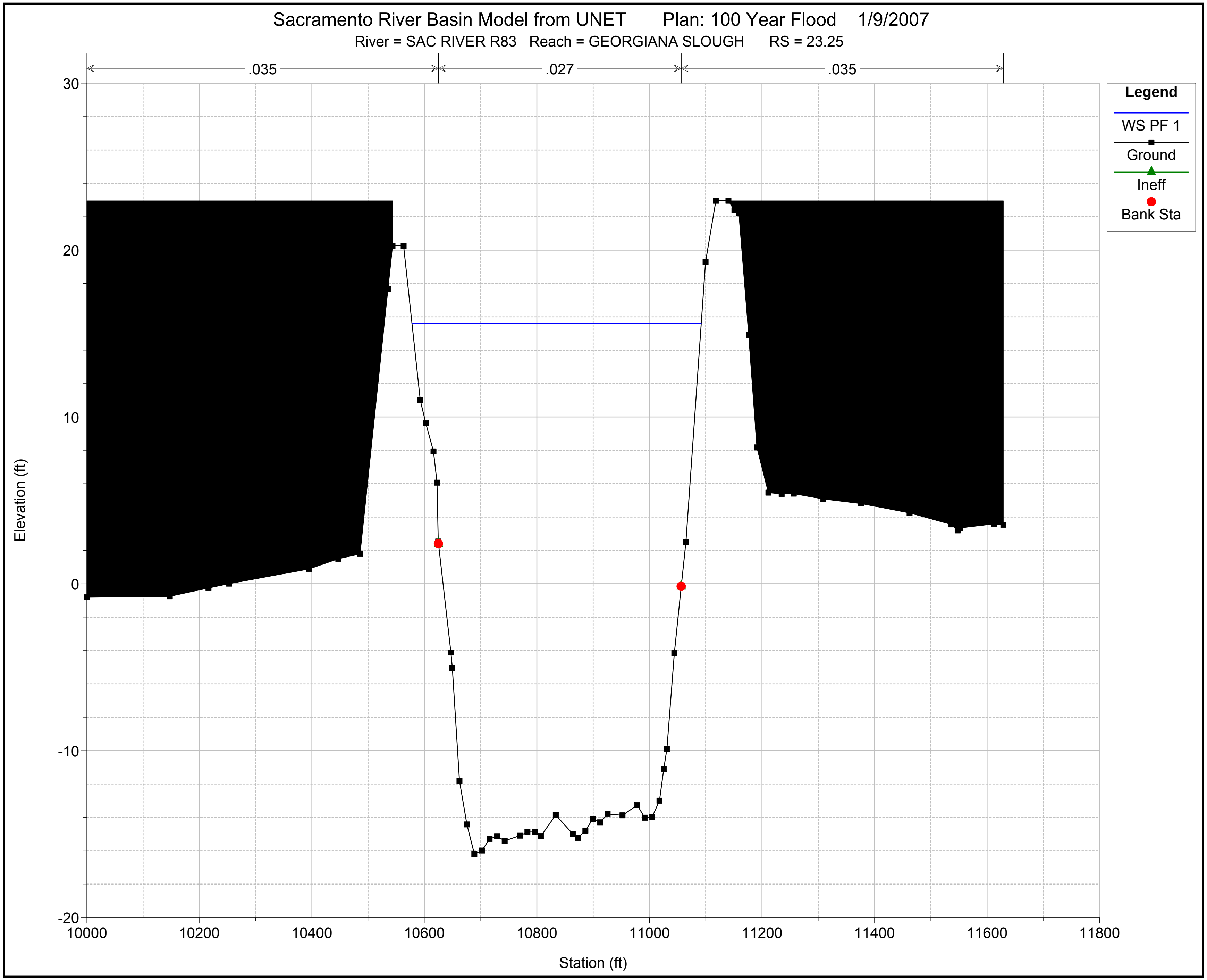
Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 23.25
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
30
20
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10800
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11200
11400
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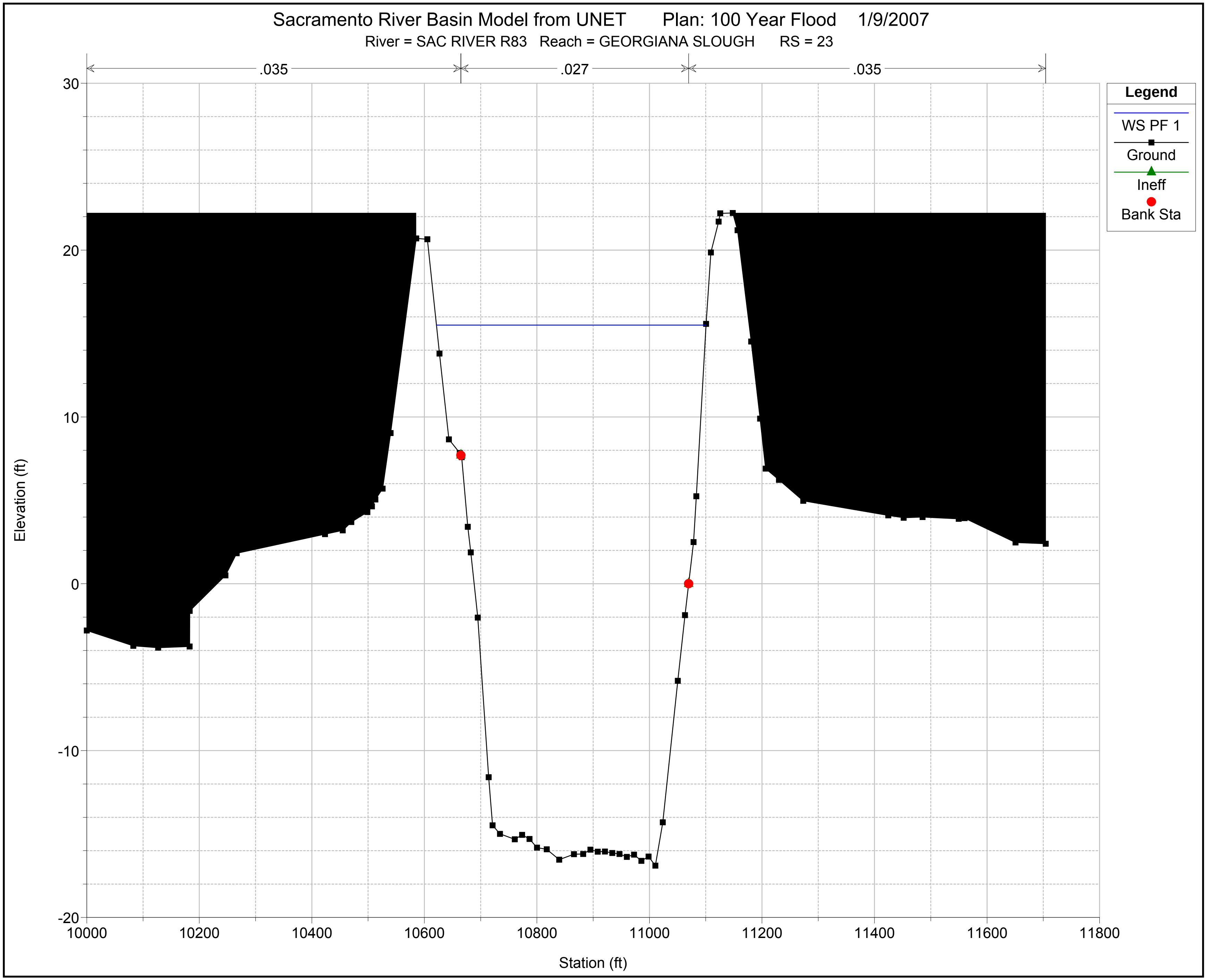
11800



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 23
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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Station (ft)
10000
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10600
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11200
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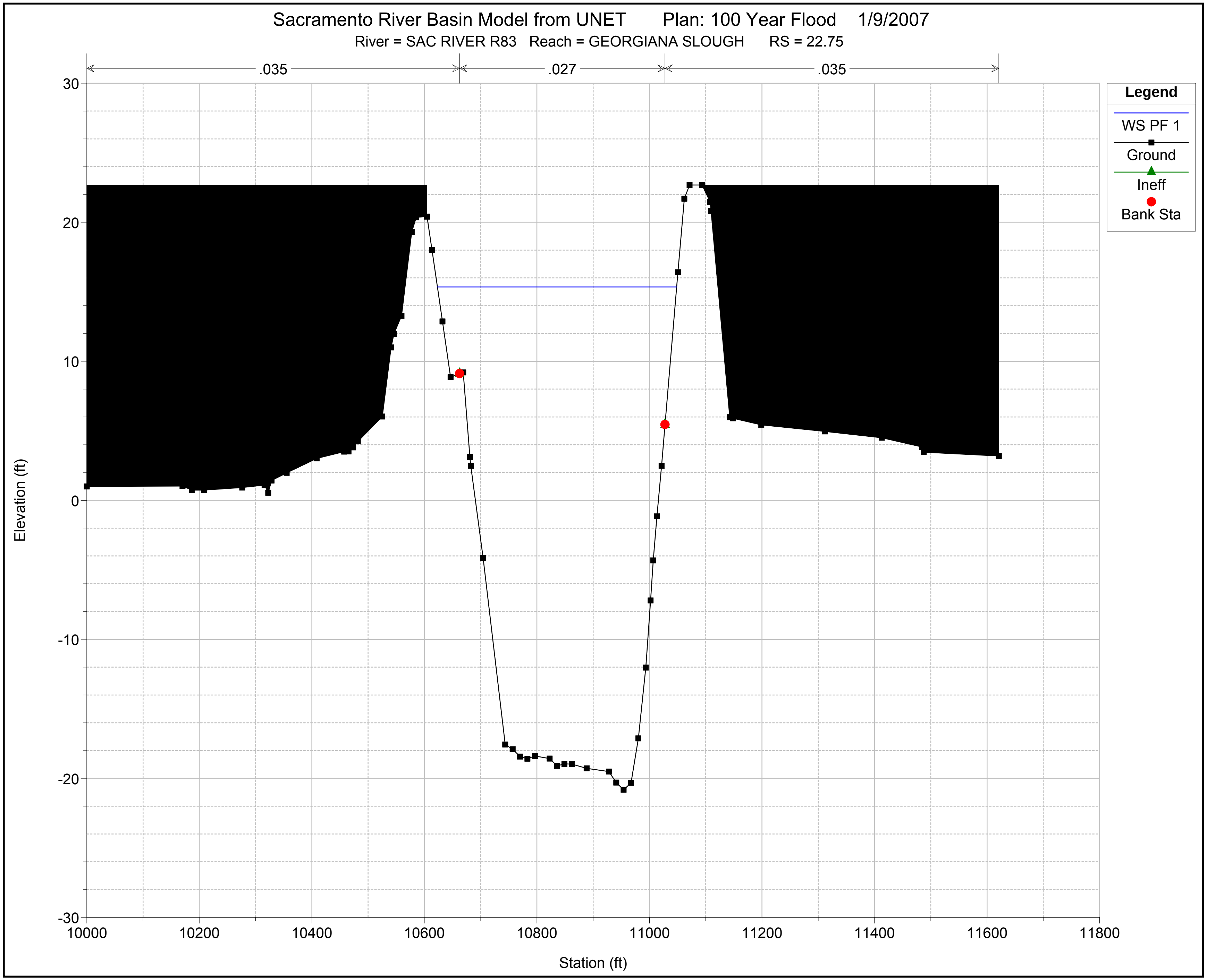
11800



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 22.75
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
30
20
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-10
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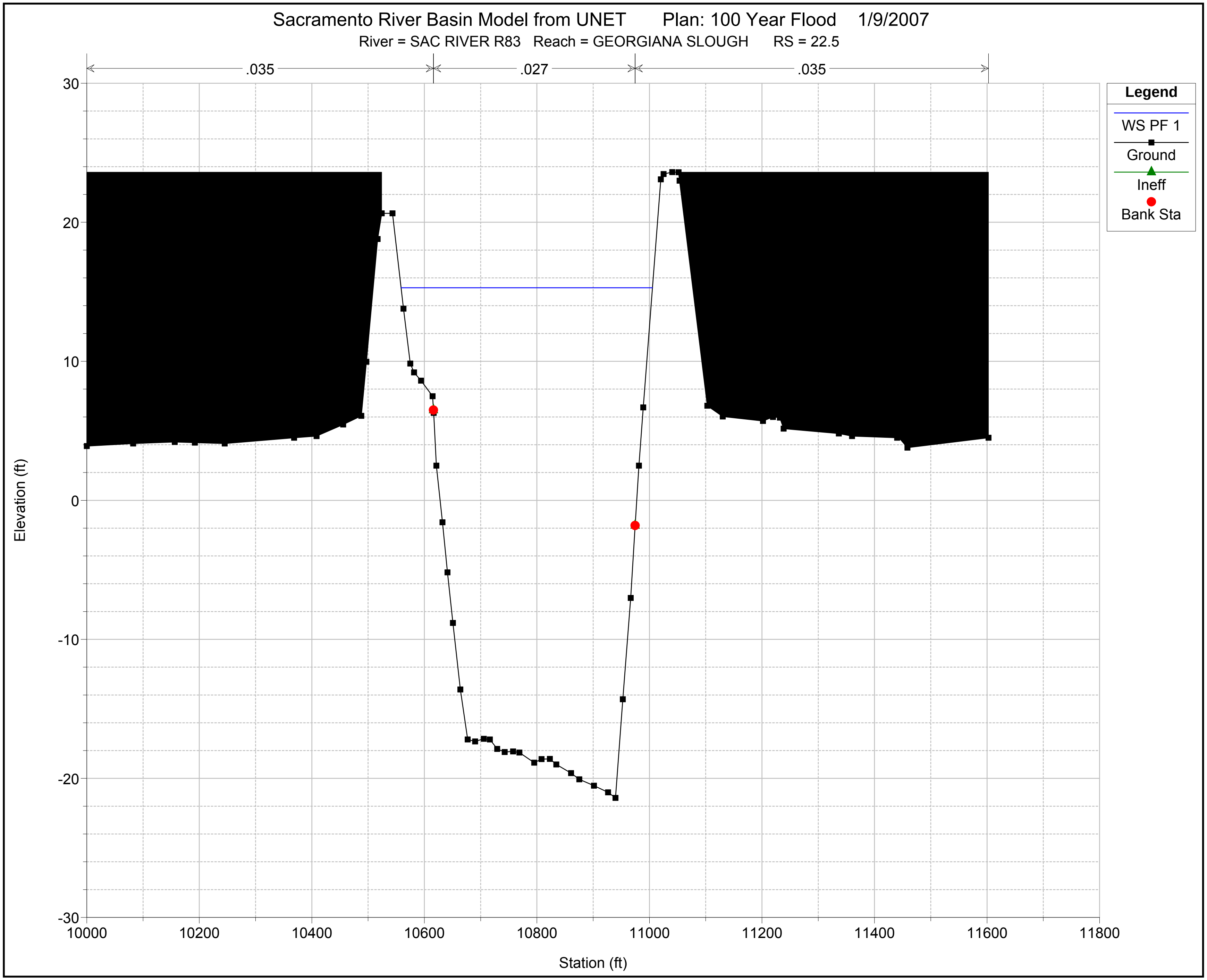
11800



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 22.5
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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11200
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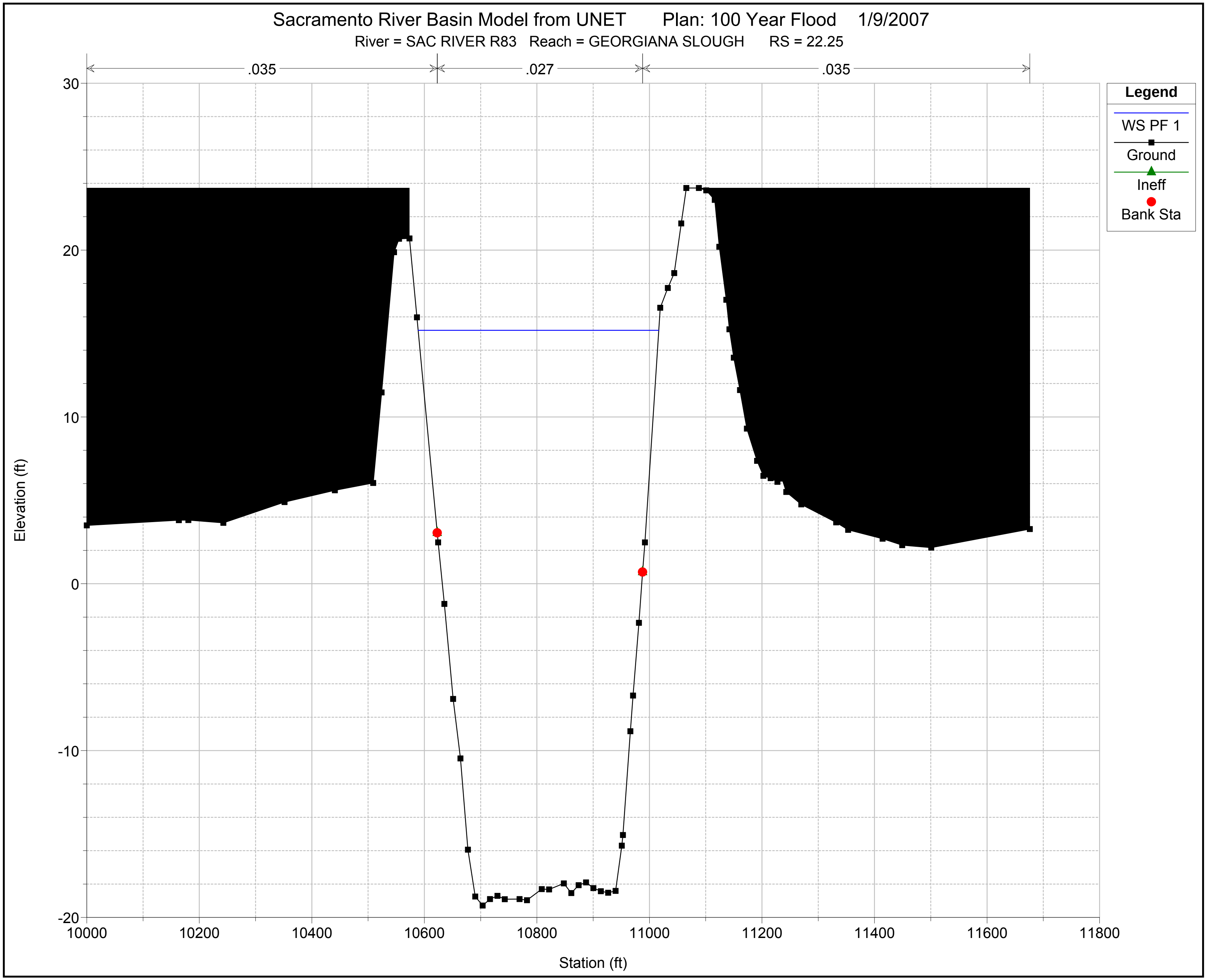
11600
11800
Station (ft)


Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 22.25
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
30
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-10
-20
Elevation (ft)
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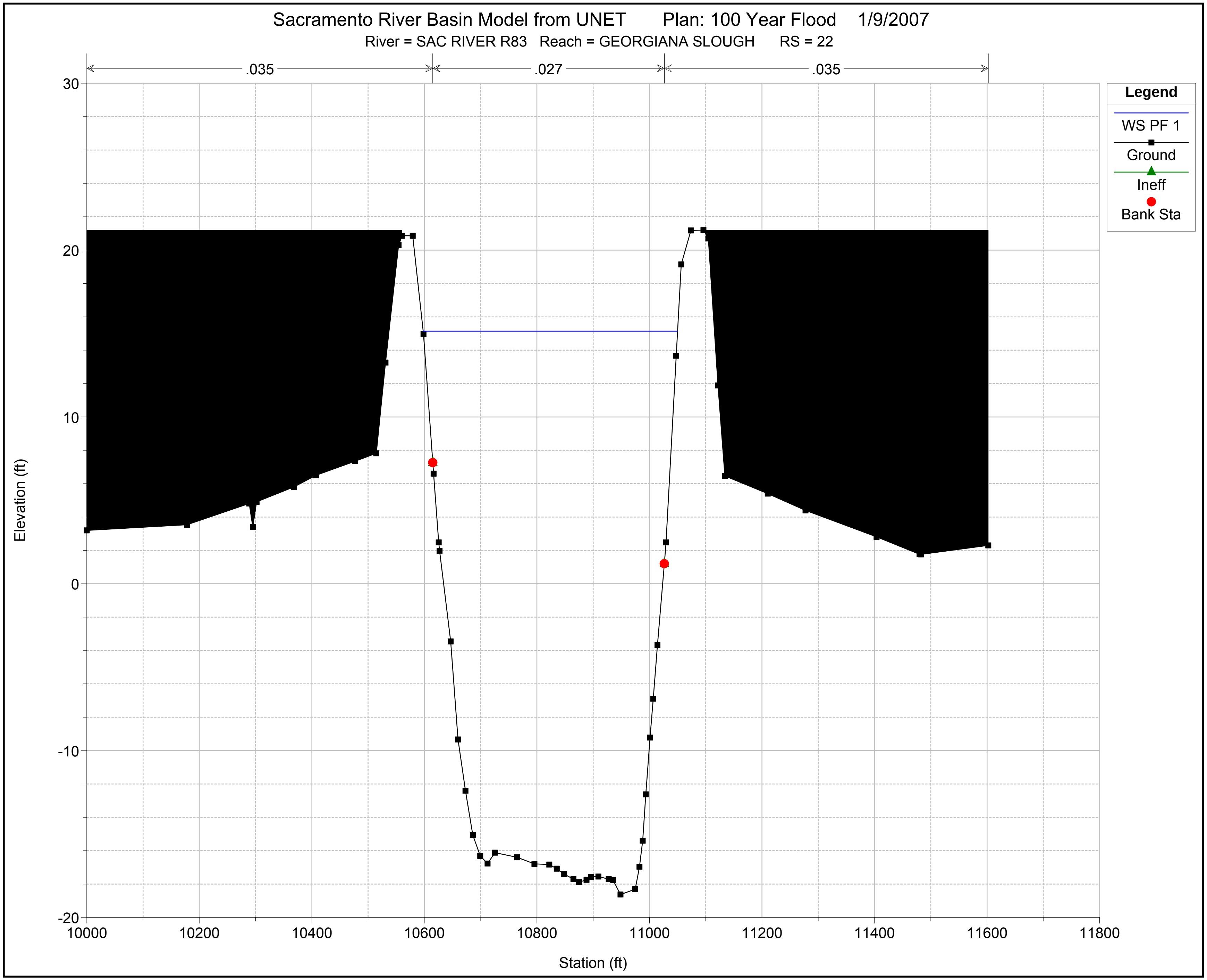
10800
11000
11200
11400
11600
11800
Station (ft)



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 22
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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Station (ft)
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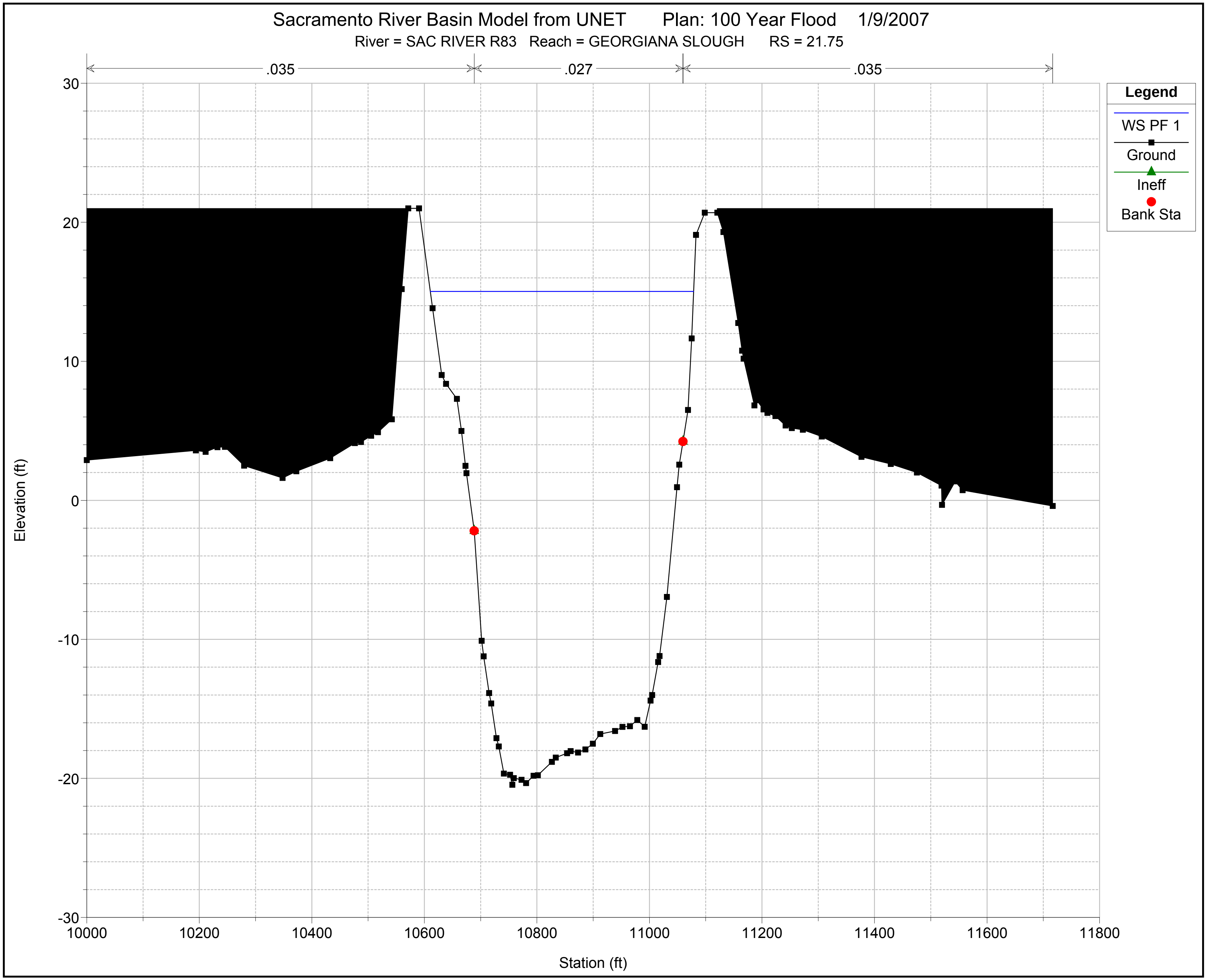

Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 21.75
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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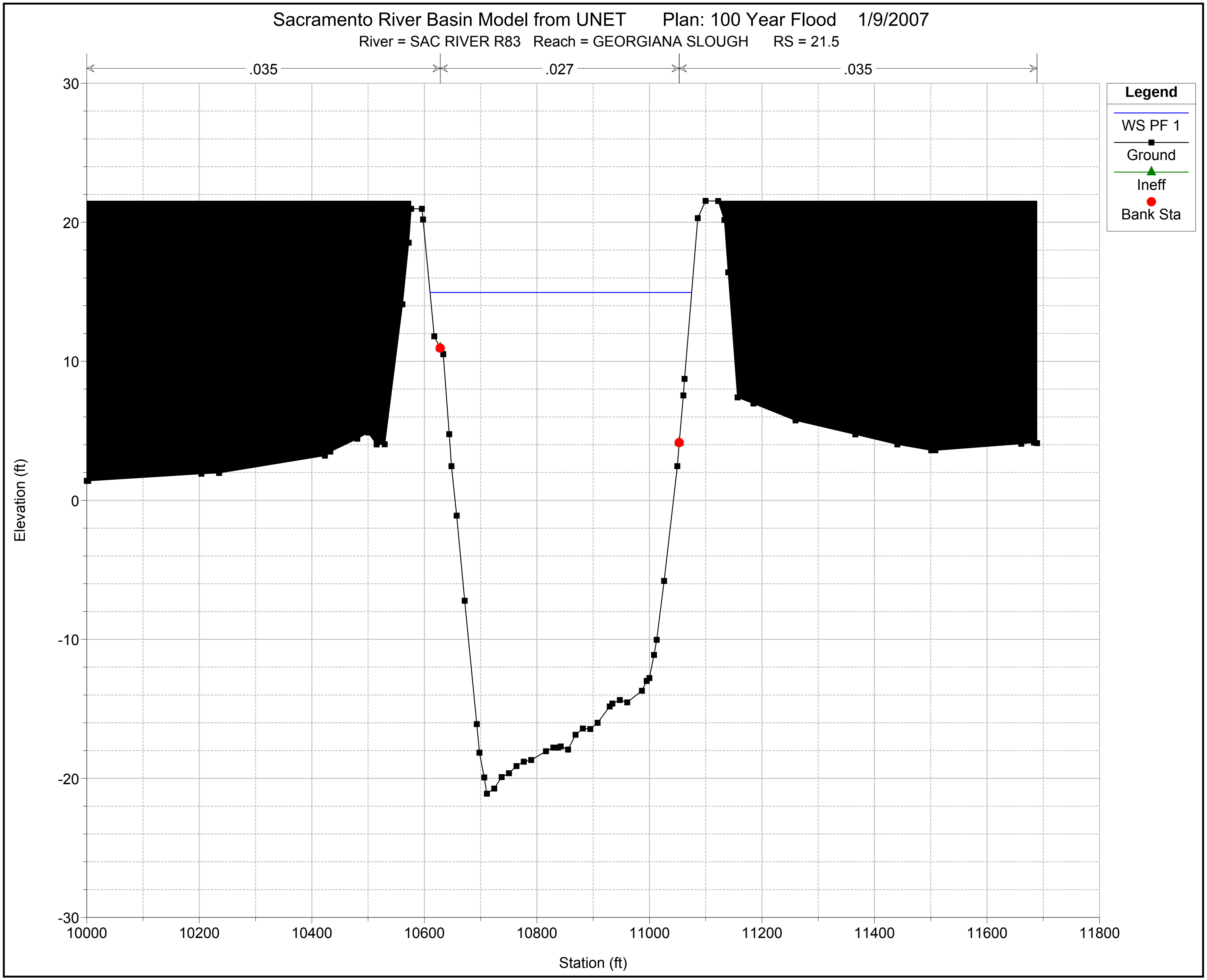

Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 21.5
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
Station (ft)
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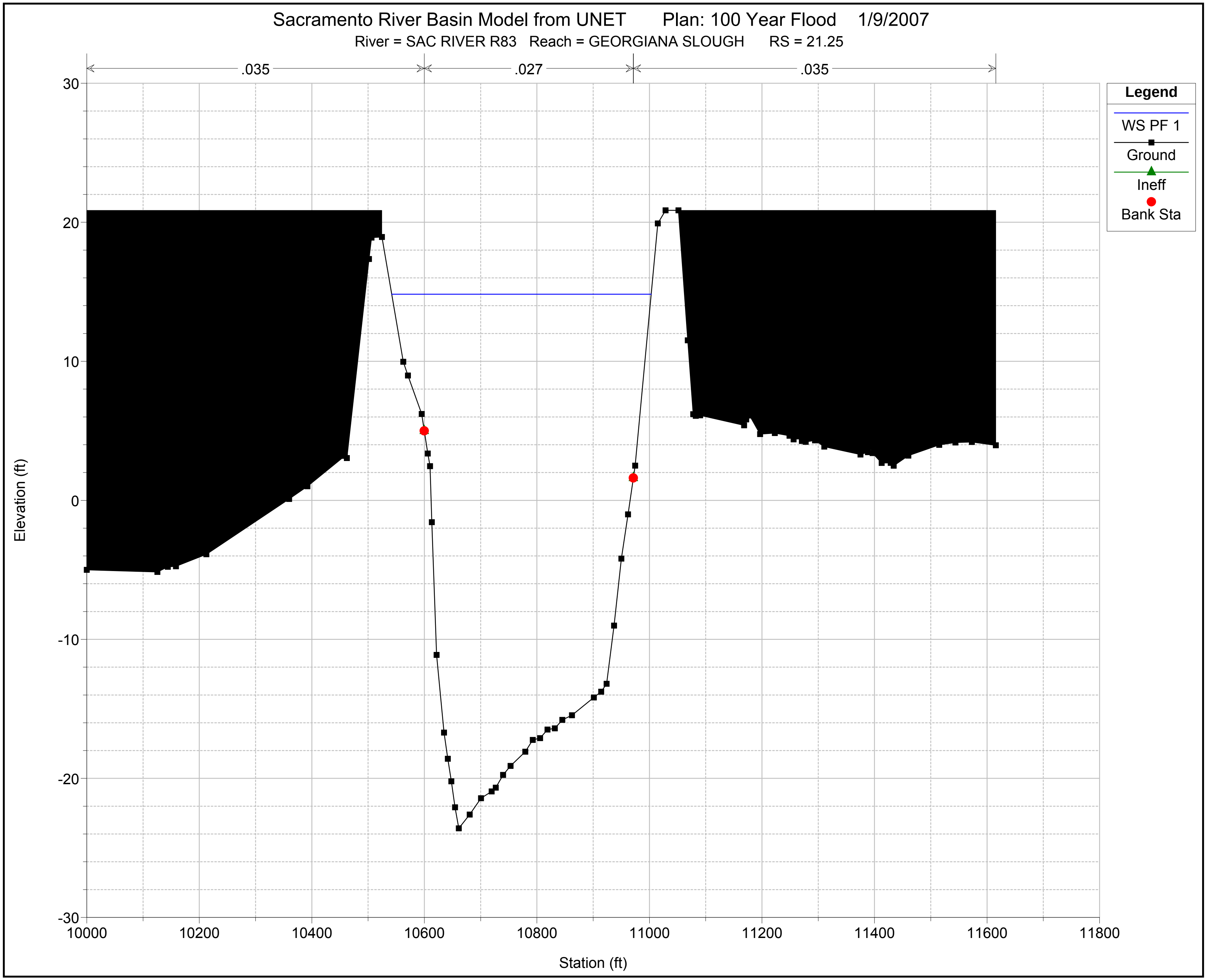
11800



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 21.25
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
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-10
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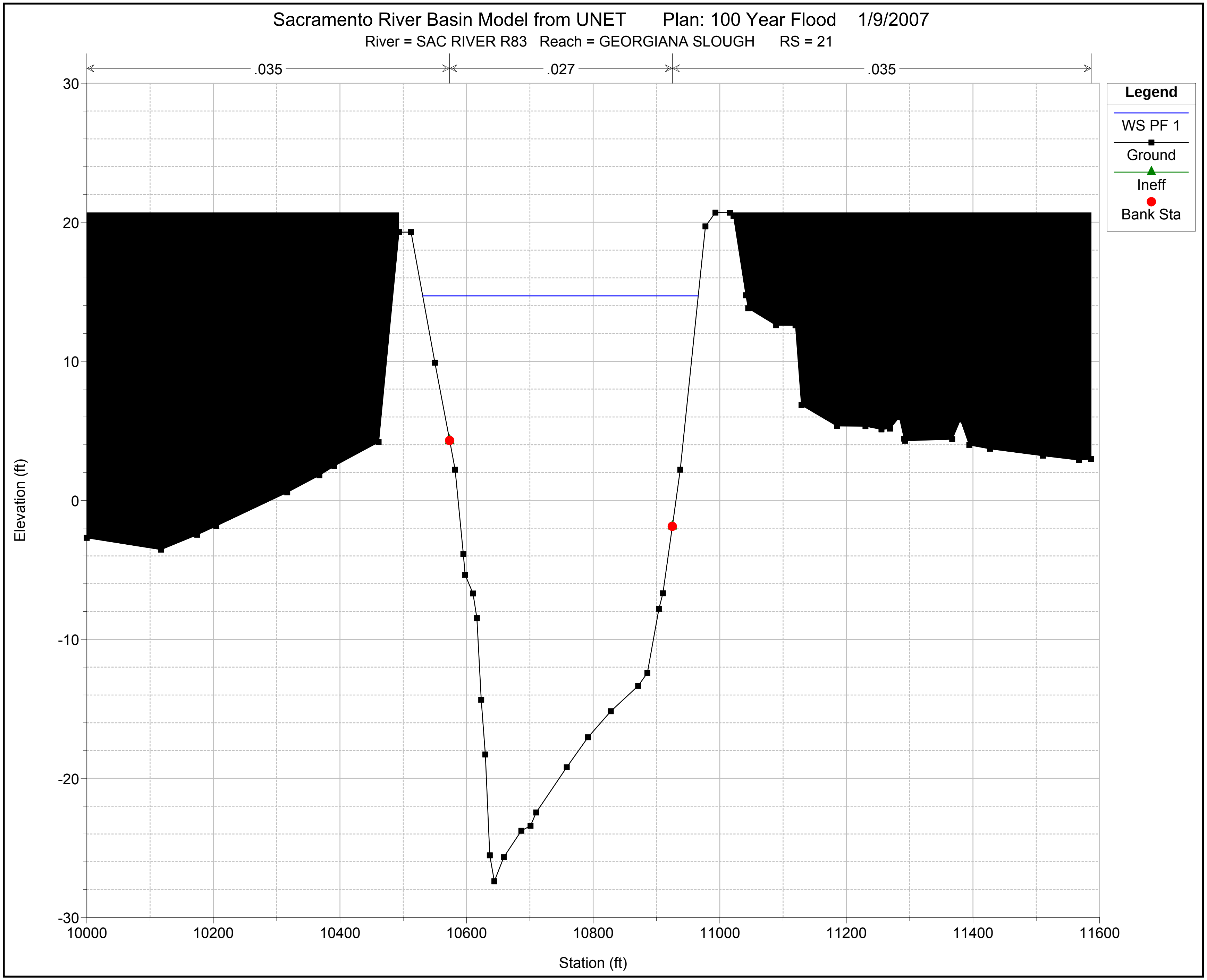
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
11800
Station (ft)



Sacramento River Basin Model from UNET Plan: 100 Year Flood 1/9/2007
River = SAC RIVER R83 Reach = GEORGIANA SLOUGH RS = 21
.035
.027
.035
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (ft)
30
20
10
0
-10
-20
-30
10000
10200
10400
10600
10800
11000
11200
11400
11600
Station (ft)

Levee Geometry
Technical Memorandum

Sacramento River Bank Protection Project
Sacramento River Basin, California

U.S. Army Corps of Engineers, Sacramento District

June 2011

Prepared By:

HDR Engineering, Inc.

2365 Iron Point Road, Suite 300

Folsom, CA 9563

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1.0 Levee Geometry

Levee cross section geometry is critical to overlaying the vegetation free zone per the ETL and the Framework Memo. The geometry is also important for developing quantities for cost estimates. In addition, the waterside hinge point elevations relative to seasonal mean water surface elevations are critical when figuring how the treatment of the waterside of levees impacts fish habitat.

This evaluation relied on AR cross section elevation data from the AR and the Sacramento San Joaquin Basins Comprehensive Study of 2002 by USACE, and on field notes from the AR. This section only describes how elevation data for the cross sections were derived for a geometrical analysis, actual design will include an geotechnical and hydraulic analysis along with site specific conditions.

1.1 Comprehensive Repair Site Data Sheet

A Comprehensive Repair Site Data Sheet (data sheet) was prepared for each of the 107 erosion repair sites. The data sheets can be found in **Appendix A**. Each data sheet contains the information derived from the available technical resources and is presented as three individual details, labeled DETAIL1, DETAIL 2 and DETAIL3. A description of each detail is presented below.

1.1.1 DETAIL 1

This section of the data sheet presents the typical erosion repair cross section within the upstream and downstream limits of the site. The title of each data sheet describes the repair site location. For example; “Cache Creek 3.9L” describes the left bank of the Cache Creek tributary at river mile 3.9. The cross section presented is considered the worst case scenario of bank erosion along the extents of the individual repair site.

The cross section which was derived from the information provided in the AR contains the existing levee geometry modified by erosion and is denoted as a shaded dashed line, along with the AR recommended erosion repair surface which is denoted as a bold black line. Each cross section contains dimensions which denote the limits of the VFZ relative to the waterside of the levee. It is understood that the ETL establishes a VFZ across the entire levee prism which includes the landside of the levee, but this analysis, based on the Framework Memo, was limited to the portion of the levee that is being recommended for repair.

The two dots in the cross section represent the location of the landside and waterside toes. These are critical points that must be established in order to define the limits of the VFZ. The landside toe was established based on the information provided below under detail 2 while the waterside toe was established based on information provided from both detail 2 and 3.

For a more detailed explanation of the process for defining the VFZ refer to the Framework Memo.

1.1.2 DETAIL 2

Because there was no field investigation conducted by HDR as part of this analysis, and the field notes provided in the AR only present detailed information on the waterside of the levee prism, it was necessary to utilize other technical resources to establish the elevation of the landside toe. This section of the data sheet presents a summary of the method and key components used to determine the landside toe as well as establish the elevation of the waterside toe. In short, the VFZ is defined as the area between a point beginning 15 feet landward of the landside toe to a point 15 feet waterward of the waterside toe. Therefore, two critical points necessary for establishing the limits of the VFZ are the landside and waterside levee toes.

The most current and accurate technical resource available is the Comprehensive Study prepared by the USACE. This study provides a cross section at random intervals along the Sacramento River and its tributaries. These intervals range from 1000 feet to 15,000 feet. Each cross section contains an elevation point at the landside toe, the landside and waterside hinge point of the levee crown and all critical grade break elevations on the waterside and landside of the levee. A critical grade break would be characterized as an existing riparian bench or some other large waterside feature. The landside would include seepage berms or stability berms.

The first step in HDR's analysis was to establish the location of the actual repair site in relation to a known cross section provided in the Comprehensive Study. In some instances, a Comprehensive Study cross section was available at or near the actual repair site location. In these cases the data from that individual cross section was used to establish the landside toe elevation. In other instances, the repair site was not located near a known Comprehensive Study cross section which would place the repair site some incremental distance between two individual cross sections. In these cases, the landside toe elevation at the location of the repair site was interpolated based on the data provided by each upstream and downstream cross section. The result of this analysis is shown graphically in Detail 2 under the title "CROSS-SECTION FROM DWR COMPREHENSIVE STUDY". Each cross section is shown graphically and labeled as "upstream x-section", "downstream x-section" and "repair site x-section" if interpolated. If not, only the "repair site x-section" is provided.

The second step in this analysis was to determine the actual elevation of the landside toe relative to the cross section provided in the AR. A summary of this procedure is presented in Detail 2 under the title "KEY DATA FOR DETERMINING LANDSIDE TOE". When reviewing the data provided in the Comprehensive Study and the elevation information provided in the AR, it was evident that there were a minor discrepancies in the elevations at the repair site location. This discrepancy ranged from two to five feet in elevation. Because of this discrepancy the estimated Comprehensive Study toe elevation was not used. Instead, the elevation difference between the Comprehensive Study crown and landside levee toe was calculated. This elevation difference was then subtracted from the AR crown elevation to determine the elevation of the landside toe relative to the AR repair site. This revised elevation was then applied to the cross section in Detail 1 as the proposed landside toe.

1.1.3 DETAIL 3

Because of the existing geometry of the waterside slope and in most instances heavy vegetation and emergent benches that may be manmade, it is difficult, if not impossible, to establish the location of the waterside toe by observation. In addition, the existing geometry of the waterside slope has been altered by some form of bank erosion, in effect displacing the location of the pre-eroded toe location. In an effort to recreate the existing eroded waterside slope geometry as shown in Detail 1, the AR field notes were used and are presented in Detail 3 for reference.

1.1.4 Levee Geometry Summary

The critical elements necessary for conducting a comprehensive analysis and preparing an accurate representation of the existing levee geometry with regard to requirements presented in the ETL are the landside toe, waterside toe, levee crown waterside hinge point, and the geometry of the waterside slope. Each of the aforementioned elements has been established based on the preceding discussion on Details 1, 2 & 3. The final element needed to complete the geometry of the existing levee cross section is establishing the waterside toe. This point is not apparent by inspection; it is actually a point that must be established by determining the landside toe.

As mentioned in the preceding discussion the waterside toe has been eroded, sediment may have been deposited or soil has been placed over the waterside toe to create a waterside bench or for a previous repair. Because of this, the waterside toe must be established by identifying known points, and then assuming various projections of those points.

The first critical point to establish is the landside toe which is located at the intersection of the existing ground and the landside slope. To establish the elevation of the waterside toe, the elevation of the landside toe is projected infinitely in the waterward direction. Without borings of the repair site and conducting a soils analysis it was assumed that the elevation of this line would have been the elevation of the existing river bank prior to constructing the levee, and serves at the horizontal element needed to establish the waterside toe.

The second critical point is the waterside levee crown hinge point. This is the point of beginning for the waterside slope projection, which can either be an actual slope or an assumed slope depending on the existing condition of the waterside bank geometry. In either case, the minimum slope projection is a 2:1 ratio if the existing slope was greater; if less than a 2:1 ratio, the actual slope was projected. Once the slope ratio was defined, that line was projected from the waterside hinge point to the previously projected original ground elevation; this intersect is considered the waterside toe and is presented as a blue dot in Detail 1.

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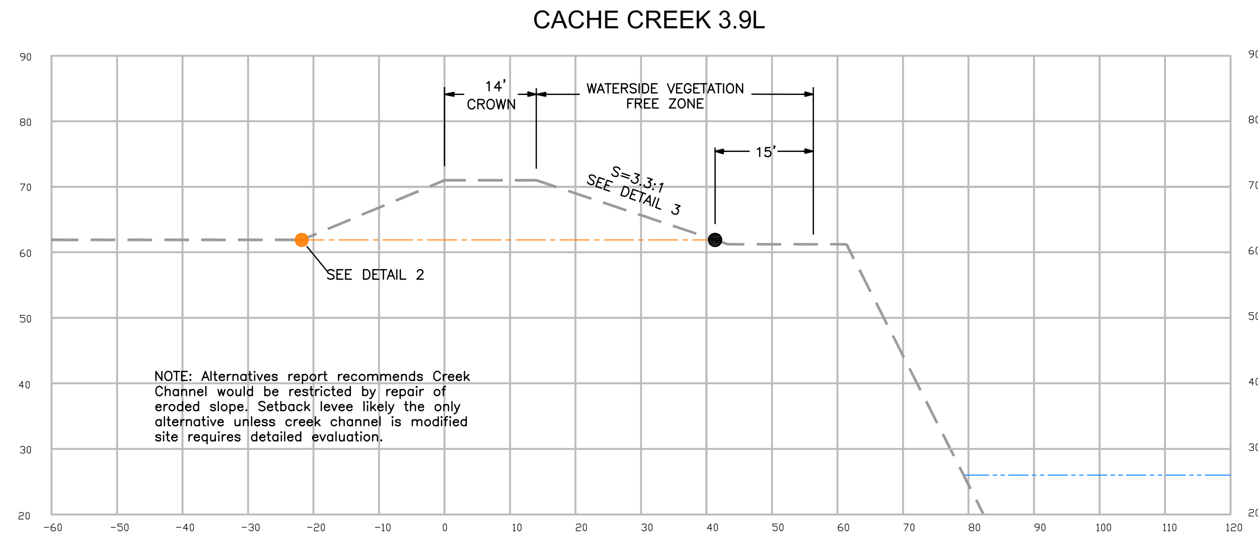
DETAIL 1

CACHE CREEK 3.9L



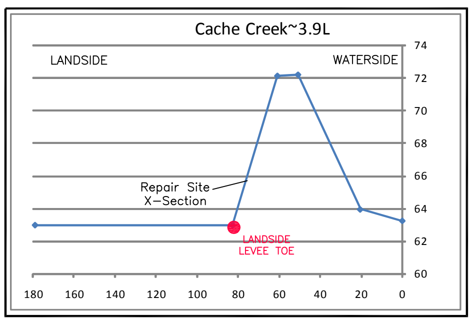
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	63.3
20.5	64.0
50.8	72.2
60.9	72.1
82.7	63.0
178.9	63.0

KEY DATA FOR DETERMINING LANDSIDE TOE

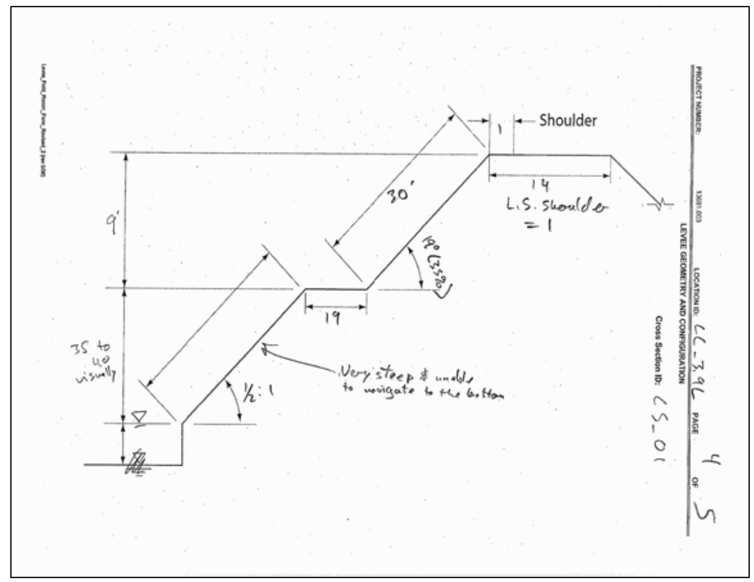
Comp Study Levee Crown Elevation	72.1
Comp Study Landside Toe Elevation	63.0
Comp Study Difference	9.1

Alternatives Report Analysis Levee Crown Elevation	71.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	61.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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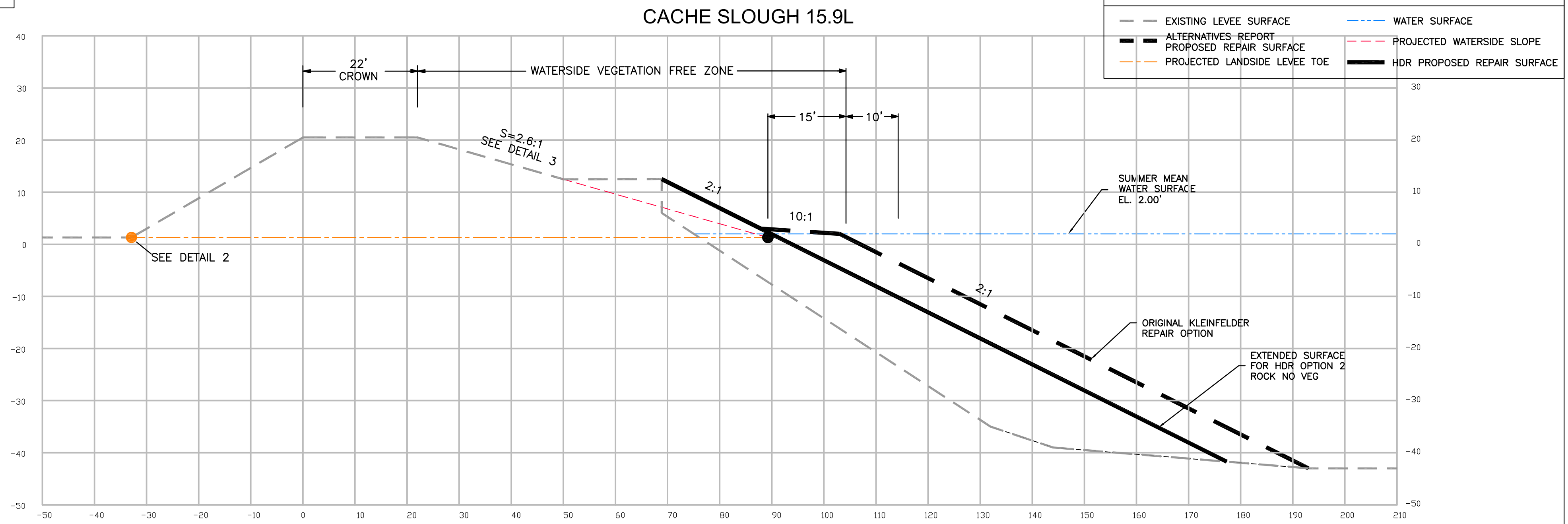
Checked By: R. Little
QA/QC Review: D. Teak

CACHE CREEK ~ 3.9L

Date 3/31/11

Figure CC 3.9L

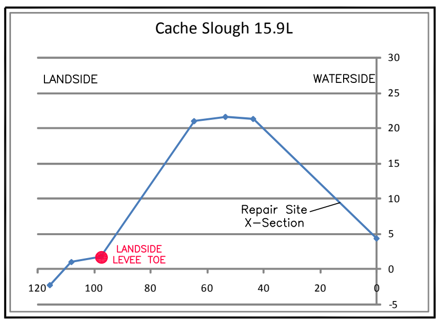
DETAIL 1



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	4.3
43.7	21.3
53.5	21.6
64.6	21.0
97.4	1.8
107.9	1.0
115.6	-2.3

KEY DATA FOR DETERMINING LANDSIDE TOE

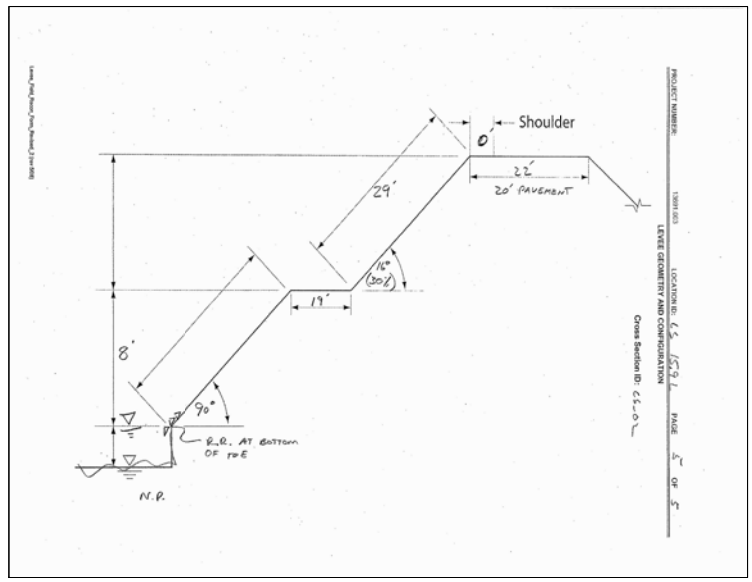
Comp Study Levee Crown Elevation	21.0
Comp Study Landside Toe Elevation	1.8
Comp Study Difference	19.2

Alternatives Report Analysis Levee Crown Elevation	20.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	1.3

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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HDR Engineering, Inc.

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Checked By:	R. Little
QA/QC Review:	D. Teak

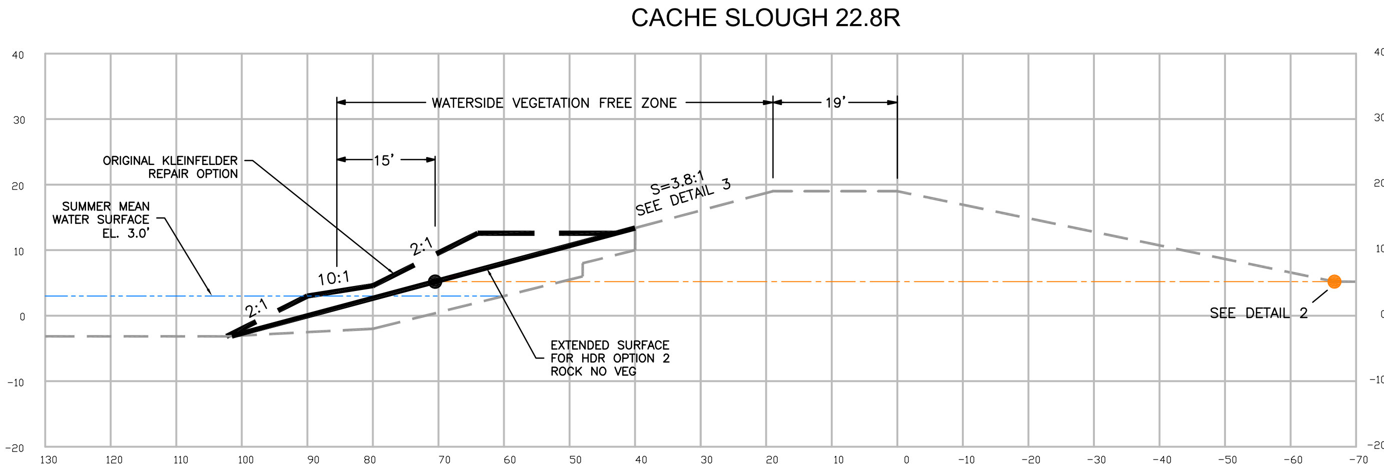
CACHE SLOUGH ~ 15.9L

Date	3/31/11
Figure	CS 15.9L

DETAIL 1

LEGEND

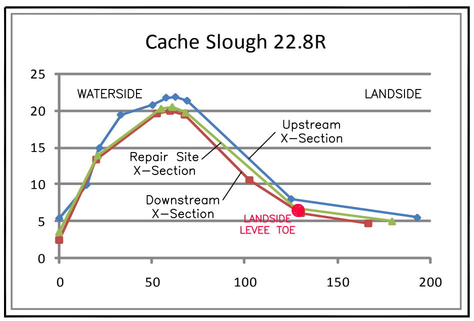
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- HDR PROPOSED REPAIR SURFACE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	3.5
20.8	14.0
55.1	20.4
61.1	20.6
68.2	19.9
127.8	6.8
179.8	5.0

KEY DATA FOR DETERMINING LANDSIDE TOE

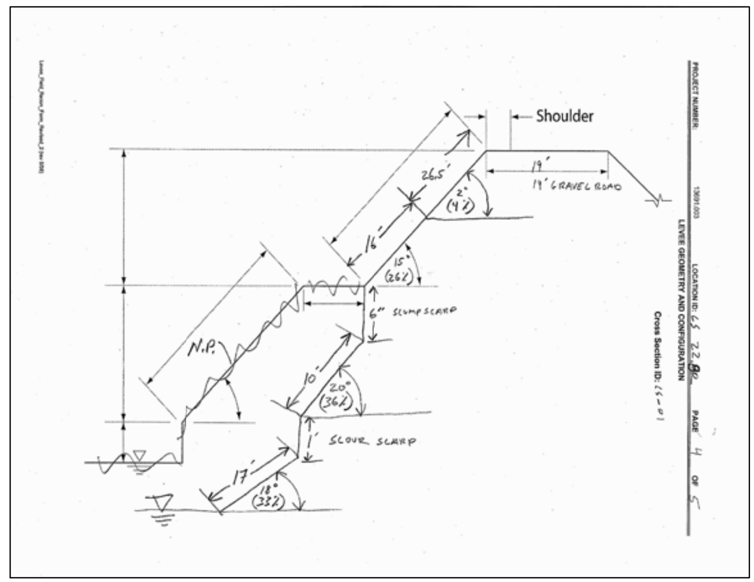
Comp Study Levee Crown Elevation	20.6
Comp Study Landside Toe Elevation	6.8
Comp Study Difference	13.8

Alternatives Report Analysis Levee Crown Elevation	19.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	5.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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HDR Engineering, Inc.

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QA/QC Review:	D. Teak

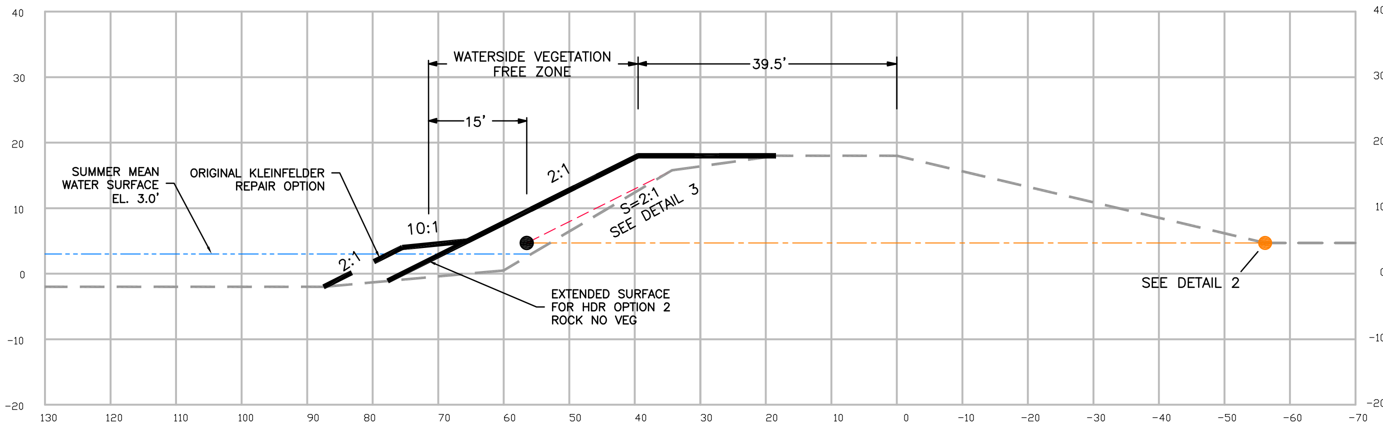
CACHE SLOUGH ~ 22.8R

Date	3/31/11
Figure	CS 22.8R

DETAIL 1

LEGEND

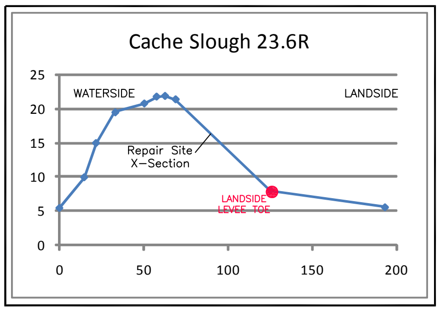
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- HDR PROPOSED REPAIR SURFACE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.5
14.7	10.0
21.7	15.0
33.2	19.5
50.4	20.8
57.7	21.8
62.7	21.9
69.0	21.4
125.2	8.1
193.2	5.6

KEY DATA FOR DETERMINING LANDSIDE TOE

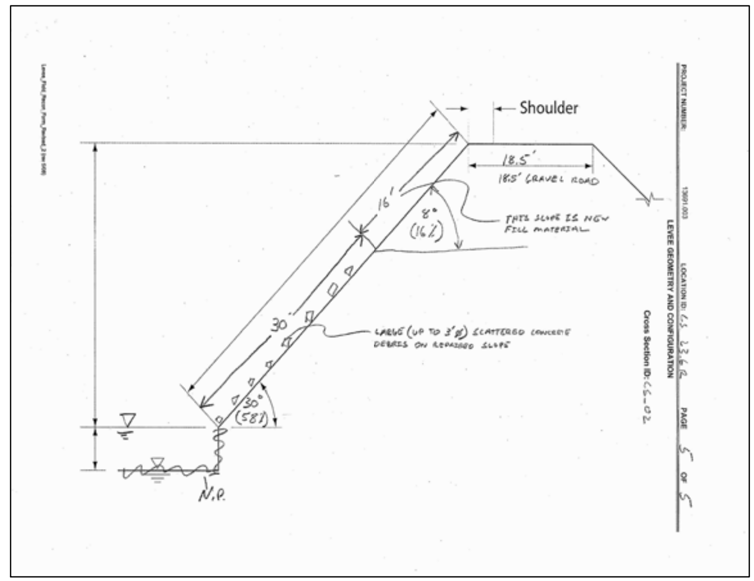
Comp Study Levee Crown Elevation	21.4
Comp Study Landside Toe Elevation	8.1
Comp Study Difference	13.3

Alternatives Report Analysis Levee Crown Elevation	18.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Checked By:	R. Little
QA/QC Review:	D. Teak

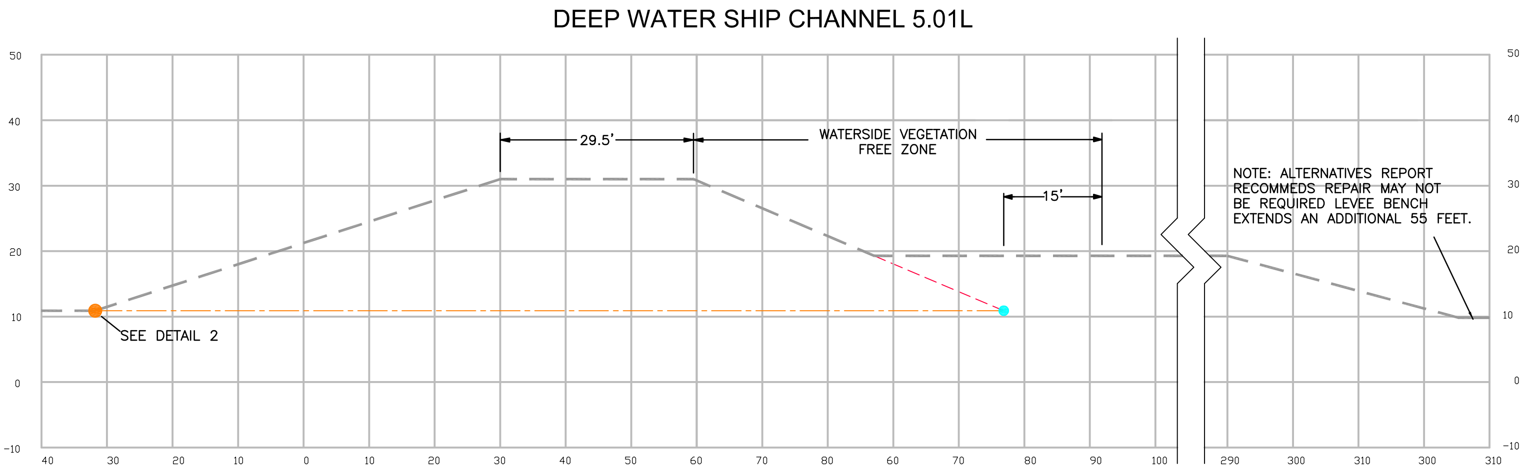
CACHE SLOUGH ~ 23.6R

Date	3/31/11
Figure	CS 23.6R

DETAIL 1

LEGEND

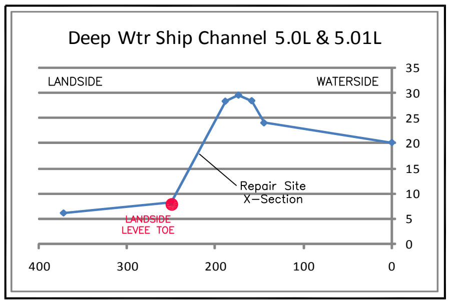
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.3
145.1	24.2
159.0	28.6
174.0	29.7
189.0	28.5
250.8	8.4
372.4	6.3

KEY DATA FOR DETERMINING LANDSIDE TOE

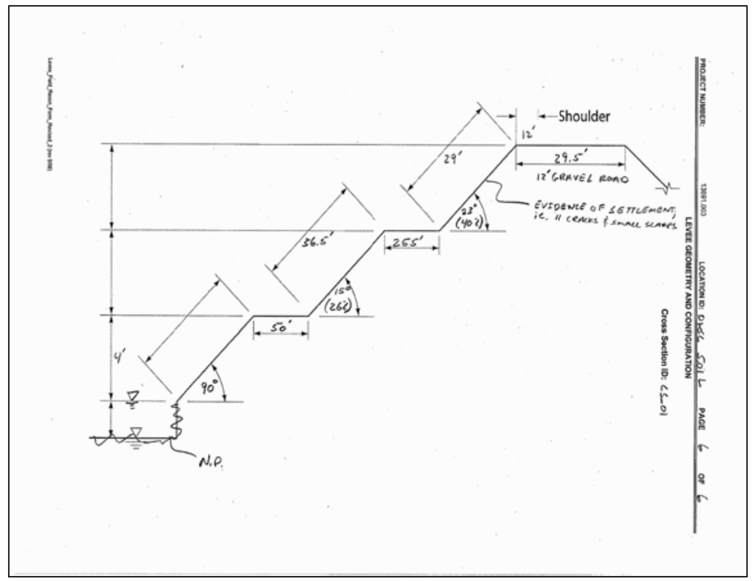
Comp Study Levee Crown Elevation	28.5
Comp Study Landside Toe Elevation	8.4
Comp Study Difference	20.1

Alternatives Report Analysis Levee Crown Elevation	26.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	5.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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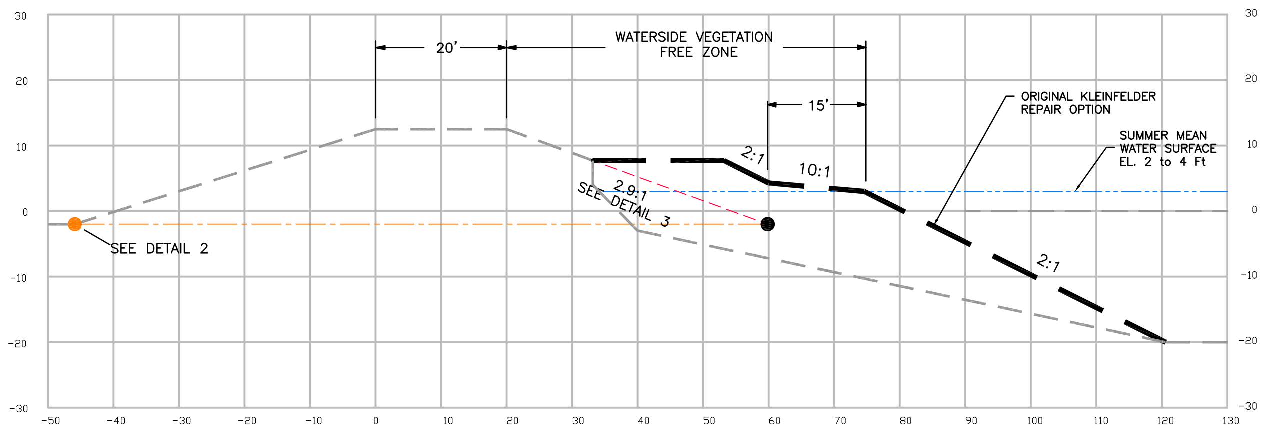
DEEP WTR SHIP CHANNEL ~ 5.01L

Date	3/31/11
Figure	DWSC 5.01L

DETAIL 1

LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE

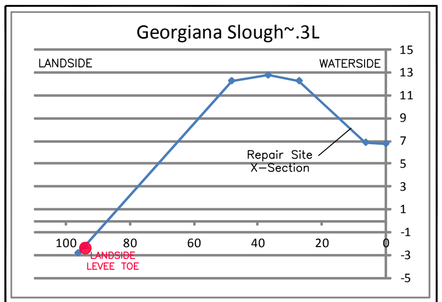
GEORGIANA SLOUGH 0.3L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.8
6.3	6.9
27.1	12.3
36.8	12.8
48.2	12.3
94.1	-2.2
96.2	-2.8

KEY DATA FOR DETERMINING LANDSIDE TOE

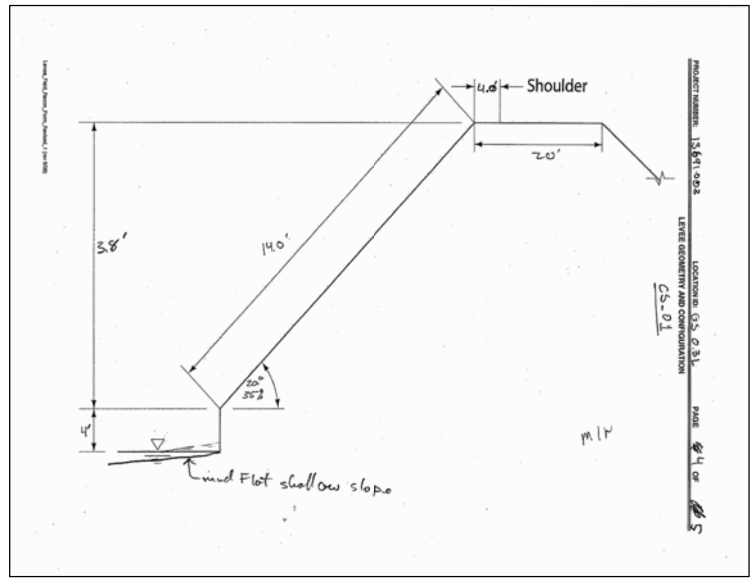
Comp Study Levee Crown Elevation	12.3
Comp Study Landside Toe Elevation	-2.2
Comp Study Difference	14.5

Alternatives Report Analysis Levee Crown Elevation	12.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	-2.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



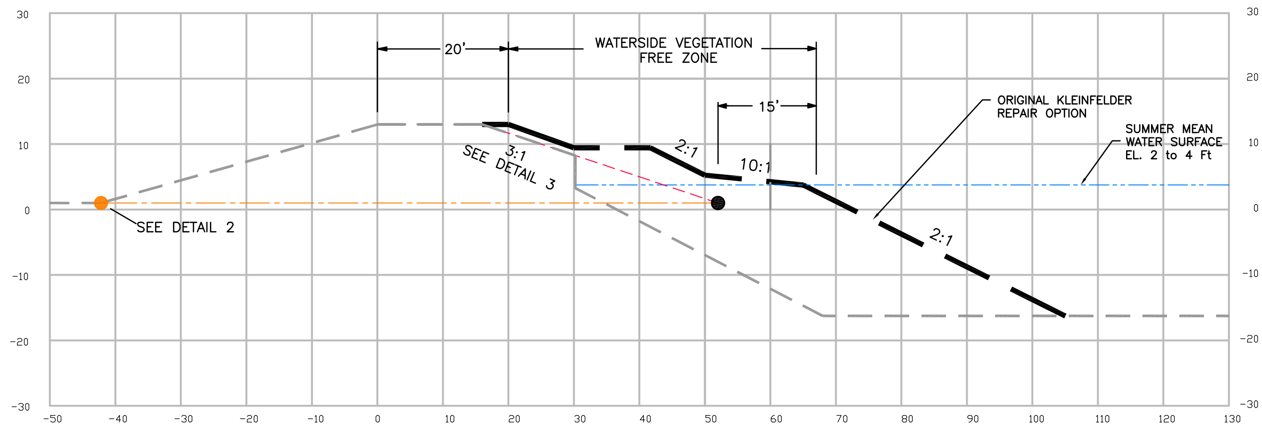
Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	GEORGIANA SLOUGH ~ 0.3L	Date 3/31/11 Figure GS 0.3L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

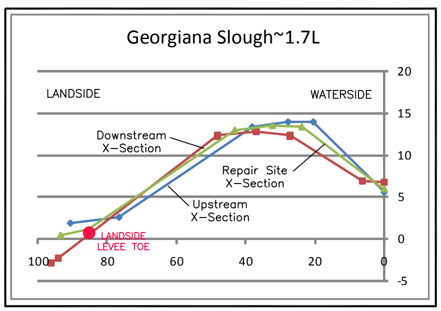
GEORGIANA SLOUGH 1.7L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.0
23.8	13.5
32.3	13.6
43.2	13.0
85.4	1.1
93.5	0.4

KEY DATA FOR DETERMINING LANDSIDE TOE

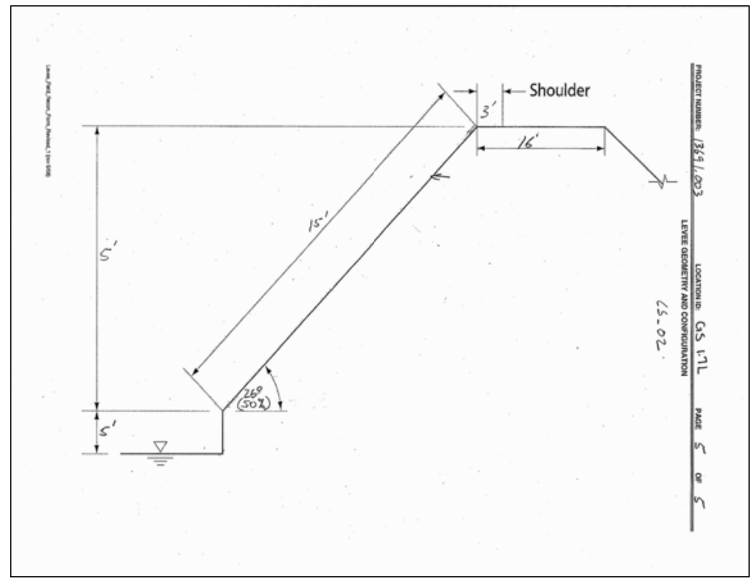
Comp Study Levee Crown Elevation	13.0
Comp Study Landside Toe Elevation	1.1
Comp Study Difference	12.0

Alternatives Report Analysis Levee Crown Elevation	13.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	1.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Checked By: R. Little
QA/QC Review: D. Teak

GEORGIANA SLOUGH ~1.7L

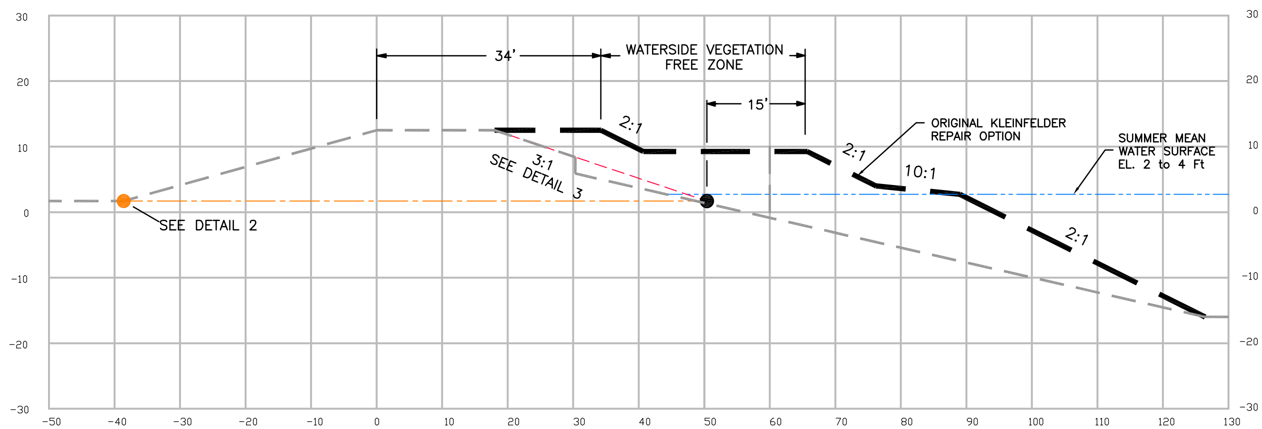
Date 3/31/11

Figure GS 1.7L

DETAIL 1

LEGEND
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

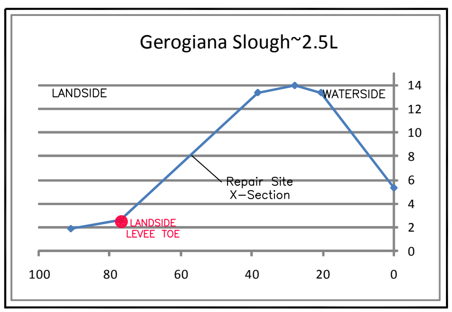
GEORGIANA SLOUGH 2.5L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.4
20.5	13.4
27.9	14.0
38.3	13.4
76.9	2.6
90.9	1.9

KEY DATA FOR DETERMINING LANDSIDE TOE

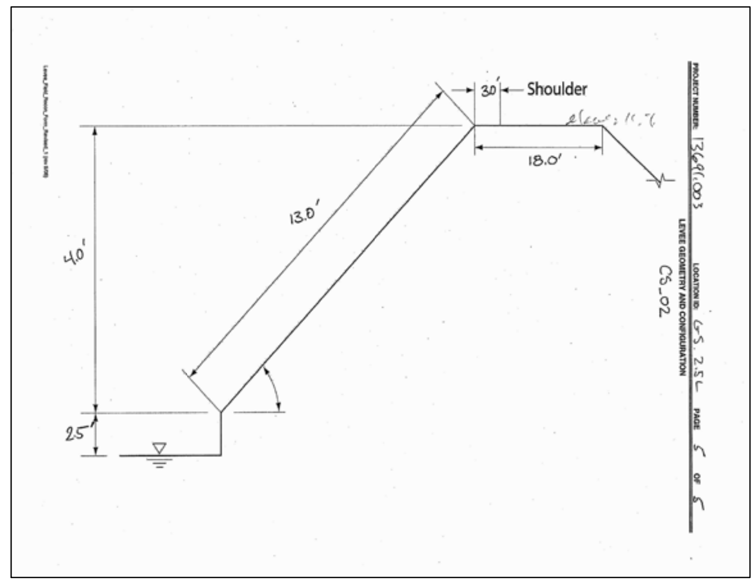
Comp Study Levee Crown Elevation	13.4
Comp Study Landside Toe Elevation	2.6
Comp Study Difference	10.8

Alternatives Report Analysis Levee Crown Elevation	12.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	1.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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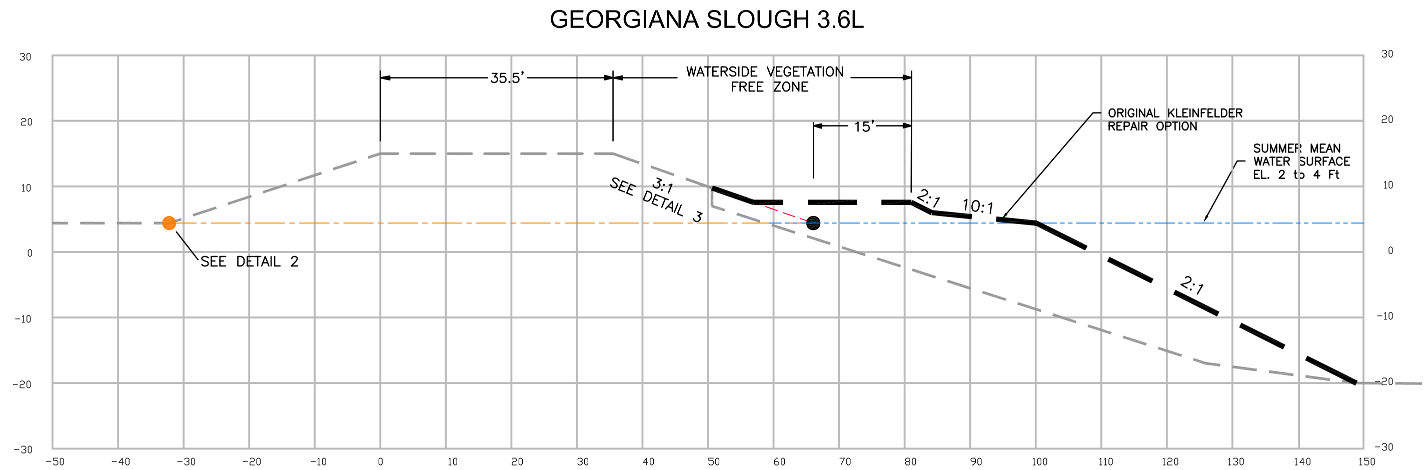
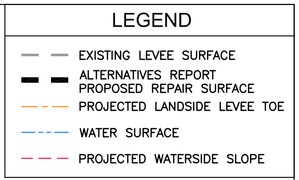
QA/QC Review:	D. Teak

GEORGIANA SLOUGH ~2.5L

Date	3/31/11
Figure	GS 2.5L

DETAIL 1

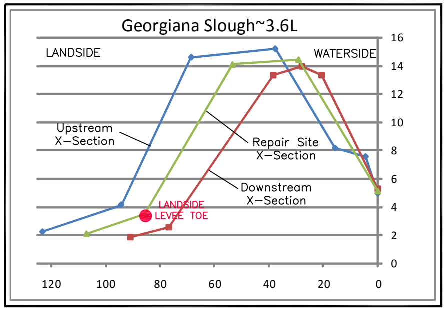




DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.2
29.1	14.4
53.4	14.1
85.6	3.5
107.1	2.1

KEY DATA FOR DETERMINING LANDSIDE TOE

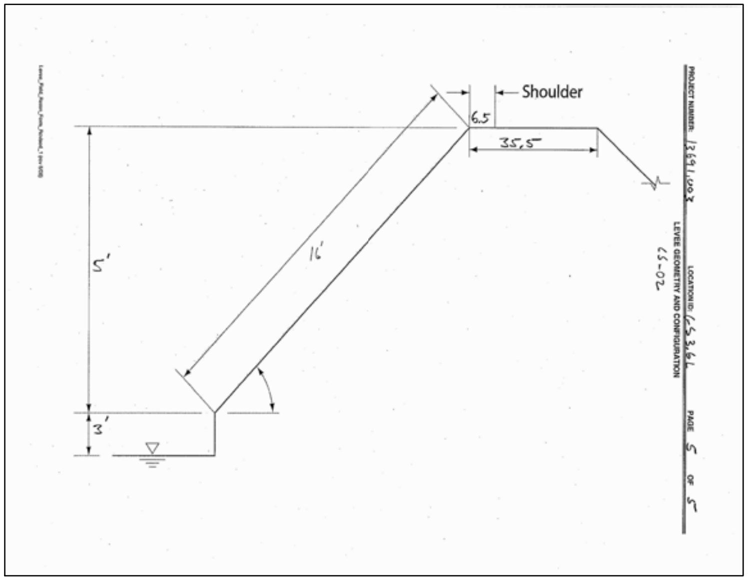
Comp Study Levee Crown Elevation	14.1
Comp Study Landside Toe Elevation	3.5
Comp Study Difference	10.6

Alternatives Report Analysis Levee Crown Elevation	15.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

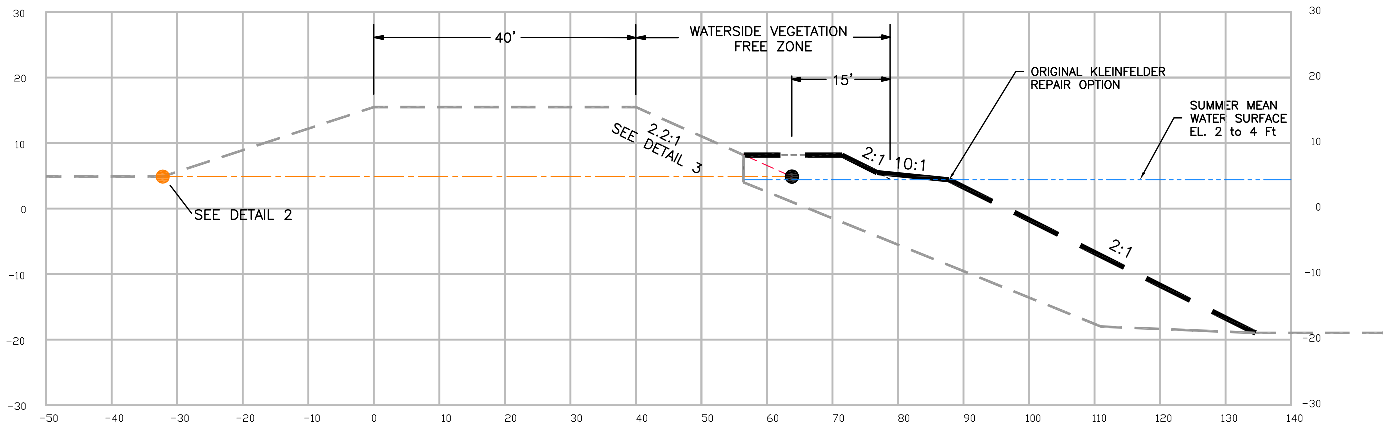
GEORGIANA SLOUGH ~3.6L

Date	3/31/11
Figure	GS 3.6L

DETAIL 1

LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE

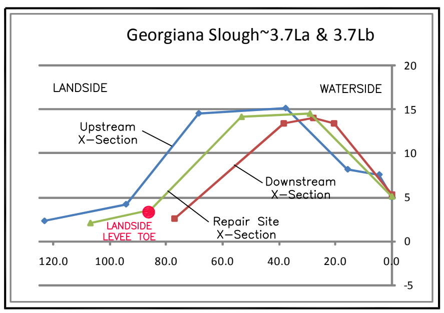
GEORGIANA SLOUGH 3.7aL



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.1
29.1	14.5
53.4	14.1
85.6	3.6
107.1	2.1

KEY DATA FOR DETERMINING LANDSIDE TOE

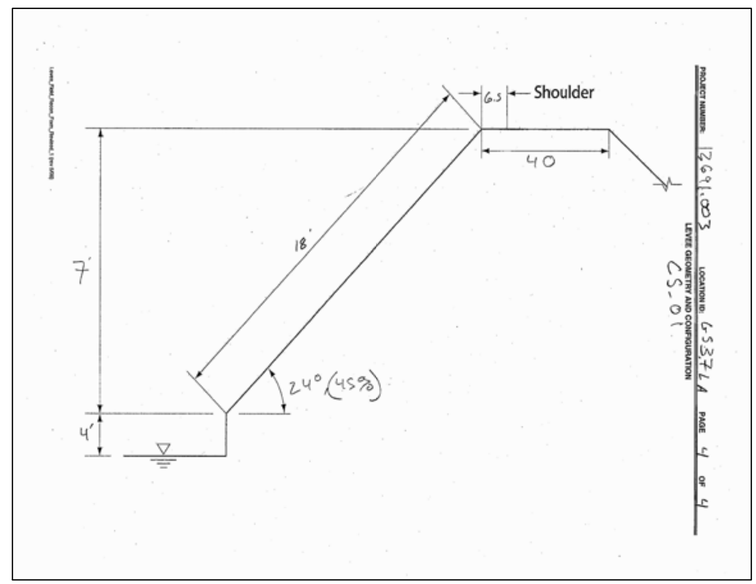
Comp Study Levee Crown Elevation	14.1
Comp Study Landside Toe Elevation	3.6
Comp Study Difference	10.6

Alternatives Report Analysis Levee Crown Elevation	15.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

GEORGIANA SLOUGH ~3.7aL

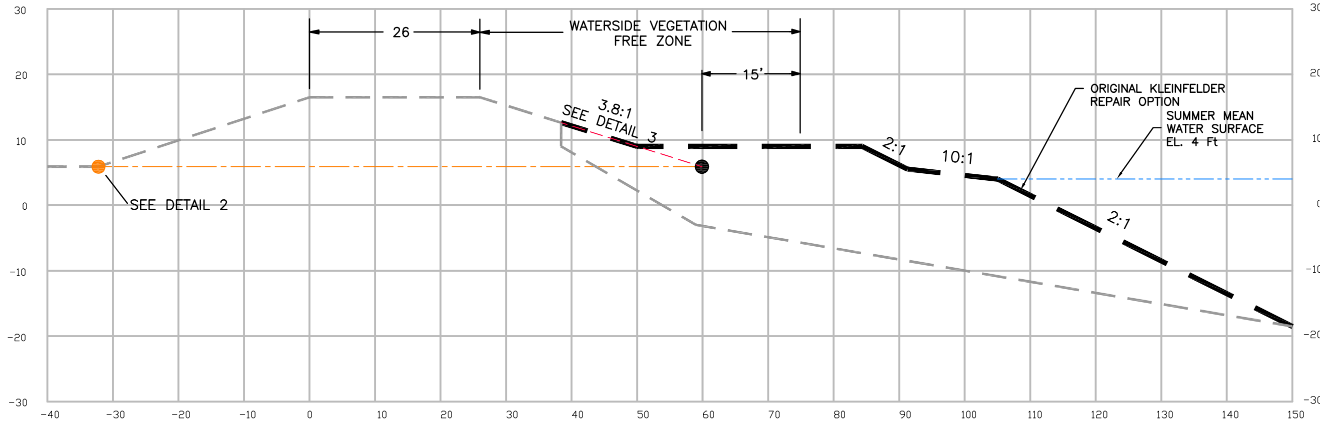
Date	3/31/11
Figure	GS 3.7aL

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

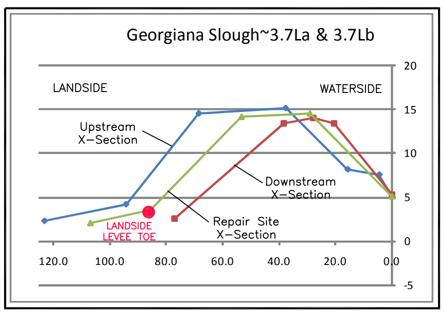
GEORGIANA SLOUGH 3.7bL



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.1
29.1	14.5
53.4	14.1
85.6	3.6
107.1	2.1

KEY DATA FOR DETERMINING LANDSIDE TOE

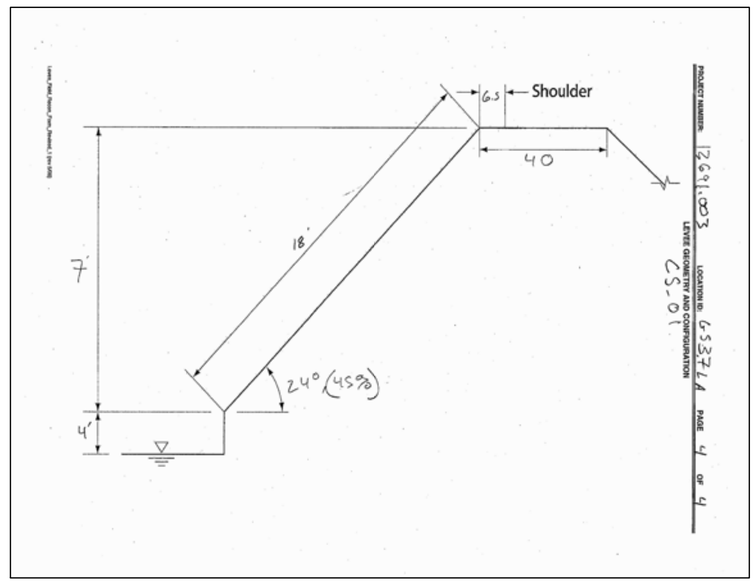
Comp Study Levee Crown Elevation	14.1
Comp Study Landside Toe Elevation	3.6
Comp Study Difference	10.6

Alternatives Report Analysis Levee Crown Elevation	15.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.9

DETAIL 3

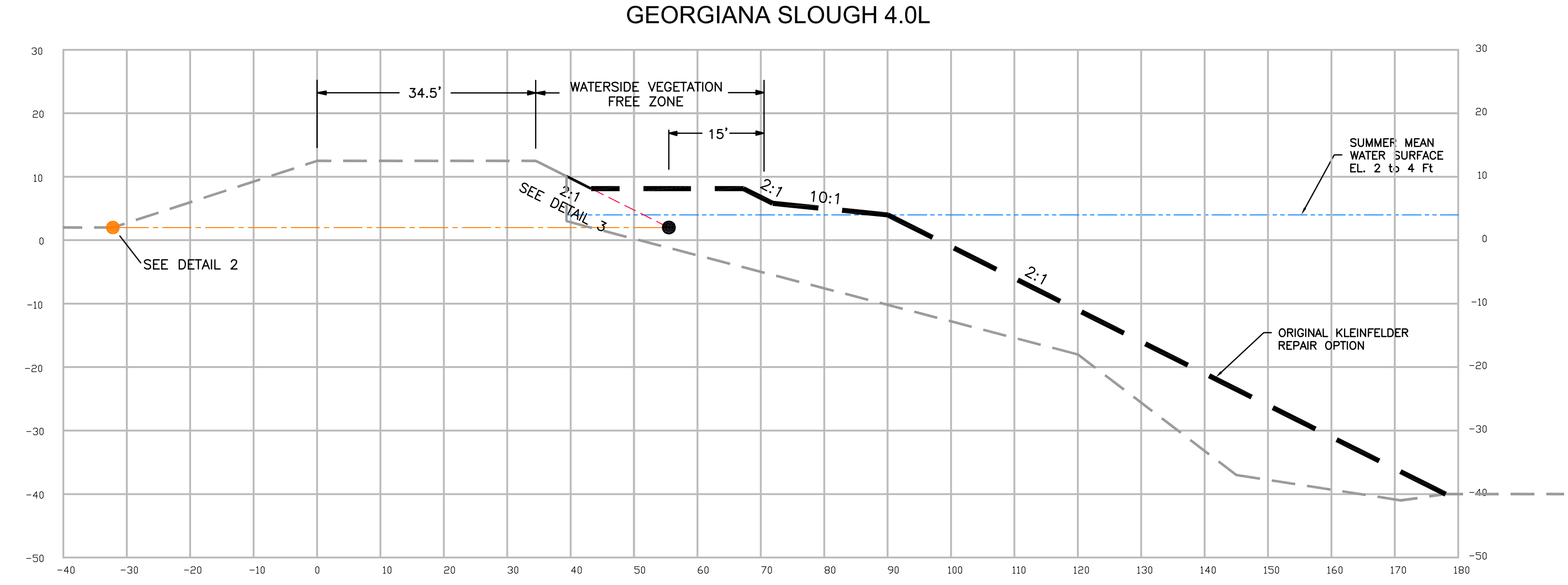
ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	GEORGIANA SLOUGH ~3.7bL
		Date: 3/31/11	Figure: GS 3.7bL

DETAIL 1

GEORGIANA SLOUGH 4.0L



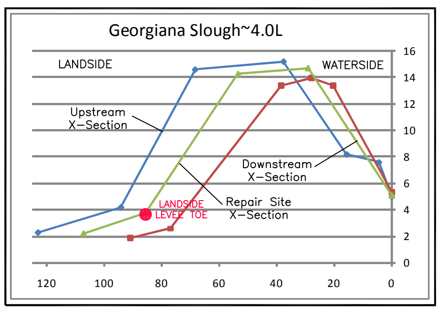
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.1
29.1	14.7
53.4	14.3
85.6	3.8
107.1	2.2

KEY DATA FOR DETERMINING LANDSIDE TOE

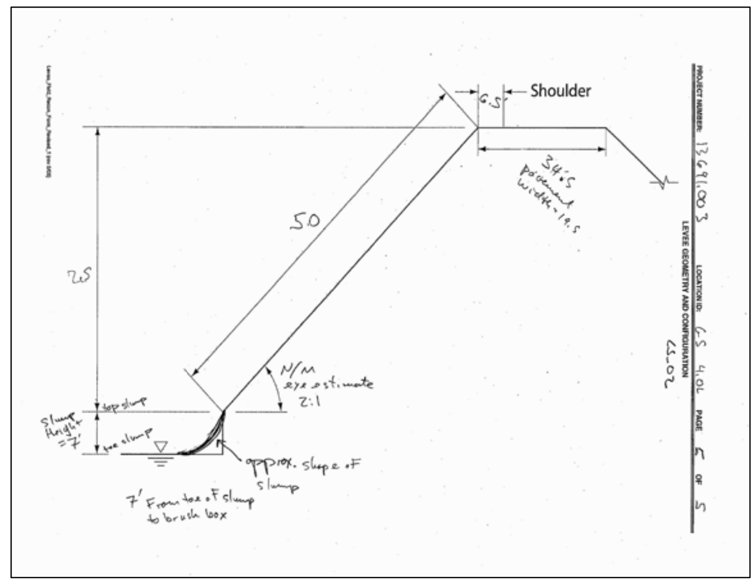
Comp Study Levee Crown Elevation	14.3
Comp Study Landside Toe Elevation	3.8
Comp Study Difference	10.5

Alternatives Report Analysis Levee Crown Elevation	12.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	2.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

GEORGIANA SLOUGH ~ 4.0L

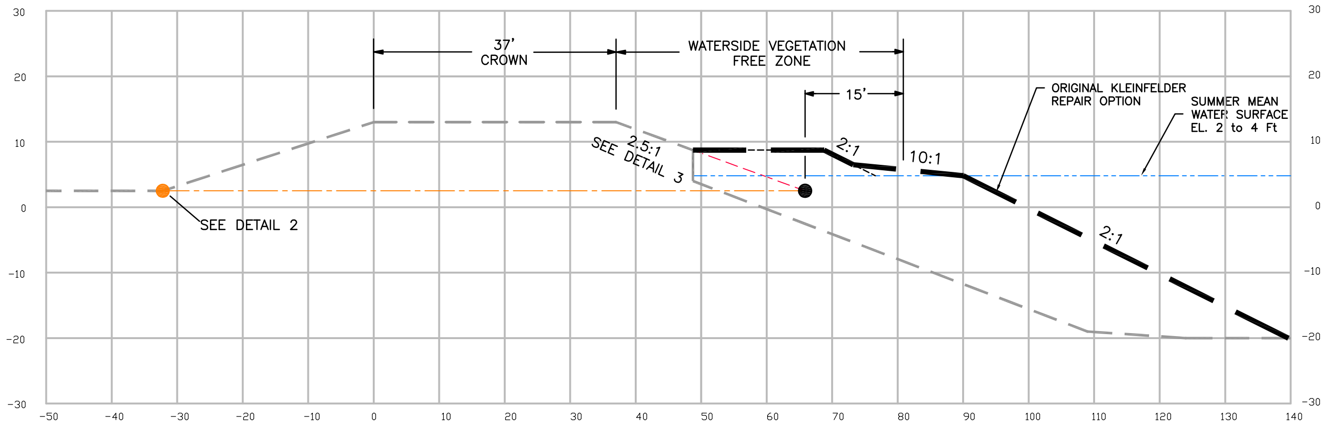
Date	3/31/11
Figure	GS 4.0L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

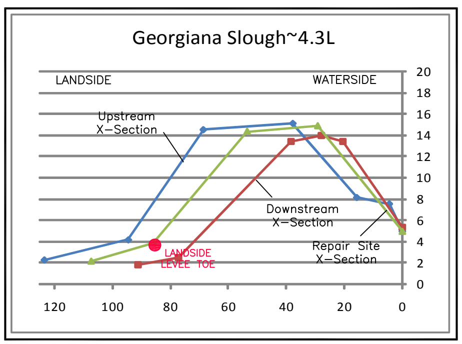
GEORGIANA SLOUGH 4.3L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.0
29.1	15.0
53.4	14.4
85.6	4.0
107.1	2.2

KEY DATA FOR DETERMINING LANDSIDE TOE

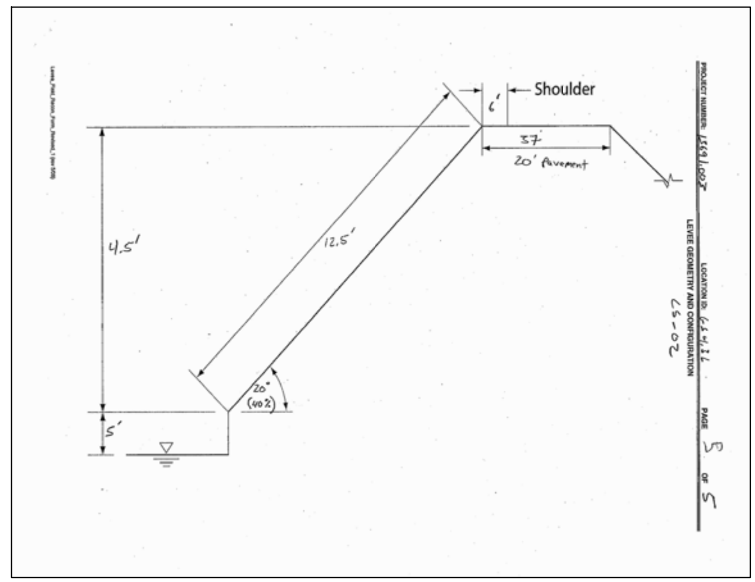
Comp Study Levee Crown Elevation	14.4
Comp Study Landside Toe Elevation	4.0
Comp Study Difference	10.5

Alternatives Report Analysis Levee Crown Elevation	12.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	2.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

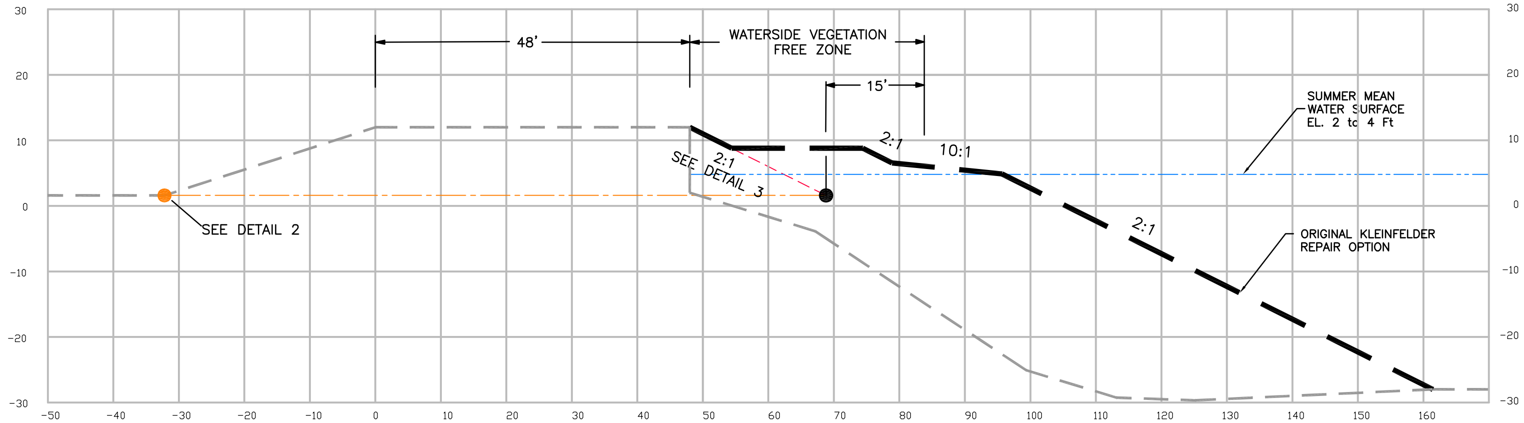
GEORGIANA SLOUGH ~ 4.3L

Date 3/31/11
Figure GS 4.3L

DETAIL 1

LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE

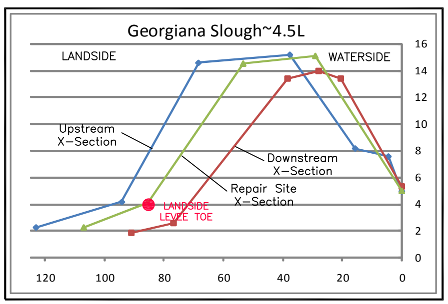
GEORGIANA SLOUGH 4.5L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.0
29.1	15.1
53.4	14.5
85.6	4.1
107.1	2.3

KEY DATA FOR DETERMINING
LANDSIDE TOE

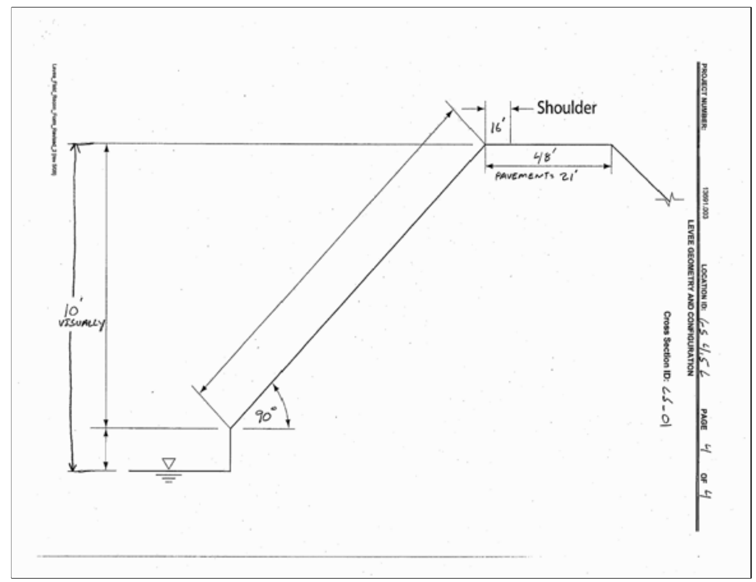
Comp Study Levee Crown Elevation	14.5
Comp Study Landside Toe Elevation	4.1
Comp Study Difference	10.4

Alternatives Report Analysis Levee Crown Elevation	12.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	1.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES

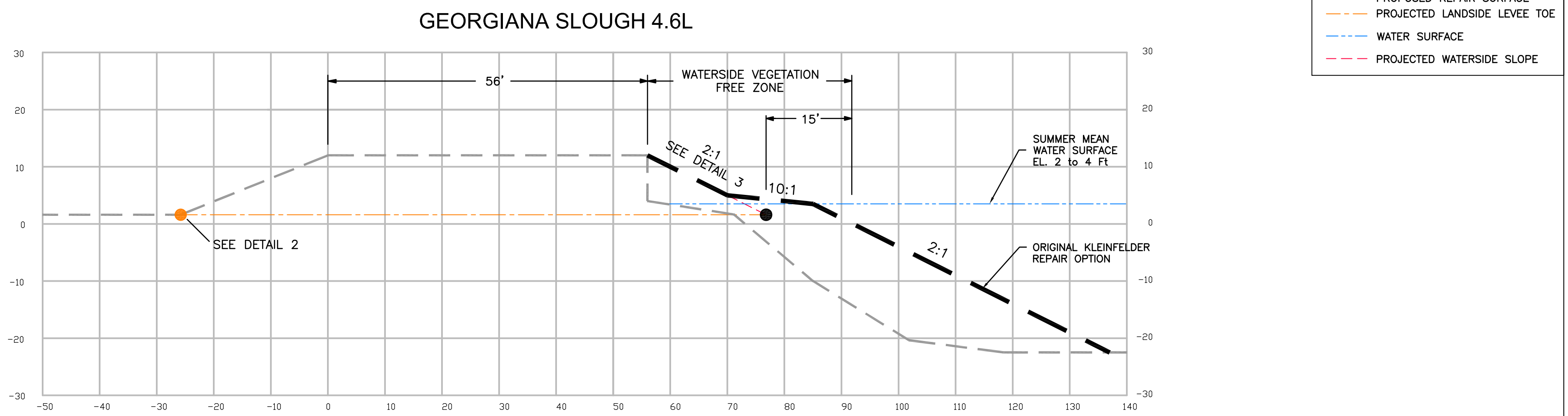


Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	GEORGIANA SLOUGH ~ 4.5L

Date 3/31/11

Figure GS 4.5L

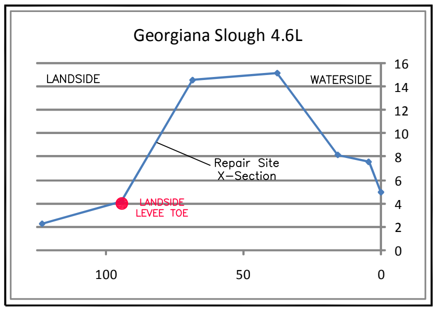
DETAIL 1



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.0
4.5	7.6
15.7	8.2
37.7	15.2
68.5	14.6
94.3	4.2
123.2	2.3

KEY DATA FOR DETERMINING LANDSIDE TOE

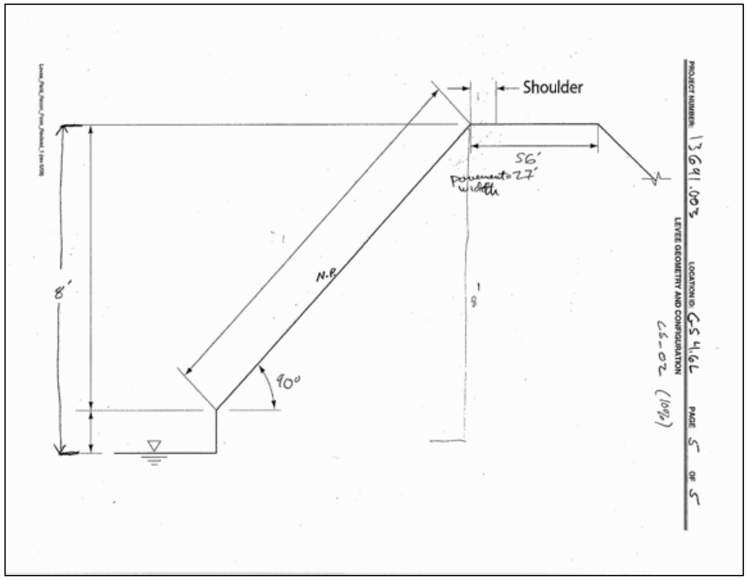
Comp Study Levee Crown Elevation	14.6
Comp Study Landside Toe Elevation	4.2
Comp Study Difference	10.4

Alternatives Report Analysis Levee Crown Elevation	12.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	1.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

GEORGIANA SLOUGH ~ 4.6L

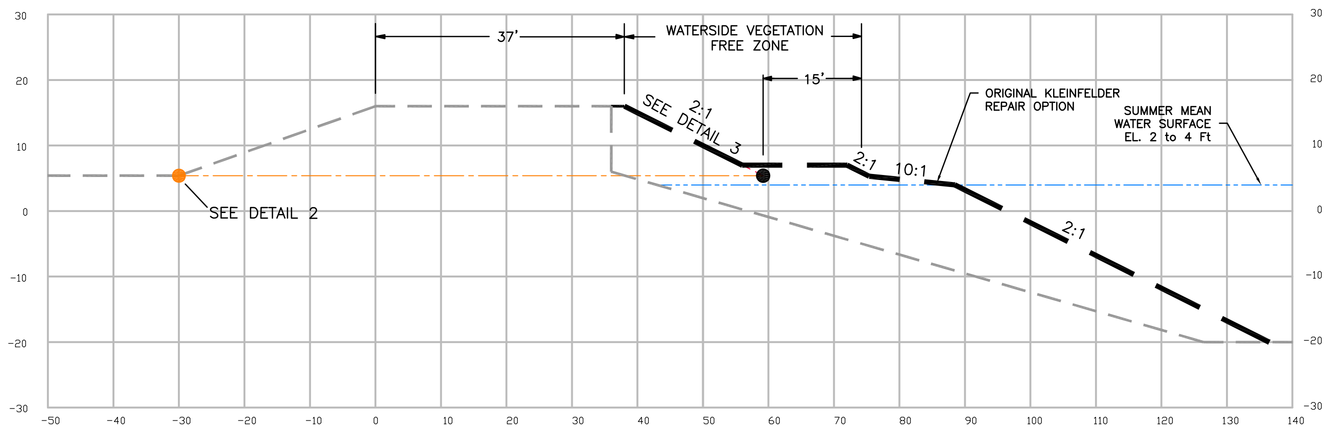
Date 3/31/11
Figure GS 4.6L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

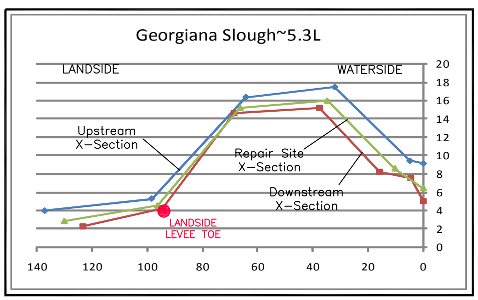
GEORGIANA SLOUGH 5.3L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.5
10.3	8.7
34.9	16.0
66.4	15.3
96.4	4.6
130.2	3.0

KEY DATA FOR DETERMINING LANDSIDE TOE

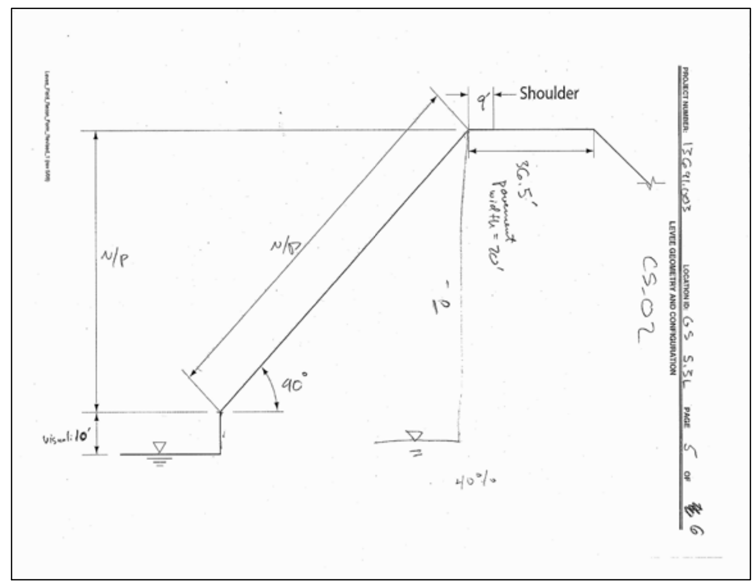
Comp Study Levee Crown Elevation	15.3
Comp Study Landside Toe Elevation	4.6
Comp Study Difference	10.6

Alternatives Report Analysis Levee Crown Elevation	16.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	5.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

GEORGIANA SLOUGH ~ 5.3L

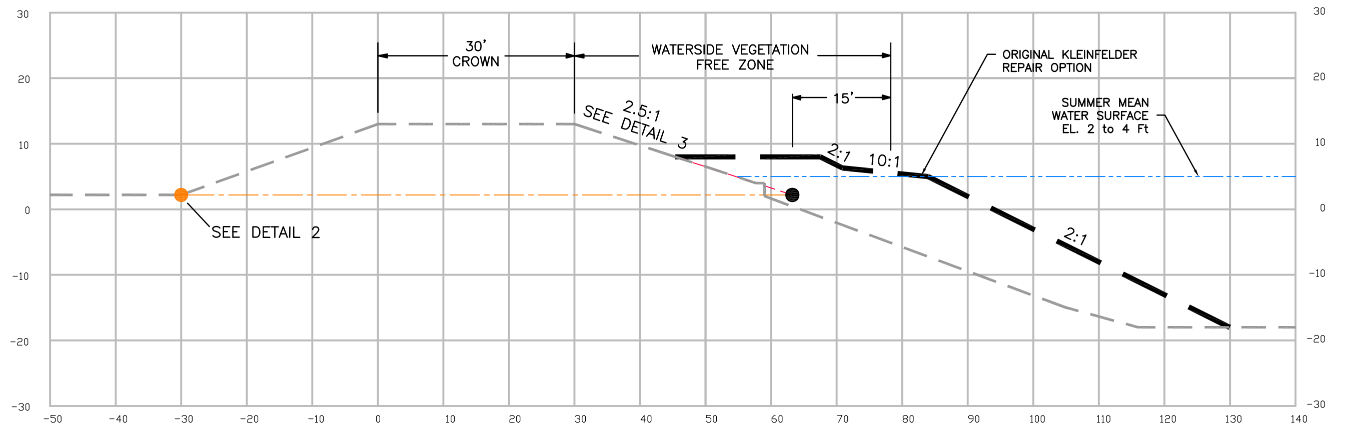
Date 3/31/11

Figure GS 5.3L

DETAIL 1

LEGEND
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

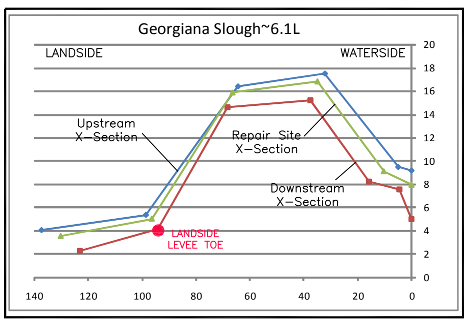
GEORGIANA SLOUGH 6.1L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.9
10.3	9.1
34.9	16.8
66.4	15.9
96.4	5.0
130.2	3.6

KEY DATA FOR DETERMINING LANDSIDE TOE

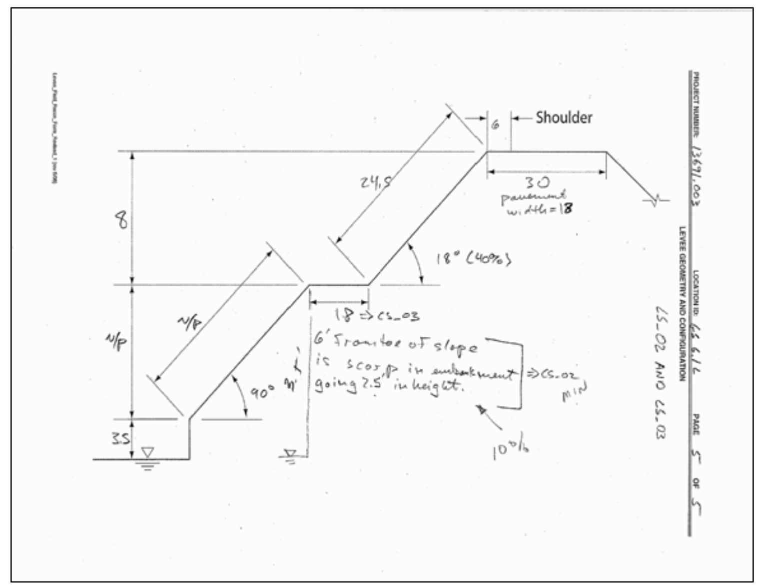
Comp Study Levee Crown Elevation	15.9
Comp Study Landside Toe Elevation	5.0
Comp Study Difference	10.8

Alternatives Report Analysis Levee Crown Elevation	13.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	2.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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HDR Engineering, Inc.

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Checked By:	R. Little
QA/QC Review:	D. Teak

GEORGIANA SLOUGH ~ 6.1L

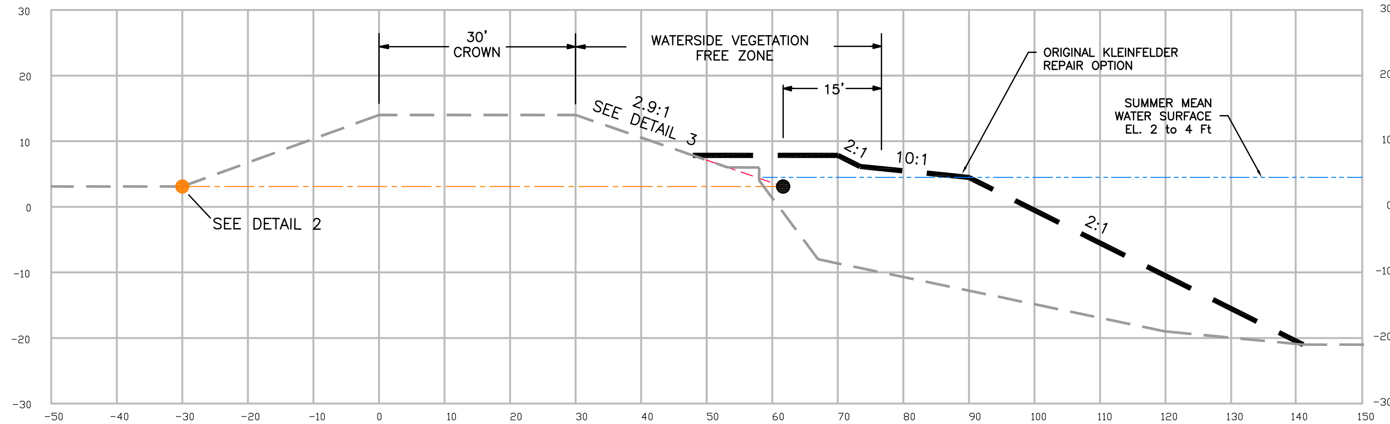
Date	3/31/11
Figure	GS 6.1L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

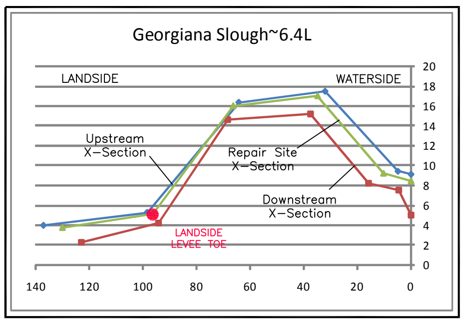
GEORGIANA SLOUGH 6.4L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.5
10.3	9.3
34.9	17.1
66.4	16.1
96.4	5.2
130.2	3.8

KEY DATA FOR DETERMINING LANDSIDE TOE

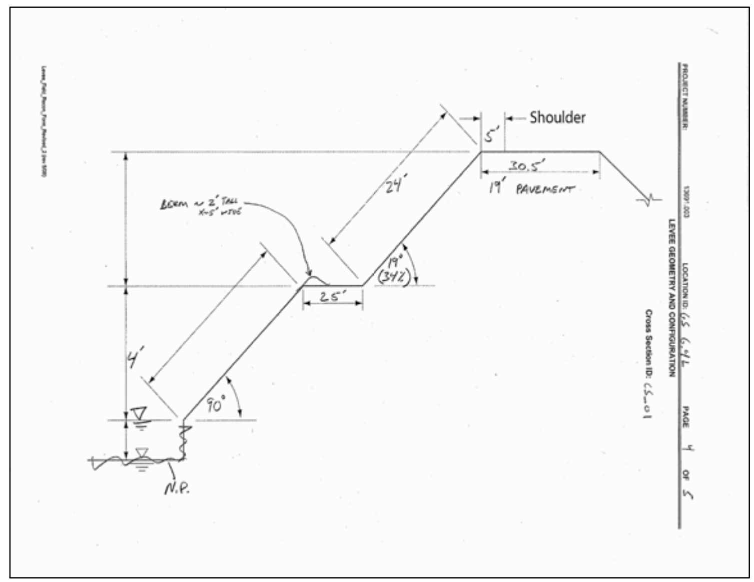
Comp Study Levee Crown Elevation	16.1
Comp Study Landside Toe Elevation	5.2
Comp Study Difference	10.9

Alternatives Report Analysis Levee Crown Elevation	14.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	3.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES

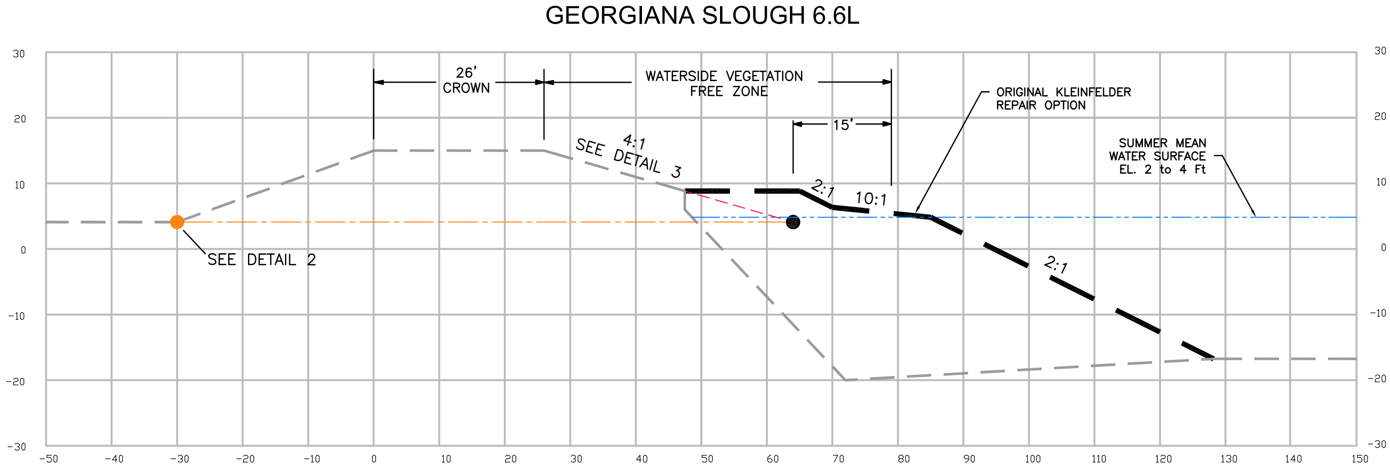


Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	GEORGIANA SLOUGH ~ 6.4L
		Date	3/31/11
		Figure	GS 6.4L

DETAIL 1

LEGEND

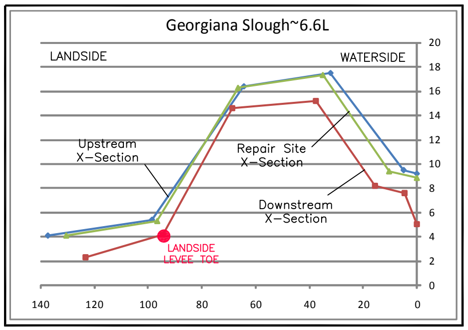
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.8
10.3	9.4
34.9	17.3
66.4	16.2
96.4	5.3
130.2	4.1

KEY DATA FOR DETERMINING LANDSIDE TOE

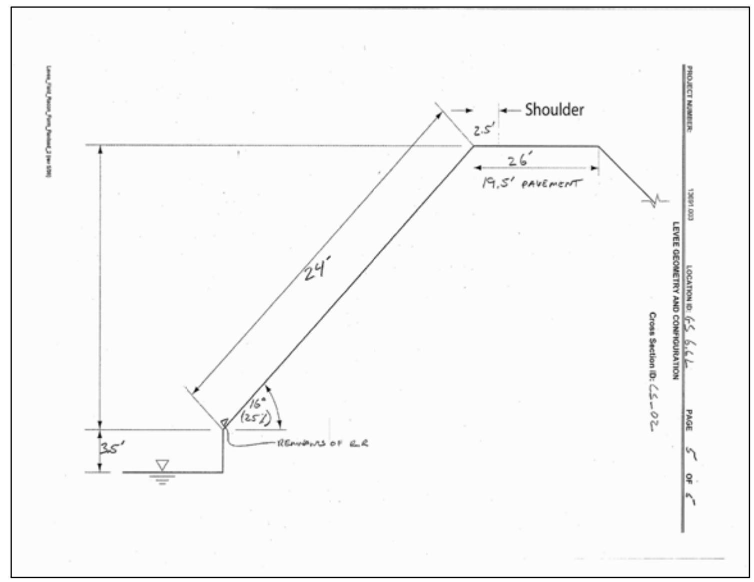
Comp Study Levee Crown Elevation	16.2
Comp Study Landside Toe Elevation	5.3
Comp Study Difference	10.9

Alternatives Report Analysis Levee Crown Elevation	15.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

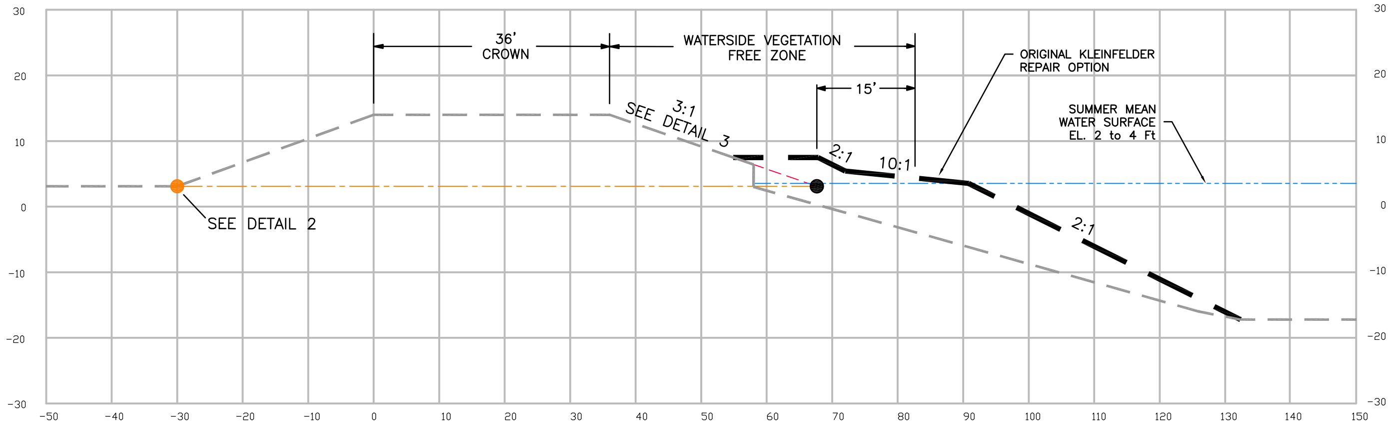
GEORGIANA SLOUGH 6.6L

Date	3/31/11
Figure	GS 6.6L

DETAIL 1

LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE

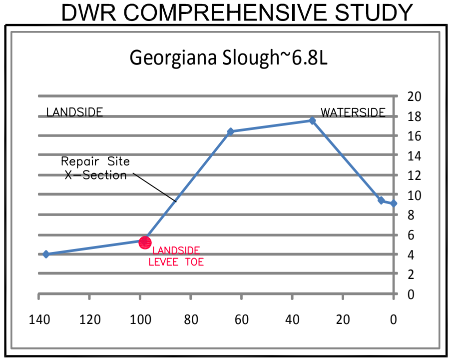
GEORGIANA SLOUGH 6.8L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	9.2
4.9	9.5
32.1	17.5
64.3	16.4
98.5	5.4
137.2	4.1

KEY DATA FOR DETERMINING LANDSIDE TOE

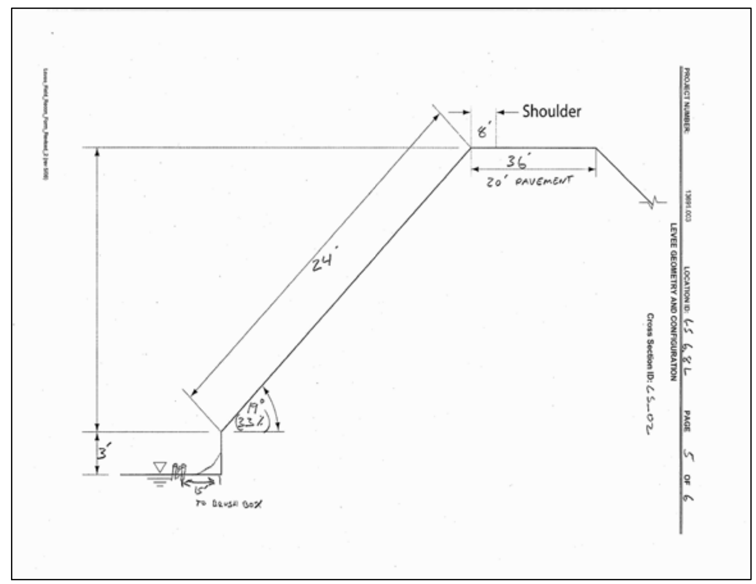
Comp Study Levee Crown Elevation	16.4
Comp Study Landside Toe Elevation	5.4
Comp Study Difference	11.0

Alternatives Report Analysis Levee Crown Elevation	14.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	3.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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Programmatic Plan Framework Memorandum

HDR

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

GEORGIANA SLOUGH ~ 6.8L

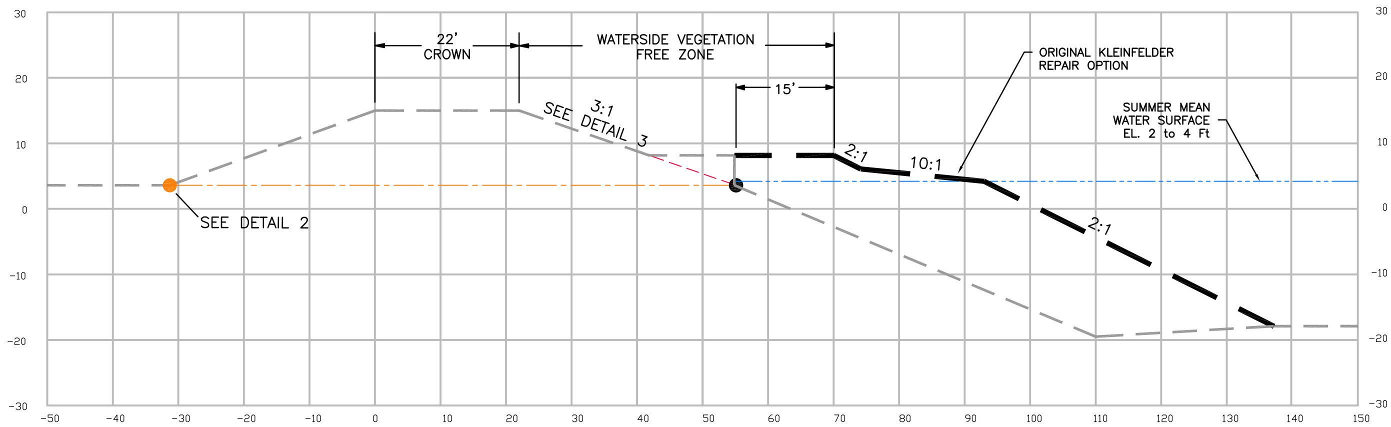
Date	3/31/11
Figure	GS 6.8L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

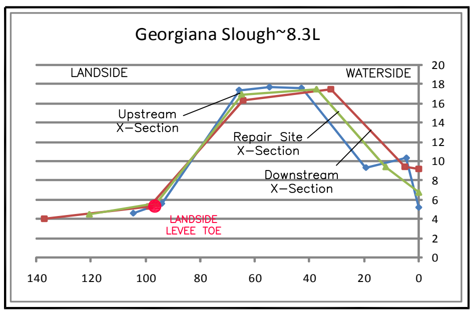
GEORGIANA SLOUGH 8.3L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.8
12.1	9.4
37.5	17.6
65.0	17.0
96.3	5.6
120.8	4.5

KEY DATA FOR DETERMINING LANDSIDE TOE

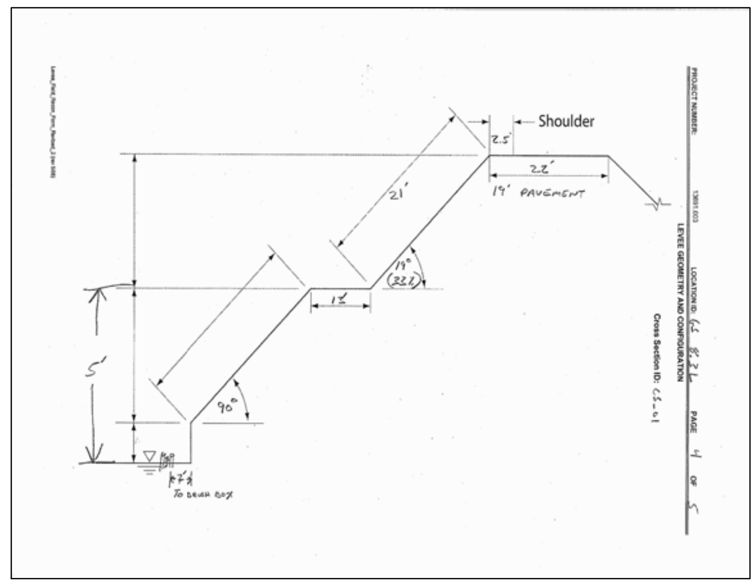
Comp Study Levee Crown Elevation	17.0
Comp Study Landside Toe Elevation	5.6
Comp Study Difference	11.4

Alternatives Report Analysis Levee Crown Elevation	15.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	3.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

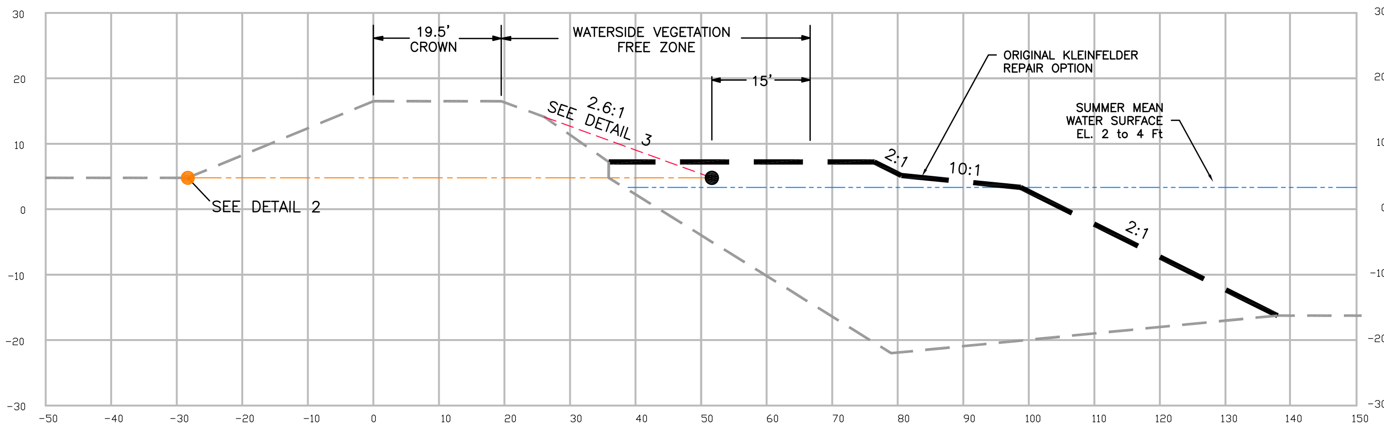
GEORGIANA SLOUGH ~ 8.3L

Date	3/31/11
Figure	GS 8.3L

DETAIL 1

LEGEND

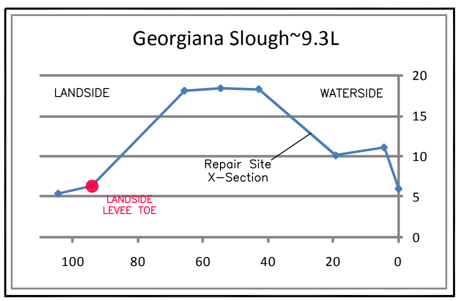
— — (grey dashed)	EXISTING LEVEE SURFACE
— — (black heavy dashed)	ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
— · — (orange)	PROJECTED LANDSIDE LEVEE TOE
— · — (blue)	WATER SURFACE
— — (red)	PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.1
4.5	11.2
19.3	10.2
42.9	18.4
54.6	18.5
65.7	18.2
94.0	6.5
104.4	5.5

KEY DATA FOR DETERMINING LANDSIDE TOE

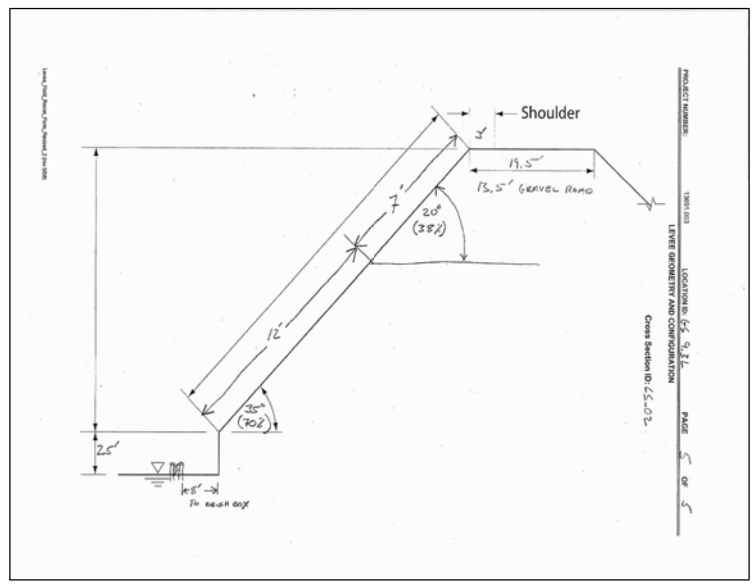
Comp Study Levee Crown Elevation	18.2
Comp Study Landside Toe Elevation	6.5
Comp Study Difference	11.7

Alternatives Report Analysis Levee Crown Elevation	16.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



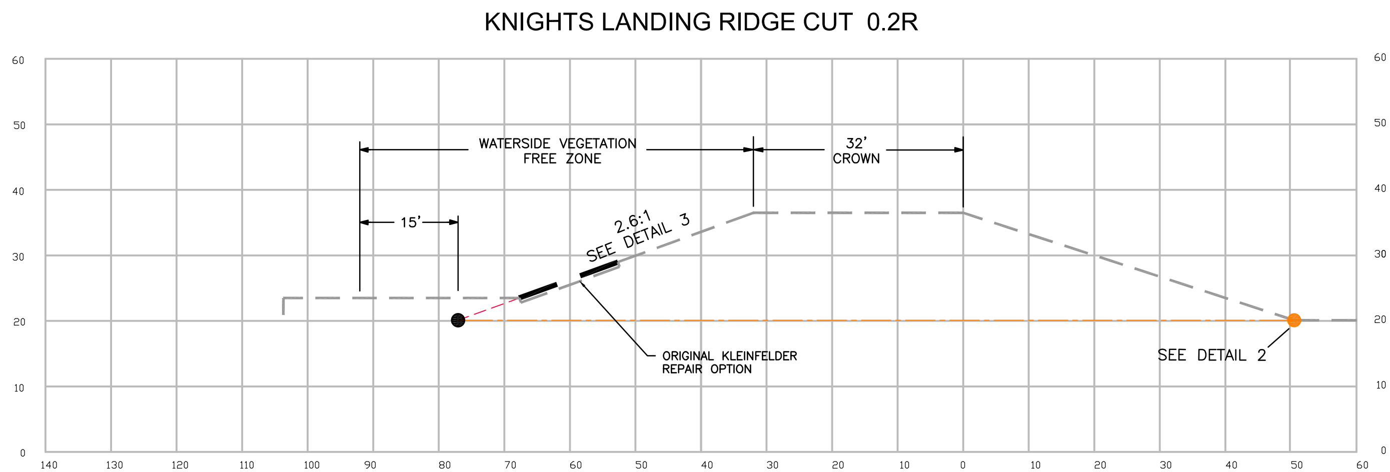
Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	GEORGIANA SLOUGH ~ 9.3L	Date 3/31/11 Figure GS 9.3L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

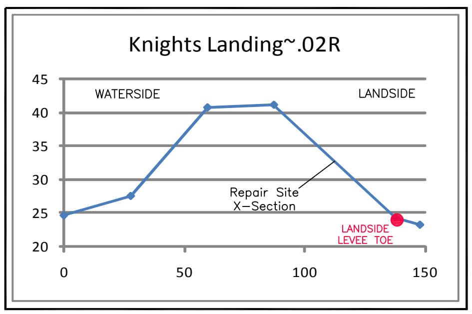
KNIGHTS LANDING RIDGE CUT 0.2R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	24.8
27.8	27.7
59.7	40.9
87.3	41.3
137.8	24.5
148.0	23.4

KEY DATA FOR DETERMINING LANDSIDE TOE

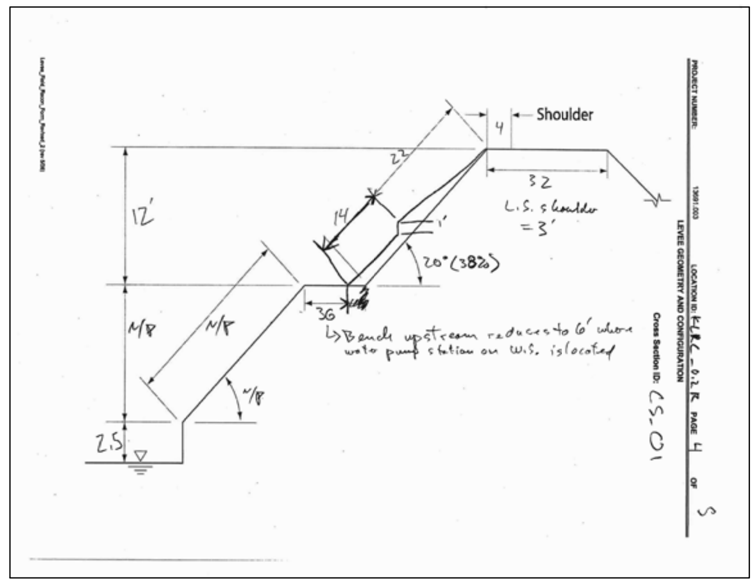
Comp Study Levee Crown Elevation	40.9
Comp Study Landside Toe Elevation	24.5
Comp Study Difference	16.4

Alternatives Report Analysis Levee Crown Elevation	36.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	20.1

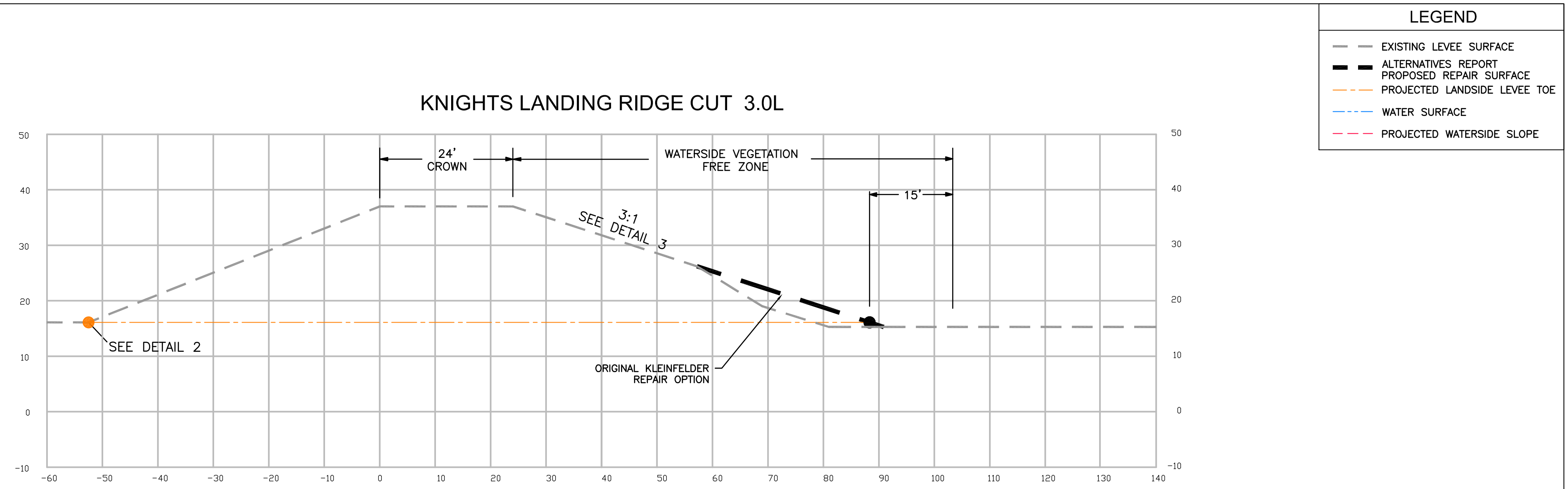
DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	KNIGHTS LANDING RIDGE CUT ~ 0.2R
			Date 3/31/11
			Figure KLRC 0.2R

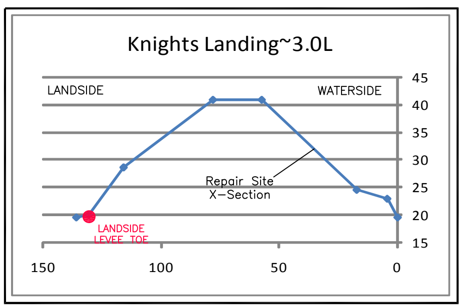
DETAIL 1



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	19.6
4.4	23.0
17.3	24.6
57.5	41.0
78.1	41.0
115.9	28.7
130.6	20.1
135.9	19.6

KEY DATA FOR DETERMINING LANDSIDE TOE

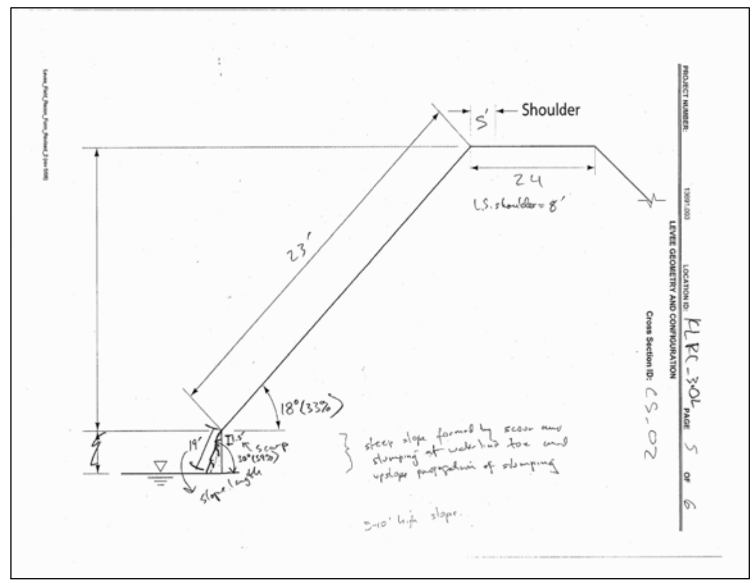
Comp Study Levee Crown Elevation	41.0
Comp Study Landside Toe Elevation	20.1
Comp Study Difference	20.9

Alternatives Report Analysis Levee Crown Elevation	37.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	16.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

KNIGHTS LANDING RIDGE CUT ~ 3.0L

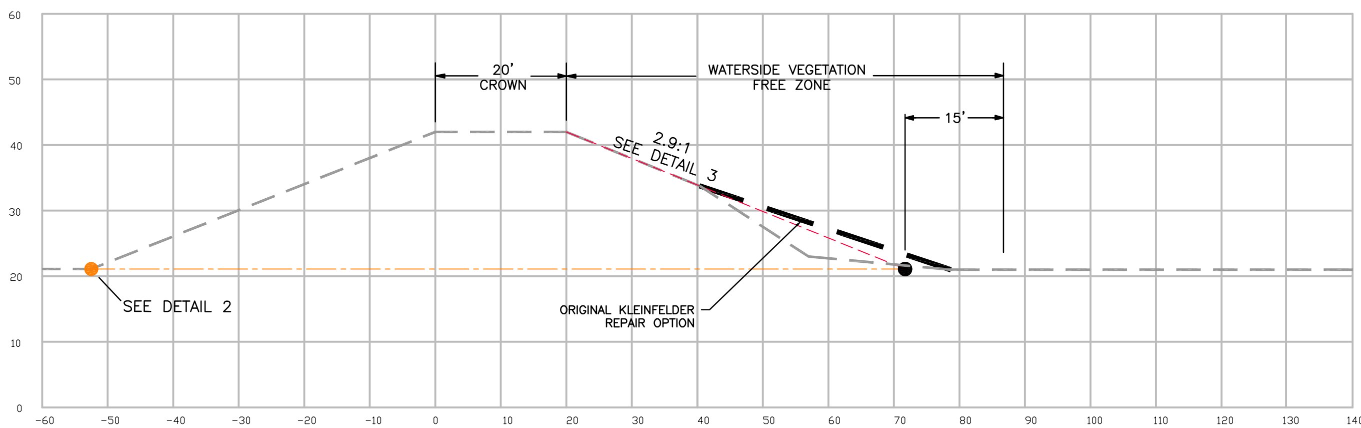
Date	3/31/11
Figure	KLRC 3.0L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

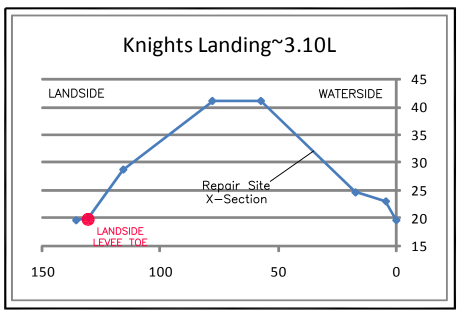
KNIGHTS LANDING RIDGE CUT 3.1L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	19.7
4.4	23.1
17.3	24.7
57.5	41.1
78.1	41.1
115.9	28.8
130.6	20.2
135.9	19.7

KEY DATA FOR DETERMINING LANDSIDE TOE

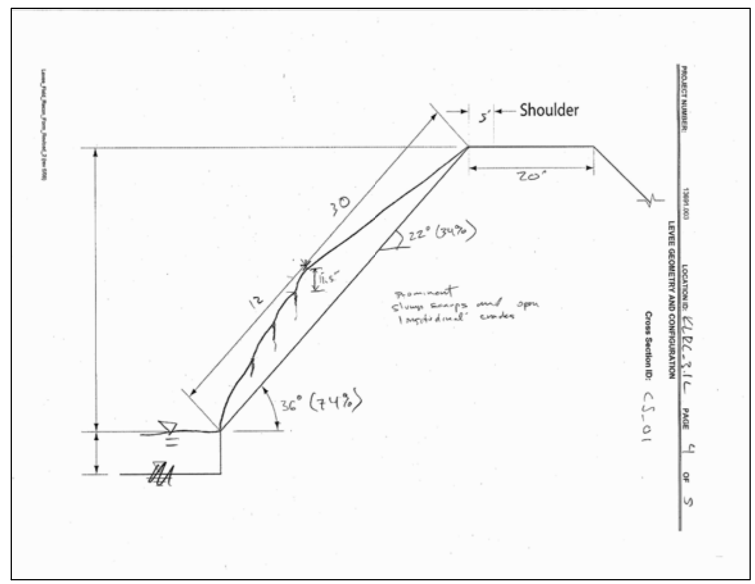
Comp Study Levee Crown Elevation	41.1
Comp Study Landside Toe Elevation	20.2
Comp Study Difference	20.9

Alternatives Report Analysis Levee Crown Elevation	42.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	21.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

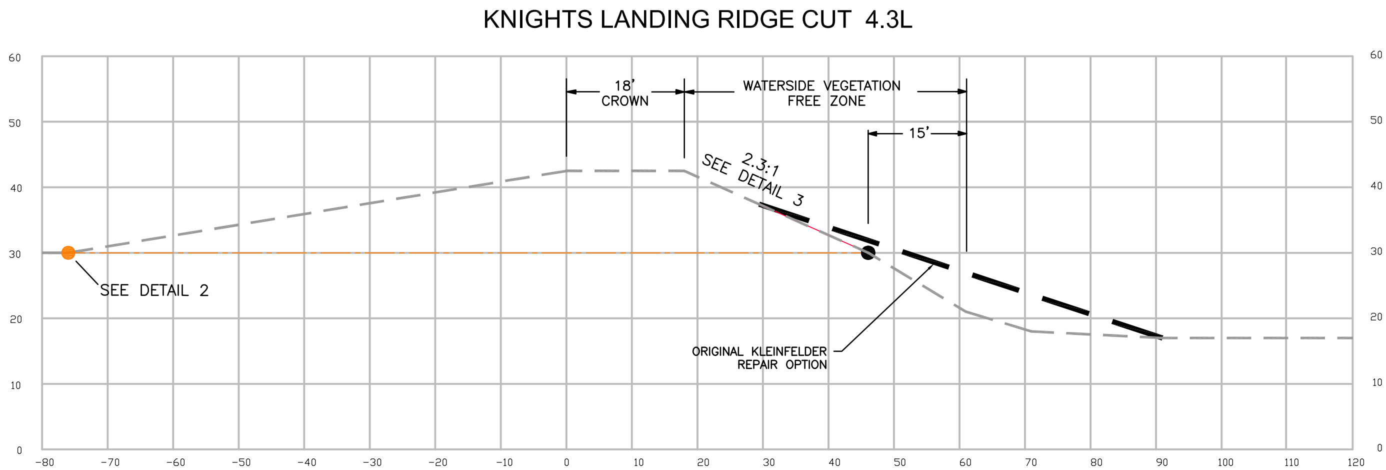
KNIGHTS LANDING RIDGE CUT ~ 3.1L

Date	3/31/11
Figure	KLRC 3.1L

DETAIL 1

LEGEND

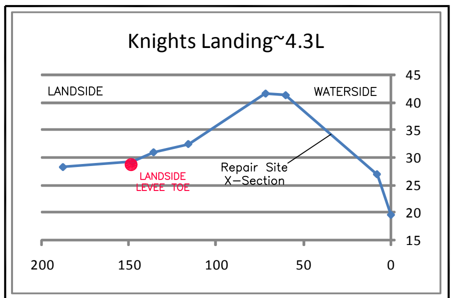
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	19.6
8.0	27.0
60.2	41.4
71.7	41.7
115.9	32.5
135.8	31.0
147.7	29.2
187.6	28.3

KEY DATA FOR DETERMINING LANDSIDE TOE

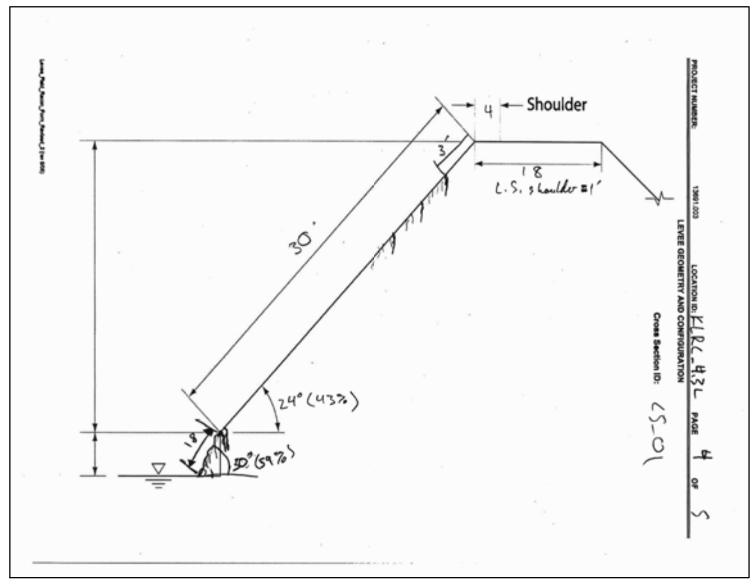
Comp Study Levee Crown Elevation	41.7
Comp Study Landside Toe Elevation	29.2
Comp Study Difference	12.5

Alternatives Report Analysis Levee Crown Elevation	42.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	30.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR
HDR Engineering, Inc.

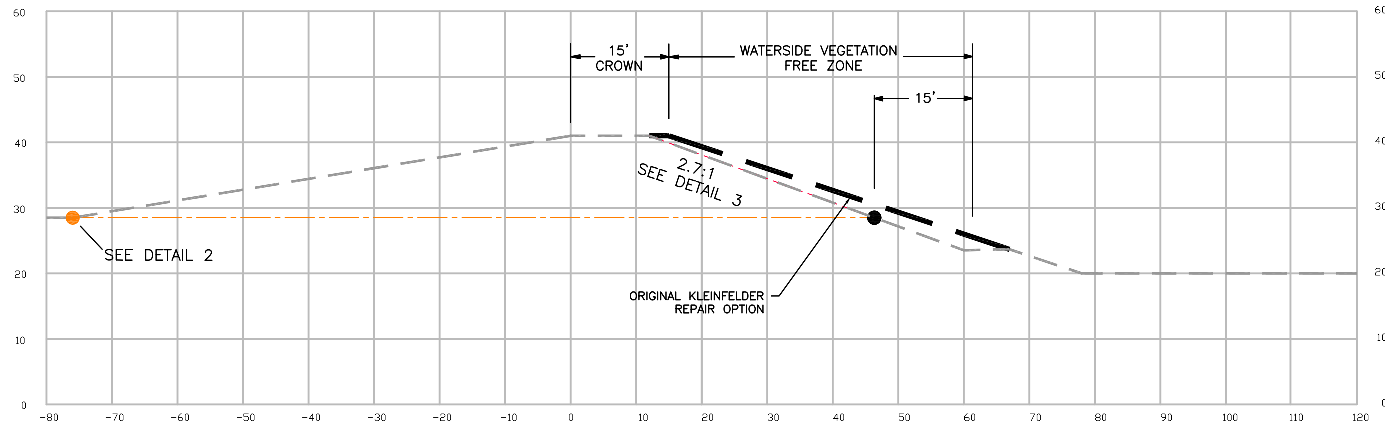
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

KNIGHTS LANDING RIDGE CUT ~ 4.3L

Date	3/31/11
Figure	KLRC 4.3L

DETAIL 1

KNIGHTS LANDING RIDGE CUT 5.3L



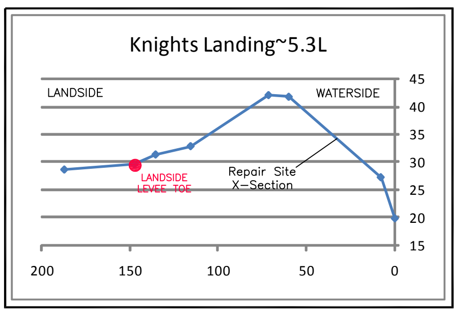
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.0
8.0	27.4
60.2	41.9
71.7	42.2
115.9	33.0
135.8	31.5
147.7	29.7
187.6	28.8

KEY DATA FOR DETERMINING LANDSIDE TOE

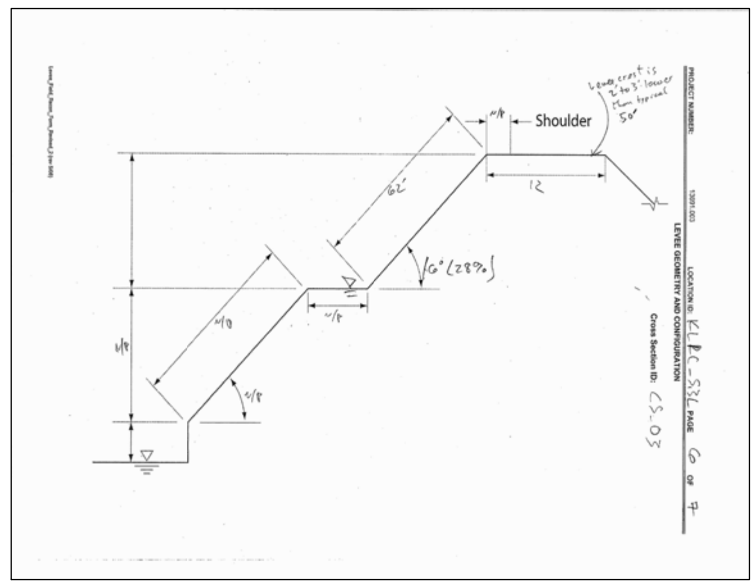
Comp Study Levee Crown Elevation	42.2
Comp Study Landside Toe Elevation	29.7
Comp Study Difference	12.5

Alternatives Report Analysis Levee Crown Elevation	41.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	28.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

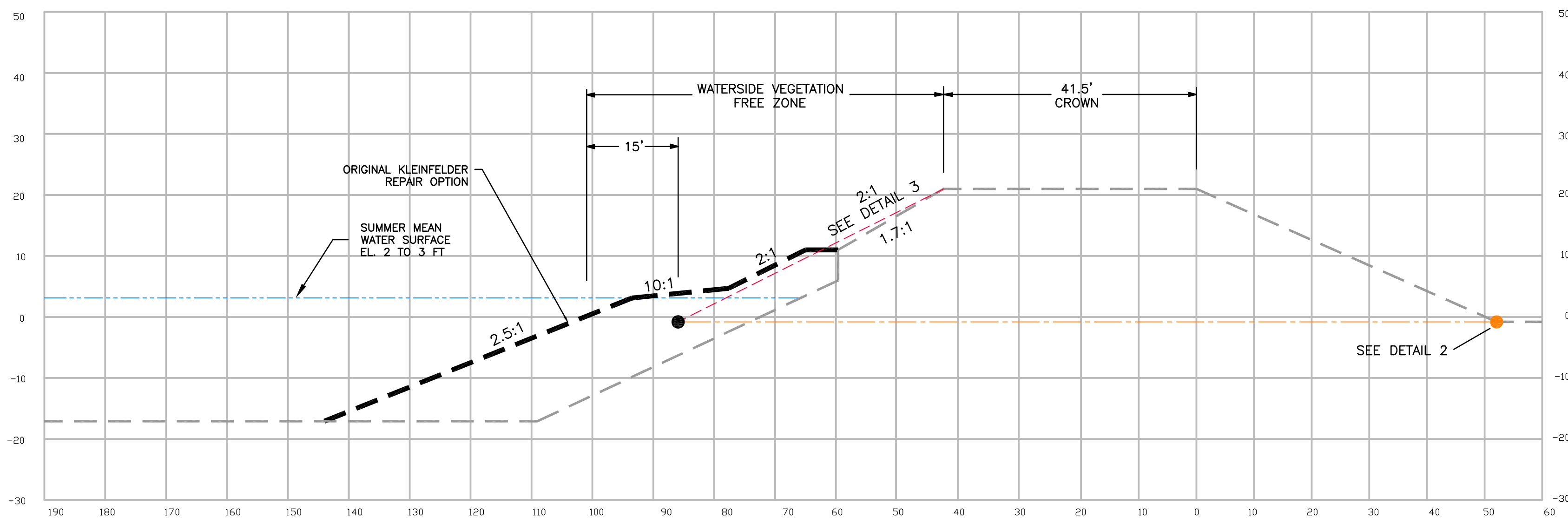
KNIGHTS LANDING
RIDGE CUT ~ 5.3L

Date 3/31/11

Figure KLRC 5.3L

DETAIL 1

STEAMBOAT SLOUGH 18.8R



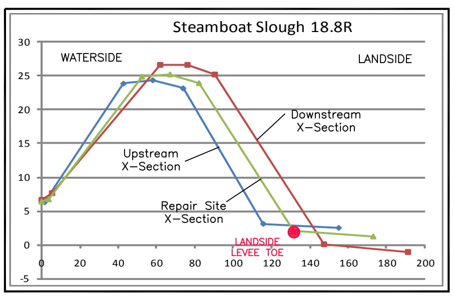
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.4
3.7	6.8
52.3	24.8
67.0	25.2
82.1	23.9
131.4	2.1
173.0	1.3

KEY DATA FOR DETERMINING LANDSIDE TOE

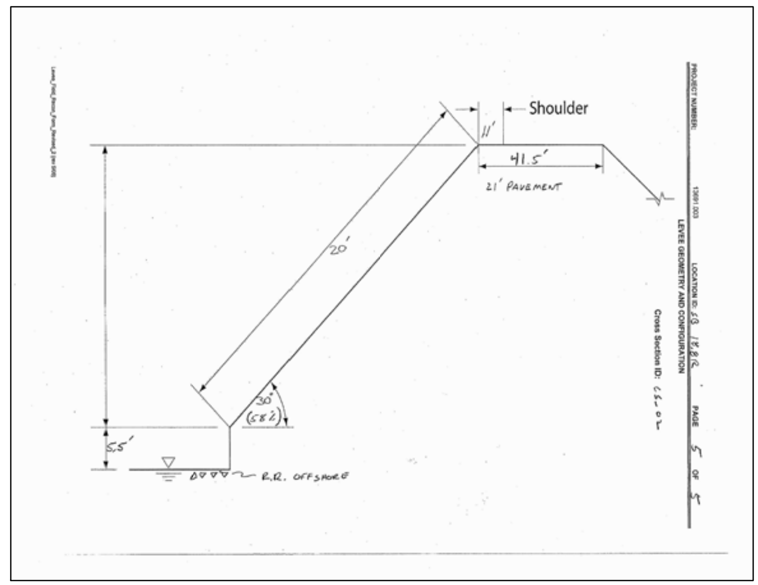
Comp Study Levee Crown Elevation	23.9
Comp Study Landside Toe Elevation	2.1
Comp Study Difference	21.8

Alternatives Report Analysis Levee Crown Elevation	21.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	-0.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR

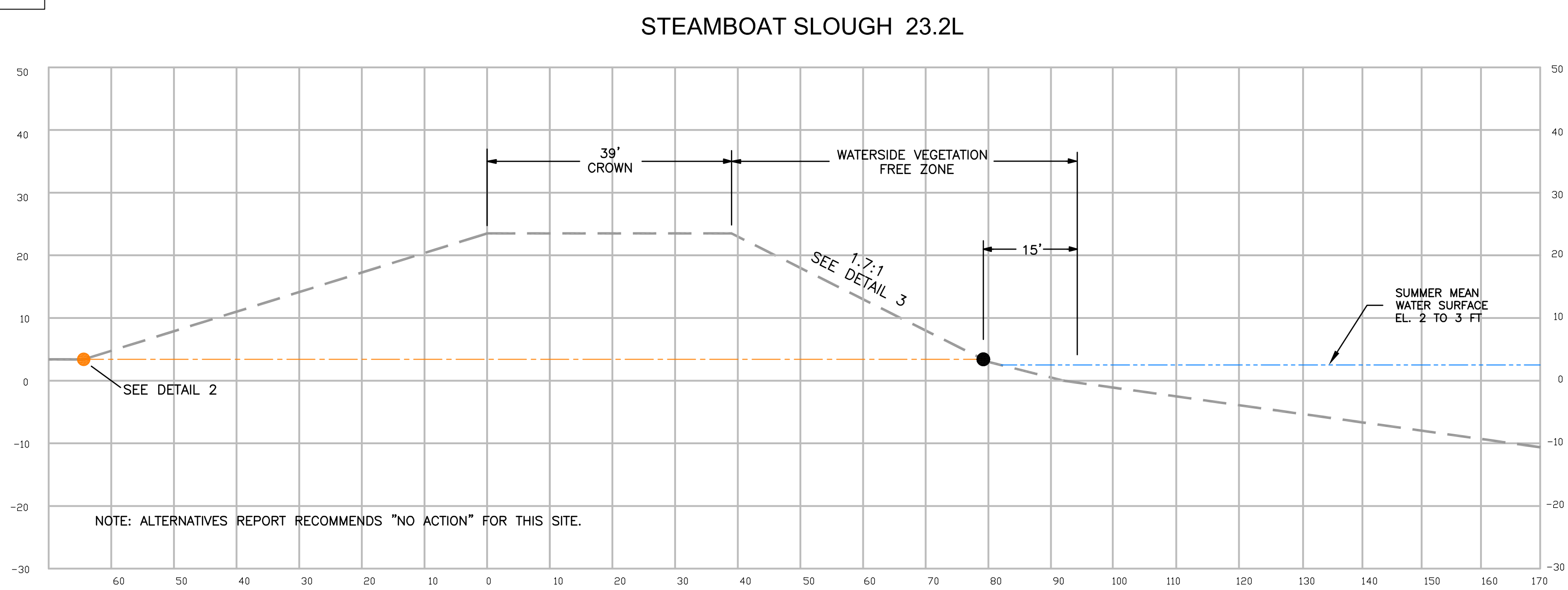
HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

STEAMBOAT SLOUGH ~ 18.8R

Date	3/31/11
Figure	StS 18.8R

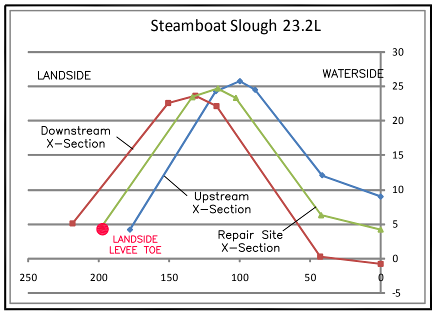
DETAIL 1



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	4.3
42.3	6.3
102.8	23.4
115.5	24.7
133.6	23.5
198.0	4.7

KEY DATA FOR DETERMINING LANDSIDE TOE

Comp Study Levee Crown Elevation	24.7
Comp Study Landside Toe Elevation	4.7
Comp Study Difference	20.1

Alternatives Report Analysis Levee Crown Elevation	23.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	3.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES

NO FIELD NOTES EXISTS

Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

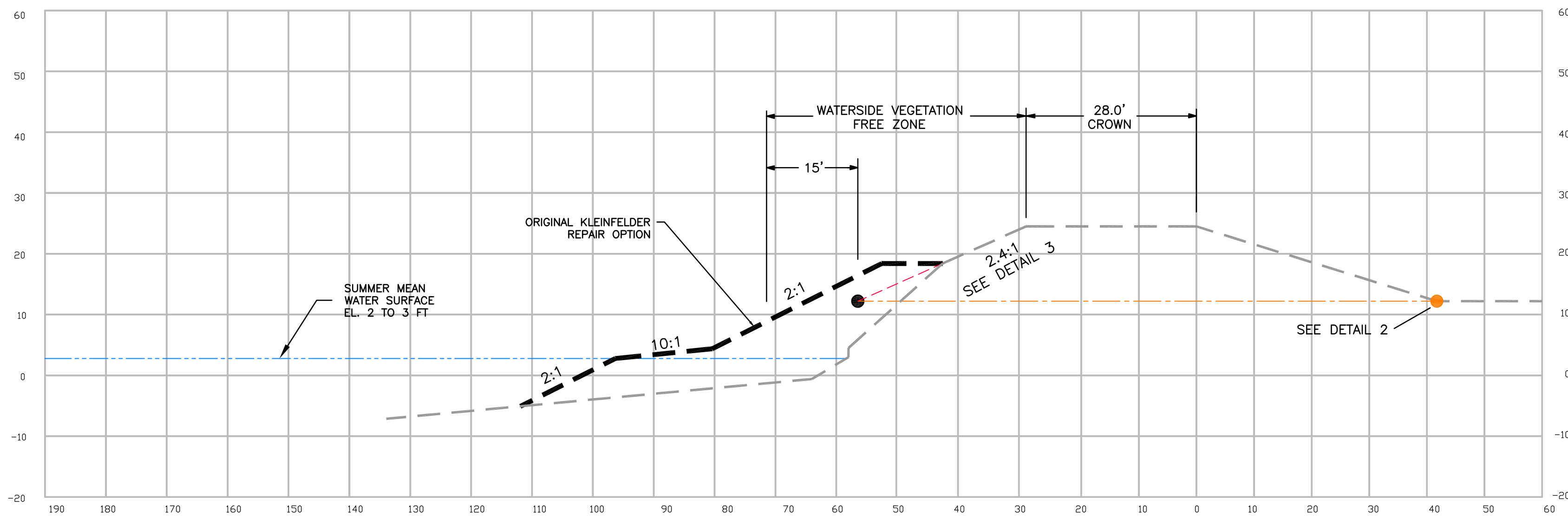
Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

STEAMBOAT SLOUGH ~ 23.2R

Date 3/31/11
Figure StS 23.2R

DETAIL 1

STEAMBOAT SLOUGH 23.9R



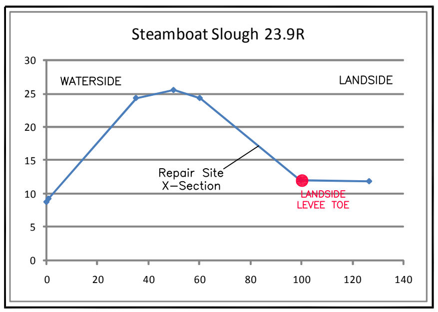
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.8
0.8	9.3
35.1	24.4
49.8	25.6
60.1	24.4
99.6	12.1
126.5	11.9

KEY DATA FOR DETERMINING LANDSIDE TOE

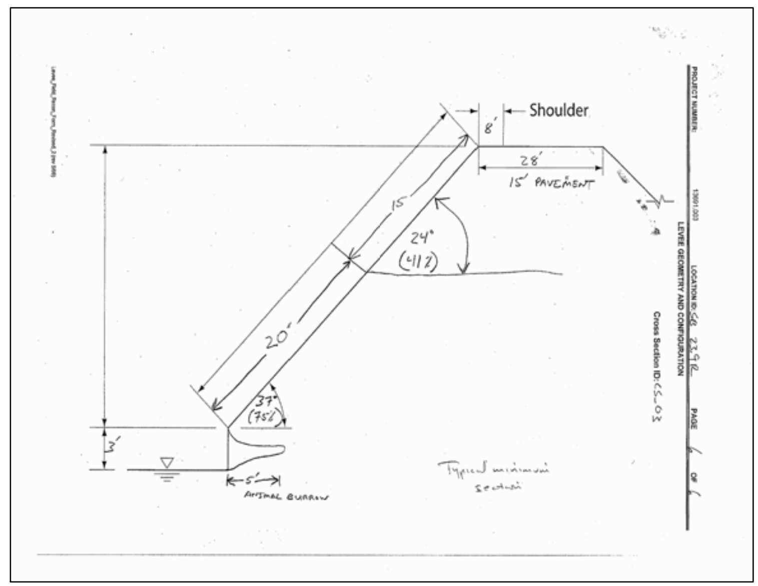
Comp Study Levee Crown Elevation	24.4
Comp Study Landside Toe Elevation	12.1
Comp Study Difference	12.3

Alternatives Report Analysis Levee Crown Elevation	24.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	12.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Programmatic Plan Framework Memorandum

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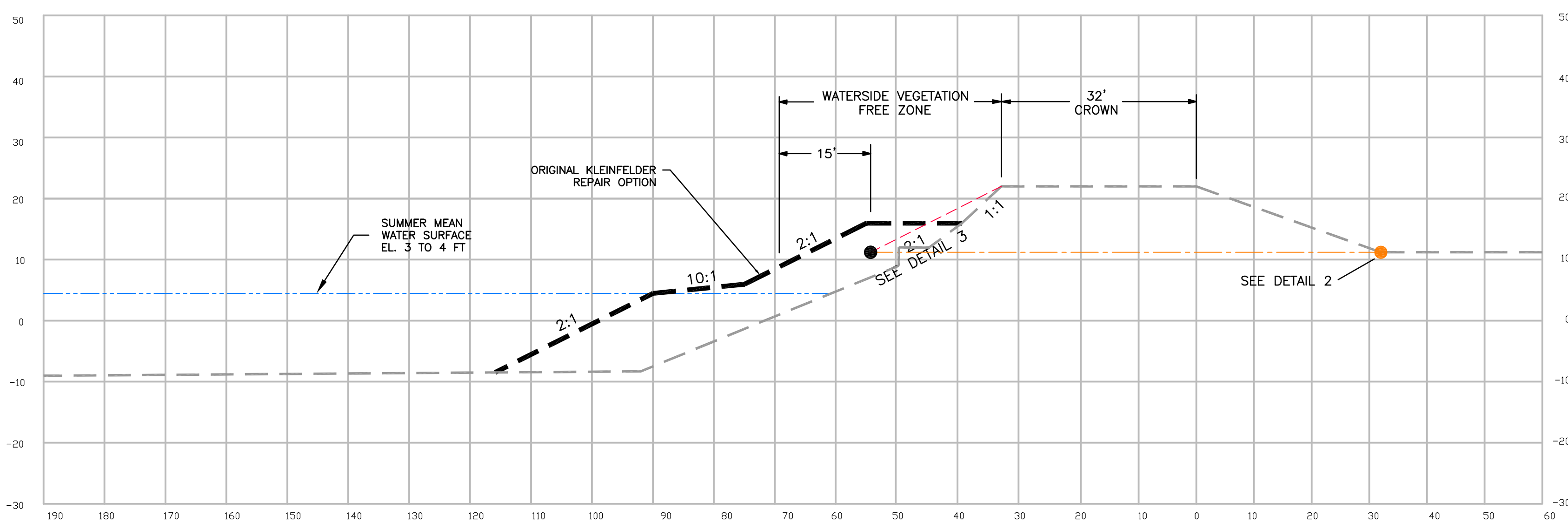
Checked By:	R. Little
QA/QC Review:	D. Teak

STEAMBOAT SLOUGH ~ 23.9R

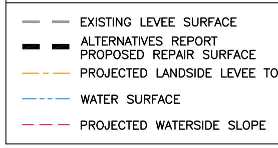
Date	3/31/11
Figure	StS 23.9R

DETAIL 1

STEAMBOAT SLOUGH 24.7R



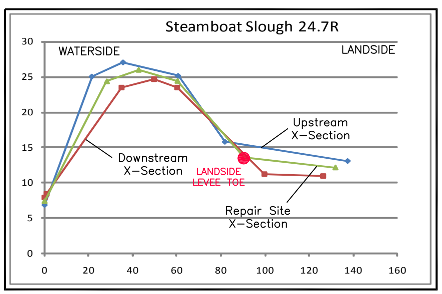
LEGEND



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.4
28.3	24.3
42.7	25.9
60.4	24.4
90.7	13.6
132.0	12.1

KEY DATA FOR DETERMINING LANDSIDE TOE

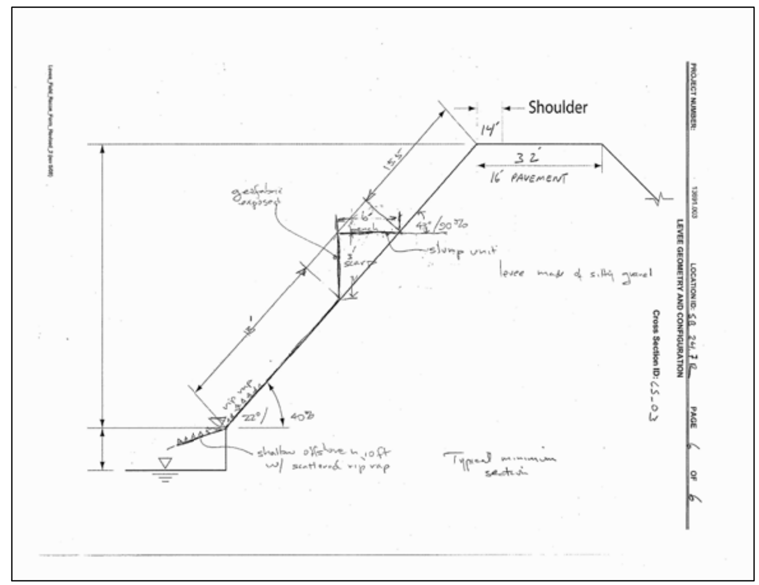
Comp Study Levee Crown Elevation	24.4
Comp Study Landside Toe Elevation	13.6
Comp Study Difference	10.8

Alternatives Report Analysis Levee Crown Elevation	22.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	11.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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HDR

HDR Engineering, Inc.

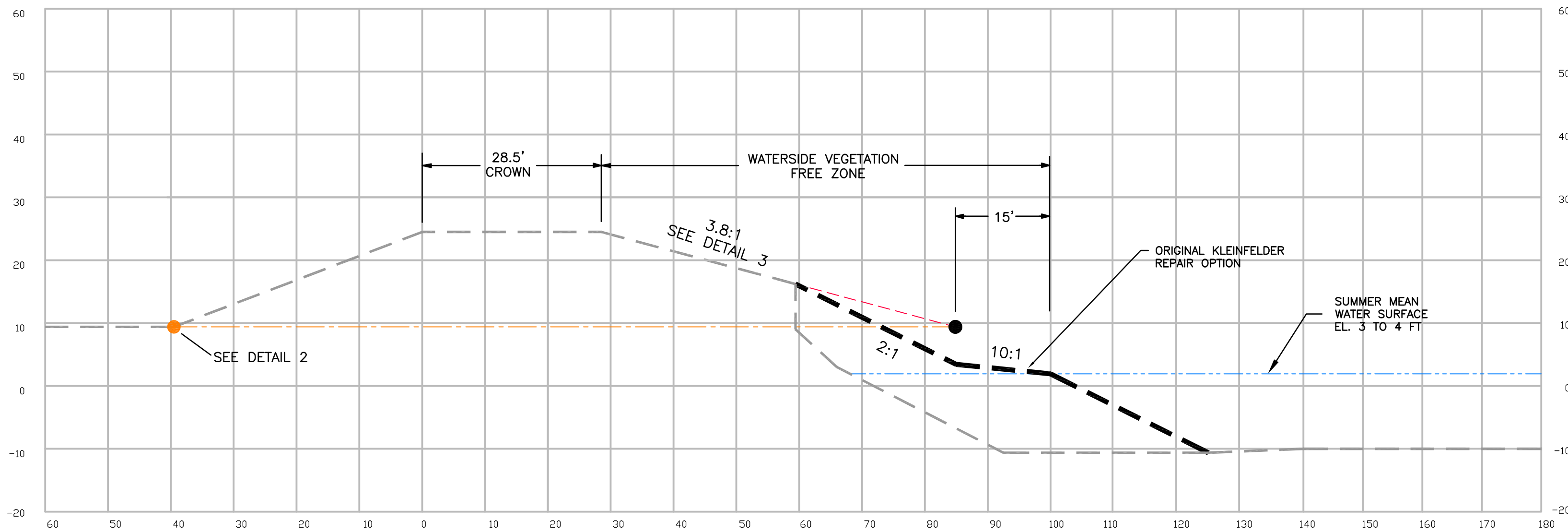
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

STEAMBOAT SLOUGH ~ 24.7R

Date	3/31/11
Figure	StS 24.7R

DETAIL 1

STEAMBOAT SLOUGH 25.0L



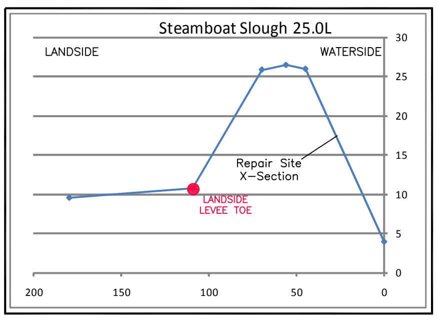
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	4.0
45.0	26.0
56.1	26.5
69.9	25.9
109.4	10.8
179.9	9.6

KEY DATA FOR DETERMINING LANDSIDE TOE

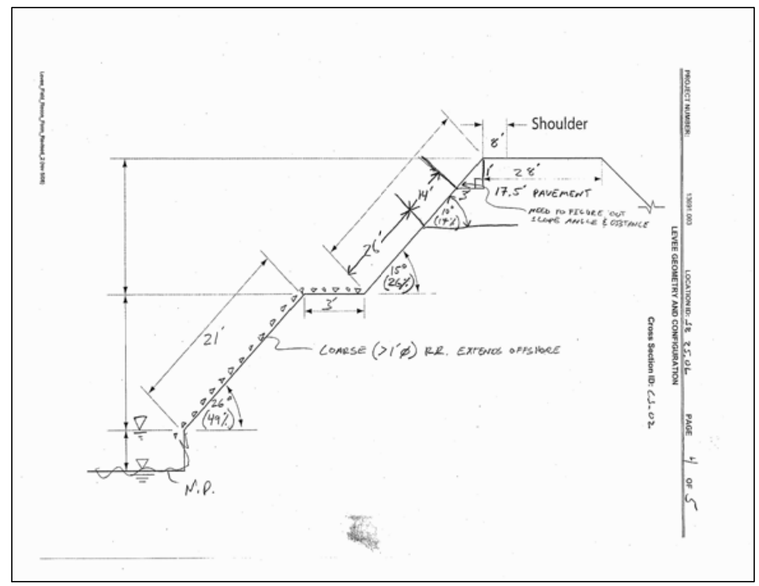
Comp Study Levee Crown Elevation	25.9
Comp Study Landside Toe Elevation	10.8
Comp Study Difference	15.1

Alternatives Report Analysis Levee Crown Elevation	24.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	9.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

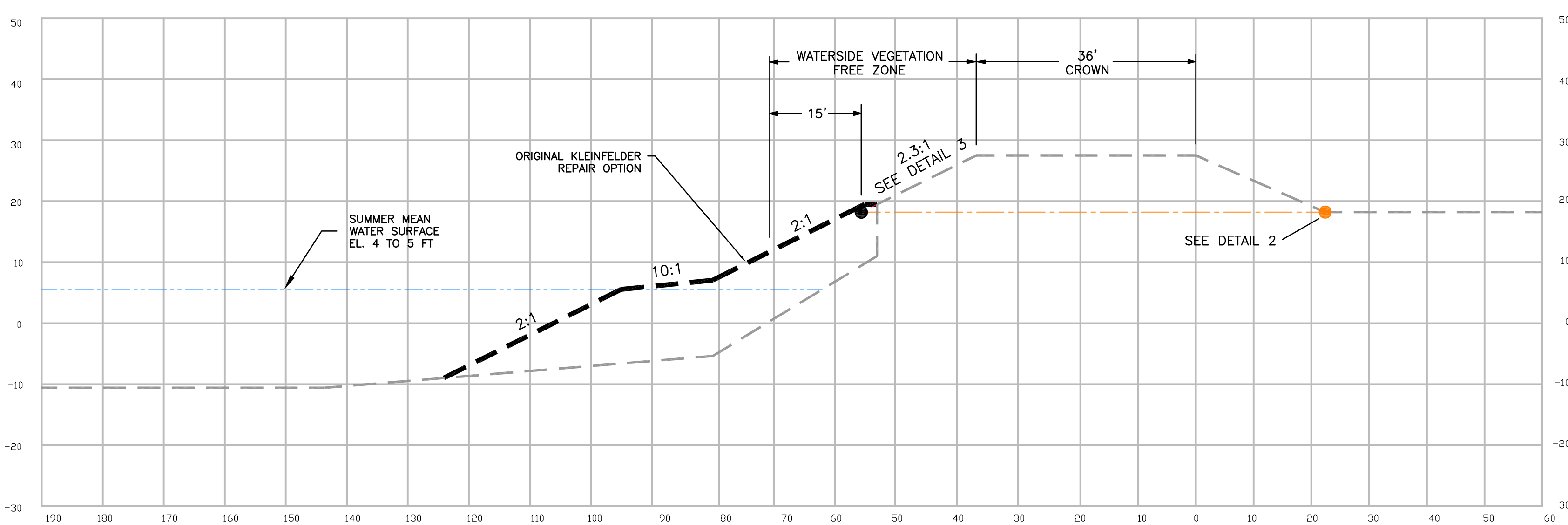
STEAMBOAT SLOUGH ~ 25.0L

Date 3/31/11

Figure StS 25.0L

DETAIL 1

STEAMBOAT SLOUGH 25.8R



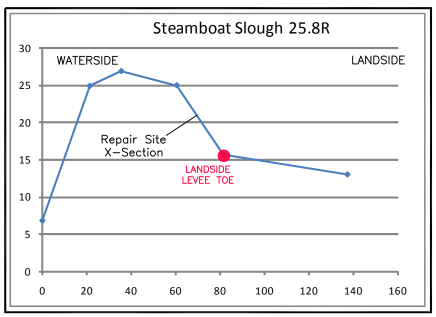
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	6.9
21.4	25.0
35.6	27.0
60.6	25.1
81.8	15.8
137.5	13.1

KEY DATA FOR DETERMINING LANDSIDE TOE

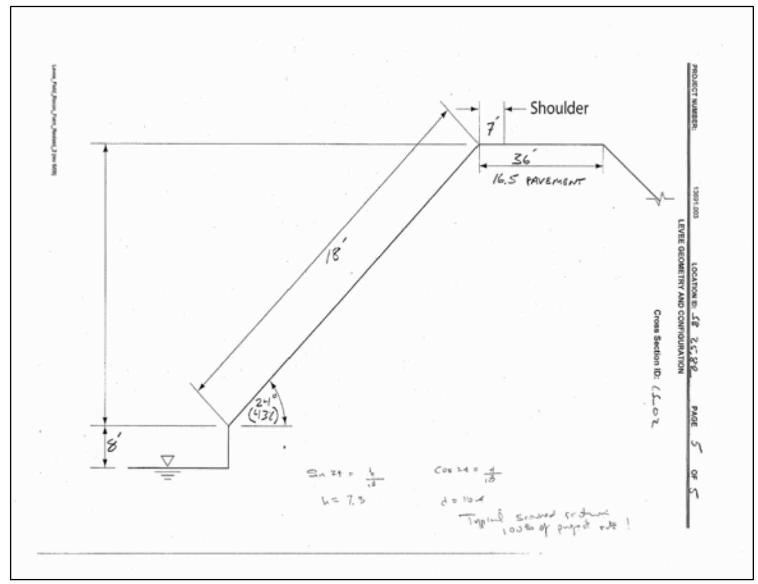
Comp Study Levee Crown Elevation	25.1
Comp Study Landside Toe Elevation	15.8
Comp Study Difference	9.3

Alternatives Report Analysis Levee Crown Elevation	27.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	18.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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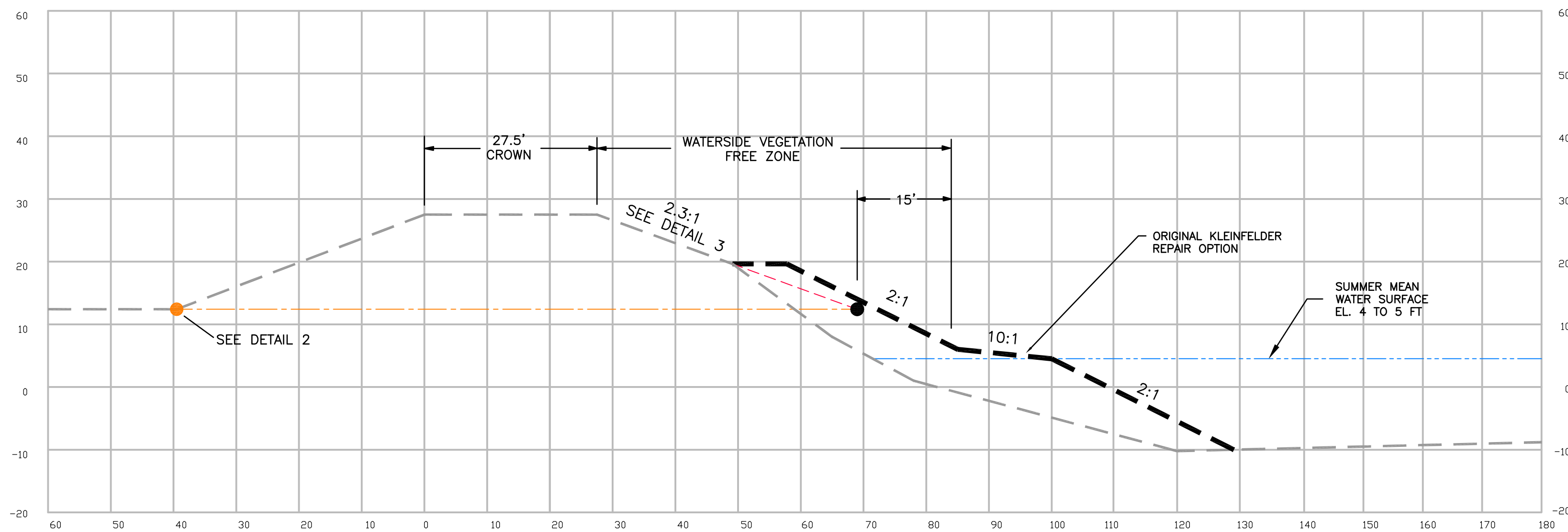
Checked By:	R. Little
QA/QC Review:	D. Teak

STEAMBOAT SLOUGH ~ 25.8R

Date	3/31/11
Figure	StS 25.8R

DETAIL 1

STEAMBOAT SLOUGH RIVER 26.0L



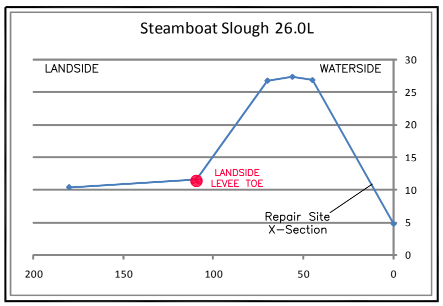
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	4.9
45.0	26.9
56.1	27.4
69.9	26.8
109.4	11.7
179.9	10.5

KEY DATA FOR DETERMINING LANDSIDE TOE

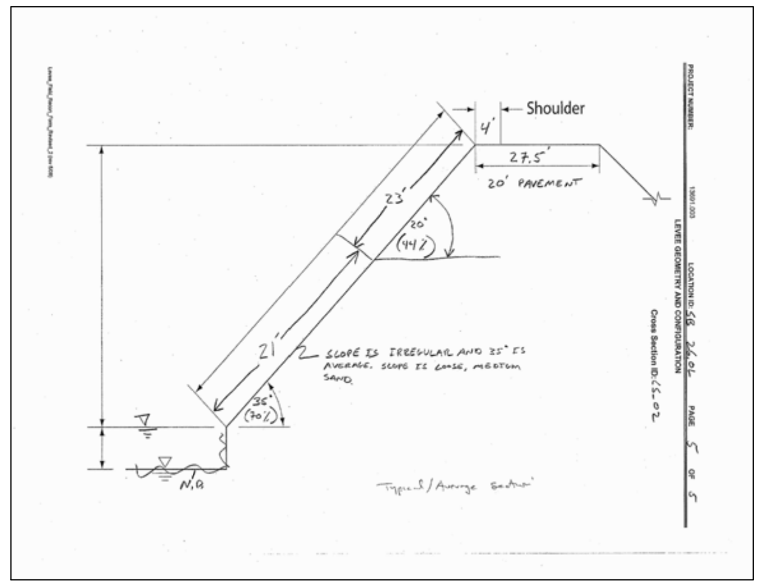
Comp Study Levee Crown Elevation	26.8
Comp Study Landside Toe Elevation	11.7
Comp Study Difference	15.1

Alternatives Report Analysis Levee Crown Elevation	27.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	12.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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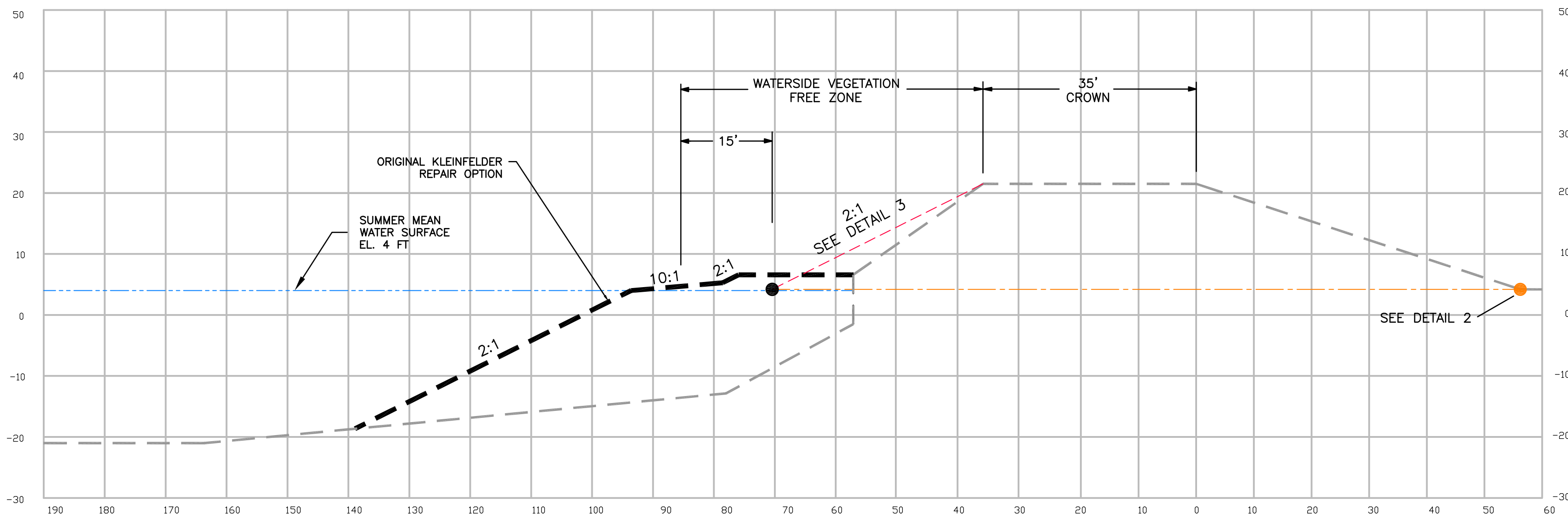
QA/QC Review:	D. Teak

STEAMBOAT SLOUGH ~ 26.0L

Date	3/31/11
Figure	StS 26.0L

DETAIL 1

SUTTER SLOUGH RIVER 24.7R



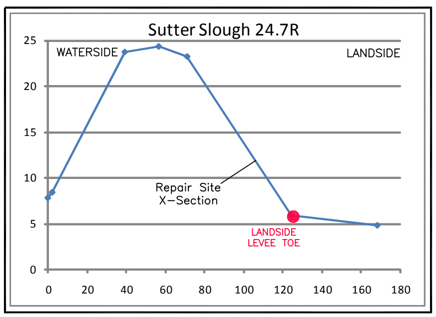
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.8
2.2	8.4
39.2	23.7
56.5	24.3
71.0	23.2
124.2	5.9
167.9	4.8

KEY DATA FOR DETERMINING LANDSIDE TOE

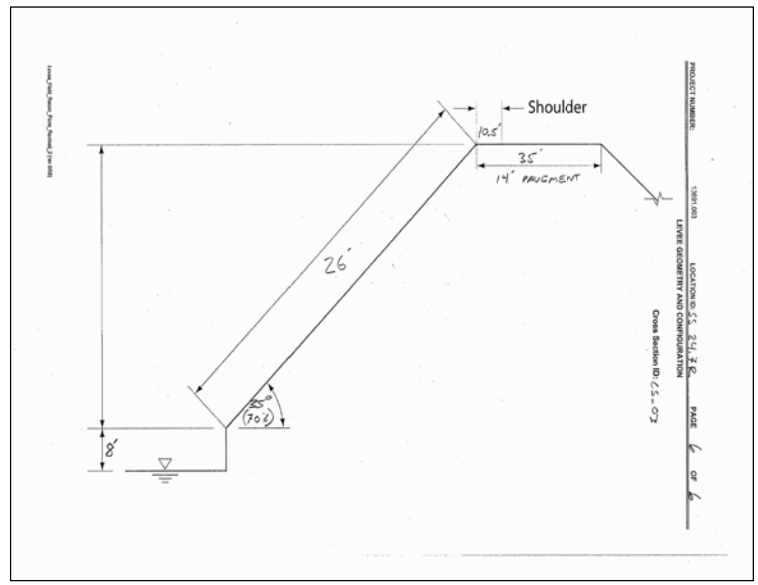
Comp Study Levee Crown Elevation	23.2
Comp Study Landside Toe Elevation	5.9
Comp Study Difference	17.3

Alternatives Report Analysis Levee Crown Elevation	21.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	4.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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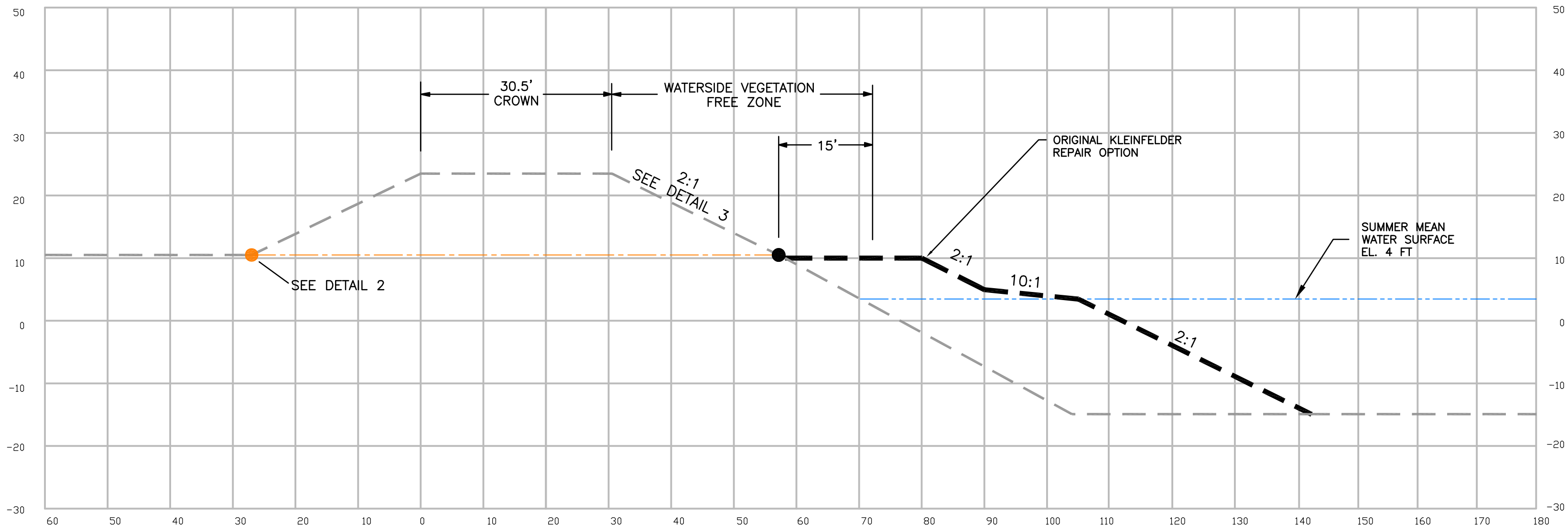
Checked By:	R. Little
QA/QC Review:	D. Teak

SUTTER SLOUGH ~ 24.7R

Date	3/31/11
Figure	SS 24.7R

DETAIL 1

SUTTER SLOUGH RIVER 26.5L



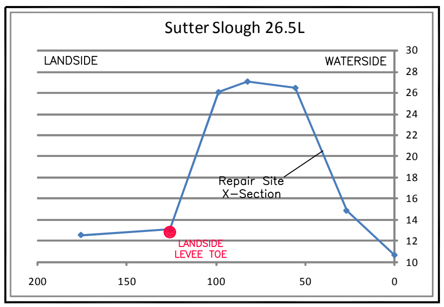
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	10.7
26.9	14.9
55.4	26.5
82.2	27.1
98.4	26.1
125.4	13.1
175.4	12.6

KEY DATA FOR DETERMINING
LANDSIDE TOE

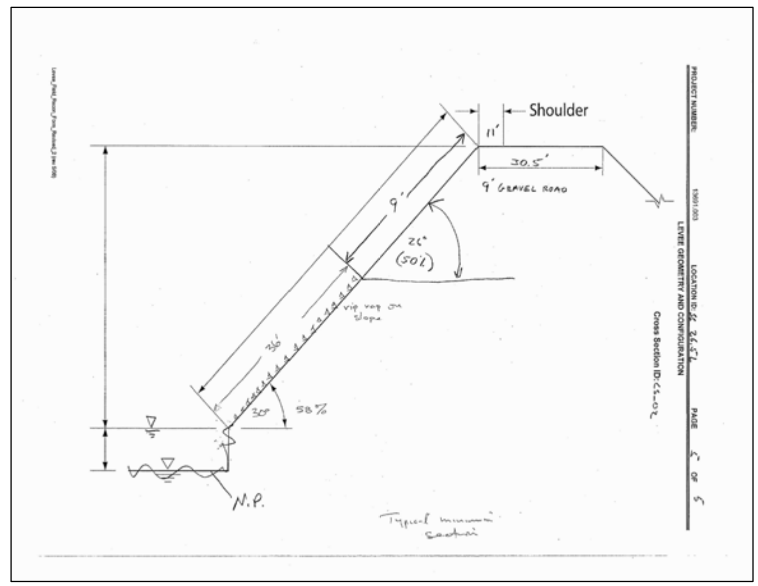
Comp Study Levee Crown Elevation	26.1
Comp Study Landside Toe Elevation	13.1
Comp Study Difference	13.0

Alternatives Report Analysis Levee Crown Elevation	23.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	10.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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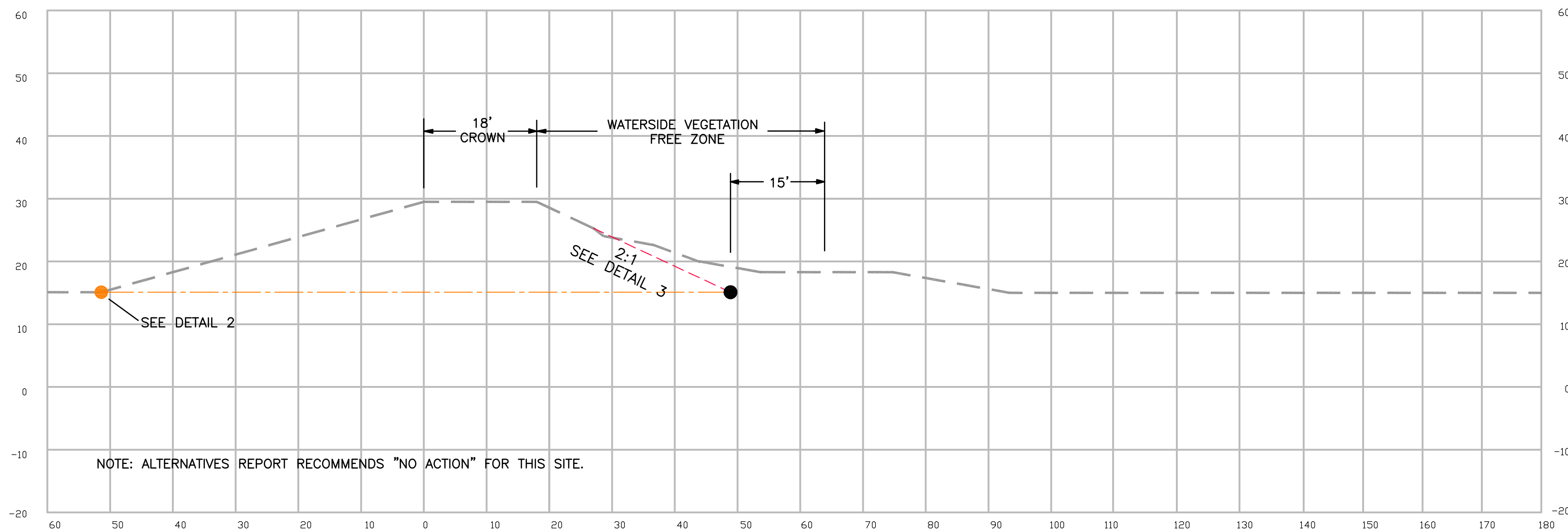
QA/QC Review:	D. Teak

SUTTER SLOUGH ~ 26.5L

Date	3/31/11
Figure	SS 26.5L

DETAIL 1

WILLOW SLOUGH BYPASS LEVEE 0.2L



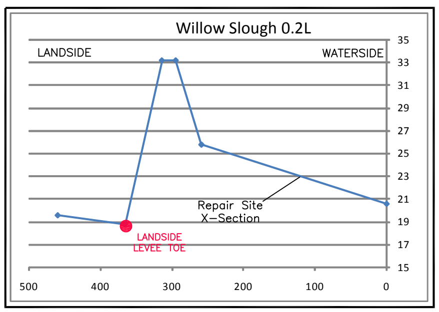
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.6
259.0	25.8
295.0	33.2
314.4	33.2
365.8	18.8
460.0	19.6

KEY DATA FOR DETERMINING LANDSIDE TOE

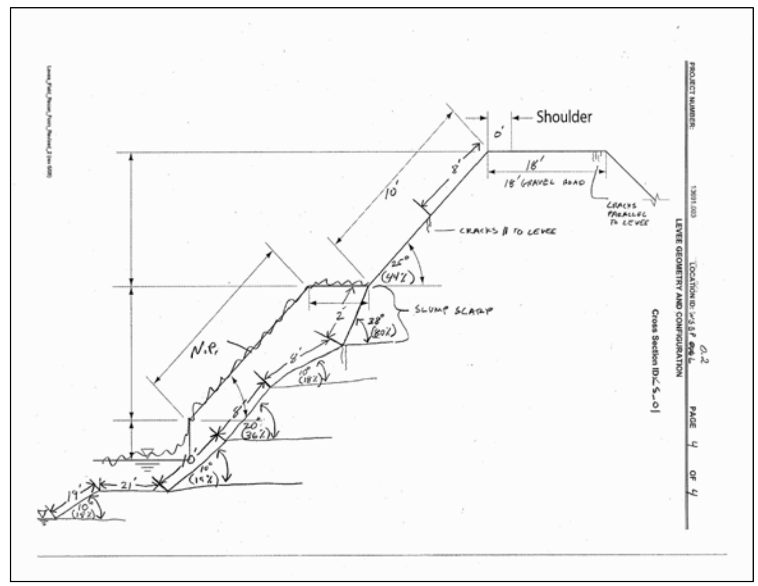
Comp Study Levee Crown Elevation	33.2
Comp Study Landside Toe Elevation	18.8
Comp Study Difference	14.4

Alternatives Report Analysis Levee Crown Elevation	29.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	15.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

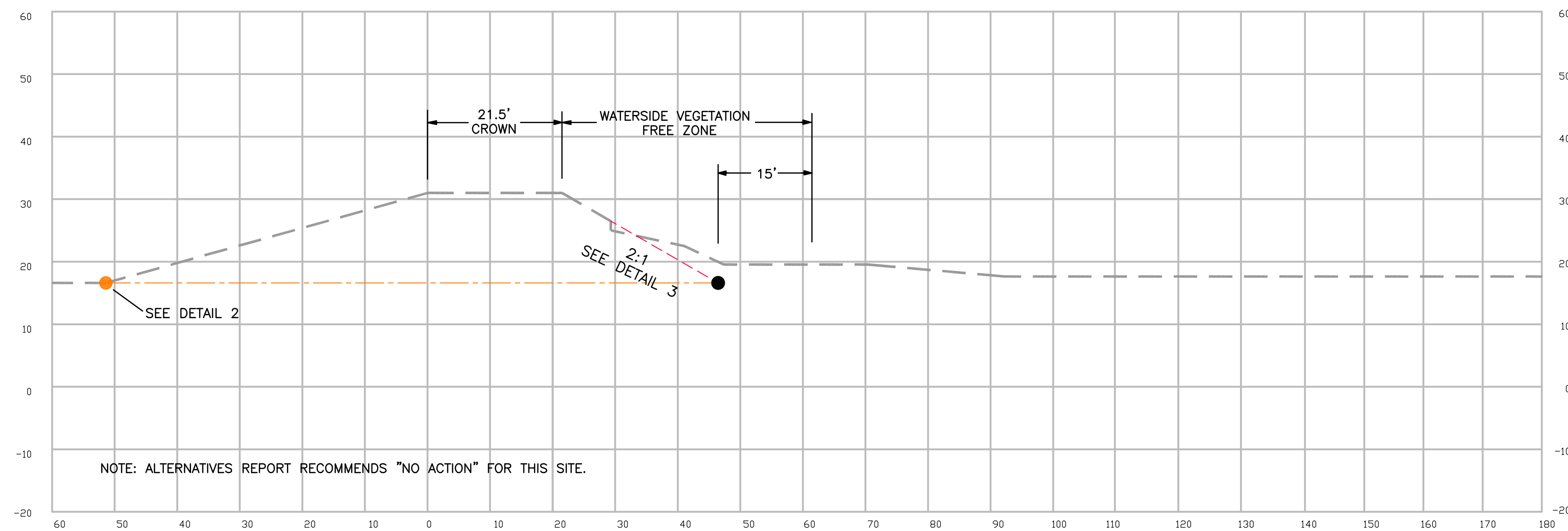
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

WILLOW SLOUGH BYPASS 0.2L

Date	3/31/11
Figure	WS 0.2L

DETAIL 1

WILLOW SLOUGH BYPASS LEVEE 0.7L



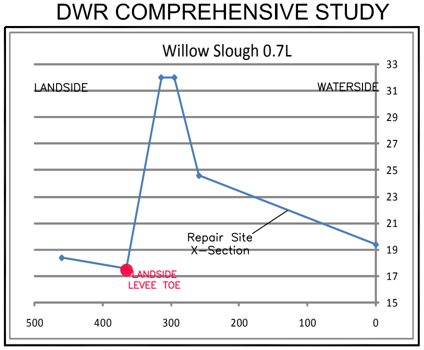
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	19.4
259.0	24.6
295.0	32.0
314.4	33.2
365.8	17.6
460.0	18.4

KEY DATA FOR DETERMINING
LANDSIDE TOE

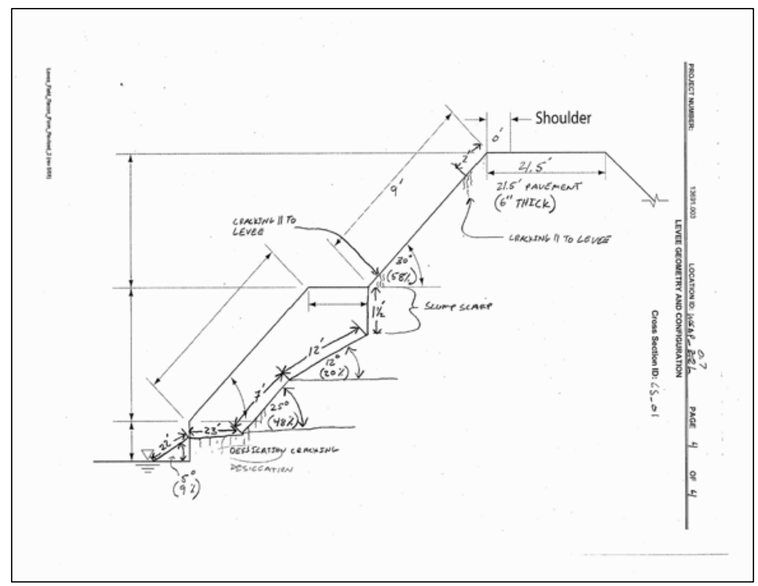
Comp Study Levee Crown Elevation	32.0
Comp Study Landside Toe Elevation	17.6
Comp Study Difference	14.4

Alternatives Report Analysis Levee Crown Elevation	31.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	16.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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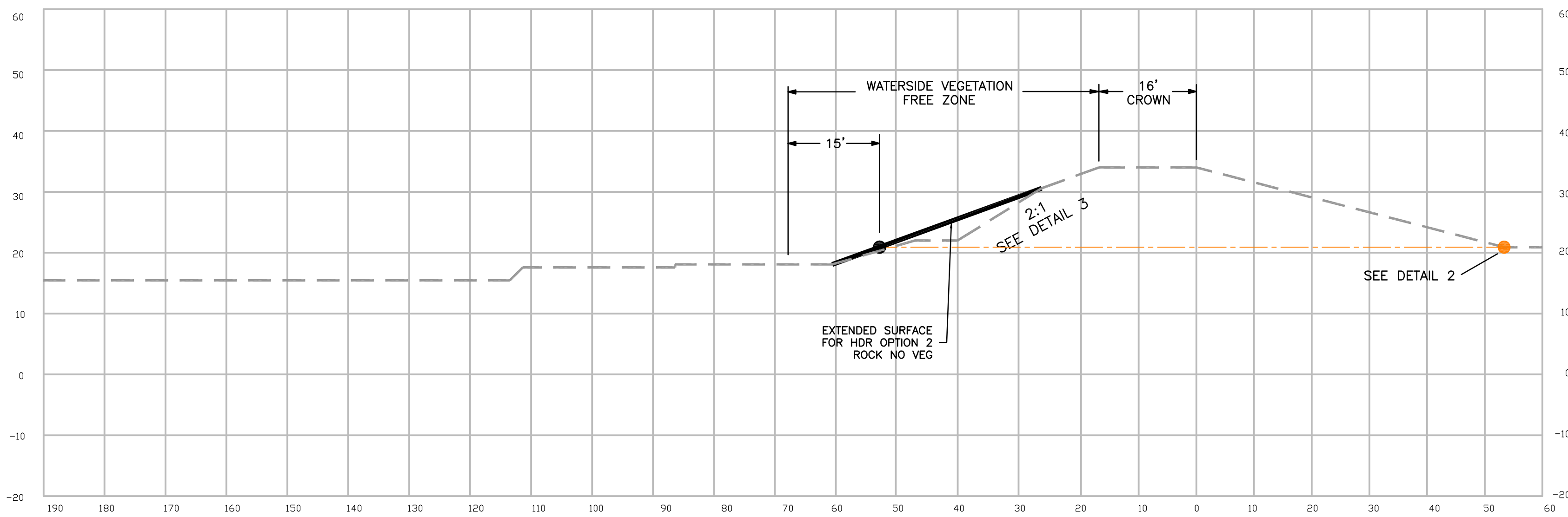
Checked By:	R. Little
QA/QC Review:	D. Teak

WILLOW SLOUGH BYPASS 0.7L

Date	3/31/11
Figure	WS 0.7L

DETAIL 1

WILLOW SLOUGH BYPASS LEVEE 6.9R



LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE
PROPOSED HDR REPAIR SURFACE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY

Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	19.5
7.0	24.5
29.4	24.4
65.9	34.7
80.2	35.0
104.0	28.3
116.3	28.2
130.7	21.9

KEY DATA FOR DETERMINING LANDSIDE TOE

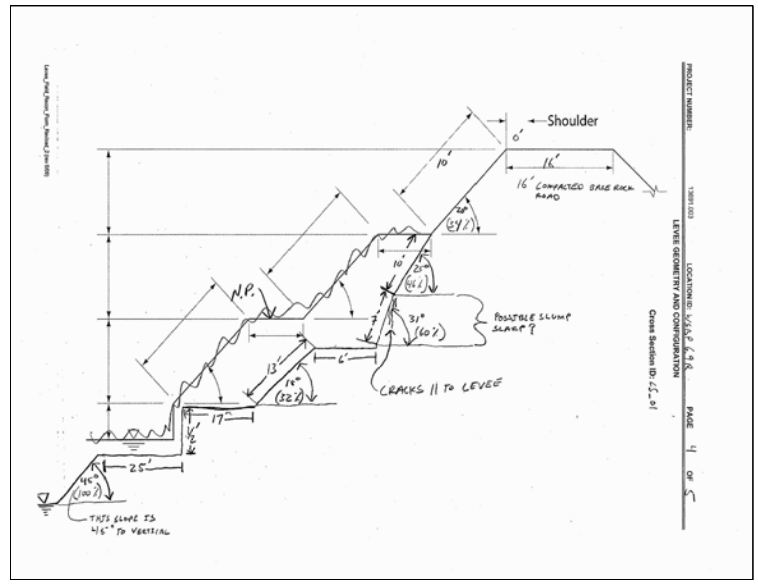
Comp Study Levee Crown Elevation	35.0
Comp Study Landside Toe Elevation	21.9
Comp Study Difference	13.1

Alternatives Report Analysis Levee Crown Elevation	34.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	20.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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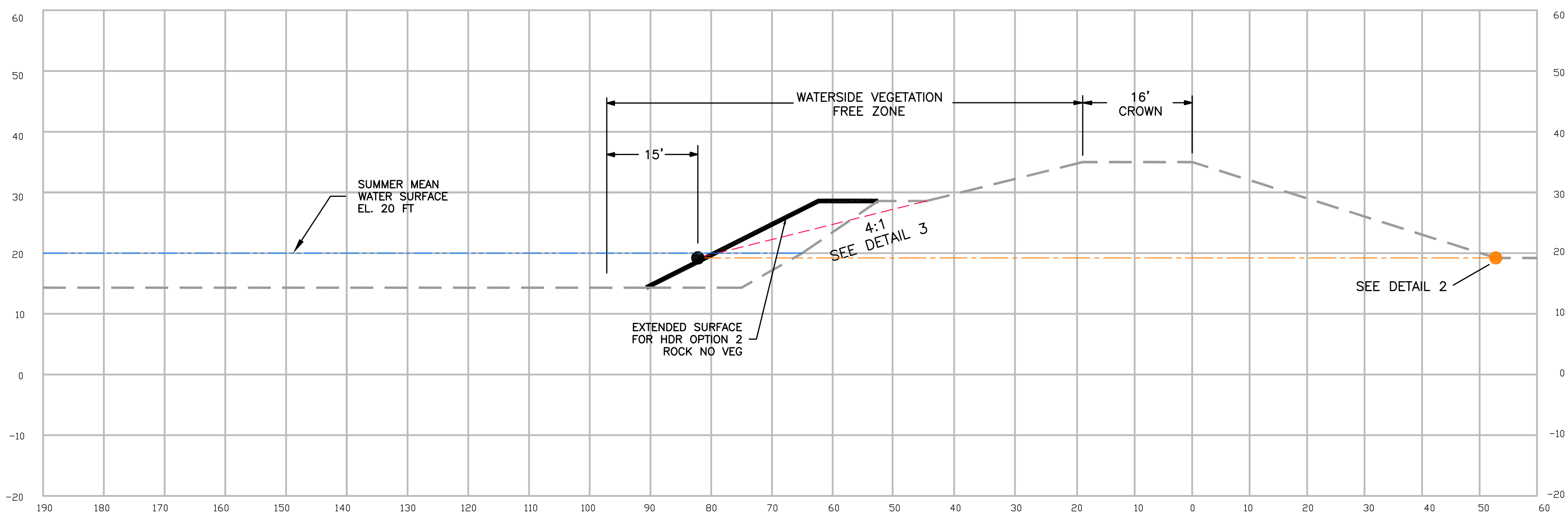
QA/QC Review:	D. Teak

WILLOW SLOUGH BYPASS 6.9R

Date	3/31/11
Figure	WS 6.9R

DETAIL 1

YOLO BYPASS 2.0R



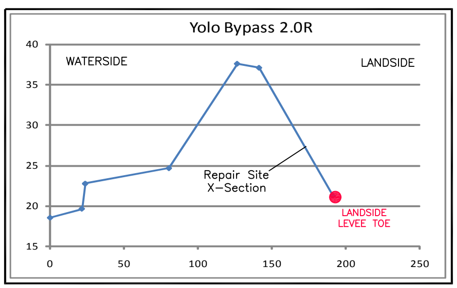
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- PROPOSED HDR REPAIR SURFACE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	18.6
21.4	19.7
23.7	22.8
80.3	24.7
126.4	37.6
141.2	37.1
191.2	21.3

KEY DATA FOR DETERMINING LANDSIDE TOE

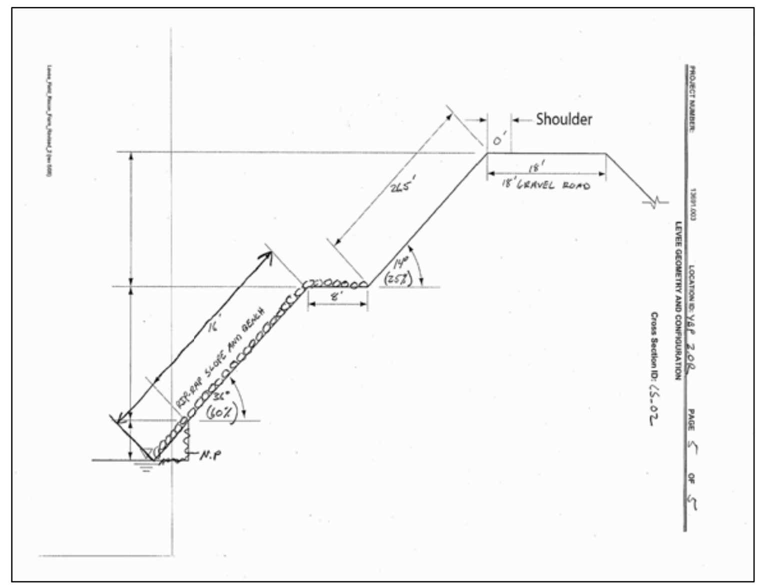
Comp Study Levee Crown Elevation	37.1
Comp Study Landside Toe Elevation	21.3
Comp Study Difference	15.8

Alternatives Report Analysis Levee Crown Elevation	35.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	19.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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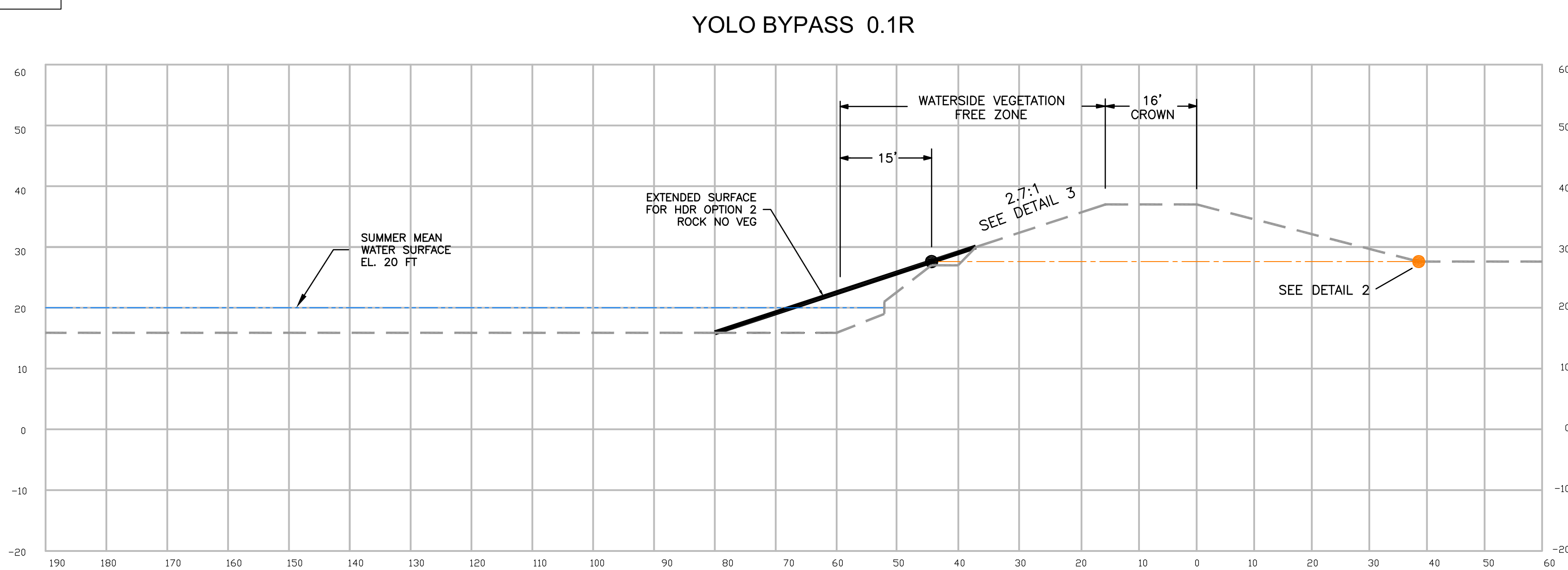
Checked By:	R. Little
QA/QC Review:	D. Teak

YOLO BYPASS ~ 2.0R

Date	3/31/11
Figure	YBP2 2.0R

DETAIL 1



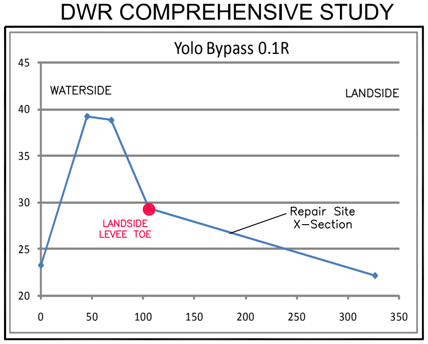
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- PROPOSED HDR REPAIR SURFACE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	23.3
45.2	39.2
68.8	38.8
105.3	29.4
326.4	22.2

KEY DATA FOR DETERMINING LANDSIDE TOE

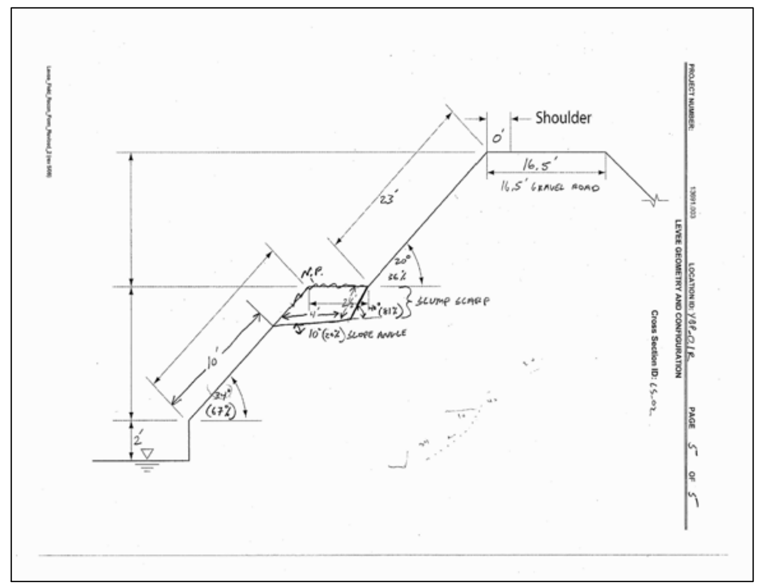
Comp Study Levee Crown Elevation	38.8
Comp Study Landside Toe Elevation	29.4
Comp Study Difference	9.4

Alternatives Report Analysis Levee Crown Elevation	37.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	27.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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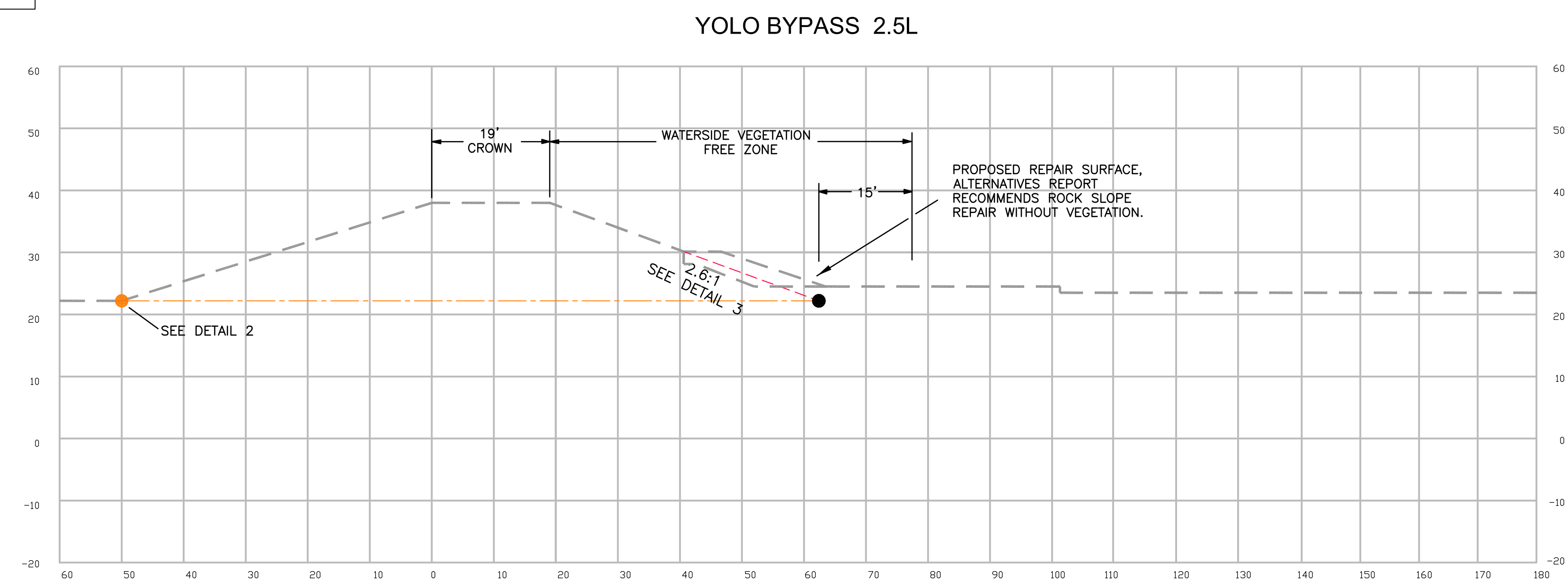
Checked By:	R. Little
QA/QC Review:	D. Teak

YOLO BYPASS ~ 0.1R

Date 3/31/11

Figure YBP2 0.1R

DETAIL 1



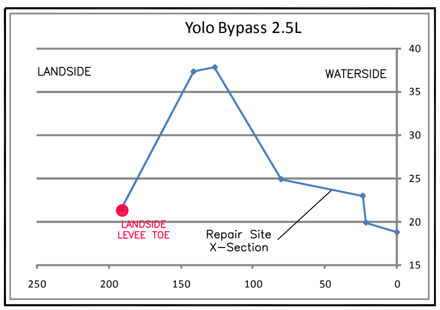
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	18.8
21.4	19.9
23.7	23.0
80.3	24.9
126.4	37.8
141.2	37.3
191.2	21.5

KEY DATA FOR DETERMINING LANDSIDE TOE

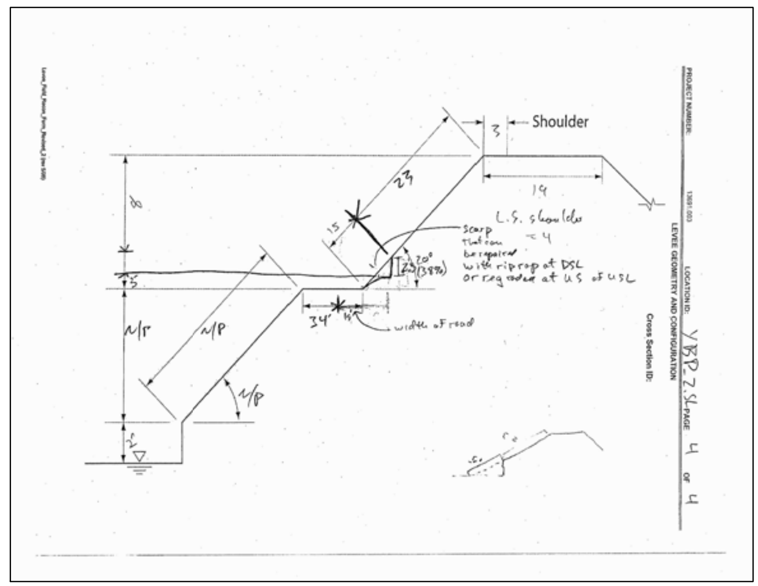
Comp Study Levee Crown Elevation	37.3
Comp Study Landside Toe Elevation	21.5
Comp Study Difference	15.8

Alternatives Report Analysis Levee Crown Elevation	38

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	22.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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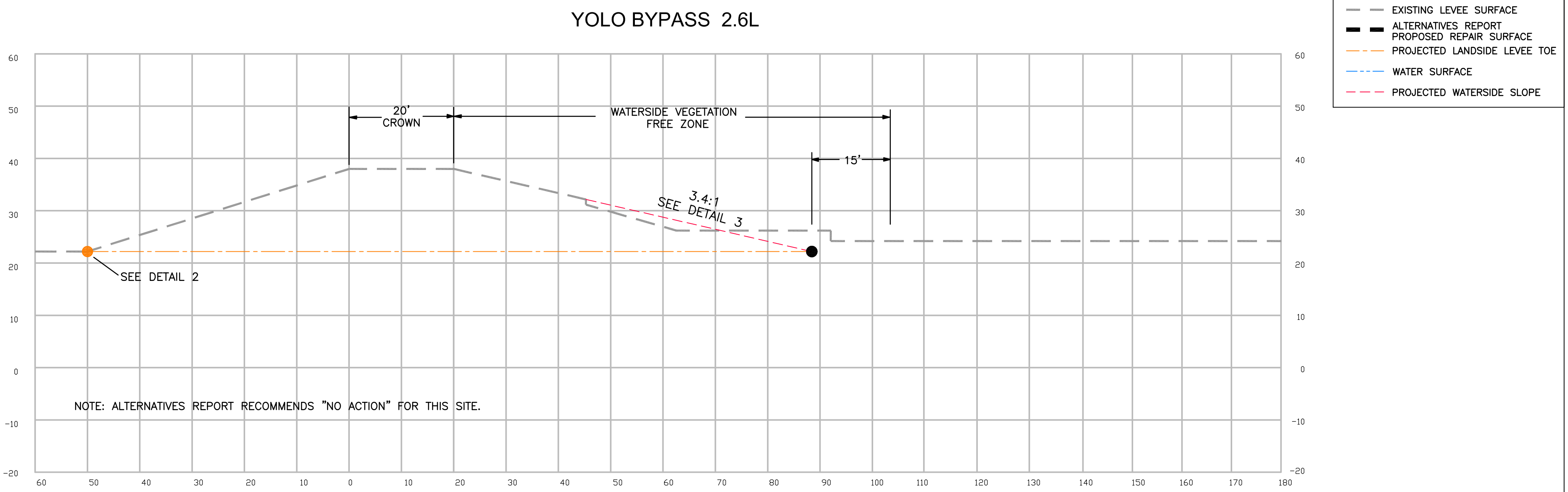
Checked By:	R. Little
QA/QC Review:	D. Teak

YOLO BYPASS ~ 2.5L

Date	3/31/11
Figure	YBP1 2.5L

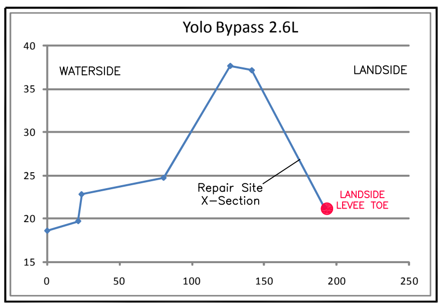
DETAIL 1



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	18.7
21.4	19.8
23.7	22.9
80.3	24.8
126.4	37.7
141.2	37.2
191.2	21.4

KEY DATA FOR DETERMINING LANDSIDE TOE

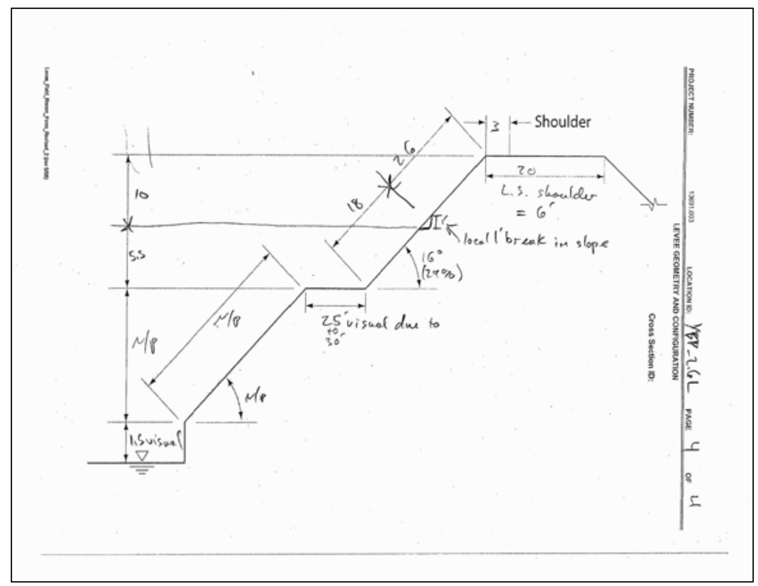
Comp Study Levee Crown Elevation	37.2
Comp Study Landside Toe Elevation	21.4
Comp Study Difference	15.8

Alternatives Report Analysis Levee Crown Elevation	38

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	22.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

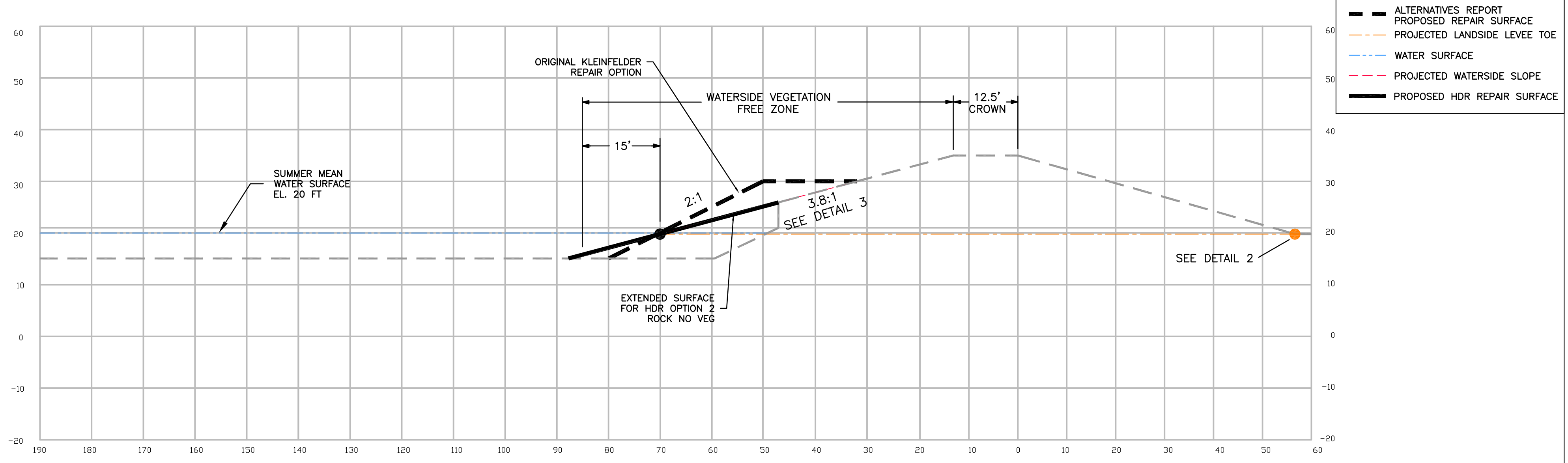
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

YOLO BYPASS ~ 2.6L

Date	3/31/11
Figure	YBP1 2.6L

DETAIL 1

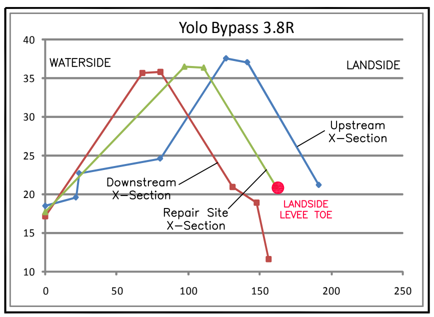
YOLO BYPASS LEVEE 3.8R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	17.7
97.3	36.5
110.8	36.3
161.1	21.1

KEY DATA FOR DETERMINING LANDSIDE TOE

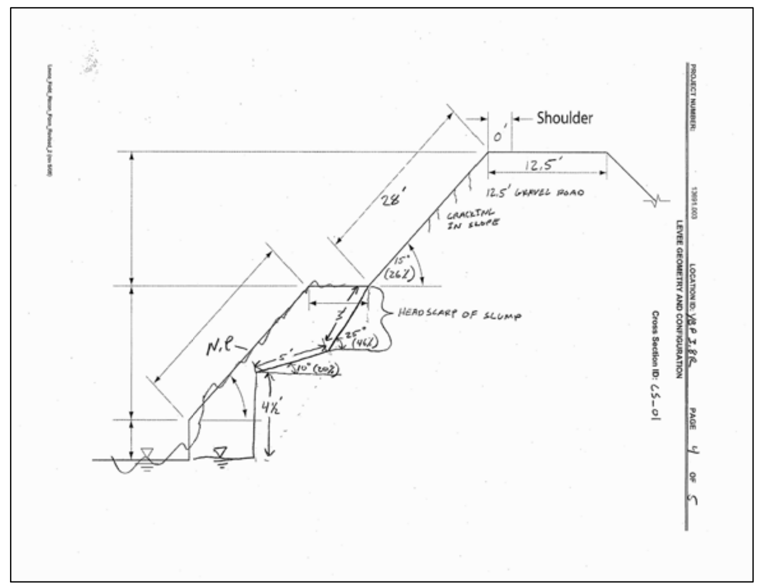
Comp Study Levee Crown Elevation	36.3
Comp Study Landside Toe Elevation	21.1
Comp Study Difference	15.2

Alternatives Report Analysis Levee Crown Elevation	35.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	19.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
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HDR Engineering, Inc.

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Checked By:	R. Little
QA/QC Review:	D. Teak

YOLO BYPASS ~ 3.8R

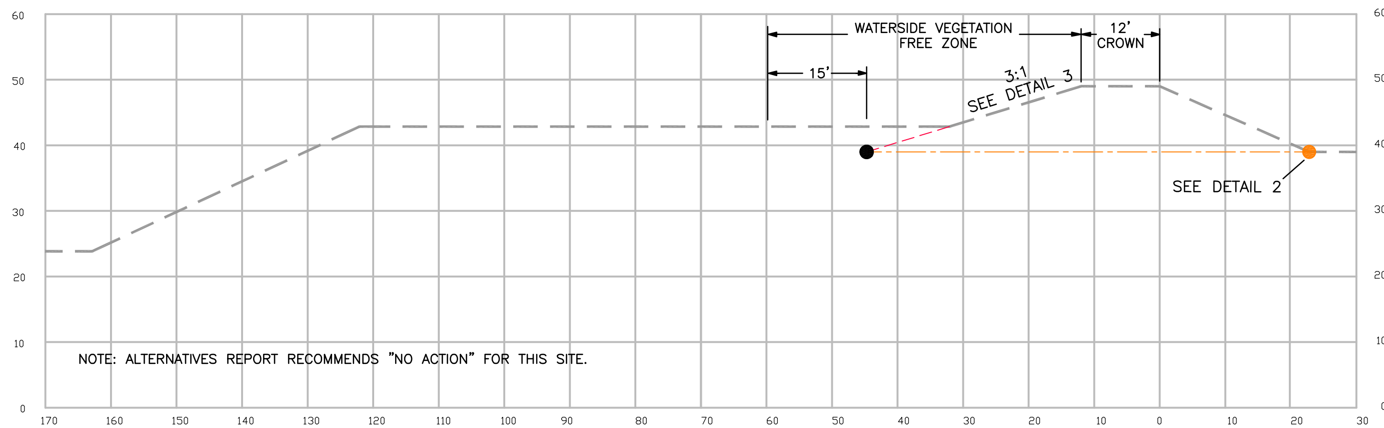
Date	3/31/11
Figure	YBP2 3.8R

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

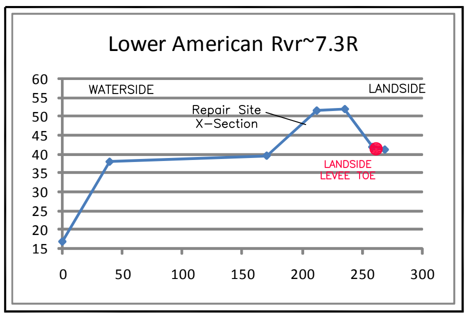
LOWER AMERICAN RIVER 7.3R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	16.9
39.4	38.0
170.4	39.6
212.2	51.5
235.6	51.9
258.4	41.9
268.9	41.2

KEY DATA FOR DETERMINING LANDSIDE TOE

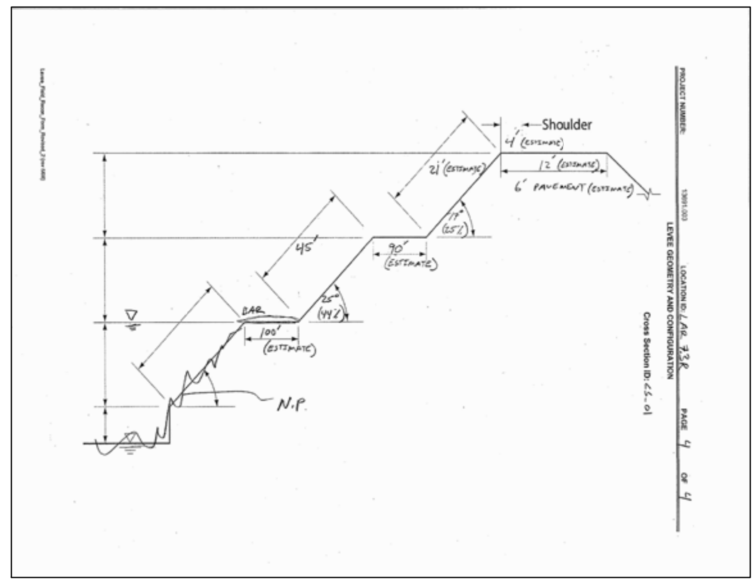
Comp Study Levee Crown Elevation	51.9
Comp Study Landside Toe Elevation	41.9
Comp Study Difference	10.0

Alternatives Report Analysis Levee Crown Elevation	49.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	39.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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QA/QC Review: D. Teak

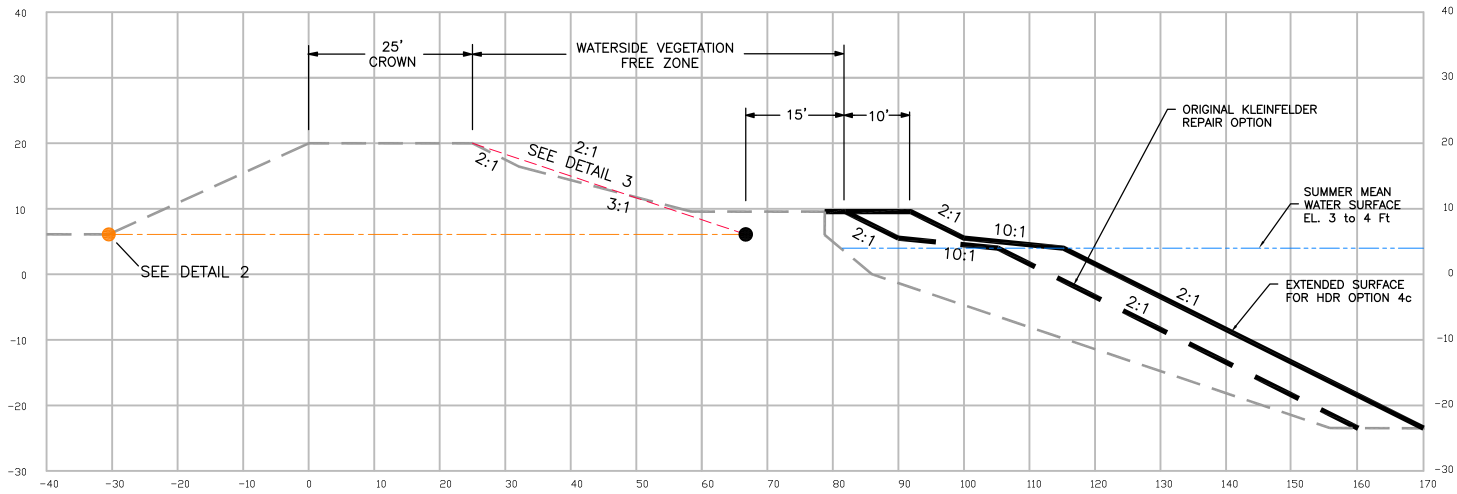
LOWER AMERICAN RIVER ~ 7.3R

Date 3/31/11

Figure LAR 7.3R

DETAIL 1

SACRAMENTO RIVER 21.5L



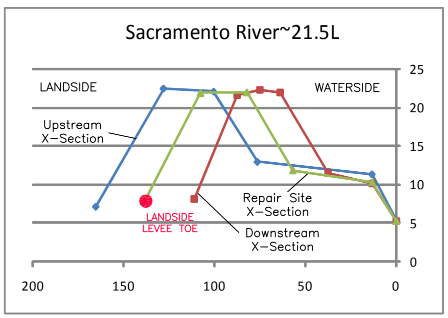
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- HDR PROPOSED REPAIR SURFACE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.3
13.2	10.4
56.8	11.9
82.1	21.9
107.6	21.9
138.1	8.0

KEY DATA FOR DETERMINING LANDSIDE TOE

Comp Study Levee Crown Elevation	21.9
Comp Study Landside Toe Elevation	8.0
Comp Study Difference	13.9

Alternatives Report Analysis Levee Crown Elevation	20.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	6.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES

NO EXISTING FIELD NOTES

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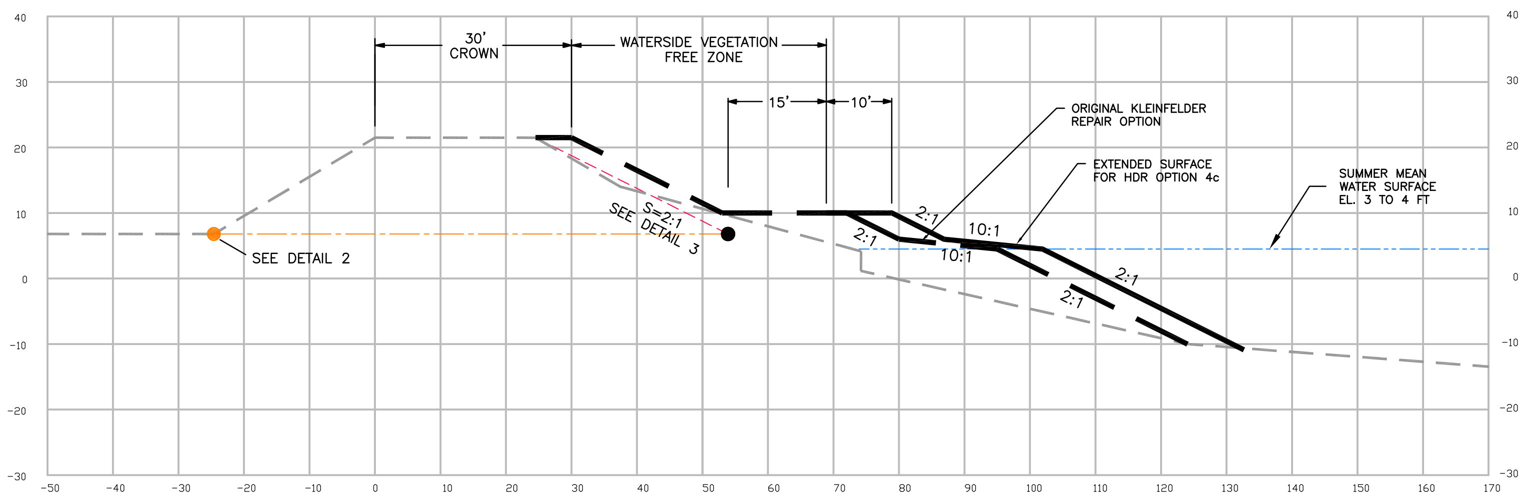
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 21.5L

Date	3/31/11
Figure	SAC 21.5L

DETAIL 1

SACRAMENTO RIVER 22.5L

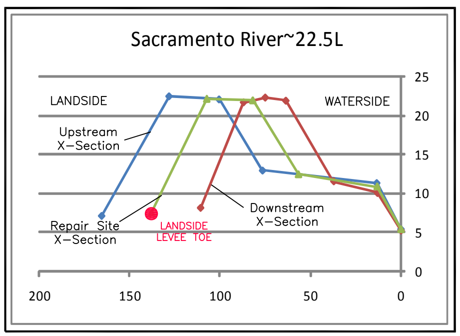


LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- HDR PROPOSED REPAIR SURFACE

DETAIL 2

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



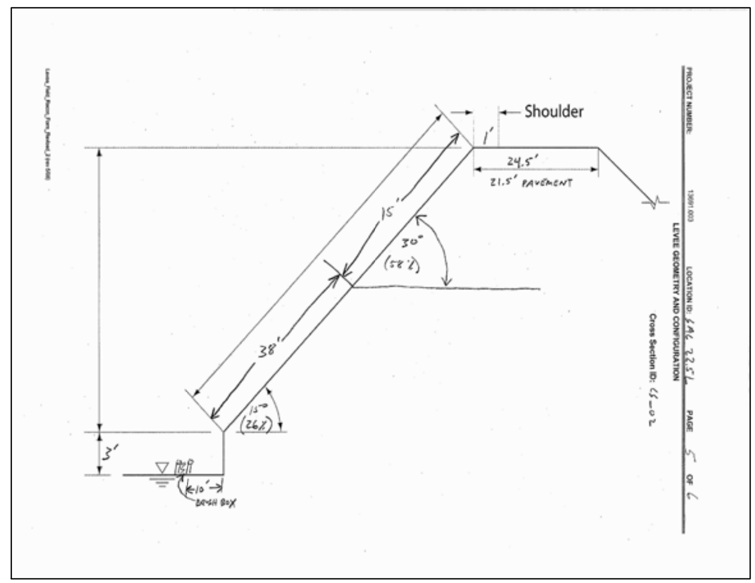
Comp Study Data Points	
Horizontal Distance From Waters Edge	Elevation
0	5.4
13.2	10.9
56.8	12.5
82.1	22.0
107.6	22.2
107.9	7.6

Waterside Toe Based on Alternatives Analysis & Comp. Study	
Comp Study Levee Crown Elevation	22.2
Comp Study Landside Toe Elevation	7.6
Comp Study Difference	14.7
Comp Study Analysis Levee Crown Elevation	21.5

Waterside Toe Defined as: (Comp. Study Crown Elev.) - (Difference)	
Determined Waterside Toe	6.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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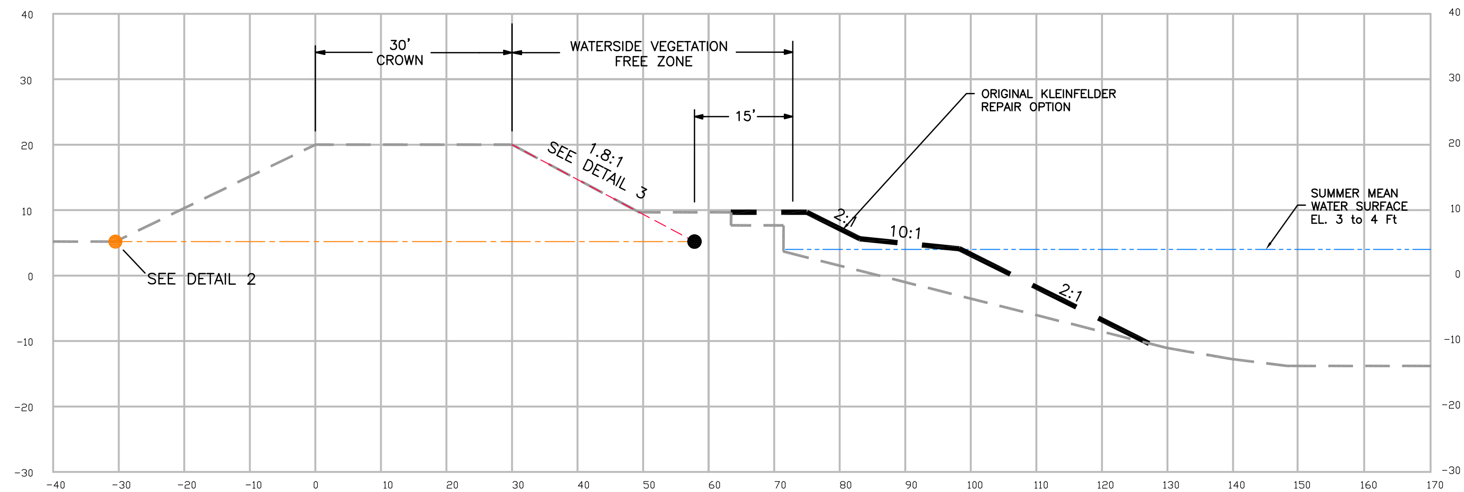
SACRAMENTO RIVER ~ 22.5L

Date	3/31/11
Figure	SAC 22.5L

DETAIL 1

SACRAMENTO RIVER 22.7L



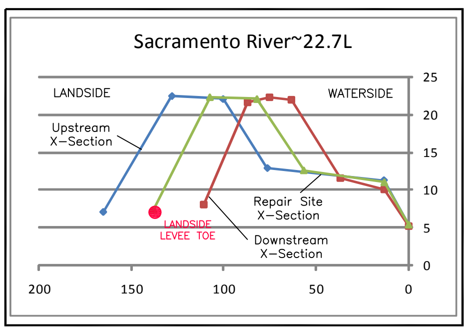
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.4
13.2	11.1
56.8	12.6
82.1	22.0
107.6	22.3
138.1	7.5

KEY DATA FOR DETERMINING LANDSIDE TOE

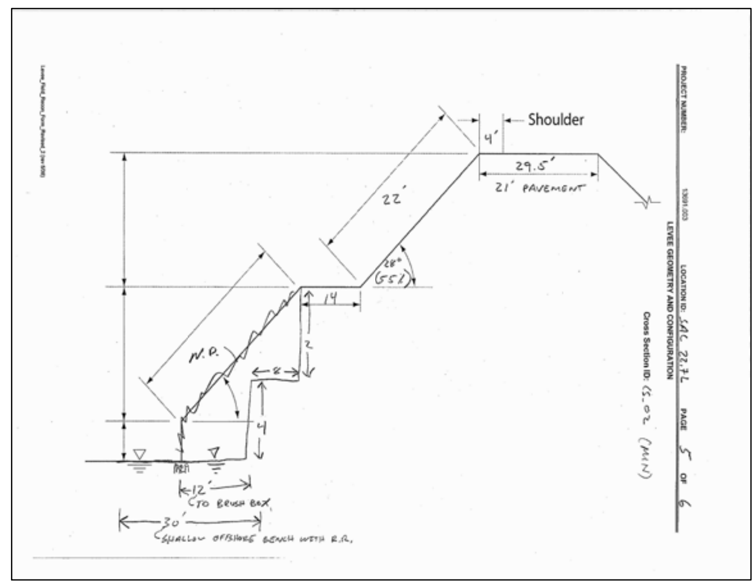
Comp Study Levee Crown Elevation	22.3
Comp Study Landside Toe Elevation	7.5
Comp Study Difference	14.8

Alternatives Report Analysis Levee Crown Elevation	20.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	5.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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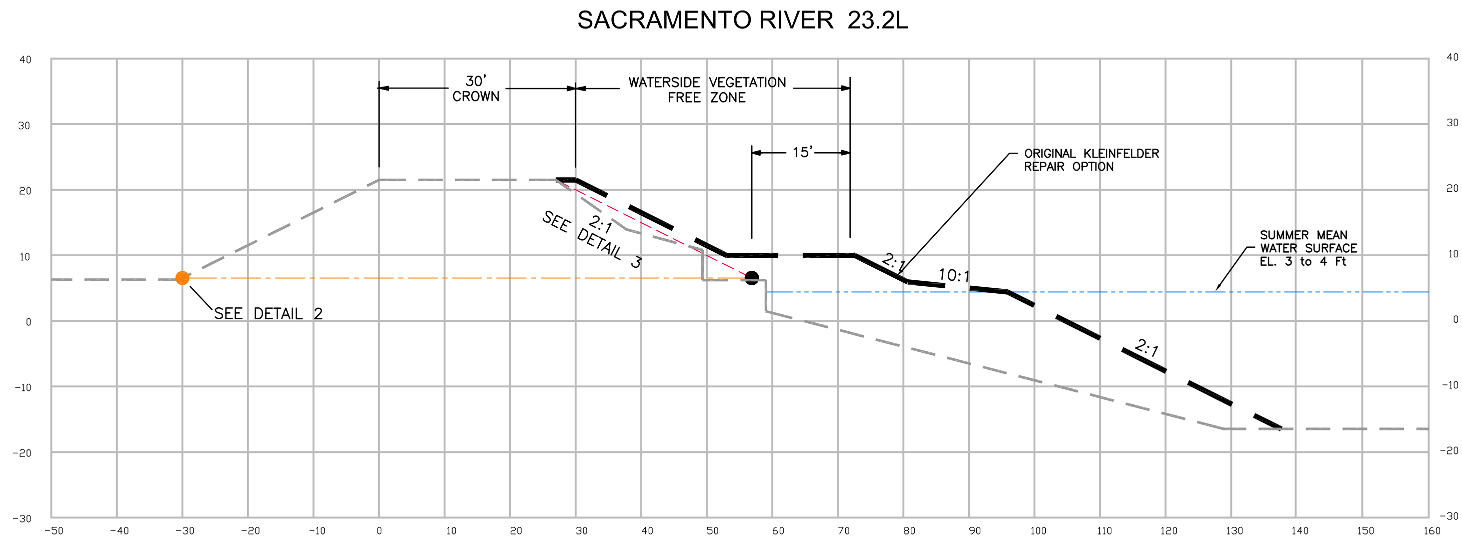
QA/QC Review: D. Teak

SACRAMENTO RIVER ~ 22.7L

Date 3/31/11
Figure SAC 22.7L

DETAIL 1

SACRAMENTO RIVER 23.2L



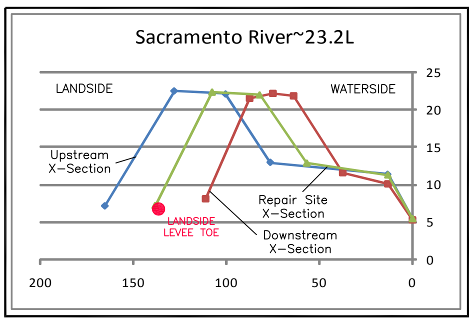
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.5
13.2	11.3
56.8	12.9
82.1	22.1
107.6	22.5
138.1	7.2

KEY DATA FOR DETERMINING LANDSIDE TOE

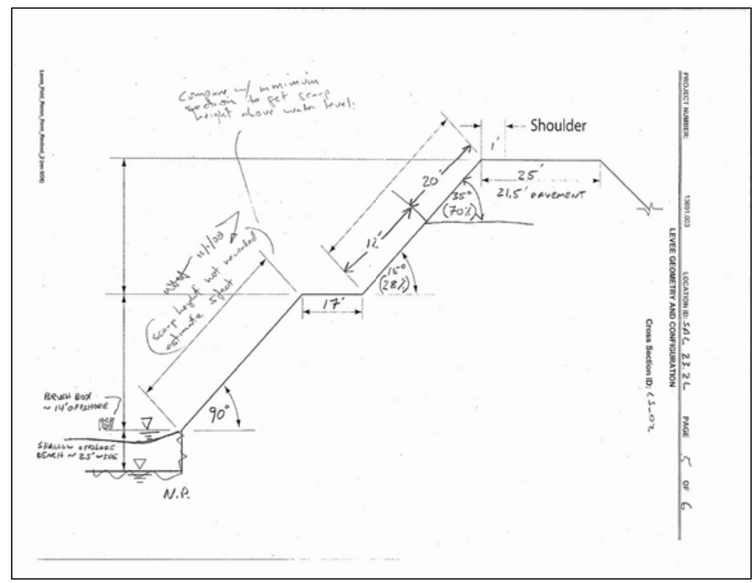
Comp Study Levee Crown Elevation	22.5
Comp Study Landside Toe Elevation	7.2
Comp Study Difference	15.2

Alternatives Report Analysis Levee Crown Elevation	21.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	6.3

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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SACRAMENTO RIVER ~ 23.2L

Date 3/31/11

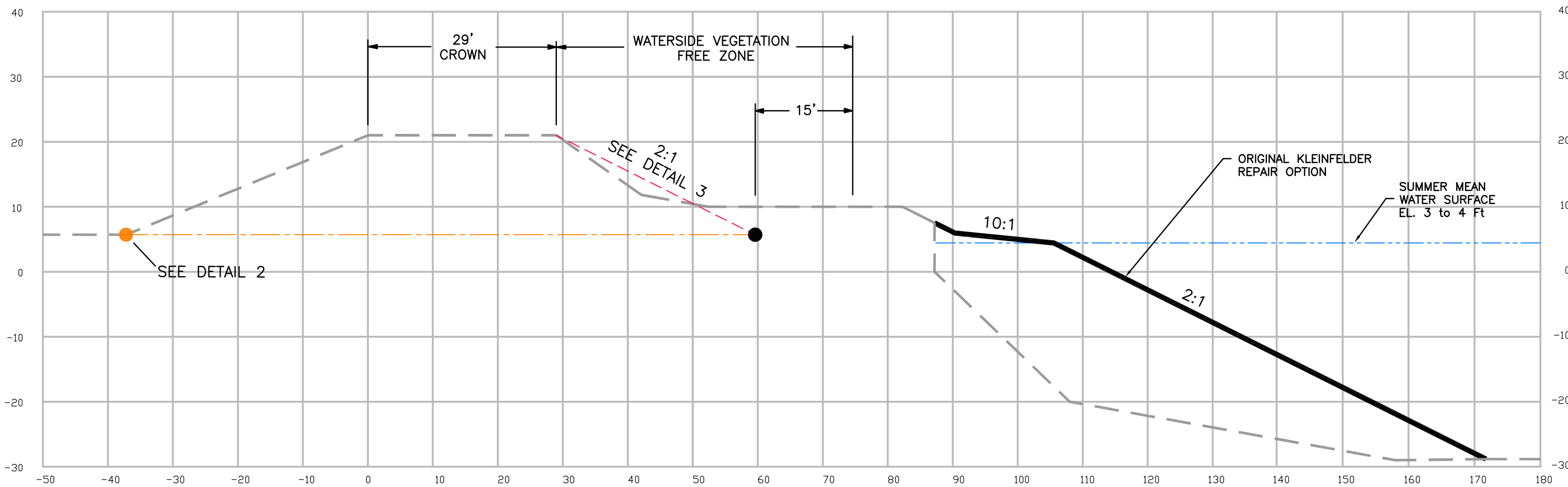
Figure SAC 23.2L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

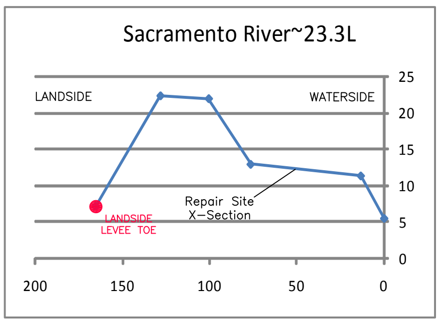
SACRAMENTO RIVER 23.3L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.5
13.4	11.4
76.4	13.0
100.4	22.1
128.0	22.5
165.2	7.2

KEY DATA FOR DETERMINING
LANDSIDE TOE

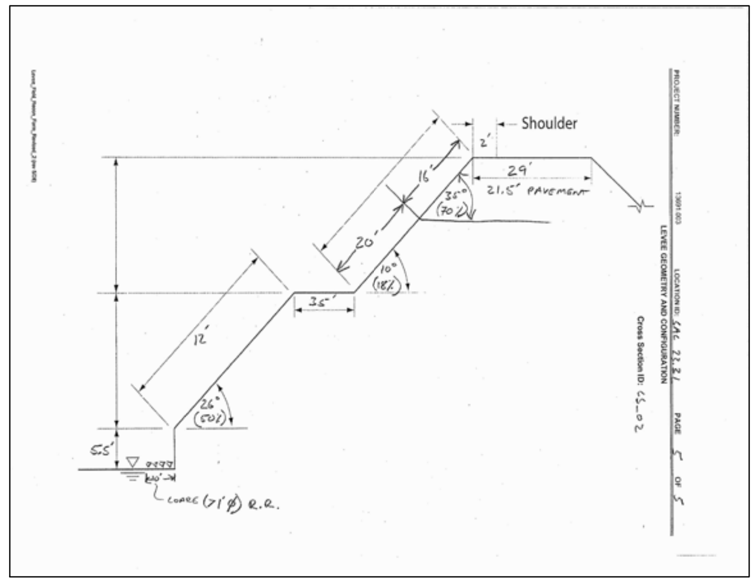
Comp Study Levee Crown Elevation	22.5
Comp Study Landside Toe Elevation	7.2
Comp Study Difference	15.3

Alternatives Report Analysis Levee Crown Elevation	21.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	5.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 23.3L

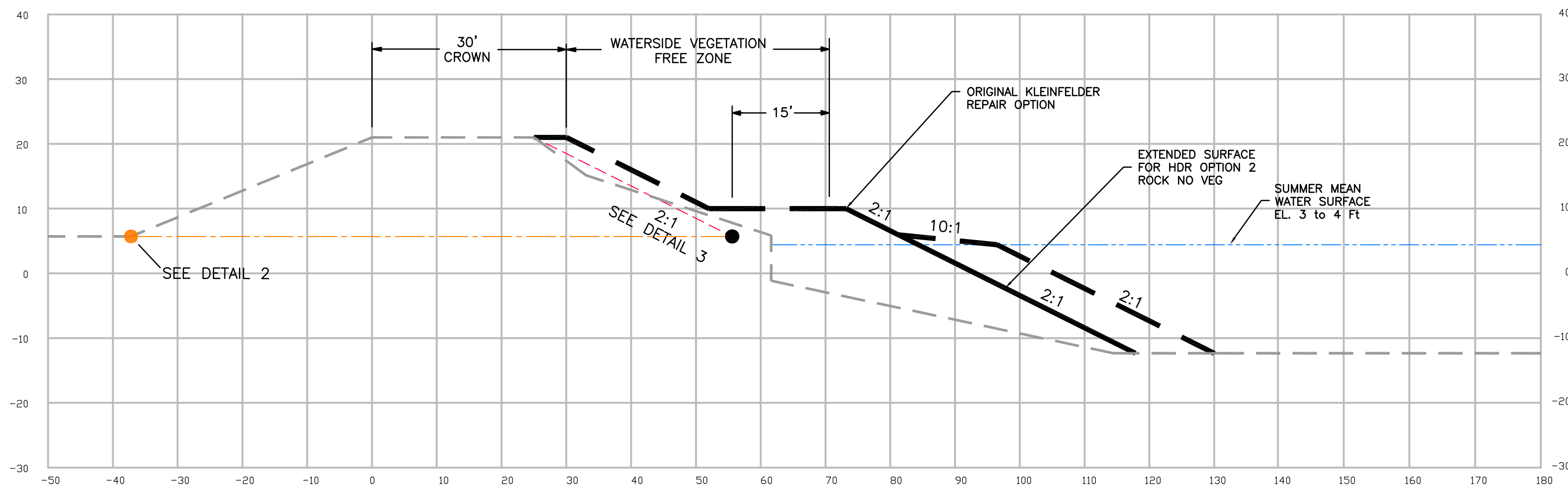
Date	3/31/11
Figure	SAC 23.3L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE
- HDR PROPOSED REPAIR SURFACE

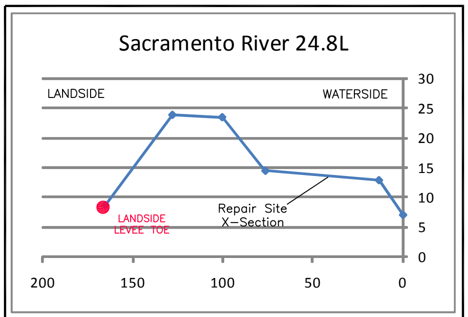
SACRAMENTO RIVER 24.8L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.1
13.4	13.0
76.4	14.6
100.4	23.7
128.0	24.1
165.2	8.8

KEY DATA FOR DETERMINING LANDSIDE TOE

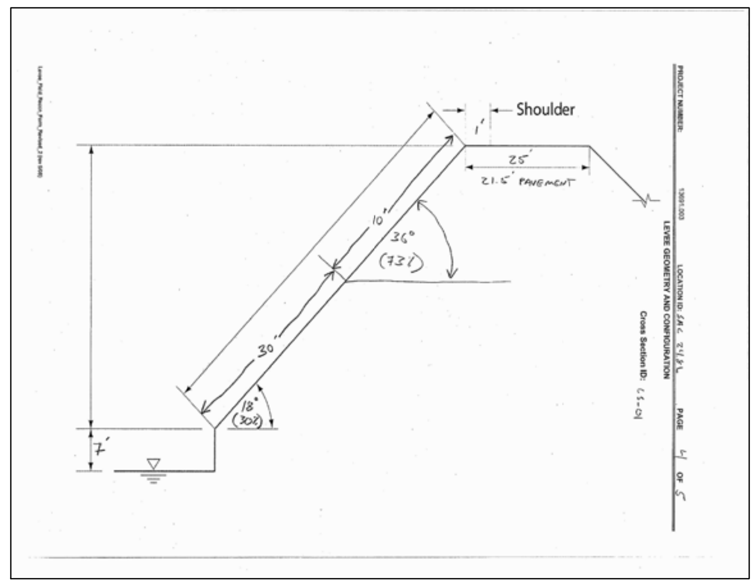
Comp Study Levee Crown Elevation	24.1
Comp Study Landside Toe Elevation	8.8
Comp Study Difference	15.3

Alternatives Report Analysis Levee Crown Elevation	21.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	5.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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Programmatic Plan Framework Memorandum

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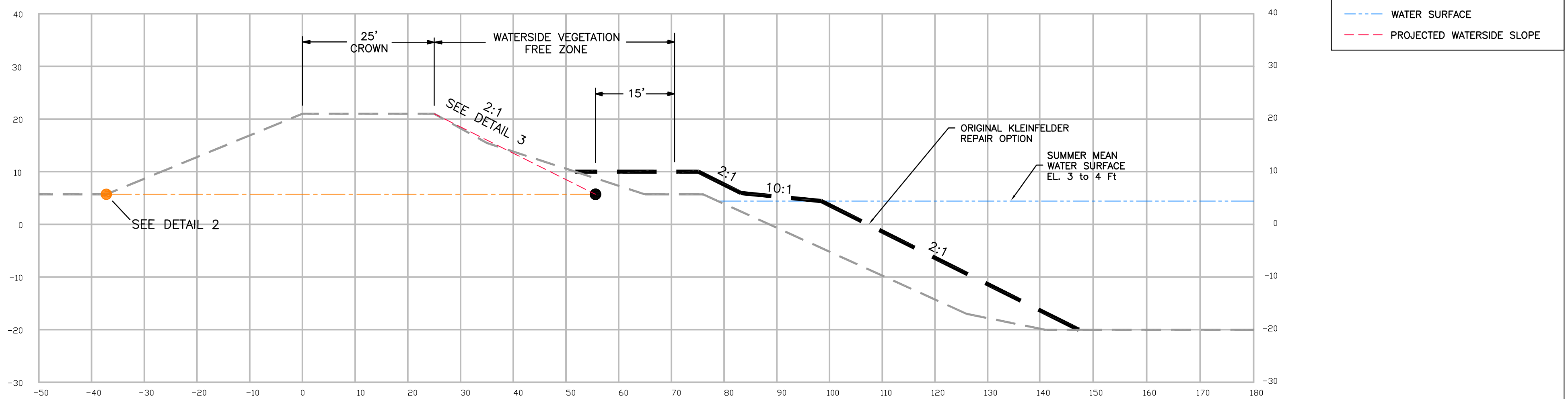
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 24.8L

Date	3/31/11
Figure	SAC 24.8L

DETAIL 1

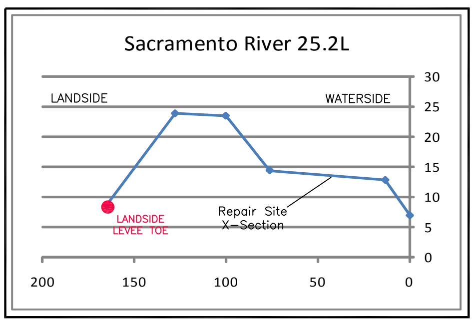
SACRAMENTO RIVER 25.2L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.0
13.4	12.9
76.4	14.5
100.4	23.6
128.0	24.0
165.2	8.7

KEY DATA FOR DETERMINING LANDSIDE TOE

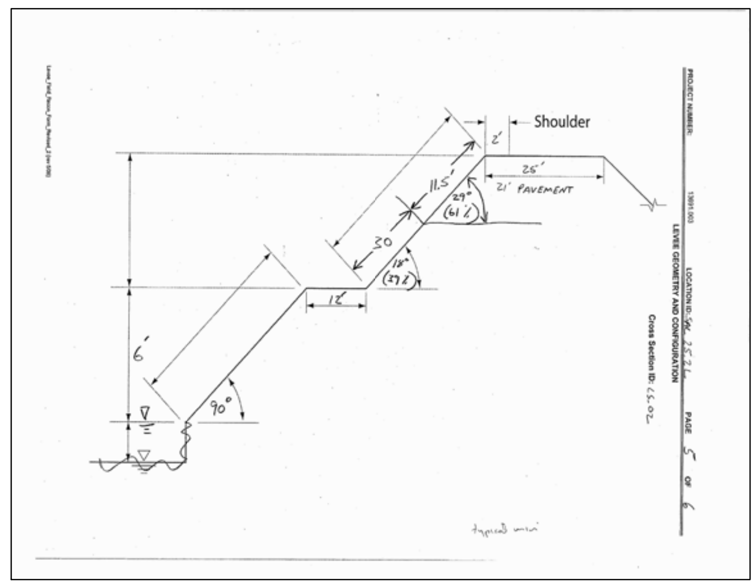
Comp Study Levee Crown Elevation	24.0
Comp Study Landside Toe Elevation	8.7
Comp Study Difference	15.3

Alternatives Report Analysis Levee Crown Elevation	22.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	6.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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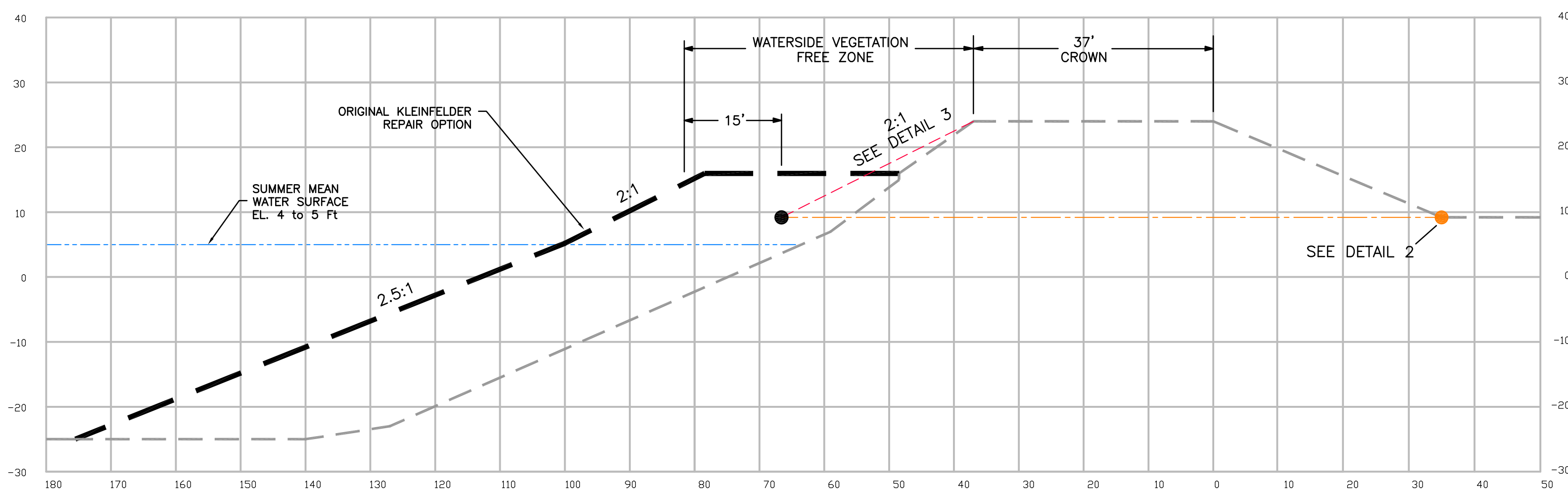
Drawn By: E. Smith	SACRAMENTO RIVER ~ 25.2L	Date	3/31/11
Checked By: R. Little		Figure	SAC 25.2L
QA/QC Review: D. Teak			

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

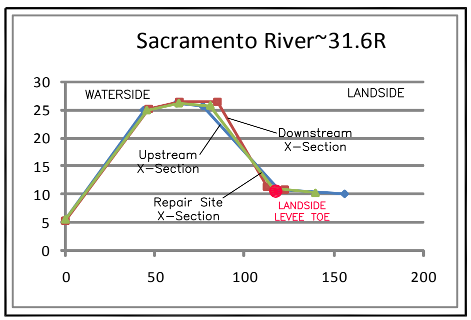
SACRAMENTO RIVER 31.6R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	5.7
45.4	25.0
63.2	26.3
80.8	25.9
116.0	11.1
139.4	14.8

KEY DATA FOR DETERMINING LANDSIDE TOE

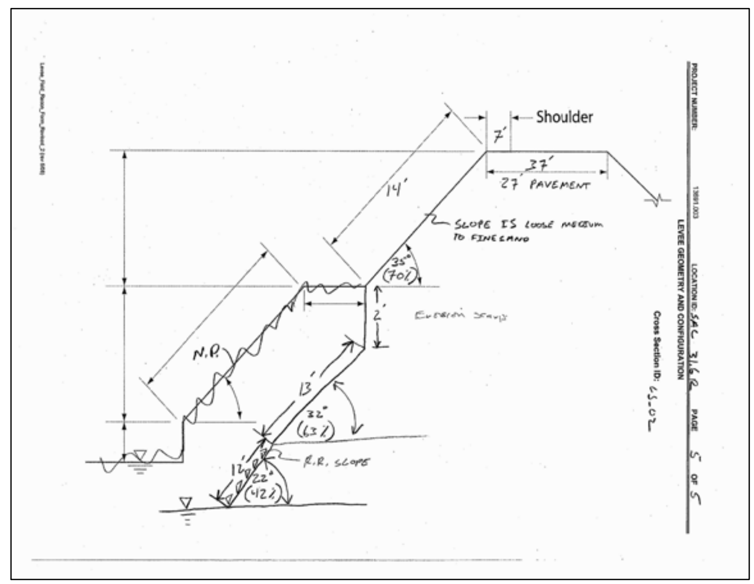
Comp Study Levee Crown Elevation	25.9
Comp Study Landside Toe Elevation	11.1
Comp Study Difference	14.8

Alternatives Report Analysis Levee Crown Elevation	24.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	9.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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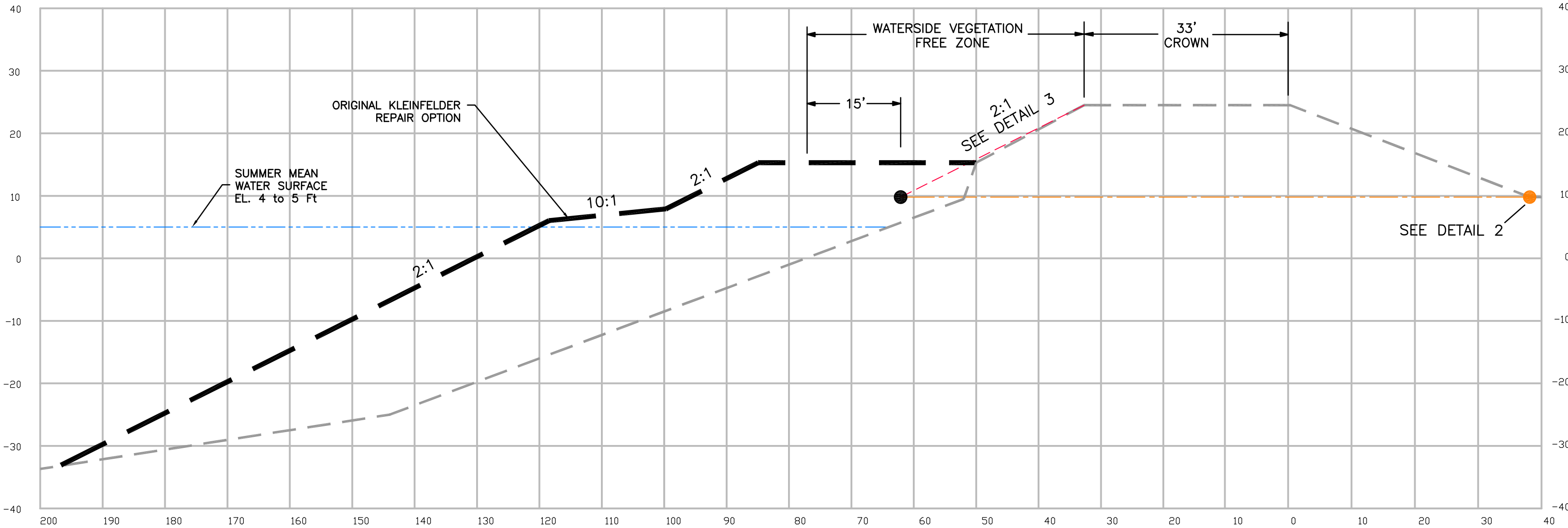
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 31.6R

Date	3/31/11
Figure	SAC 31.6R

DETAIL 1

SACRAMENTO RIVER 35.3R



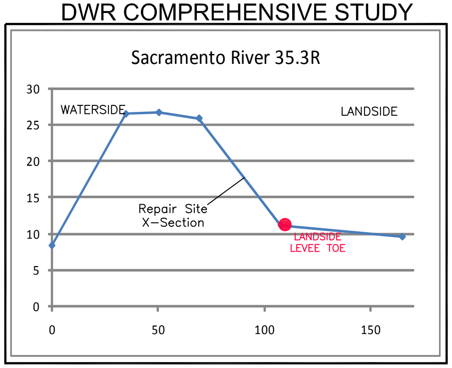
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.5
34.8	26.6
50.3	26.8
69.2	26.0
107.6	11.3
164.7	9.7

KEY DATA FOR DETERMINING LANDSIDE TOE

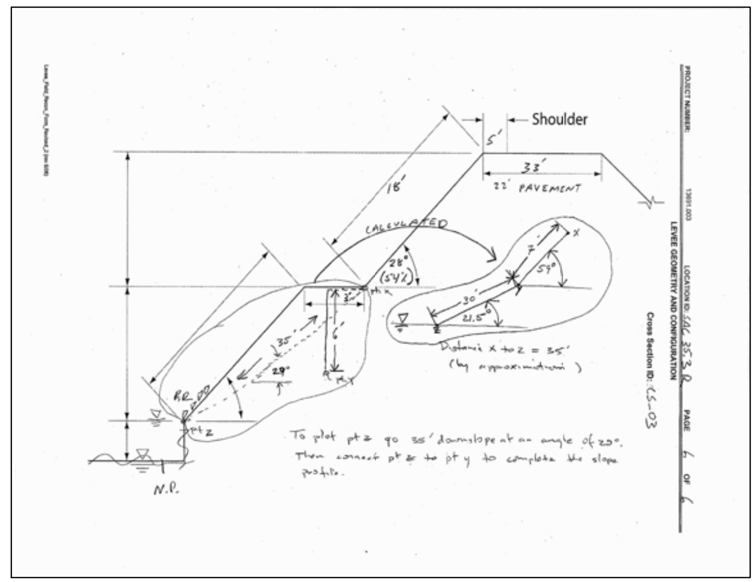
Comp Study Levee Crown Elevation	26.0
Comp Study Landside Toe Elevation	11.3
Comp Study Difference	14.7

Alternatives Report Analysis Levee Crown Elevation	24.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	9.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Checked By: R. Little
QA/QC Review: D. Teak

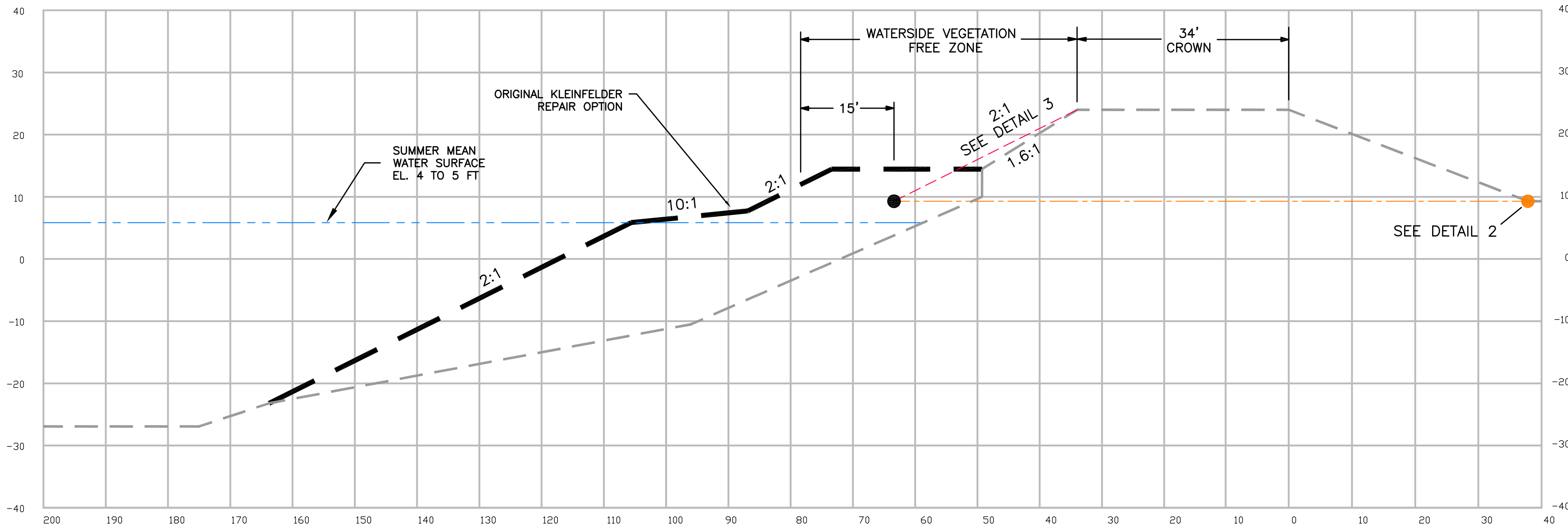
SACRAMENTO RIVER ~ 35.3R

Date 3/31/11

Figure SAC 35.3R

DETAIL 1

SACRAMENTO RIVER 35.4R



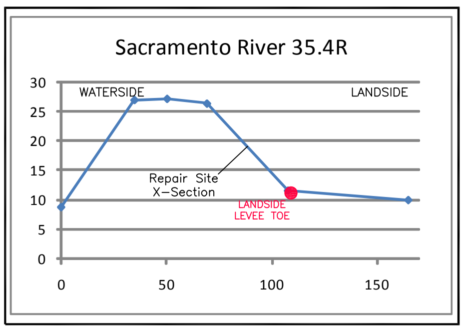
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.9
34.8	27.0
50.3	27.2
69.2	26.4
107.6	11.7
164.7	10.1

KEY DATA FOR DETERMINING LANDSIDE TOE

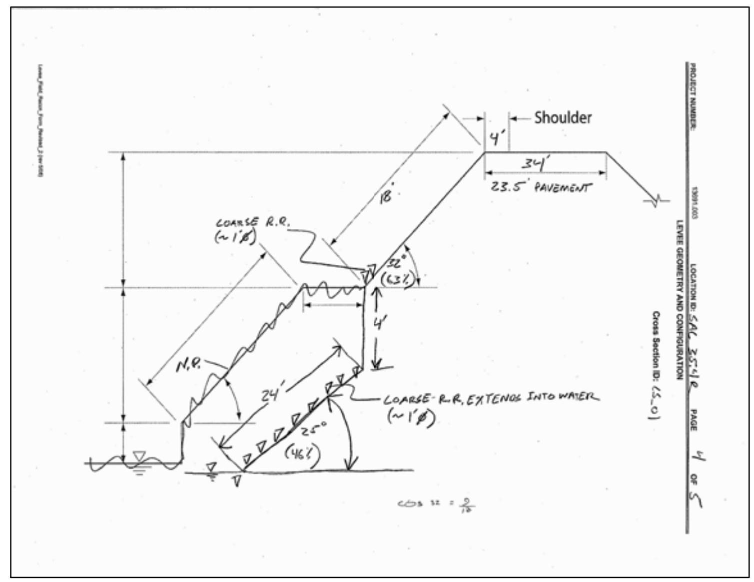
Comp Study Levee Crown Elevation	26.4
Comp Study Landside Toe Elevation	11.7
Comp Study Difference	14.7

Alternatives Report Analysis Levee Crown Elevation	24.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	9.3

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

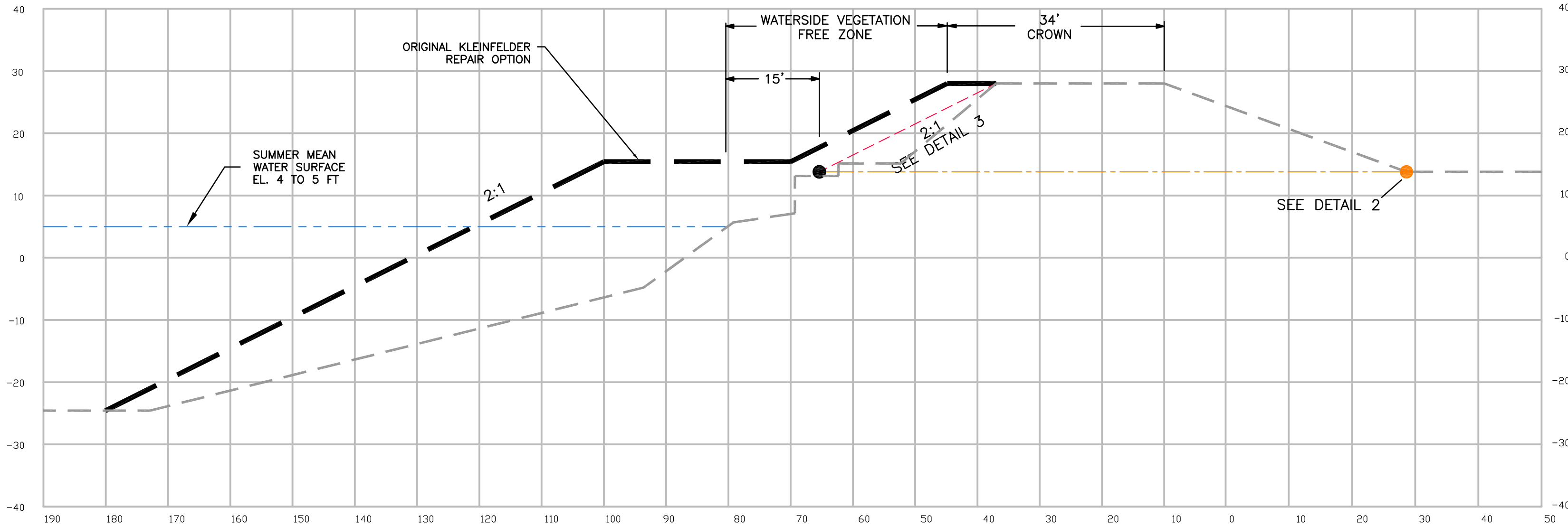
Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

SACRAMENTO RIVER ~ 35.4R

Date 3/31/11
Figure SAC 35.4R

DETAIL 1

SACRAMENTO RIVER 38.5R



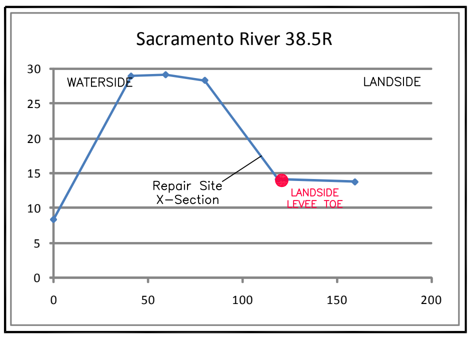
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.4
41.1	29.0
59.4	29.2
80.2	28.4
119.1	14.2
159.7	13.8

KEY DATA FOR DETERMINING LANDSIDE TOE

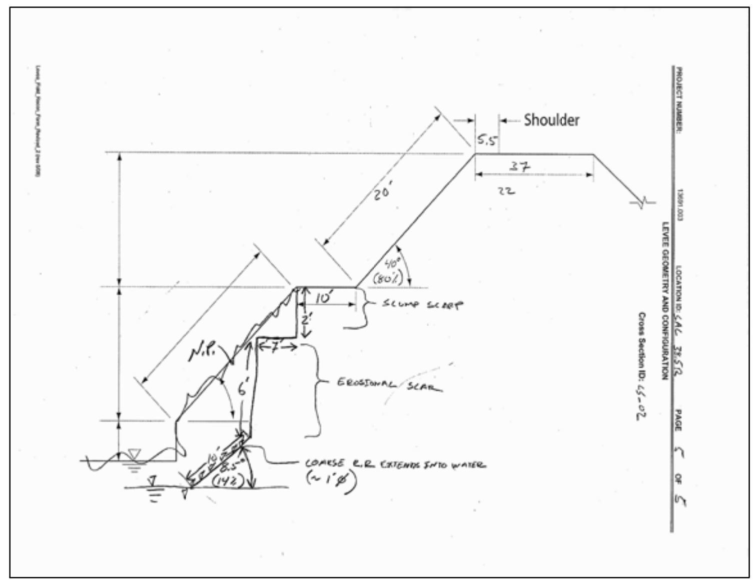
Comp Study Levee Crown Elevation	28.4
Comp Study Landside Toe Elevation	14.2
Comp Study Difference	14.2

Alternatives Report Analysis Levee Crown Elevation	28.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	13.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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Checked By: R. Little
QA/QC Review: D. Teak

SACRAMENTO RIVER ~ 38.5R

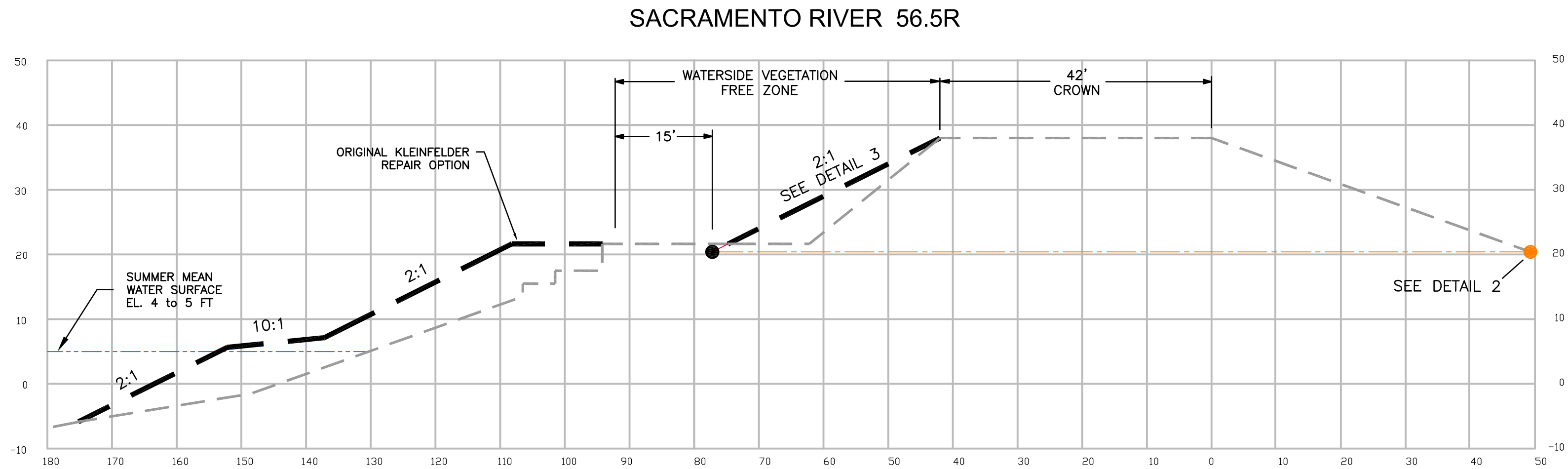
Date 3/31/11

Figure SAC 38.5R

DETAIL 1

LEGEND

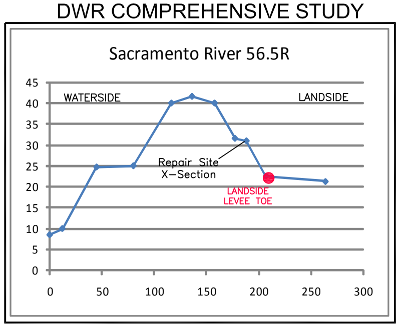
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	8.5
12.1	10.0
44.9	24.8
80.1	25.1
116.5	40.2
136.2	41.8
157.7	40.2
177.2	31.7
188.2	31.1
207.0	22.6
263.8	21.3

KEY DATA FOR DETERMINING LANDSIDE TOE

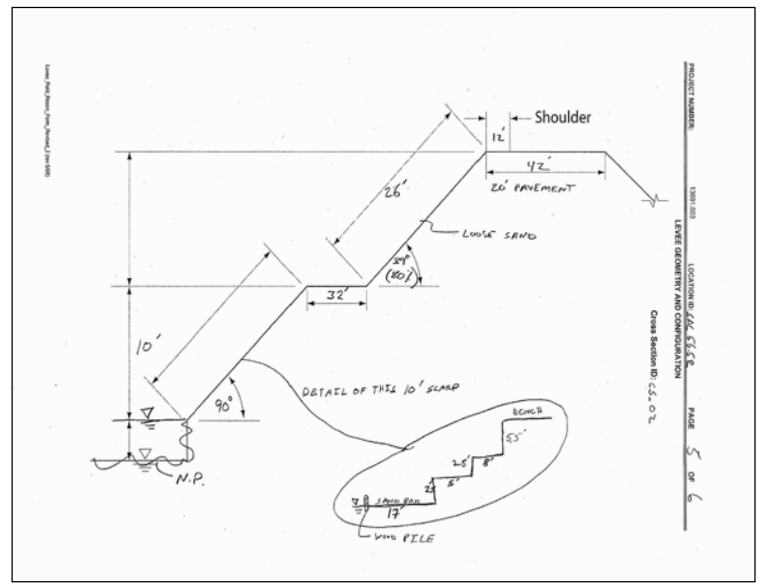
Comp Study Levee Crown Elevation	40.2
Comp Study Landside Toe Elevation	22.6
Comp Study Difference	17.6

Alternatives Report Analysis Levee Crown Elevation	38.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	20.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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HDR Engineering, Inc.

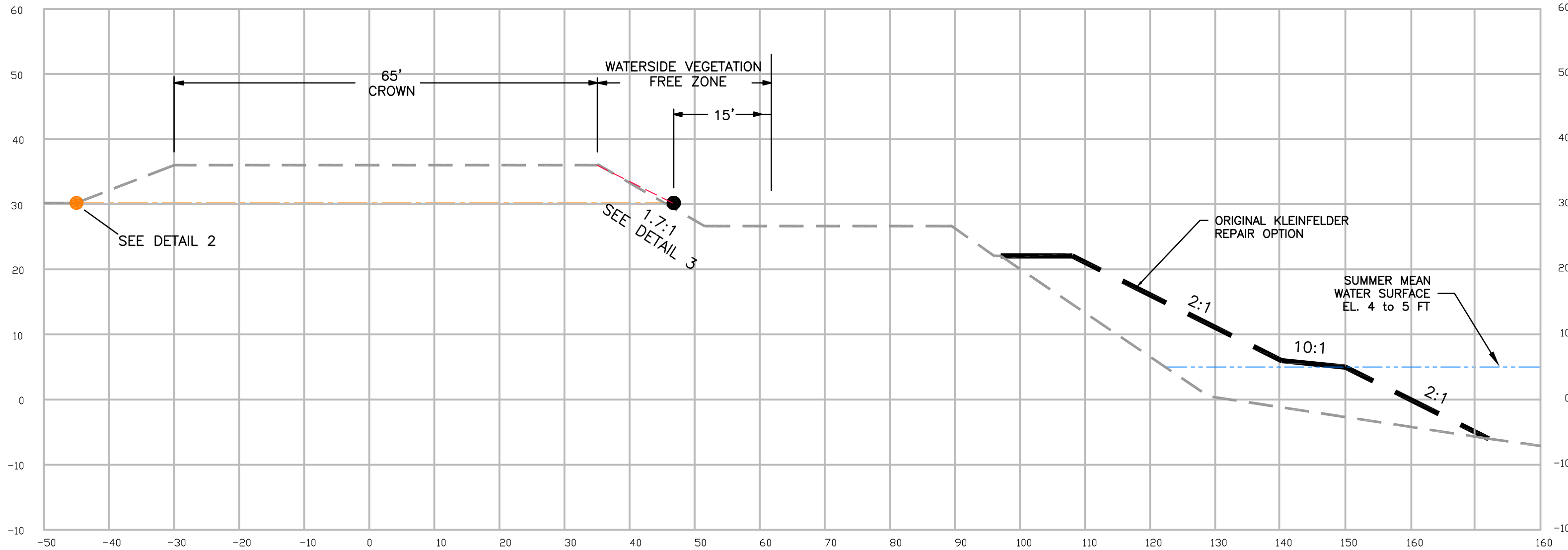
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 56.5R

Date	3/31/11
Figure	SAC 56.5R

DETAIL 1

SACRAMENTO RIVER 56.6R



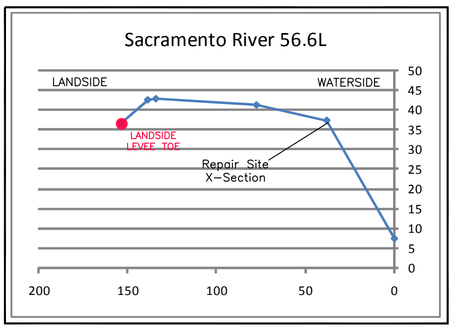
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.5
38.1	37.5
77.7	41.4
134.4	43.0
139.0	42.7
154.0	36.9

KEY DATA FOR DETERMINING LANDSIDE TOE

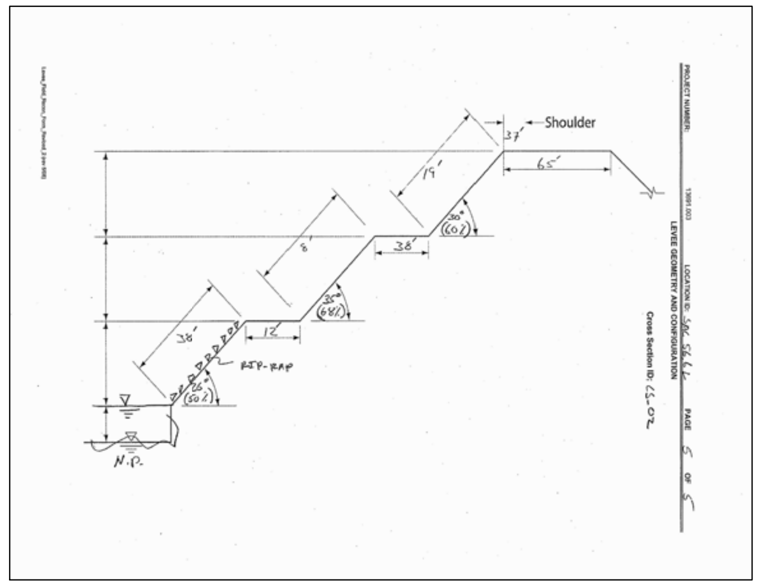
Comp Study Levee Crown Elevation	42.7
Comp Study Landside Toe Elevation	36.9
Comp Study Difference	5.8

Alternatives Report Analysis Levee Crown Elevation	36.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	30.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 56.6R

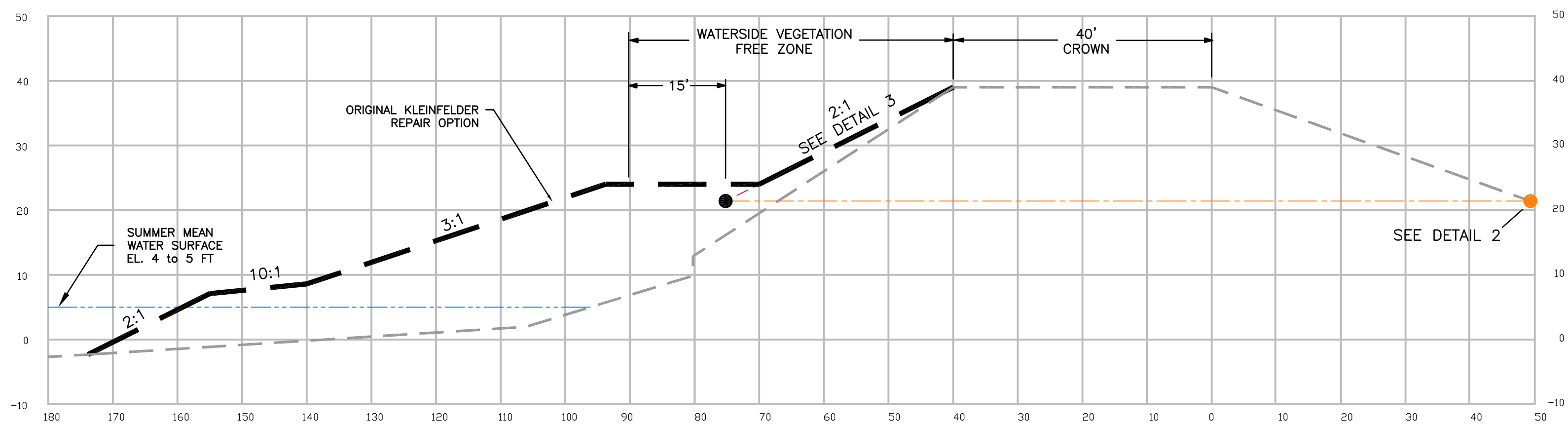
Date	3/31/11
Figure	SAC 56.6R

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

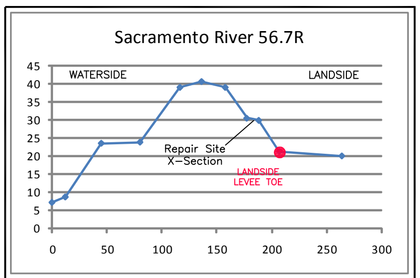
SACRAMENTO RIVER 56.7R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	7.3
12.1	8.8
44.9	23.6
80.1	23.9
116.5	39.0
136.2	40.6
157.7	39.0
177.2	30.5
188.2	29.9
207.0	21.4
263.8	20.1

KEY DATA FOR DETERMINING LANDSIDE TOE

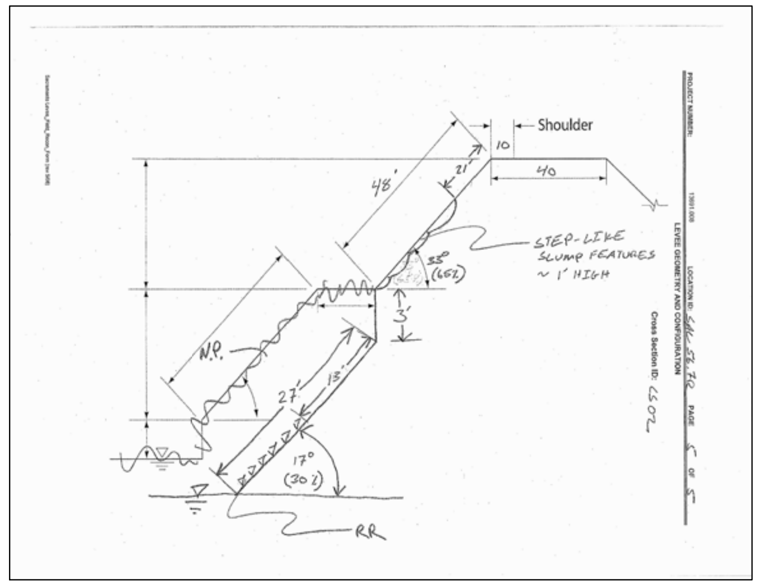
Comp Study Levee Crown Elevation	39.0
Comp Study Landside Toe Elevation	21.4
Comp Study Difference	17.6

Alternatives Report Analysis Levee Crown Elevation	39.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	21.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

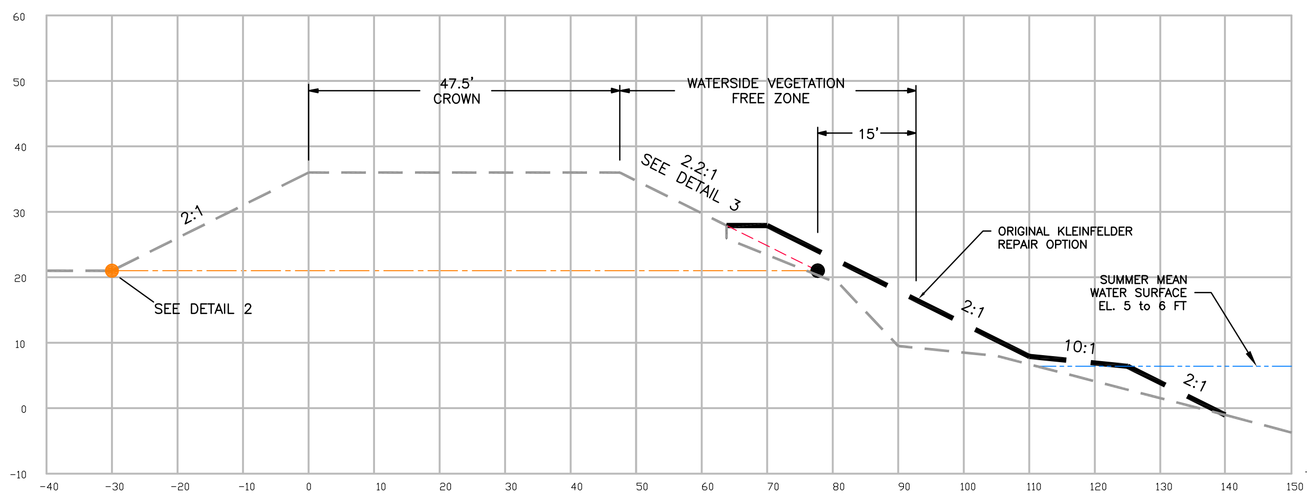
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 56.7R

Date	3/31/11
Figure	SAC 56.7R

DETAIL 1

SACRAMENTO RIVER 58.4L



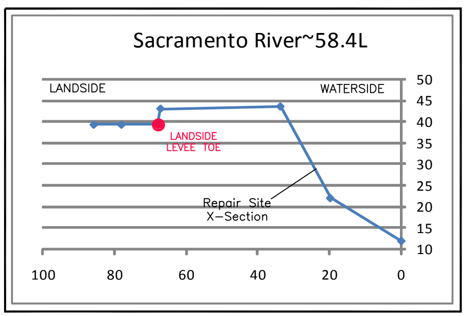
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	11.9
19.8	22.0
33.7	43.6
67.1	43.1
67.8	39.5
78.0	39.3
85.7	39.3

KEY DATA FOR DETERMINING LANDSIDE TOE

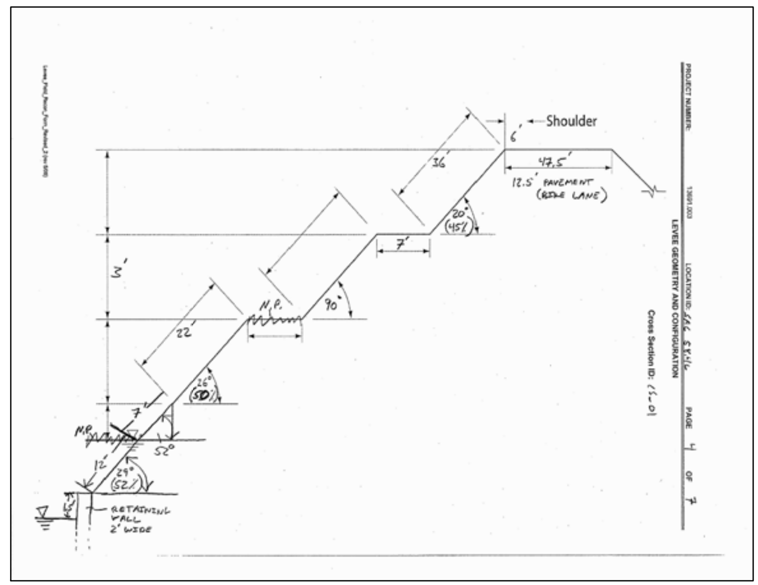
Comp Study Levee Crown Elevation	43.6
Comp Study Landside Toe Elevation	39.5
Comp Study Difference	4.1

Alternatives Report Analysis Levee Crown Elevation	36.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	31.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



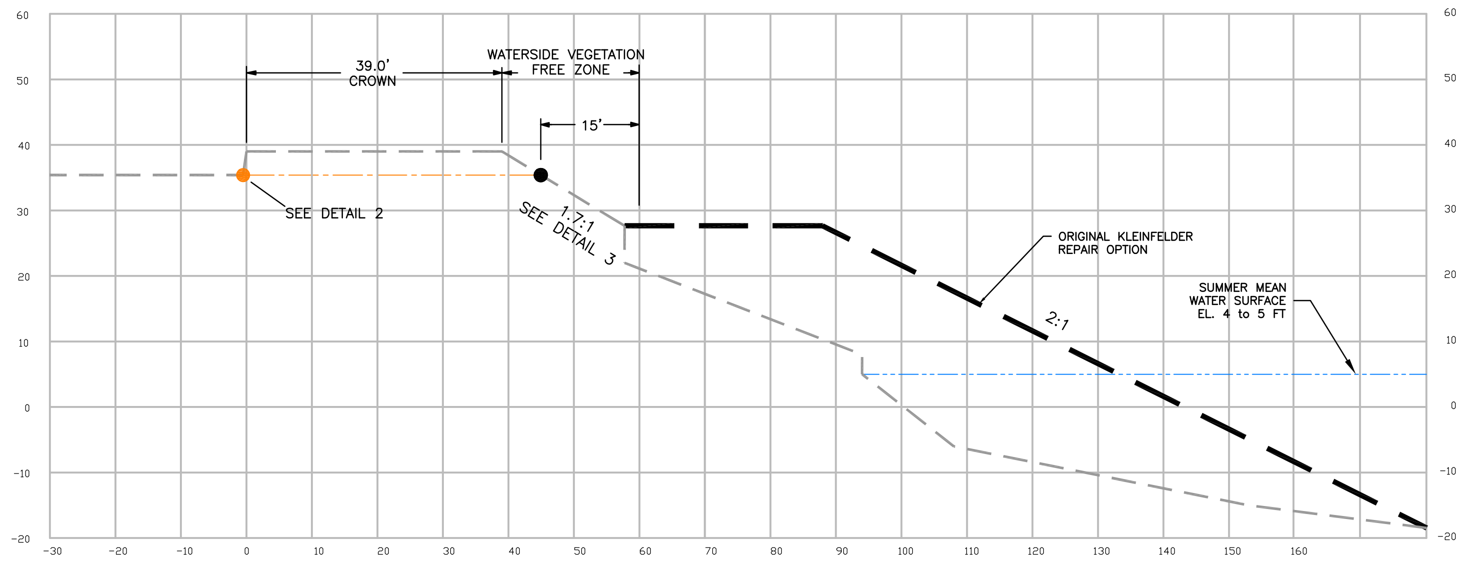
Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	SACRAMENTO RIVER ~ 58.4L

Date: 3/31/11

Figure: SAC 58.4L

DETAIL 1

SACRAMENTO RIVER 60.1L



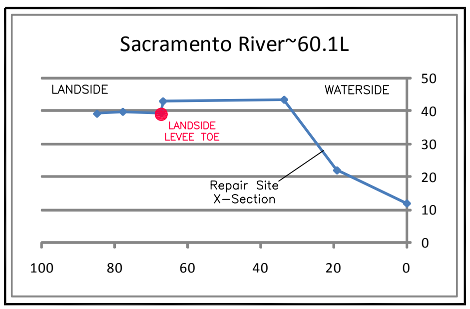
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	11.9
19.2	22.0
33.7	43.6
66.9	43.1
77.9	39.5
85.0	39.3

KEY DATA FOR DETERMINING LANDSIDE TOE

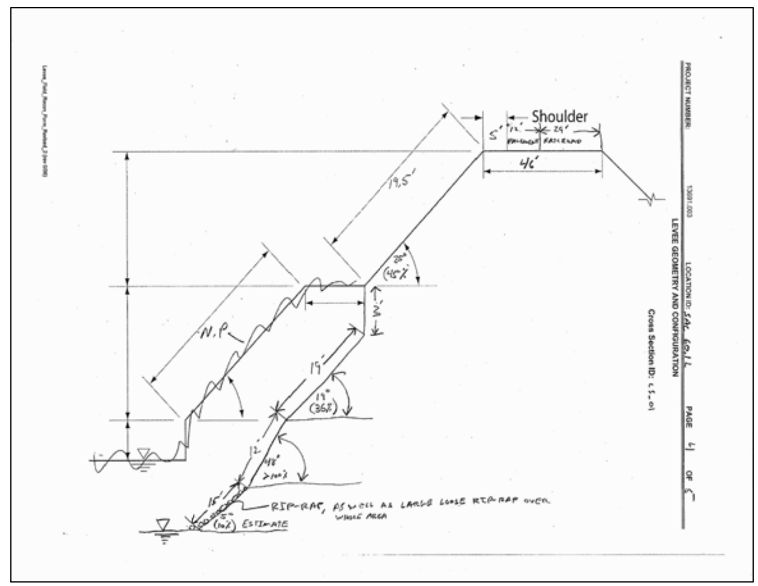
Comp Study Levee Crown Elevation	43.1
Comp Study Landside Toe Elevation	39.5
Comp Study Difference	3.6

Alternatives Report Analysis Levee Crown Elevation	39.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	35.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR
HDR Engineering, Inc.

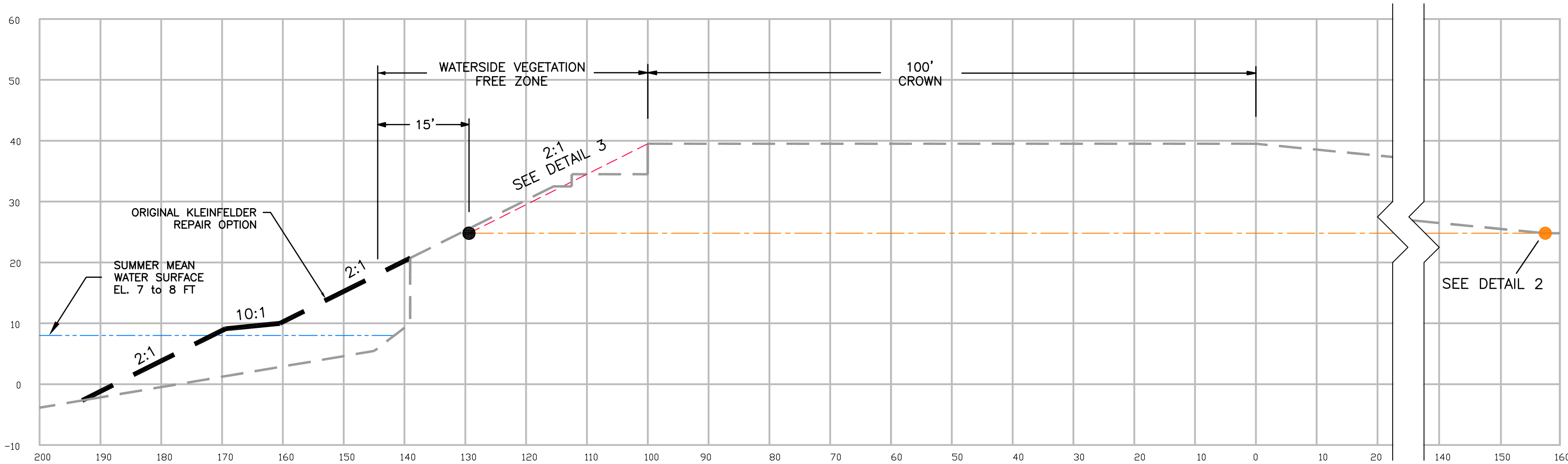
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 60.1L

Date	3/31/11
Figure	SAC 60.1L

DETAIL 1

SACRAMENTO RIVER 62.9R



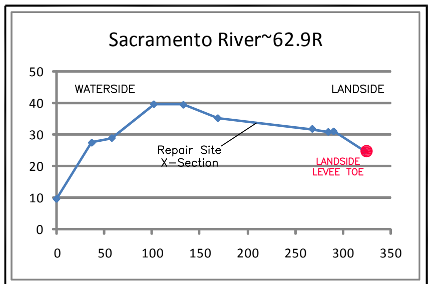
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	9.8
36.9	27.7
57.9	29.1
101.9	39.9
132.9	39.7
168.9	35.5
267.8	32.0
284.5	31.1
290.2	31.3
322.3	25.0

KEY DATA FOR DETERMINING LANDSIDE TOE

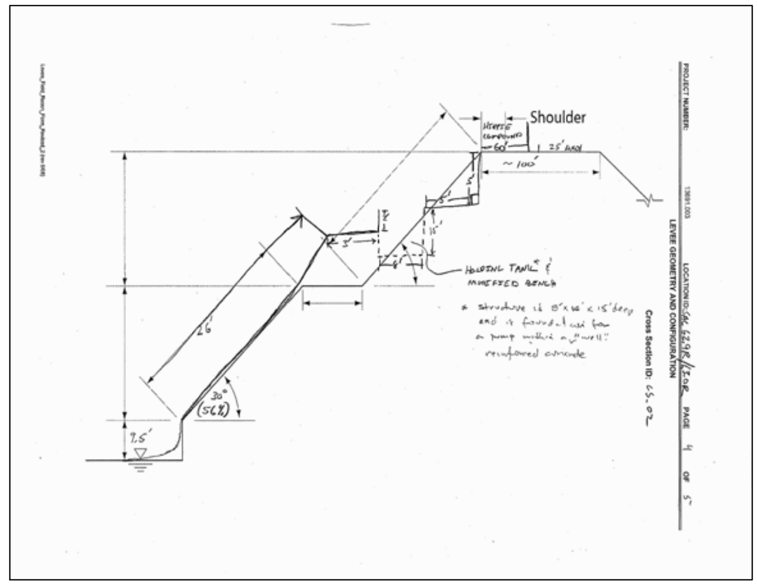
Comp Study Levee Crown Elevation	39.7
Comp Study Landside Toe Elevation	25.0
Comp Study Difference	14.7

Alternatives Report Analysis Levee Crown Elevation	39.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	24.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

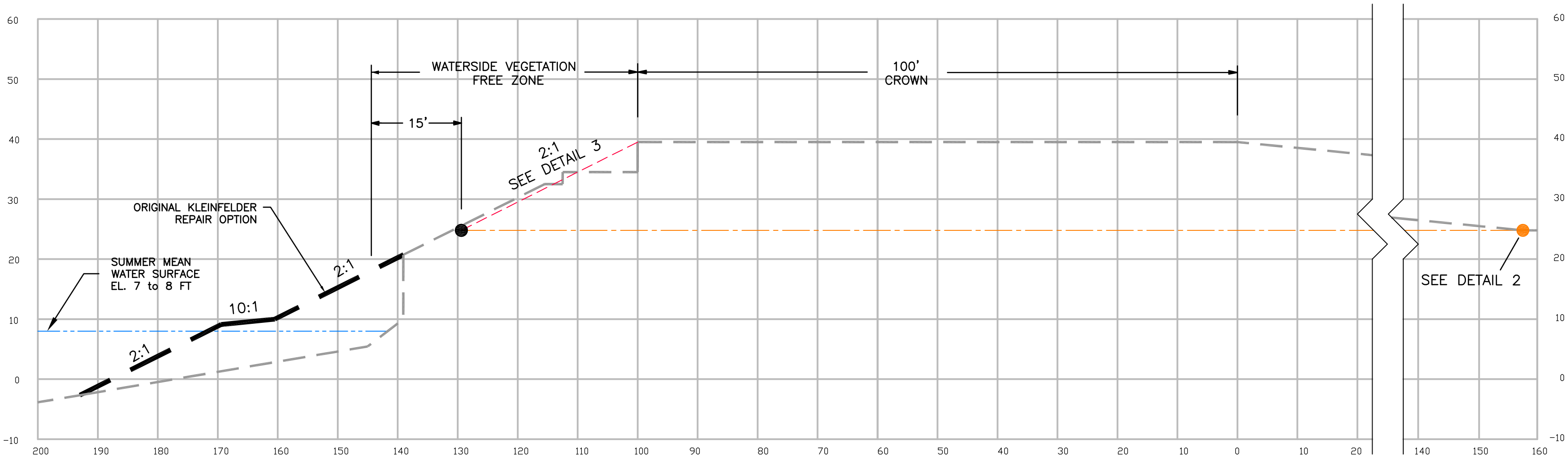
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 62.9R

Date	3/31/11
Figure	SAC 62.9R

DETAIL 1

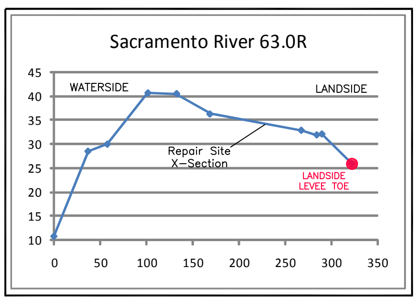
LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	10.8
36.9	28.7
57.9	30.1
101.9	40.9
132.9	40.7
168.9	36.5
267.8	33.0
284.5	32.1
290.2	32.3
322.3	26.0

KEY DATA FOR DETERMINING LANDSIDE TOE

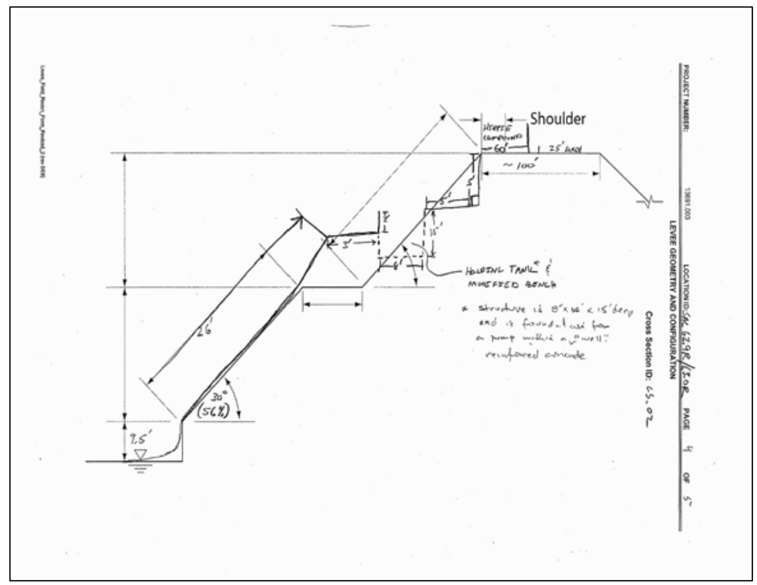
Comp Study Levee Crown Elevation	40.7
Comp Study Landside Toe Elevation	26.0
Comp Study Difference	14.7

Alternatives Report Analysis Levee Crown Elevation	39.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	24.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
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HDR Engineering, Inc.

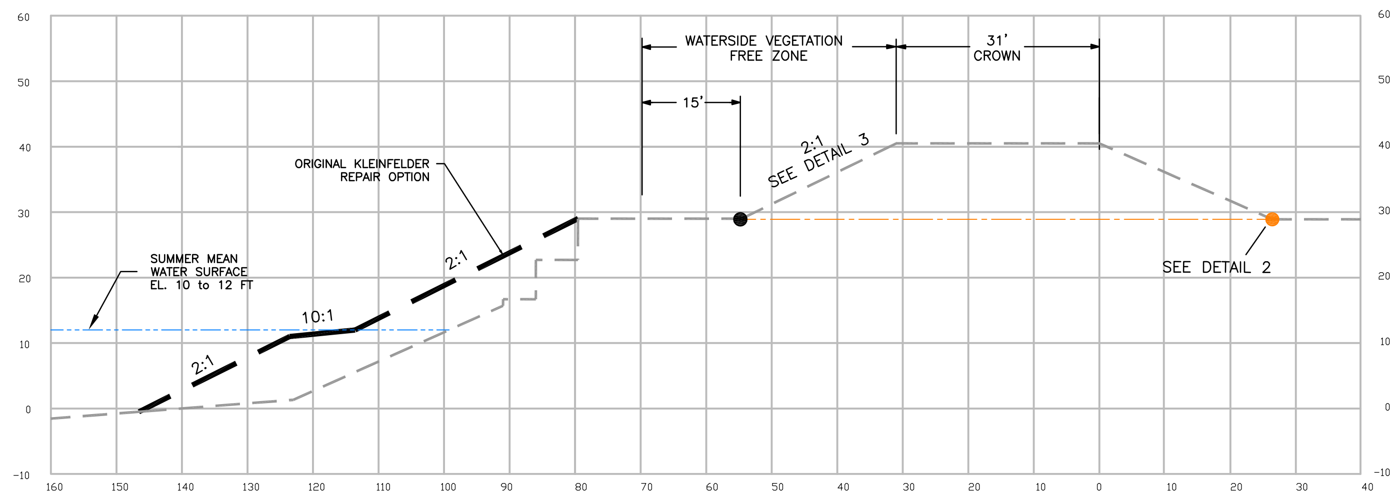
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 63.0R

Date	3/31/11
Figure	SAC 63.0R

DETAIL 1

SACRAMENTO RIVER 74.4R



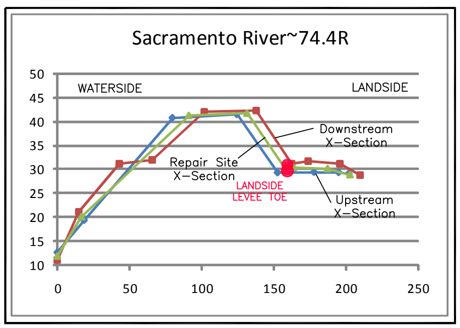
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	12.0
16.8	20.3
131.2	41.4
157.6	41.9
163.4	30.3
187.0	29.0
202.5	29.0

KEY DATA FOR DETERMINING LANDSIDE TOE

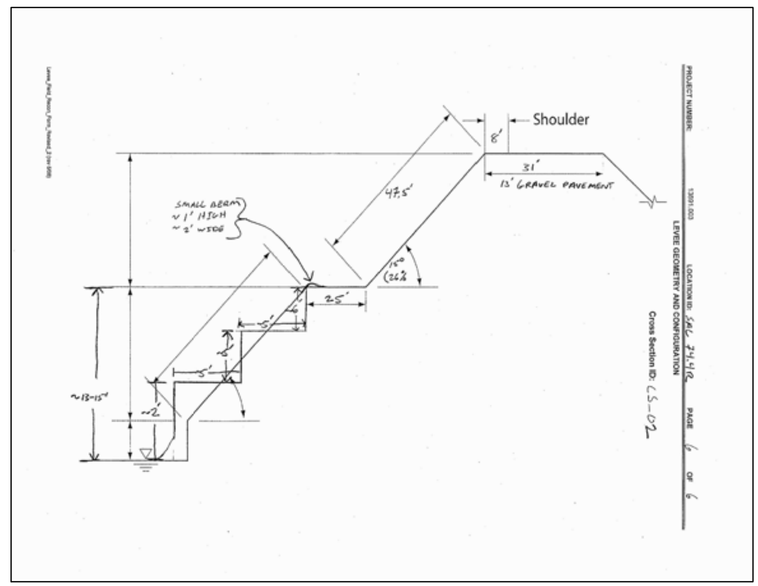
Comp Study Levee Crown Elevation	41.9
Comp Study Landside Toe Elevation	30.3
Comp Study Difference	11.6

Alternatives Report Analysis Levee Crown Elevation	40.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	28.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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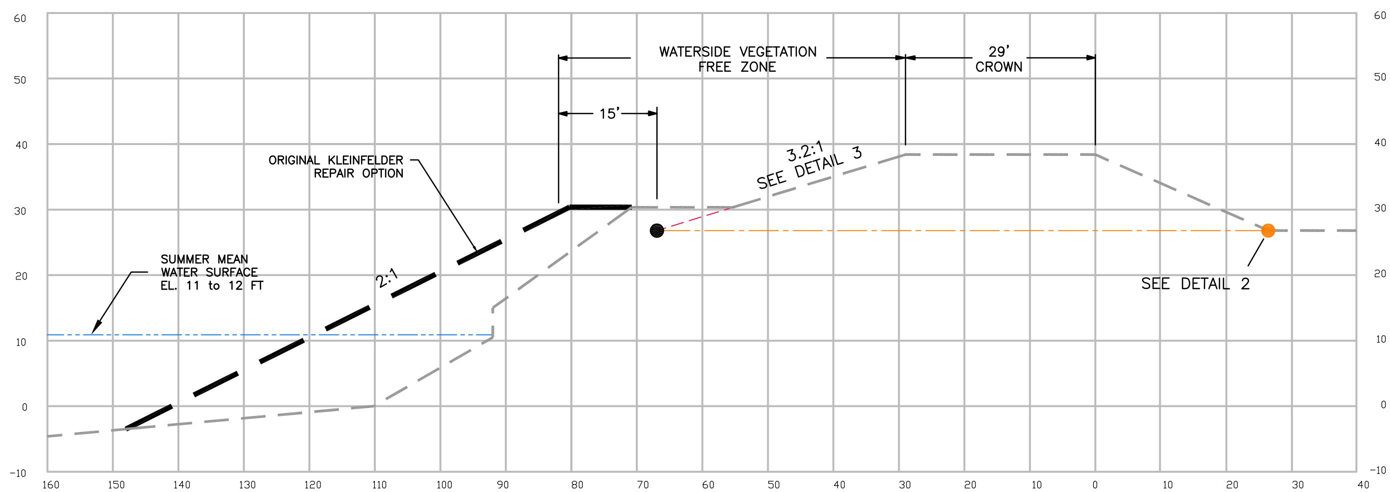
HDR Engineering, Inc.

Drawn By: E. Smith	SACRAMENTO RIVER ~ 74.4R	Date	3/31/11
Checked By: R. Little		Figure	SAC 74.4R
QA/QC Review: D. Teak			

DETAIL 1

SACRAMENTO RIVER 75.3R



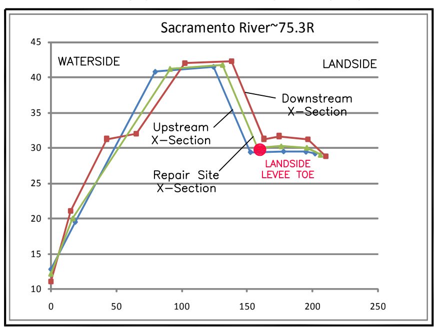
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



KEY DATA FOR DETERMINING LANDSIDE TOE

Comp Study Levee Crown Elevation	41.8
Comp Study Landside Toe Elevation	30.1
Comp Study Difference	11.7

Alternatives Report Analysis Levee Crown Elevation	38.5

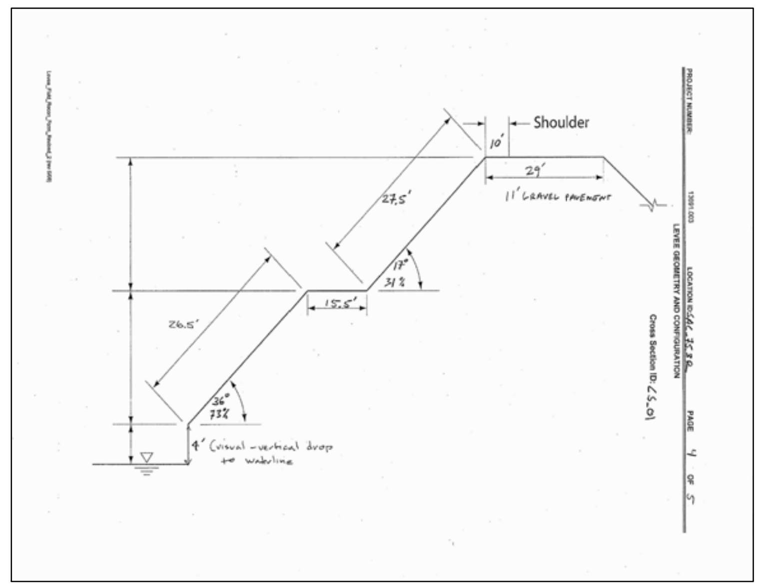
Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	26.8

Comp Study Data Points

Horizontal Distance to Data Point	Elevation at Data Point
0.0	12.2
16.8	20.1
91.0	41.2
131.2	41.8
157.6	30.1
176.1	30.3
195.6	30.1
206.0	29.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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HDR Engineering, Inc.

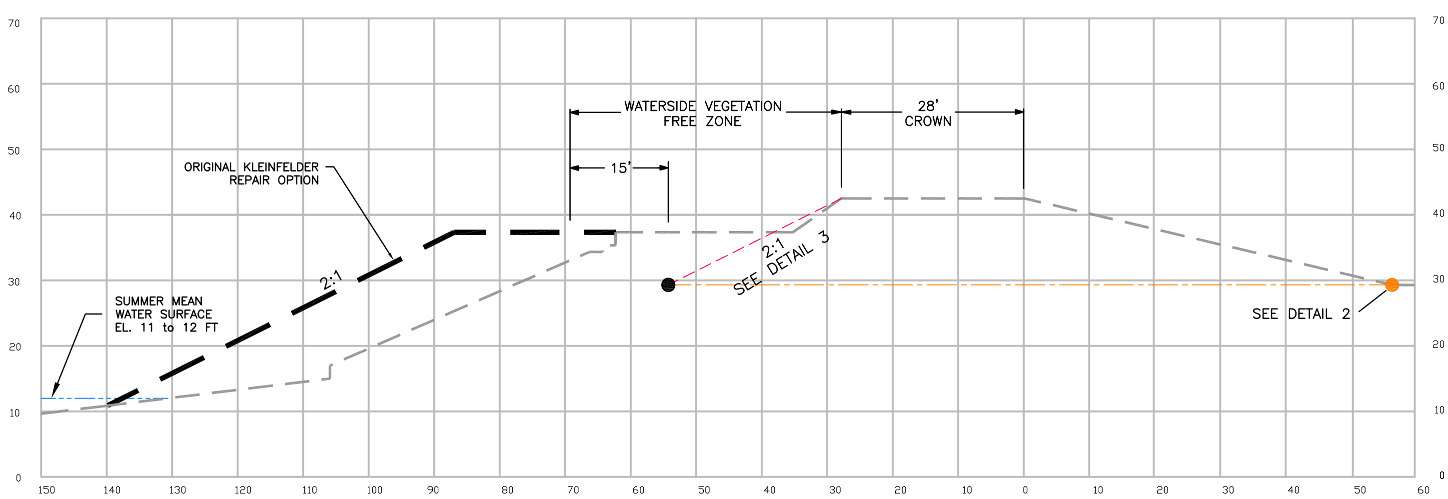
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 75.3R

Date	3/31/11
Figure	SAC 75.3R

DETAIL 1

SACRAMENTO RIVER 77.7R



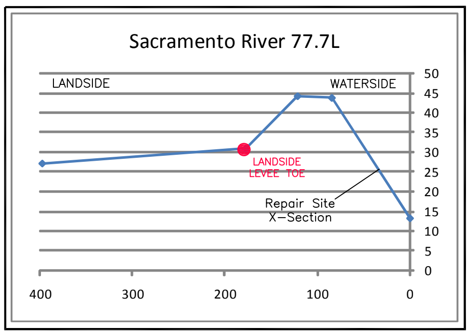
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	13.4
84.4	43.8
121.3	44.2
177.4	31.0
397.1	27.2

KEY DATA FOR DETERMINING LANDSIDE TOE

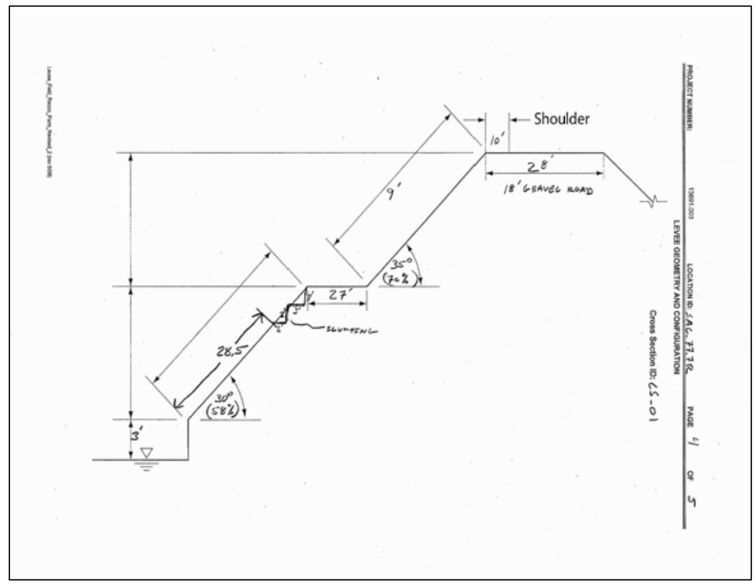
Comp Study Levee Crown Elevation	44.2
Comp Study Landside Toe Elevation	31.0
Comp Study Difference	13.2

Alternatives Report Analysis Levee Crown Elevation	42.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	29.3

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

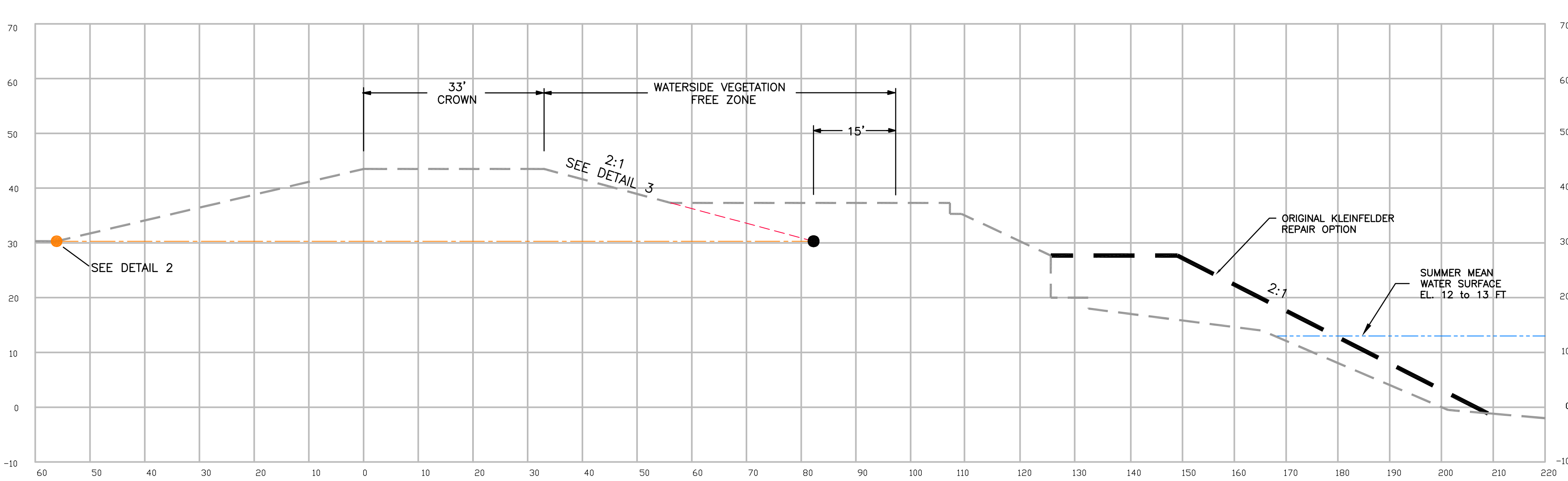
Drawn By: E. Smith			Date	3/31/11
Checked By: R. Little		SACRAMENTO RIVER ~ 77.7R	Figure	SAC 77.7R
QA/QC Review: D. Teak				

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

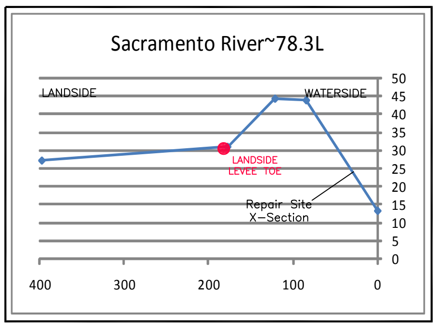
SACRAMENTO RIVER 78.3L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	13.5
84.4	43.9
121.3	44.4
177.4	31.1
397.1	27.4

KEY DATA FOR DETERMINING LANDSIDE TOE

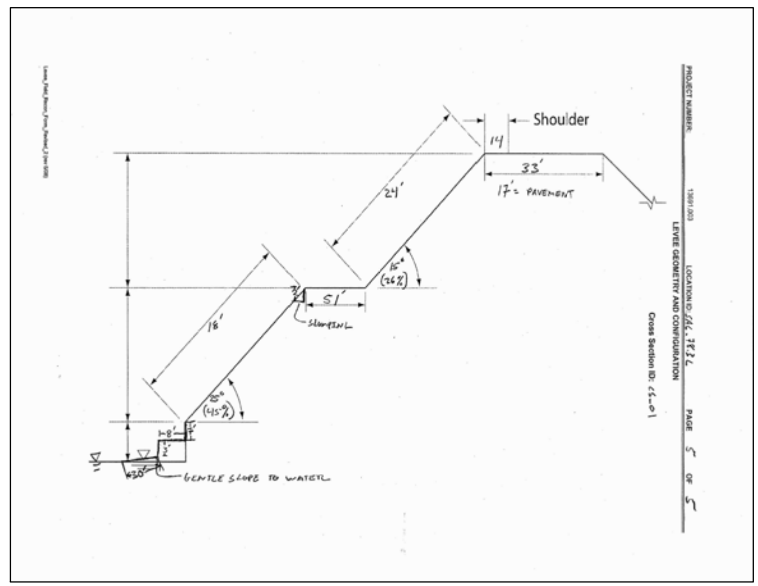
Comp Study Levee Crown Elevation	44.4
Comp Study Landside Toe Elevation	31.1
Comp Study Difference	13.2

Alternatives Report Analysis Levee Crown Elevation	43.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	30.3

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



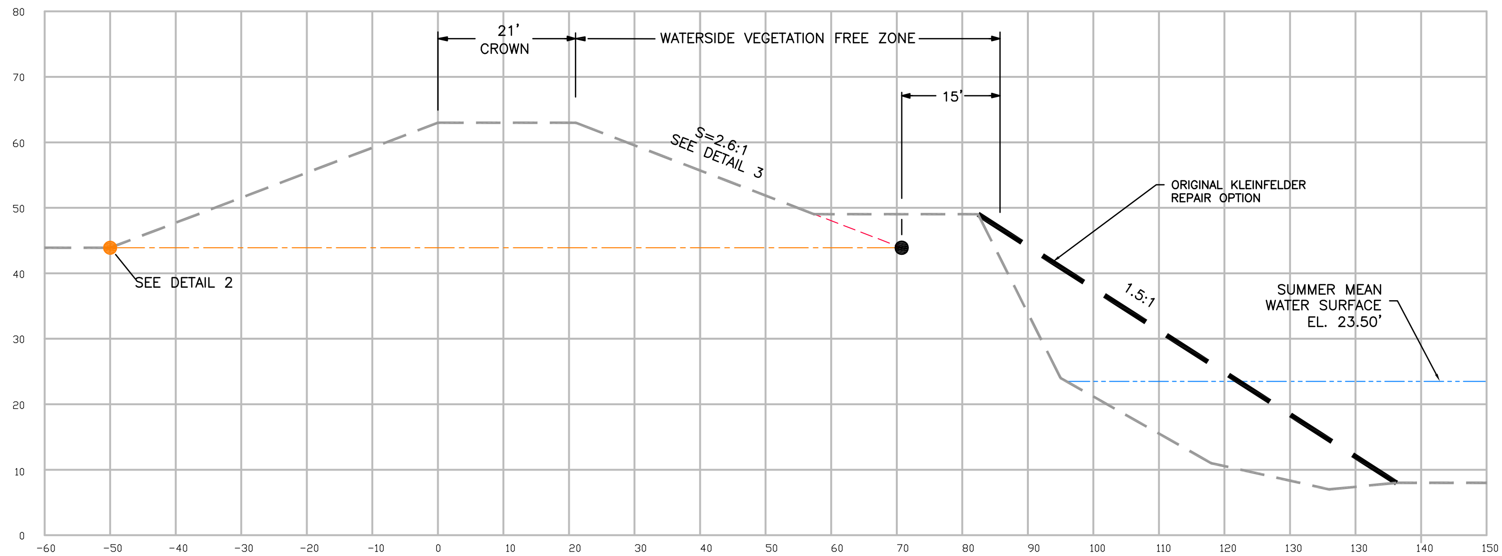
Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith	SACRAMENTO RIVER ~ 78.3L	Date	3/31/11
Checked By: R. Little		Figure	SAC 78.3L
QA/QC Review: D. Teak			

DETAIL 1

BEAR RIVER 0.8L



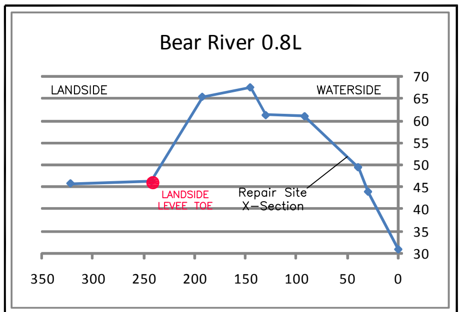
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	31.1
29.7	44.1
39.4	49.7
91.8	61.2
130.0	61.4
145.2	67.7
192.3	65.6
242.3	46.5
321.6	46.0

KEY DATA FOR DETERMINING LANDSIDE TOE

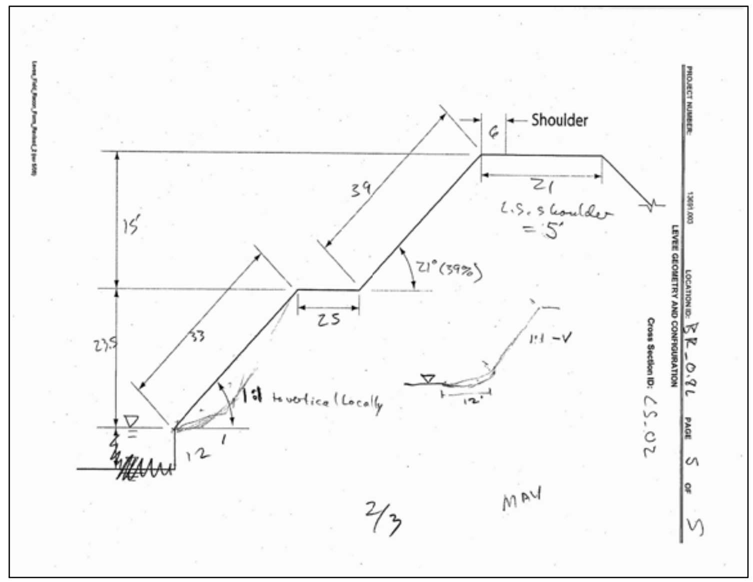
Comp Study Levee Crown Elevation	65.6
Comp Study Landside Toe Elevation	46.5
Comp Study Difference	19.1

Alternatives Report Analysis Levee Crown Elevation	63.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	43.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

BEAR RIVER ~ 0.8L

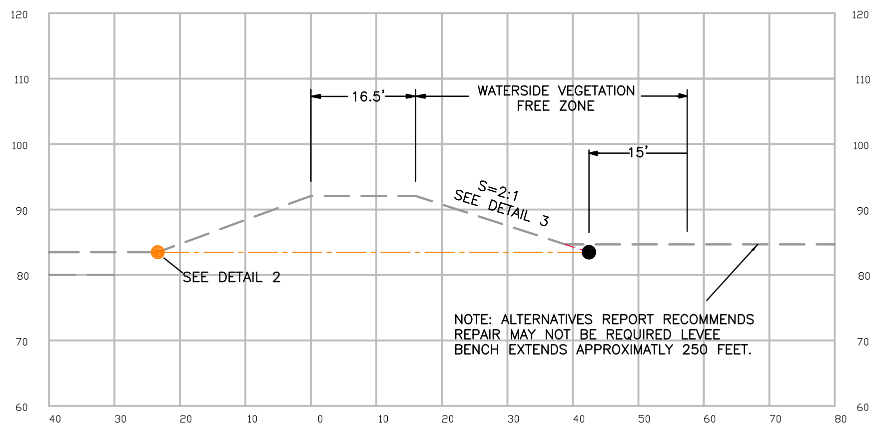
Date	3/31/11
Figure	BR 0.8L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

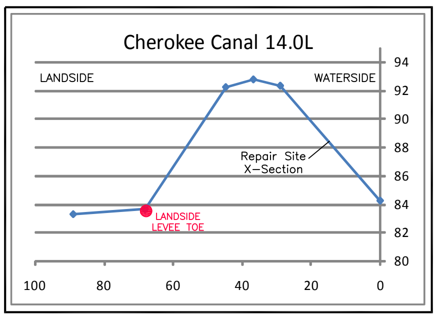
CHEROKEE CANAL 14.0L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	84.3
29.0	92.3
36.8	92.8
44.8	92.2
68.2	83.6
89.0	83.3

KEY DATA FOR DETERMINING LANDSIDE TOE

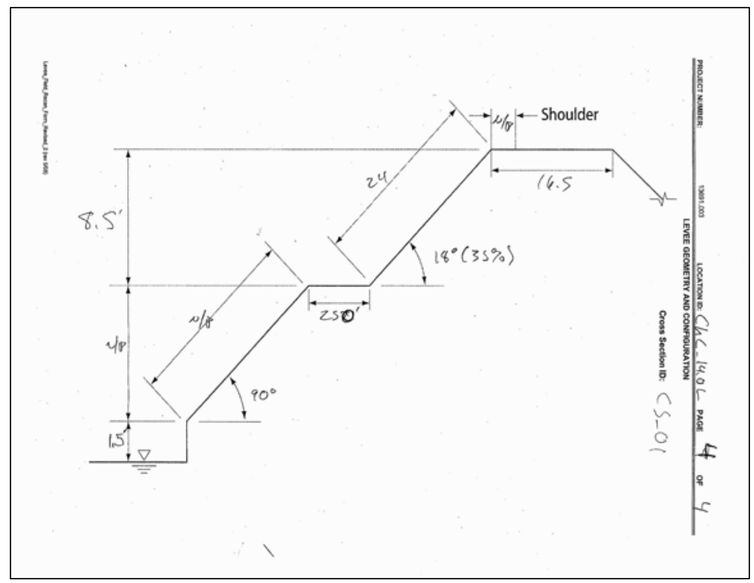
Comp Study Levee Crown Elevation	92.2
Comp Study Landside Toe Elevation	83.6
Comp Study Difference	8.6

Alternatives Report Analysis Levee Crown Elevation	95.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	86.4

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

CHEROKEE CANAL ~ 14.0L

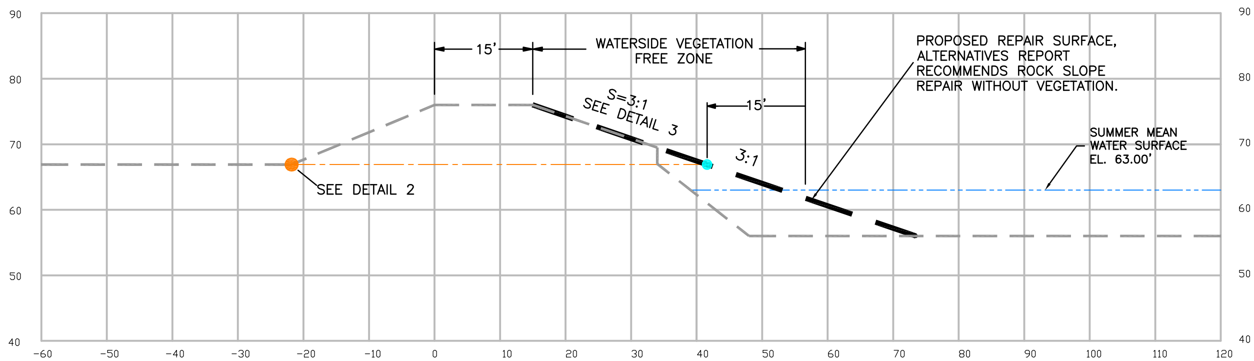
Date	3/31/11
Figure	ChC 14.0L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

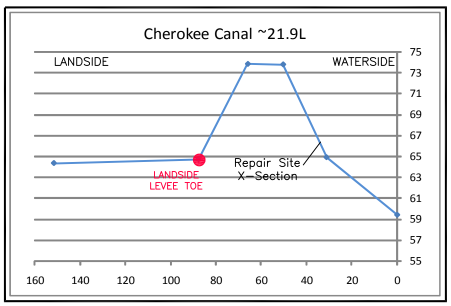
CHEROKEE CANAL 21.9L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	59.5
31.2	65.0
50.3	73.8
65.9	73.9
87.7	64.8
151.5	64.4

KEY DATA FOR DETERMINING LANDSIDE TOE

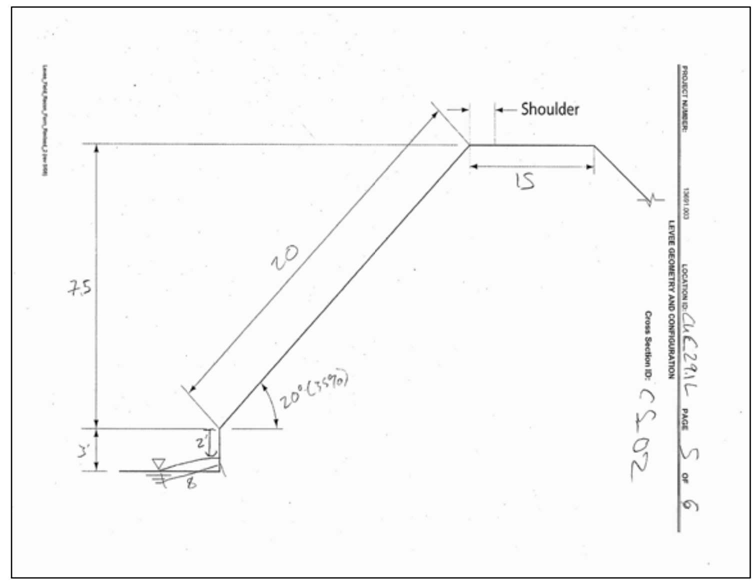
Comp Study Levee Crown Elevation	73.8
Comp Study Landside Toe Elevation	64.8
Comp Study Difference	9.1

Alternatives Report Analysis Levee Crown Elevation	76.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	66.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

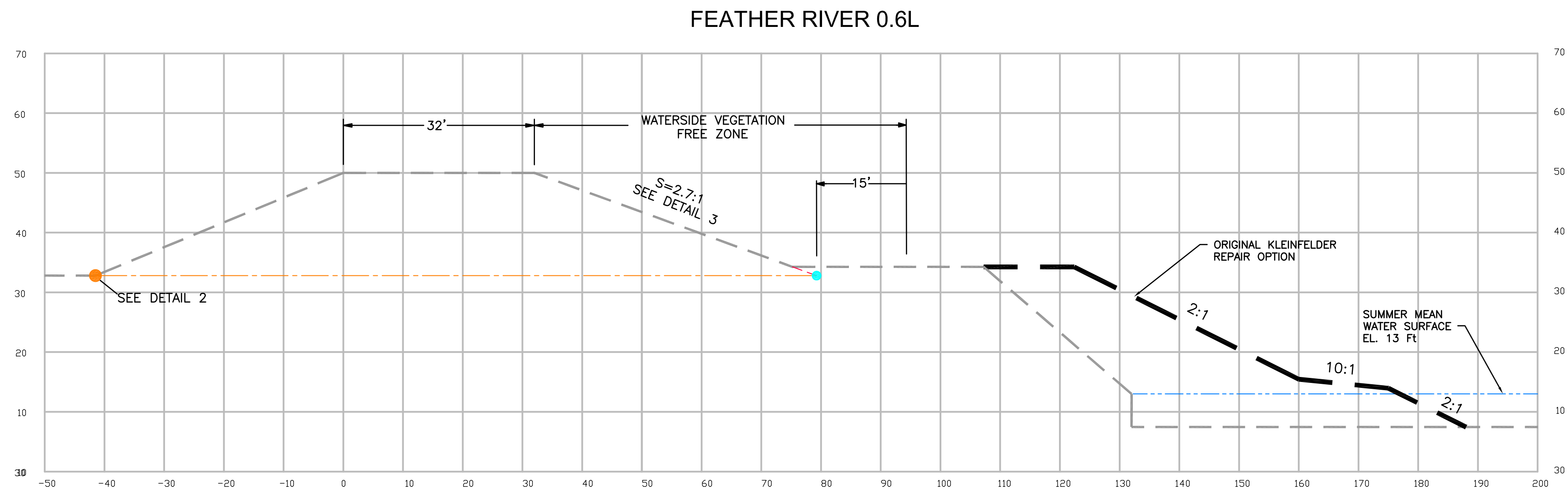
CHEROKEE CANAL ~ 21.9L

Date	3/31/11
Figure	ChC 21.9L

DETAIL 1

LEGEND

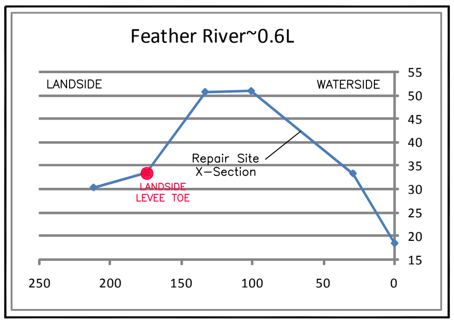
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	18.6
29.4	33.5
101.2	51.1
133.7	50.9
175.2	33.7
212.4	30.5

KEY DATA FOR DETERMINING LANDSIDE TOE

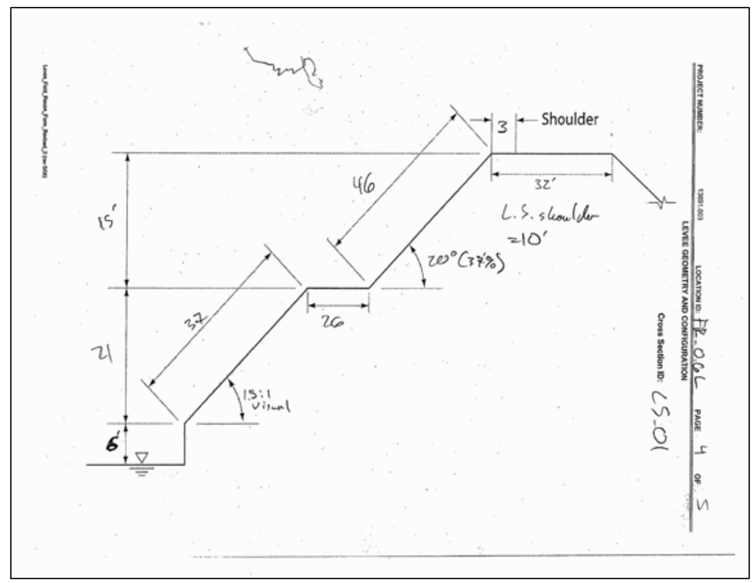
Comp Study Levee Crown Elevation	50.9
Comp Study Landside Toe Elevation	33.7
Comp Study Difference	17.2

Alternatives Report Analysis Levee Crown Elevation	50.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	32.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

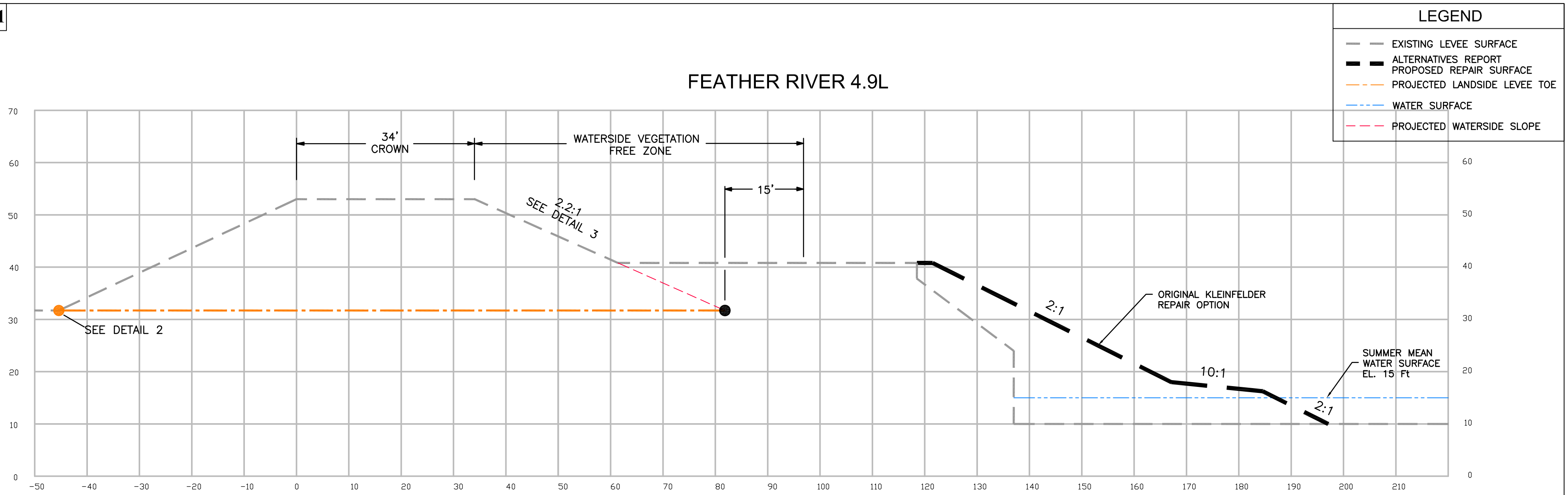
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

FEATHER RIVER ~ 0.6L

Date	3/31/11
Figure	FR 0.6L

DETAIL 1

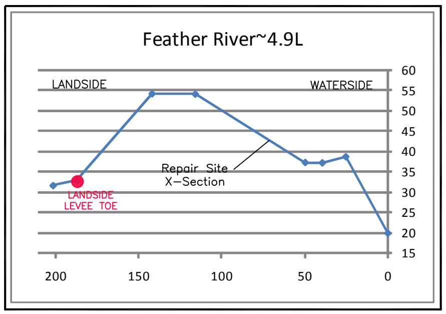
FEATHER RIVER 4.9L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.0
25.4	38.8
39.5	37.3
49.8	37.4
116.0	54.2
142.0	54.3
187.4	33.0
201.6	31.7

KEY DATA FOR DETERMINING LANDSIDE TOE

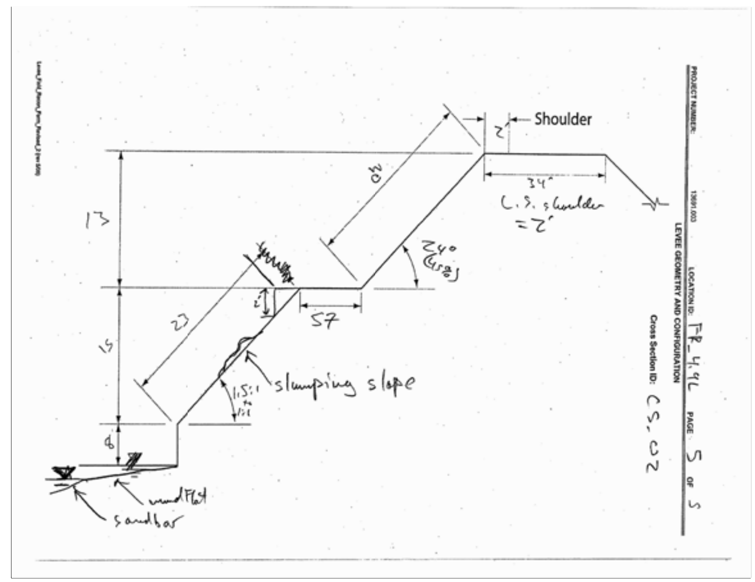
Comp Study Levee Crown Elevation	54.3
Comp Study Landside Toe Elevation	33.0
Comp Study Difference	21.3

Alternatives Report Analysis Levee Crown Elevation	53.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	31.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



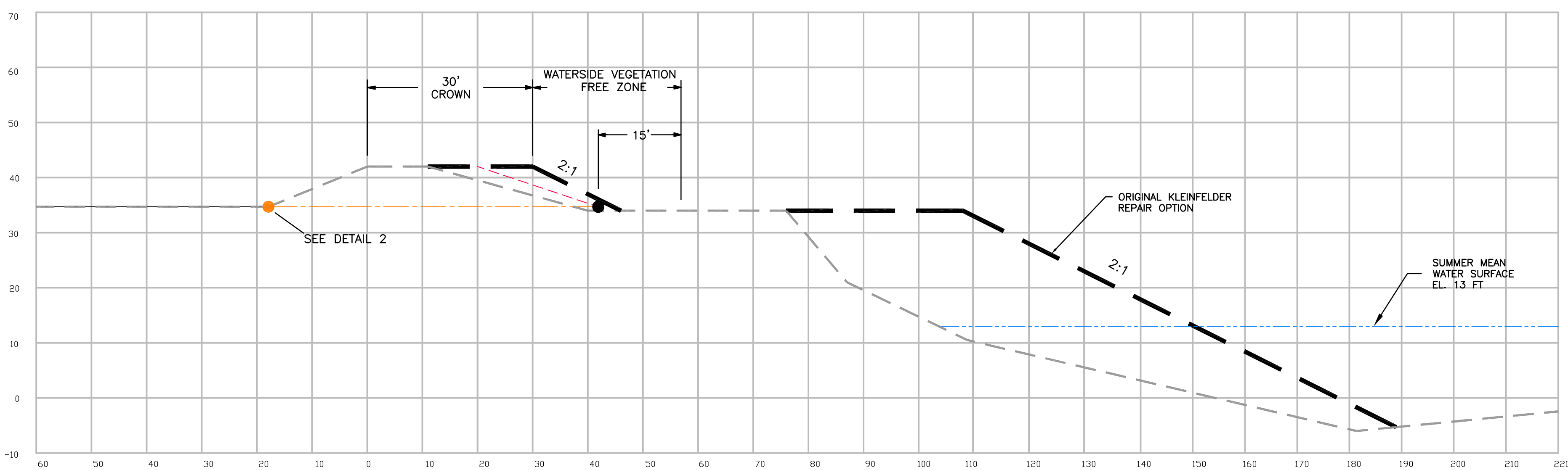
Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	FEATHER RIVER ~ 4.9L
		Date: 3/31/11	Figure: FR 4.9L

DETAIL 1

LEGEND

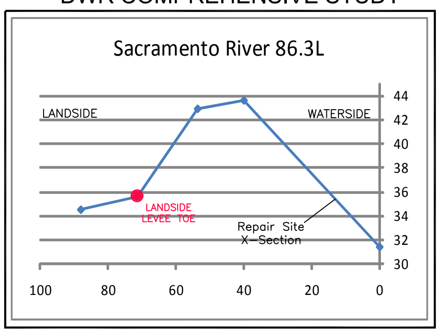
EXISTING LEVEE SURFACE	WATER SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE	PROJECTED WATERSIDE SLOPE
PROJECTED LANDSIDE LEVEE TOE	

SACRAMENTO RIVER 86.3L



DETAIL 2 **ESTABLISH LANDSIDE TOE**

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	31.5
40.0	43.7
53.6	43.0
71.5	35.7
88.0	34.6

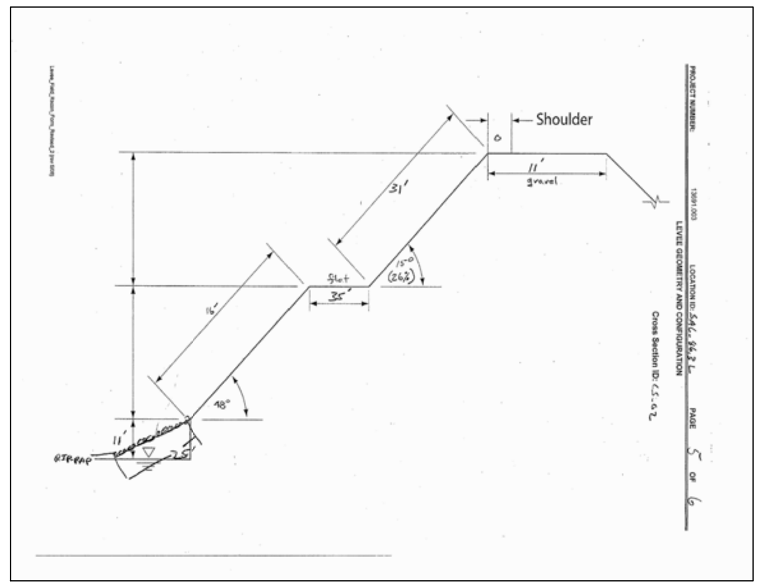
KEY DATA FOR DETERMINING LANDSIDE TOE

Comp Study Levee Crown Elevation	43.0
Comp Study Landside Toe Elevation	35.7
Comp Study Difference	7.3

Alternatives Report Analysis Levee Crown Elevation	42.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	34.7

DETAIL 3 **ALTERNATIVES REPORT (80,000LF) FIELD NOTES**



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

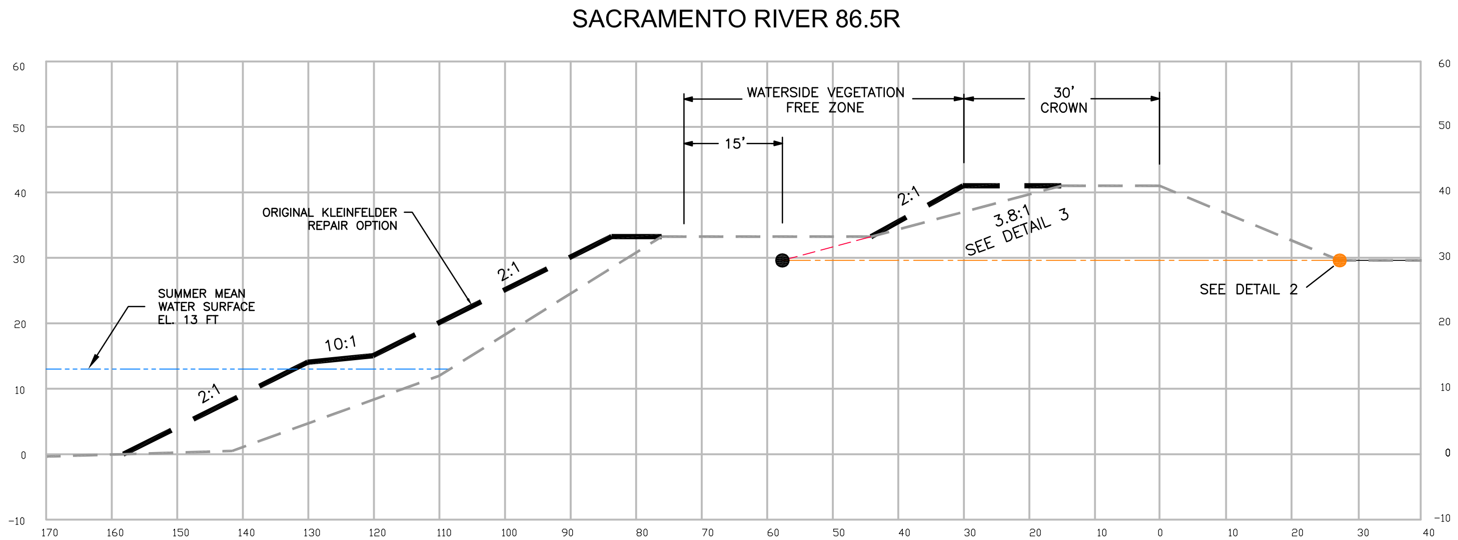
SACRAMENTO RIVER ~ 86.3L

Date	3/31/11
Figure	SAC 86.3L

DETAIL 1

LEGEND

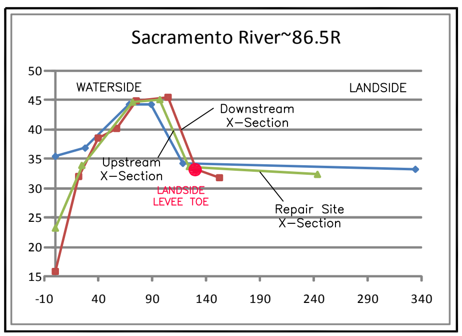
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	23.2
24.6	33.9
71.9	44.6
97.1	45.1
124.6	33.7
243.7	32.4

KEY DATA FOR DETERMINING LANDSIDE TOE

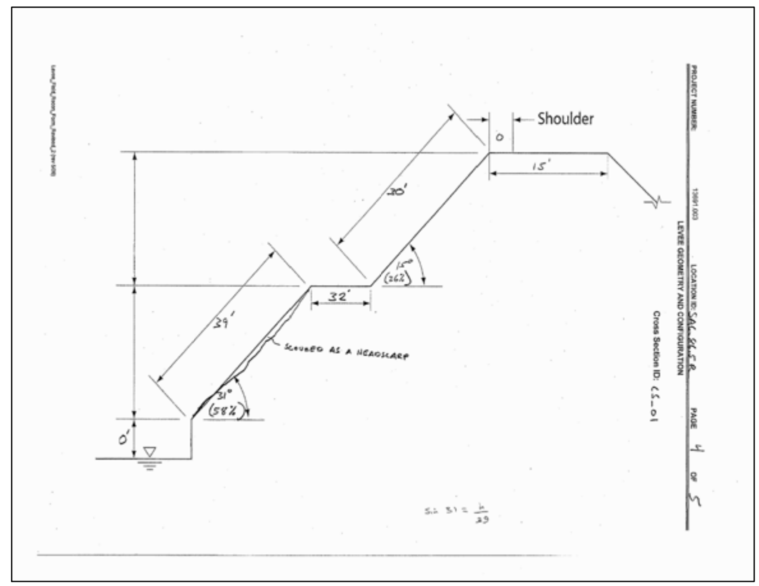
Comp Study Levee Crown Elevation	45.1
Comp Study Landside Toe Elevation	33.7
Comp Study Difference	11.4

Alternatives Report Analysis Levee Crown Elevation	41.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	29.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

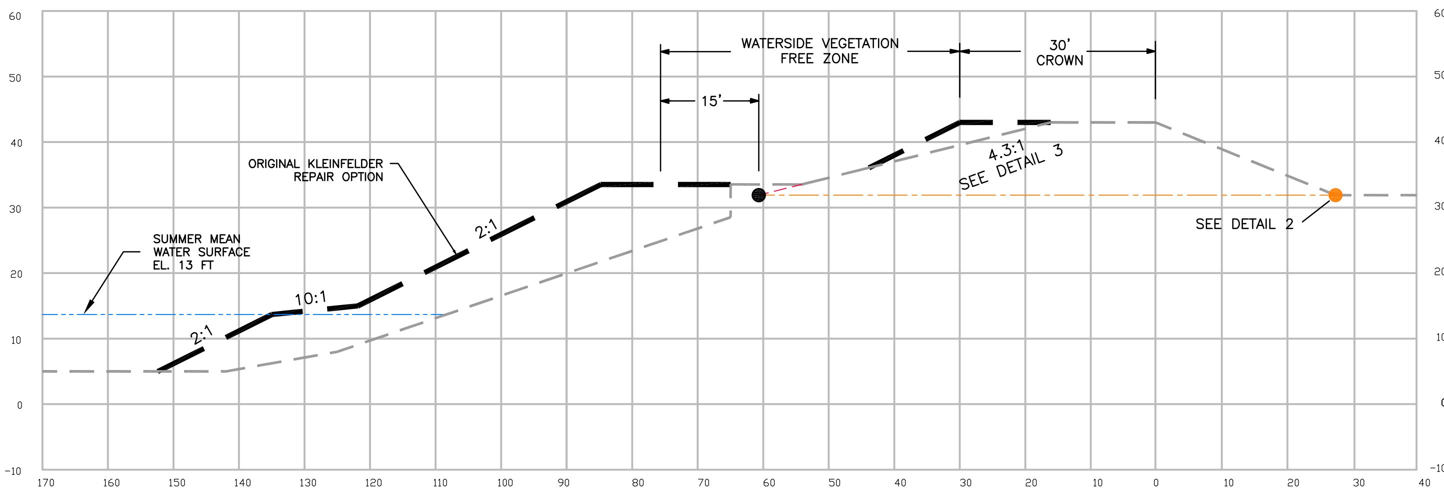
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 86.5R

Date	3/31/11
Figure	SAC 86.5R

DETAIL 1

SACRAMENTO RIVER 86.9L



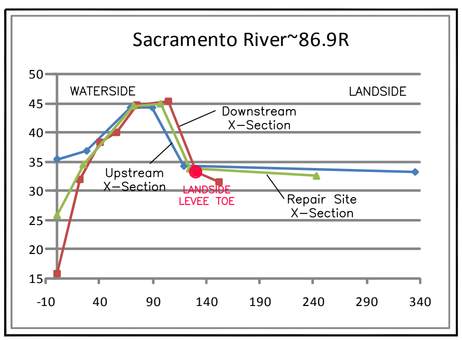
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	25.8
24.6	34.5
71.9	44.5
97.1	44.9
124.6	33.8
243.7	32.6

KEY DATA FOR DETERMINING LANDSIDE TOE

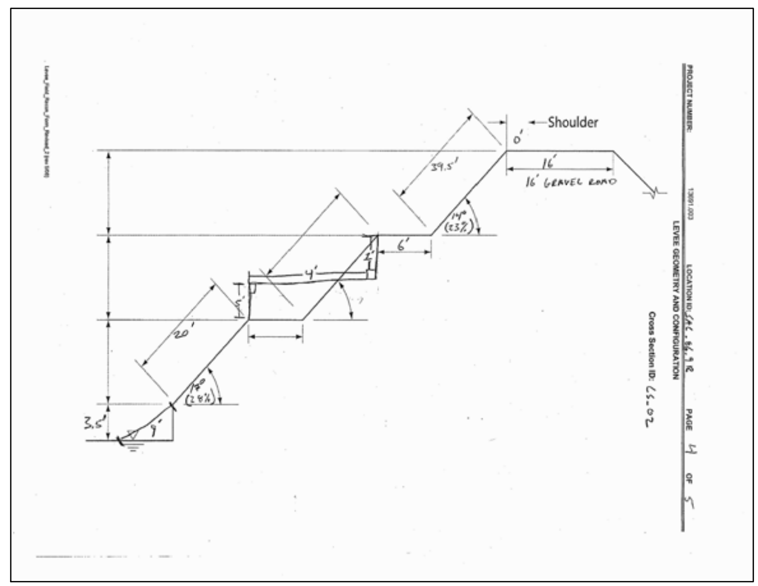
Comp Study Levee Crown Elevation	44.9
Comp Study Landside Toe Elevation	33.8
Comp Study Difference	11.1

Alternatives Report Analysis Levee Crown Elevation	43.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	31.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 86.9R

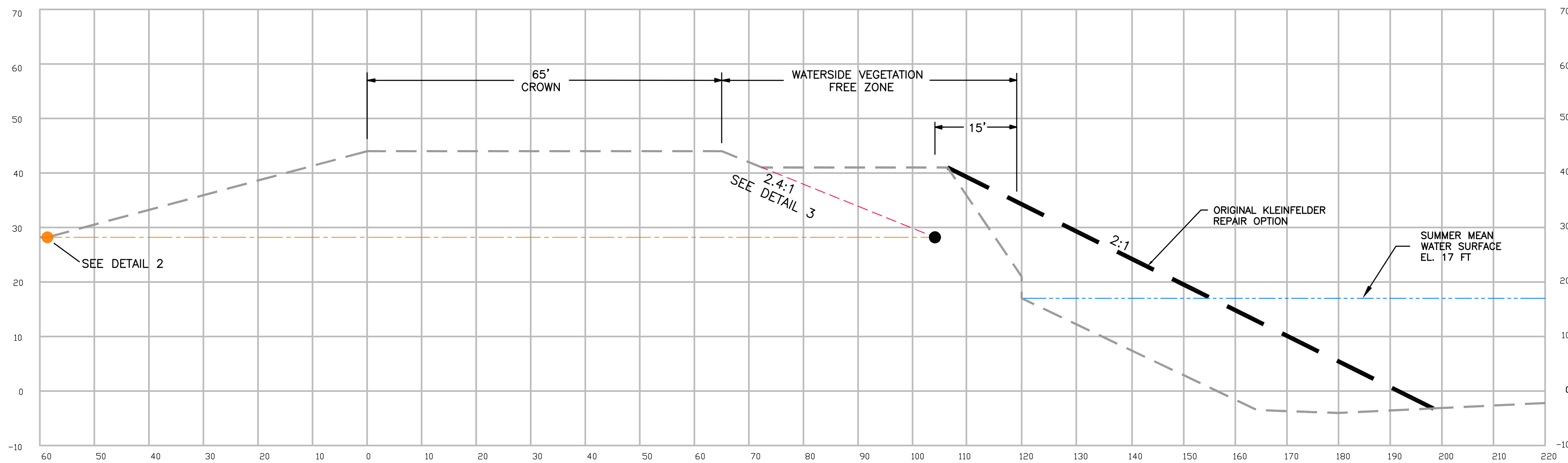
Date	3/31/11
Figure	SAC 86.9R

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

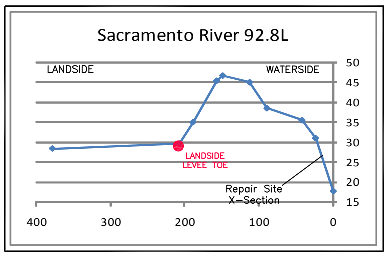
SACRAMENTO RIVER 92.8L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	17.8
23.9	31.1
42.2	35.6
89.5	38.6
112.8	45.1
149.2	46.8
157.4	45.5
189.3	35.1
207.8	29.7
378.8	28.5

KEY DATA FOR DETERMINING LANDSIDE TOE

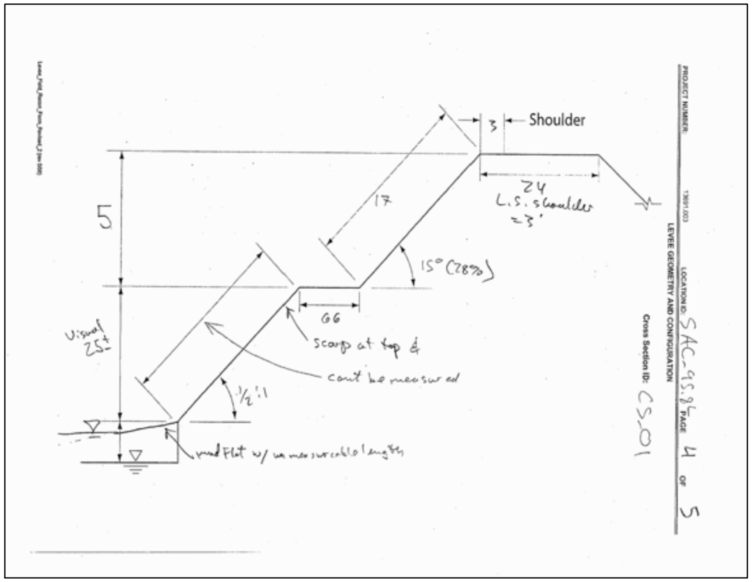
Comp Study Levee Crown Elevation	45.5
Comp Study Landside Toe Elevation	29.7
Comp Study Difference	15.8

Alternatives Report Analysis Levee Crown Elevation	44.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	28.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



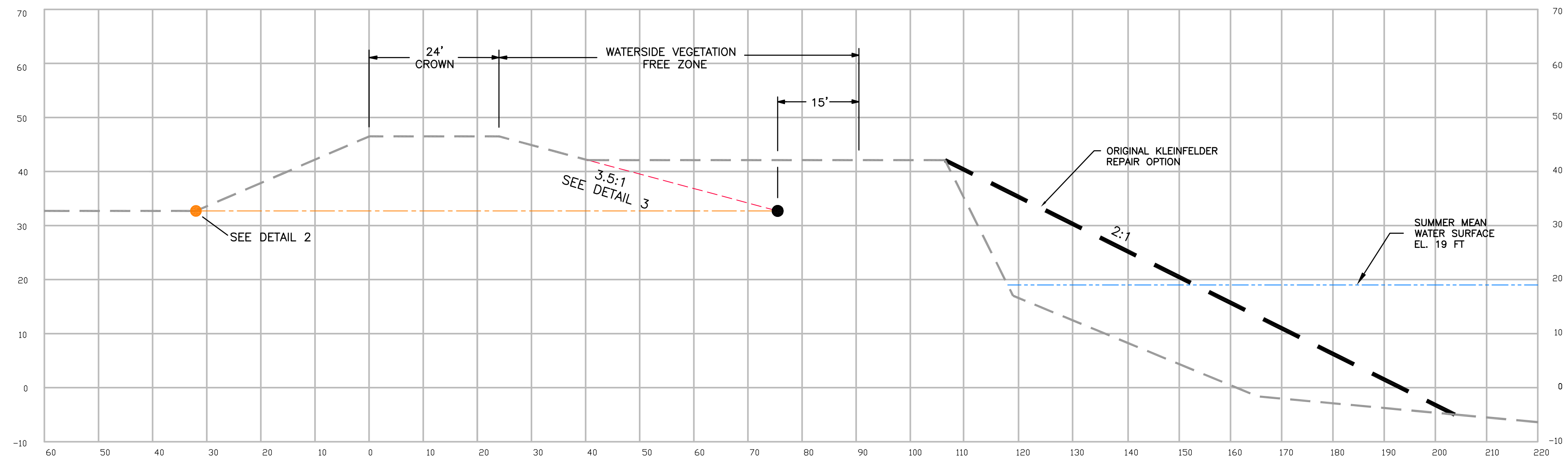
Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	SACRAMENTO RIVER ~92.8L	Date 3/31/11 Figure SAC 92.8L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

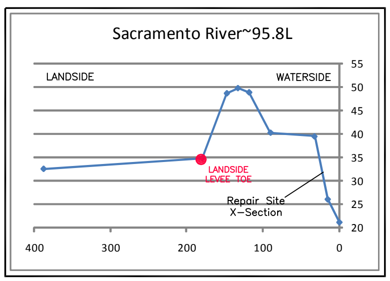
SACRAMENTO RIVER 95.8L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.1
15.3	25.0
32.7	38.4
90.3	38.9
118.4	47.8
133.1	48.8
147.6	47.6
179.6	33.8
388.0	31.5

KEY DATA FOR DETERMINING
LANDSIDE TOE

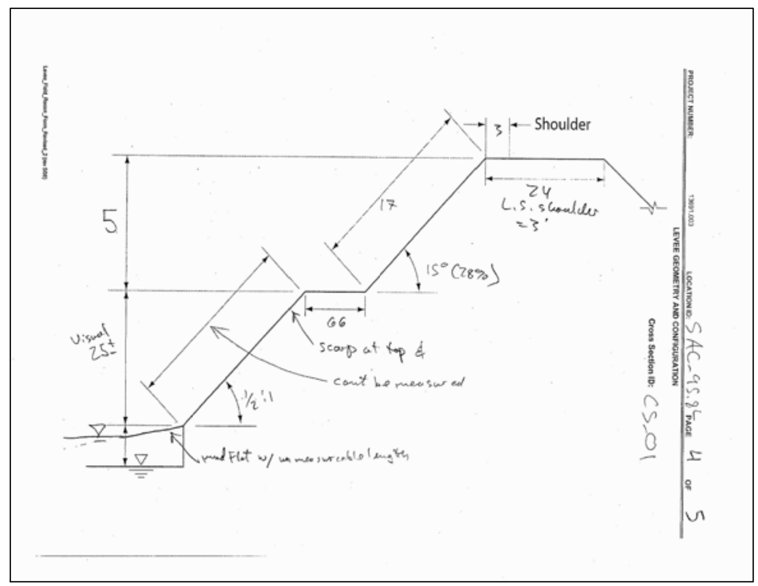
Comp Study Levee Crown Elevation	47.6
Comp Study Landside Toe Elevation	33.8
Comp Study Difference	13.8

Alternatives Report Analysis Levee Crown Elevation	46.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	32.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~95.8L

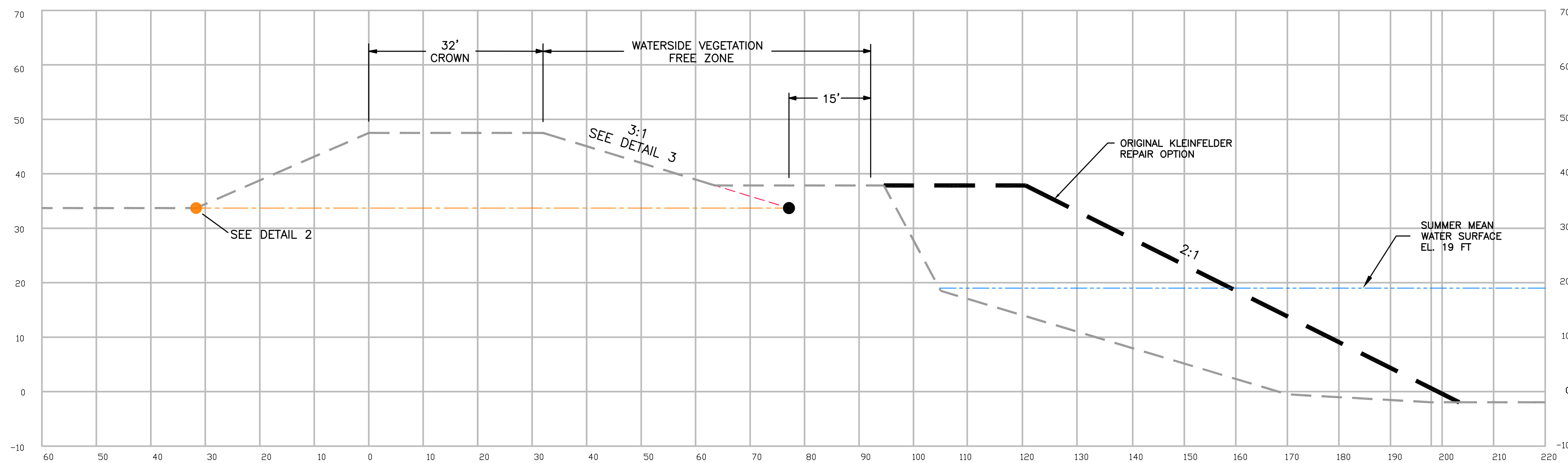
Date	3/31/11
Figure	SAC 95.8L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

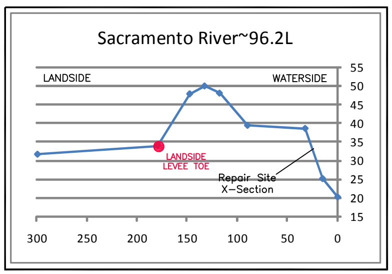
SACRAMENTO RIVER 96.2L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.4
15.0	25.3
32.4	38.7
90.0	39.5
118.0	48.1
132.9	50.0
147.7	47.9
179.4	34.1
299.7	31.8

KEY DATA FOR DETERMINING LANDSIDE TOE

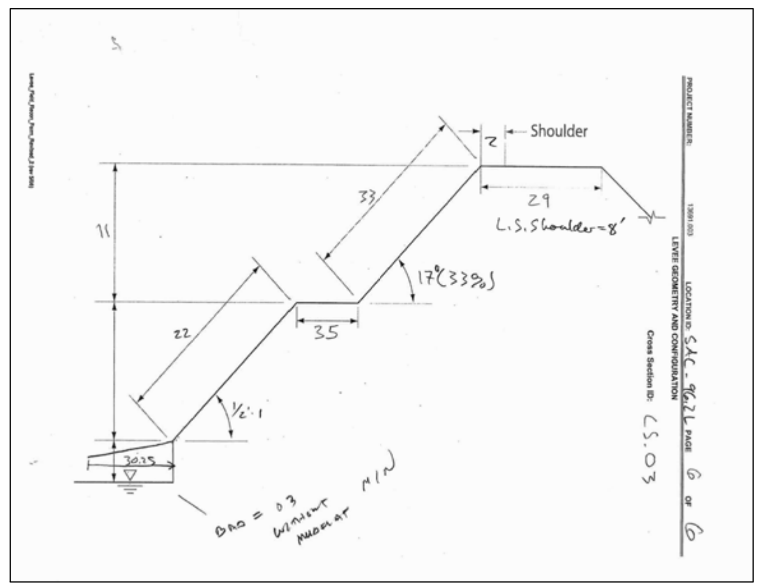
Comp Study Levee Crown Elevation	47.9
Comp Study Landside Toe Elevation	34.1
Comp Study Difference	13.8

Alternatives Report Analysis Levee Crown Elevation	47.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	33.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 96.2L

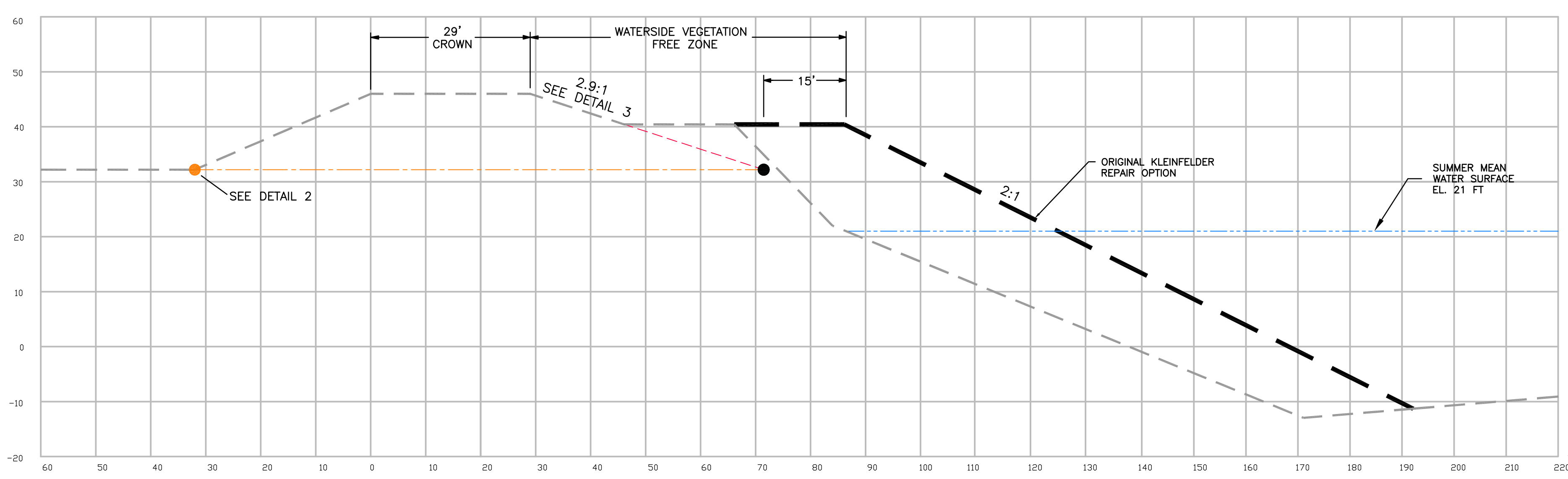
Date	3/31/11
Figure	SAC 96.2L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

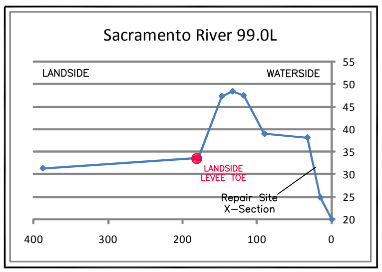
SACRAMENTO RIVER 99.0L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.0
15.3	24.9
32.7	38.3
90.3	39.1
118.4	47.7
133.1	48.6
147.6	47.5
179.6	33.7
388.0	31.4

KEY DATA FOR DETERMINING LANDSIDE TOE

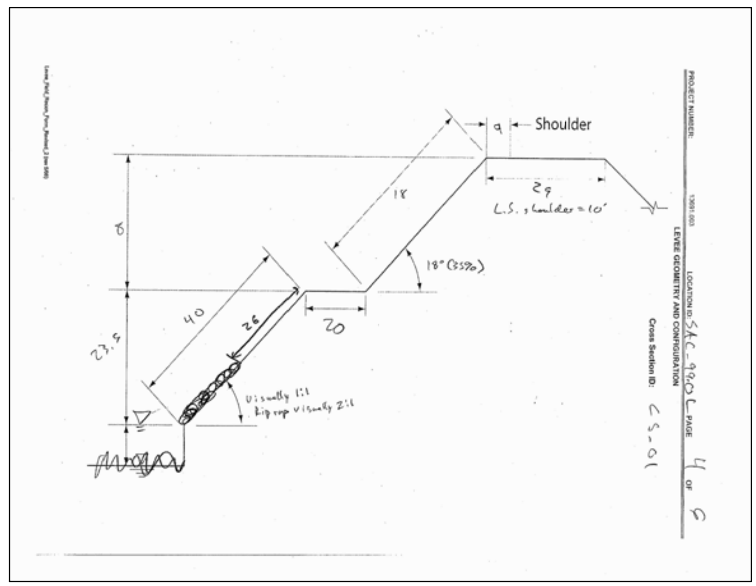
Comp Study Levee Crown Elevation	47.5
Comp Study Landside Toe Elevation	33.7
Comp Study Difference	13.8

Alternatives Report Analysis Levee Crown Elevation	46.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	32.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Phase II Post Authorization Change
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Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 99.0L

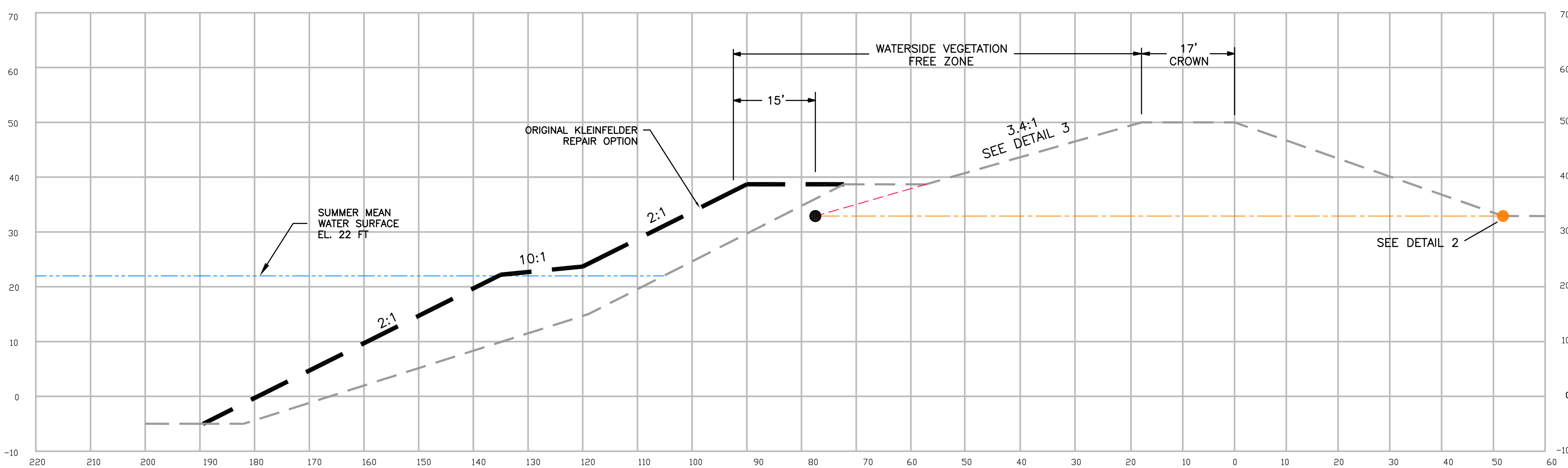
Date	3/31/11
Figure	SAC 99.0L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

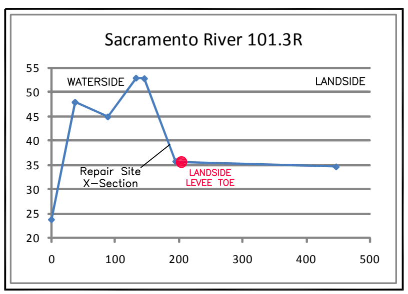
SACRAMENTO RIVER 101.3R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	23.8
37.1	48.0
88.6	45.0
132.9	53.0
146.1	52.9
195.2	35.8
447.2	34.7

KEY DATA FOR DETERMINING LANDSIDE TOE

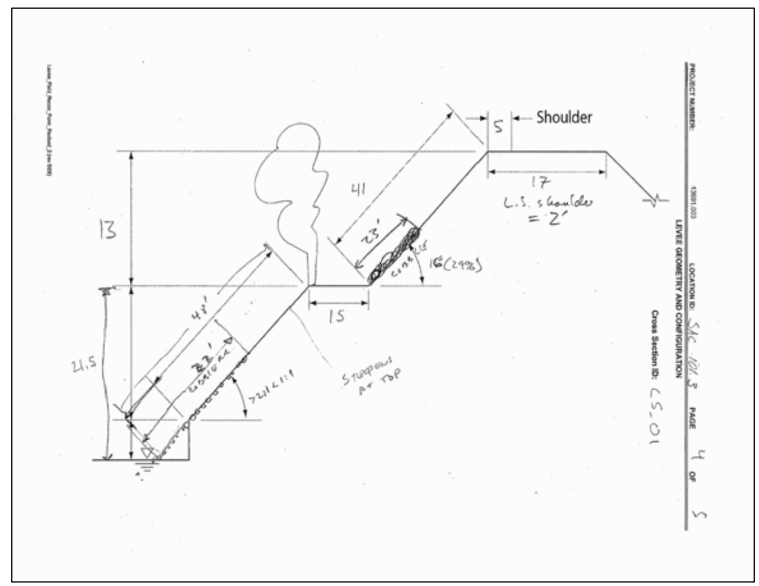
Comp Study Levee Crown Elevation	52.9
Comp Study Landside Toe Elevation	35.8
Comp Study Difference	17.1

Alternatives Report Analysis Levee Crown Elevation	50.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	32.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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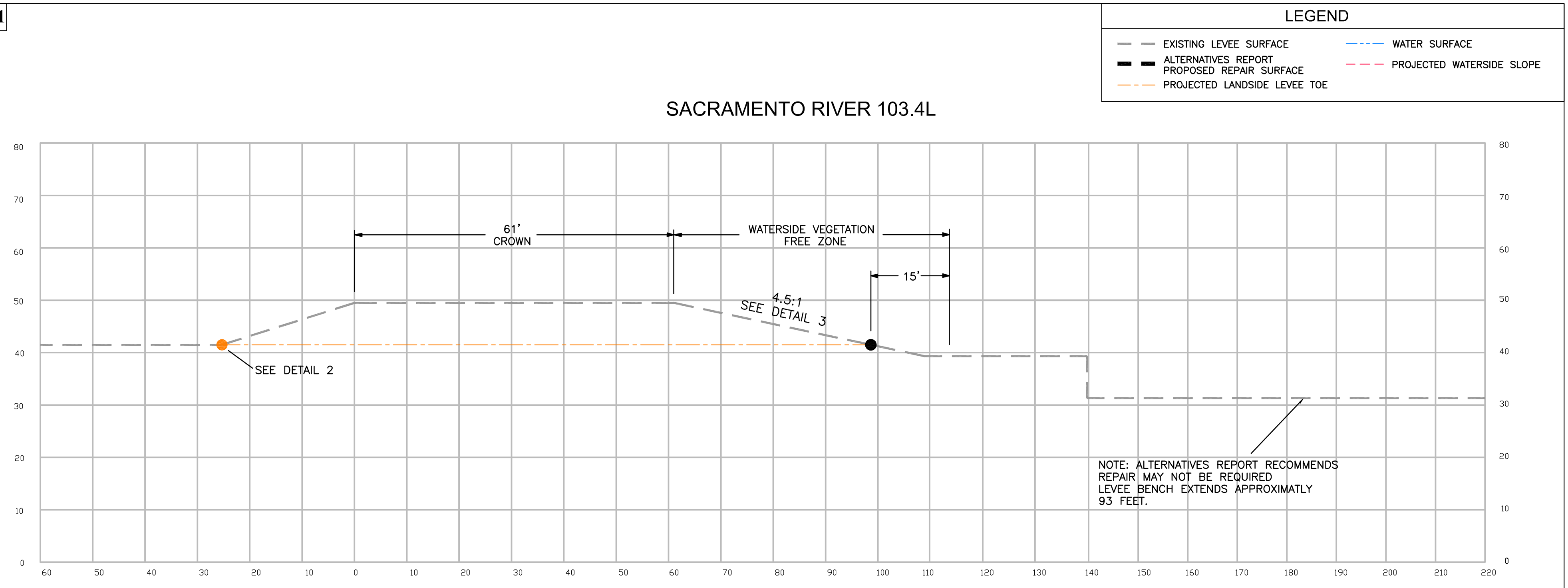
Checked By: R. Little
QA/QC Review: D. Teak

SACRAMENTO RIVER ~ 101.3R

Date 3/31/11

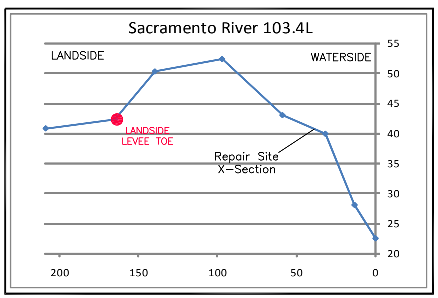
Figure SAC 101.3R

DETAIL 1



DETAIL 2

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	22.5
13.3	28.1
31.8	40.0
58.9	43.1
97.1	52.5
139.6	50.4
164.9	42.4
208.7	40.9

KEY DATA FOR DETERMINING LANDSIDE TOE

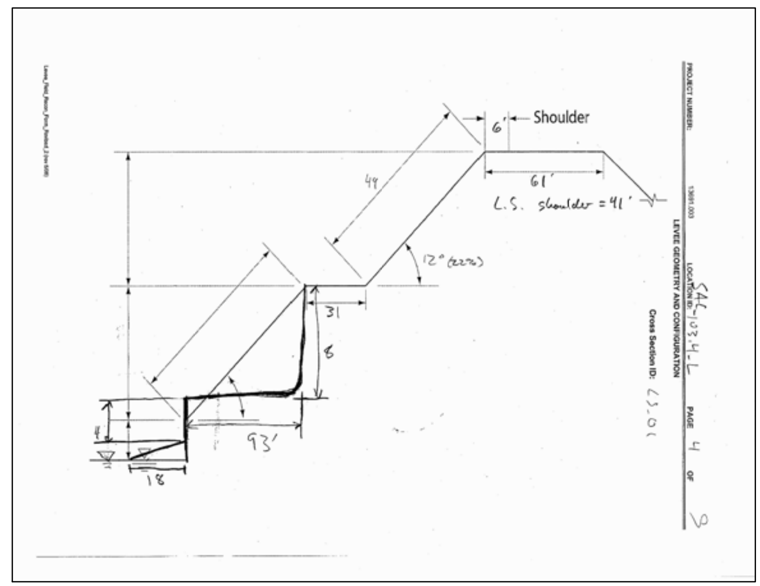
Comp Study Levee Crown Elevation	50.4
Comp Study Landside Toe Elevation	42.4
Comp Study Difference	8.0

Alternatives Report Analysis Levee Crown Elevation	49.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	41.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 103.4L

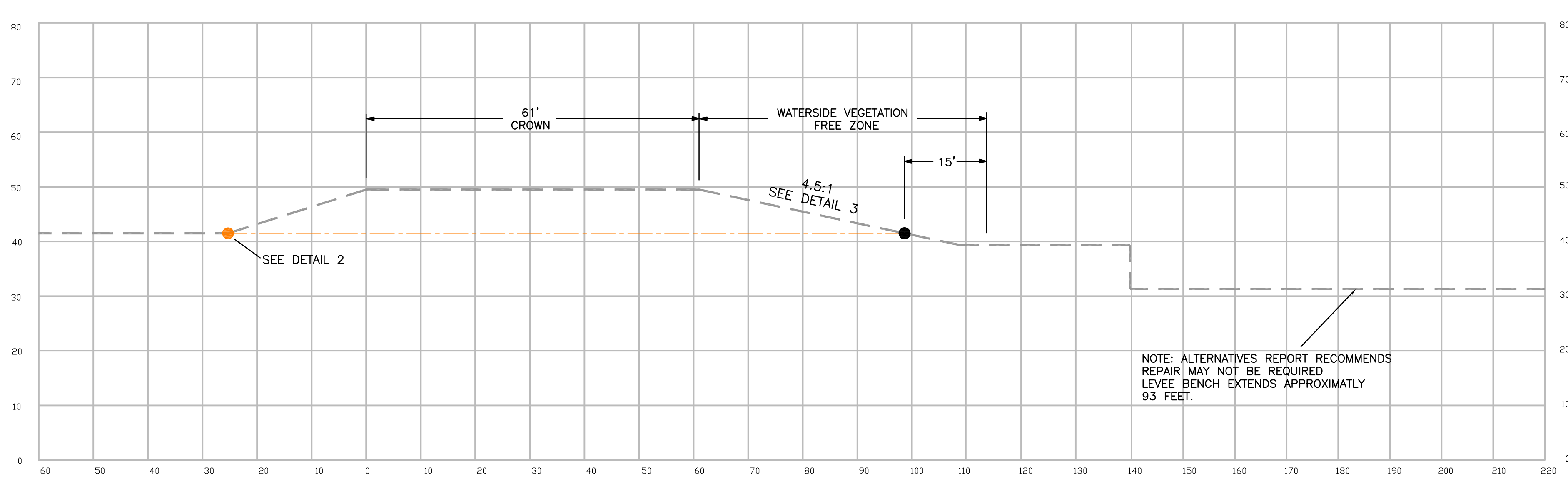
Date	3/31/11
Figure	SAC 103.4L

DETAIL 1

LEGEND

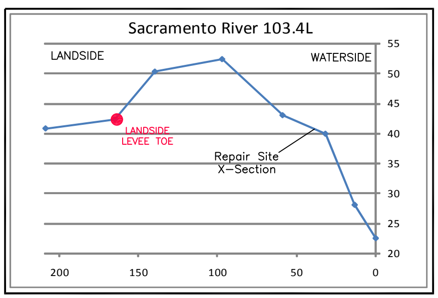
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

SACRAMENTO RIVER 103.4L



DETAIL 2

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	22.5
13.3	28.1
31.8	40.0
58.9	43.1
97.1	52.5
139.6	50.4
164.9	42.4
208.7	40.9

KEY DATA FOR DETERMINING LANDSIDE TOE

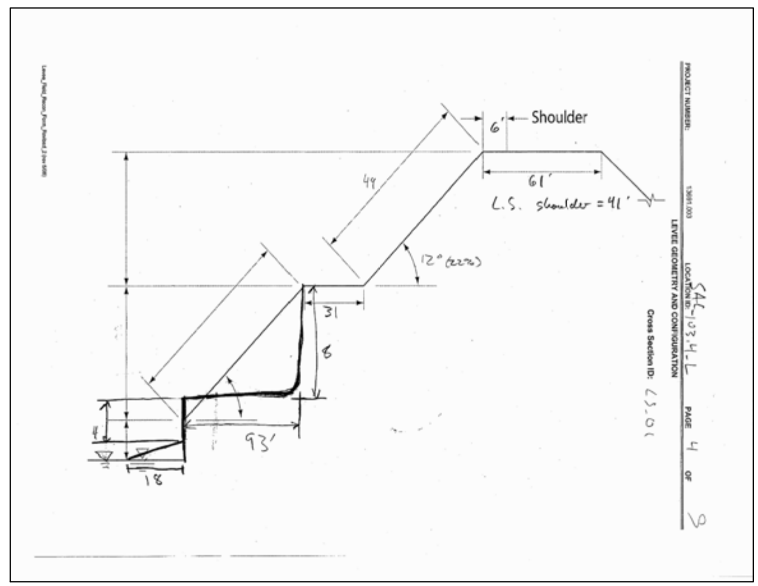
Comp Study Levee Crown Elevation	50.4
Comp Study Landside Toe Elevation	42.4
Comp Study Difference	8.0

Alternatives Report Analysis Levee Crown Elevation	49.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	41.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 103.4L

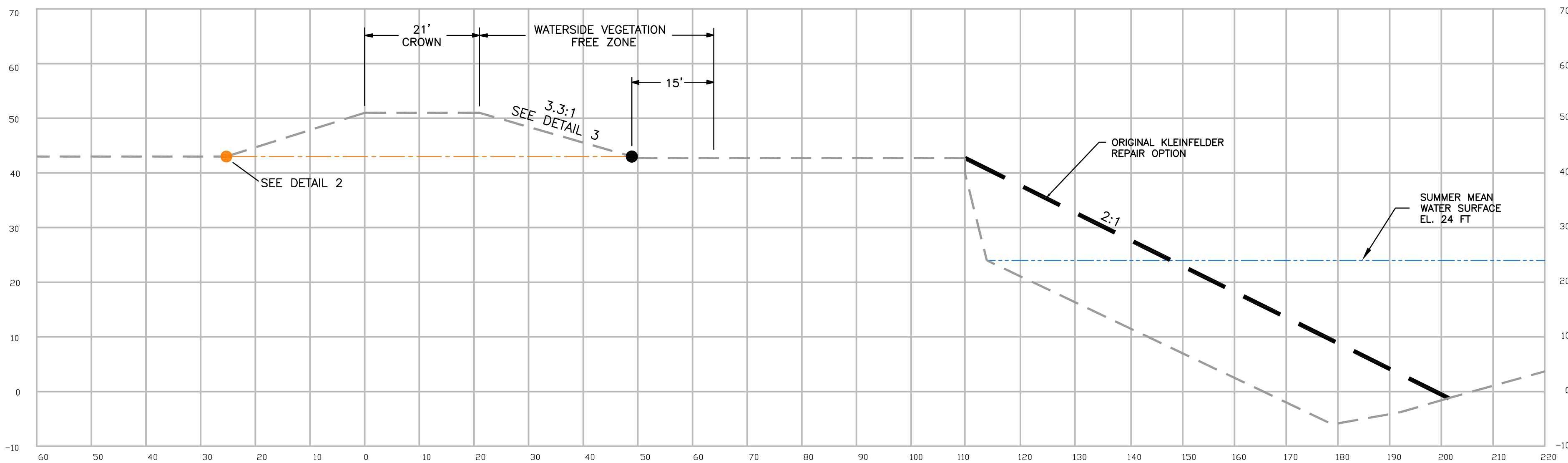
Date	3/31/11
Figure	SAC 103.4L

DETAIL 1

LEGEND

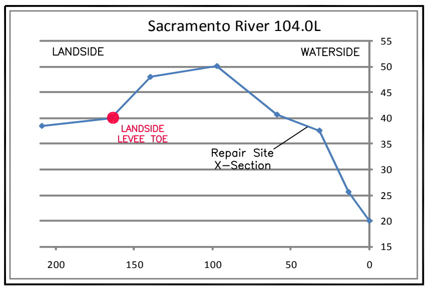
EXISTING LEVEE SURFACE	WATER SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE	PROJECTED WATERSIDE SLOPE
PROJECTED LANDSIDE LEVEE TOE	

SACRAMENTO RIVER 104.0L



DETAIL 2

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	20.1
13.3	25.7
31.8	37.6
58.9	40.7
97.1	50.1
139.6	48.0
164.9	40.0
208.7	38.5

KEY DATA FOR DETERMINING LANDSIDE TOE

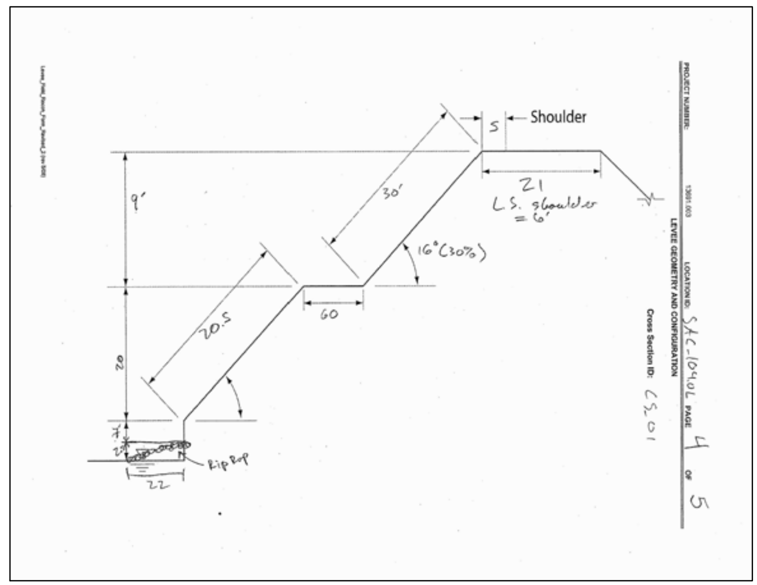
Comp Study Levee Crown Elevation	48.0
Comp Study Landside Toe Elevation	40.0
Comp Study Difference	8.0

Alternatives Report Analysis Levee Crown Elevation	51.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	43.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 104.0L

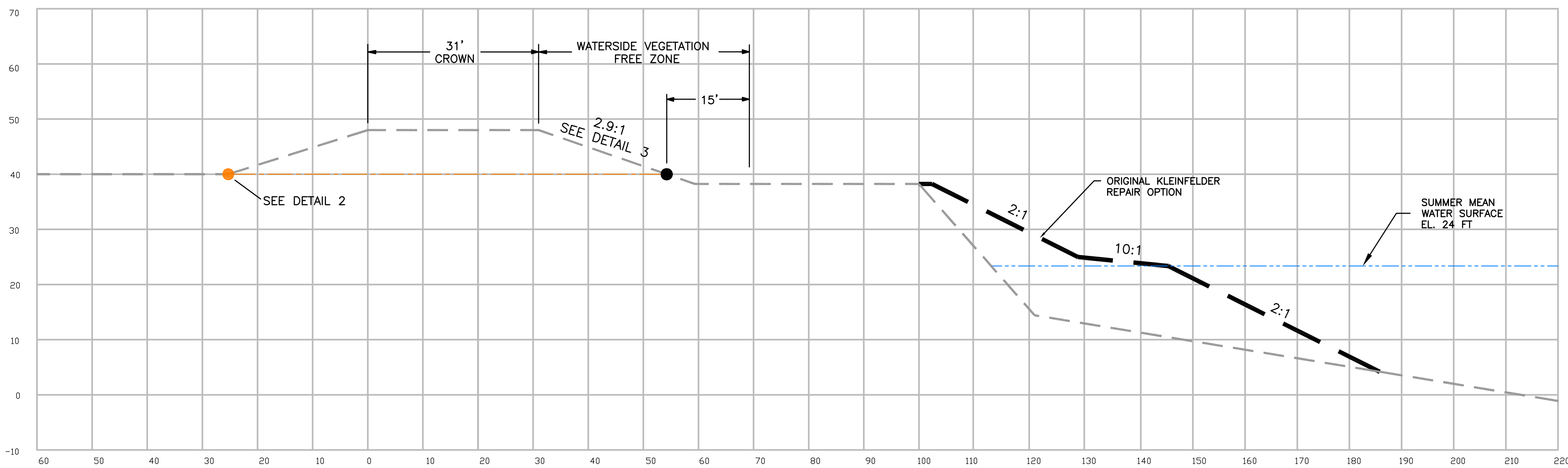
Date	3/31/11
Figure	SAC 104.0L

DETAIL 1

LEGEND

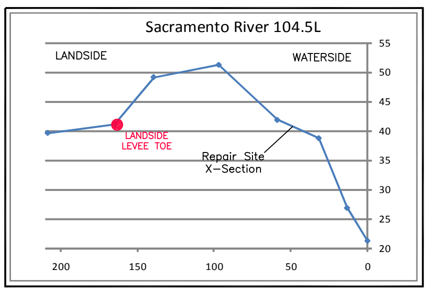
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

SACRAMENTO RIVER 104.5L



DETAIL 2

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	21.3
13.3	26.9
31.8	38.8
58.9	41.9
97.1	51.3
139.6	49.2
164.9	41.2
208.7	39.7

KEY DATA FOR DETERMINING LANDSIDE TOE

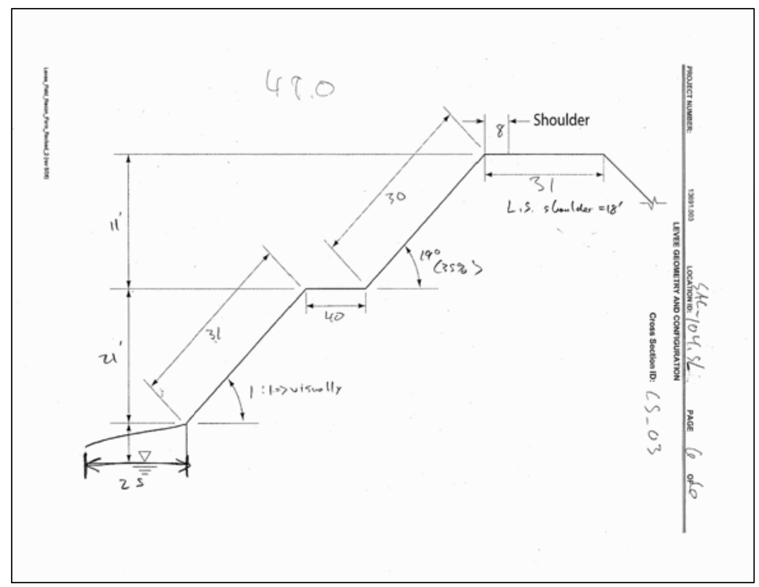
Comp Study Levee Crown Elevation	49.2
Comp Study Landside Toe Elevation	41.2
Comp Study Difference	8.0

Alternatives Report Analysis Levee Crown Elevation	48.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	40.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

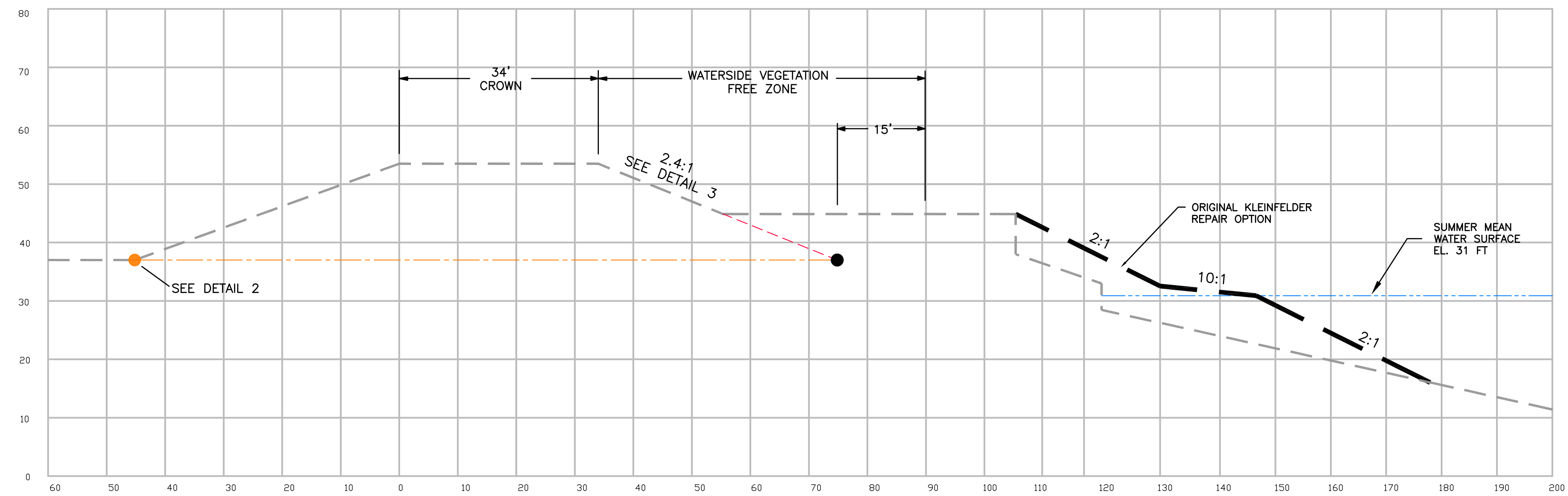
Drawn By: E. Smith	SACRAMENTO RIVER ~ 104.5L	Date	3/31/11
Checked By: R. Little		Figure	SAC 104.5L
QA/QC Review: D. Teak			

DETAIL 1

LEGEND

EXISTING LEVEE SURFACE	WATER SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE	PROJECTED WATERSIDE SLOPE
PROJECTED LANDSIDE LEVEE TOE	

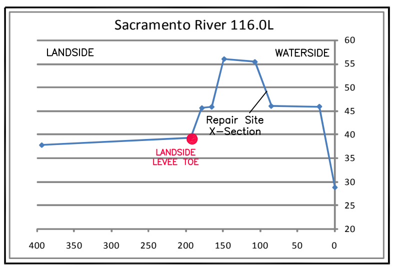
SACRAMENTO RIVER 116.0L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM
DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	28.9
20.9	45.9
85.7	46.0
107.6	55.3
148.9	55.9
165.7	45.8
178.8	45.6
194.1	39.4
394.1	37.8

KEY DATA FOR DETERMINING
LANDSIDE TOE

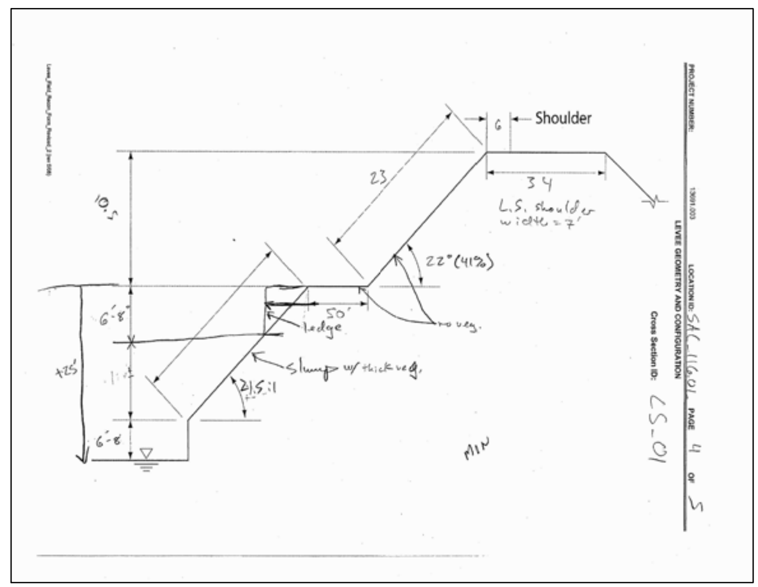
Comp Study Levee Crown Elevation	55.9
Comp Study Landside Toe Elevation	39.4
Comp Study Difference	16.5

Alternatives Report Analysis Levee Crown Elevation	53.5

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	37.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

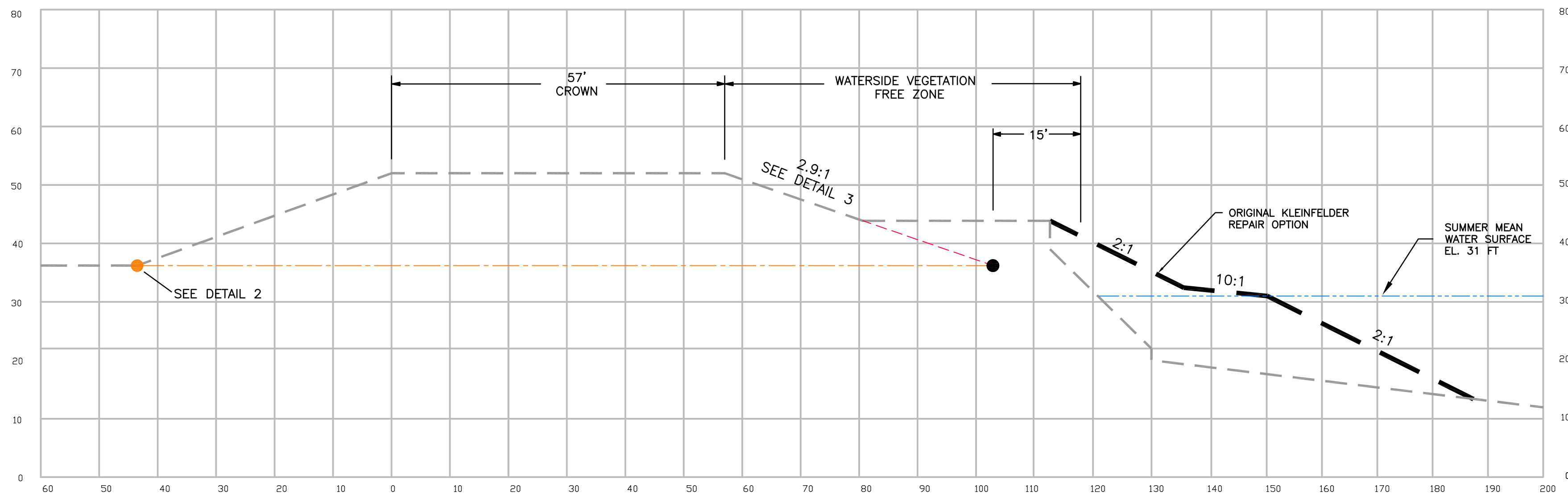
SACRAMENTO RIVER ~ 116.0L

Date	3/31/11
Figure	SAC 116.0L

DETAIL 1

LEGEND	
EXISTING LEVEE SURFACE	WATER SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE	PROJECTED WATERSIDE SLOPE
PROJECTED LANDSIDE LEVEE TOE	

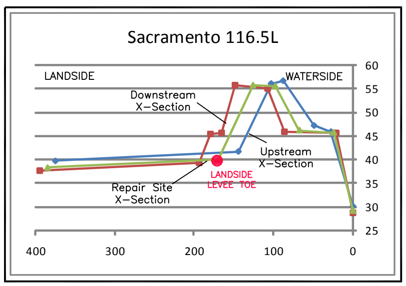
SACRAMENTO RIVER 116.5L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	29.3
24.3	45.9
67.4	46.4
97.8	55.8
125.8	56.0
169.3	40.1
384.4	38.4

KEY DATA FOR DETERMINING LANDSIDE TOE

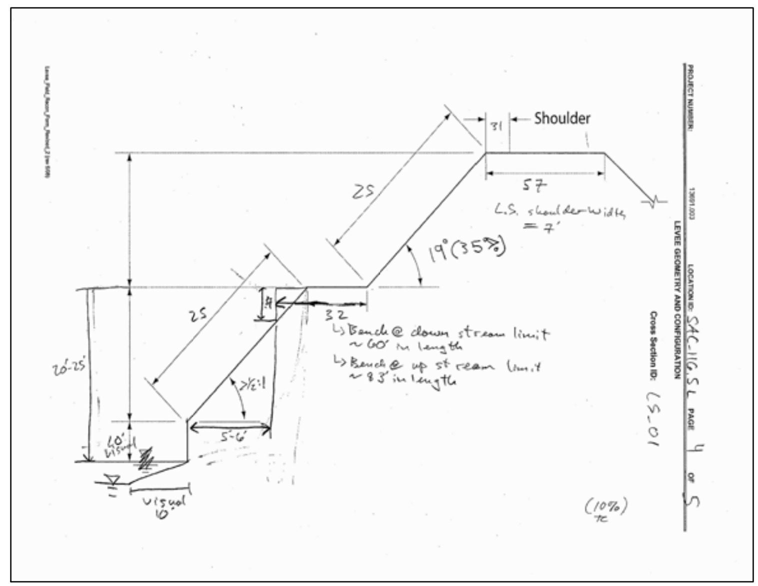
Comp Study Levee Crown Elevation	56.0
Comp Study Landside Toe Elevation	40.1
Comp Study Difference	15.8

Alternatives Report Analysis Levee Crown Elevation	52.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	36.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

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Checked By: R. Little
QA/QC Review: D. Teak

SACRAMENTO RIVER ~ 116.5L

Date 3/31/11

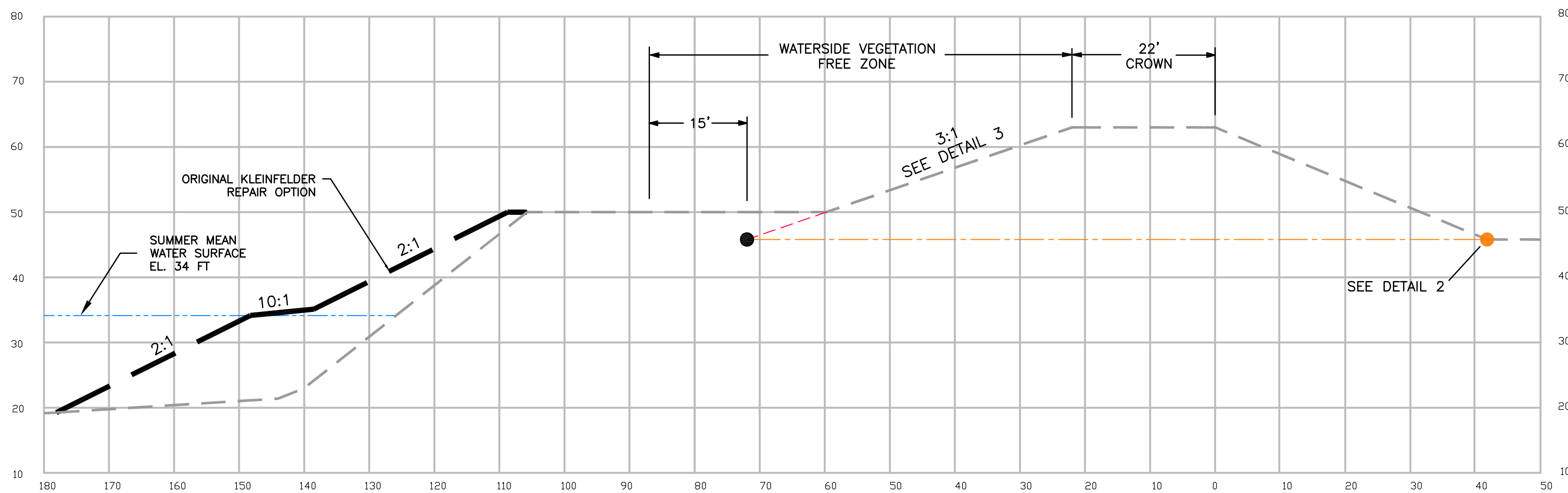
Figure SAC 116.5L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

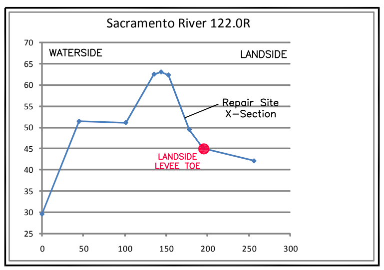
SACRAMENTO RIVER 122.0R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	29.7
44.8	51.5
101.1	51.2
135.4	62.6
143.8	63.1
152.7	62.4
178.0	49.6
194.5	45.2
256.0	42.2

KEY DATA FOR DETERMINING LANDSIDE TOE

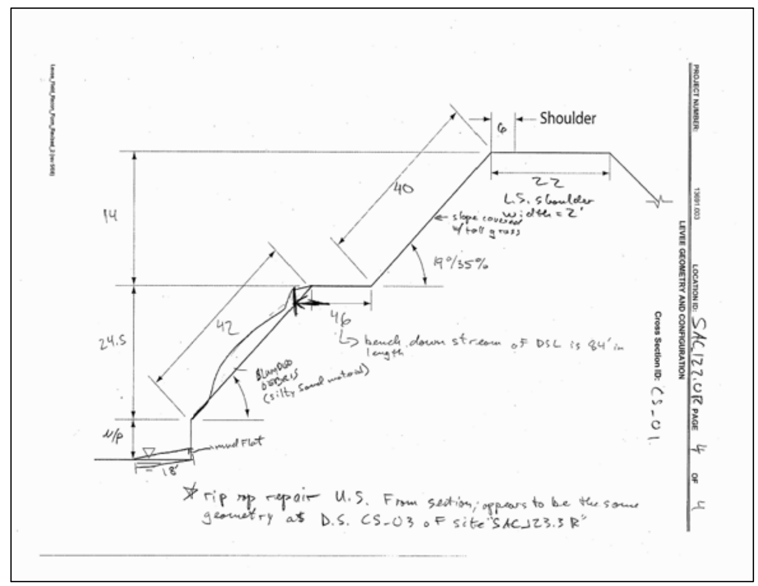
Comp Study Levee Crown Elevation	62.4
Comp Study Landside Toe Elevation	45.2
Comp Study Difference	17.2

Alternatives Report Analysis Levee Crown Elevation	63.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	45.8

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



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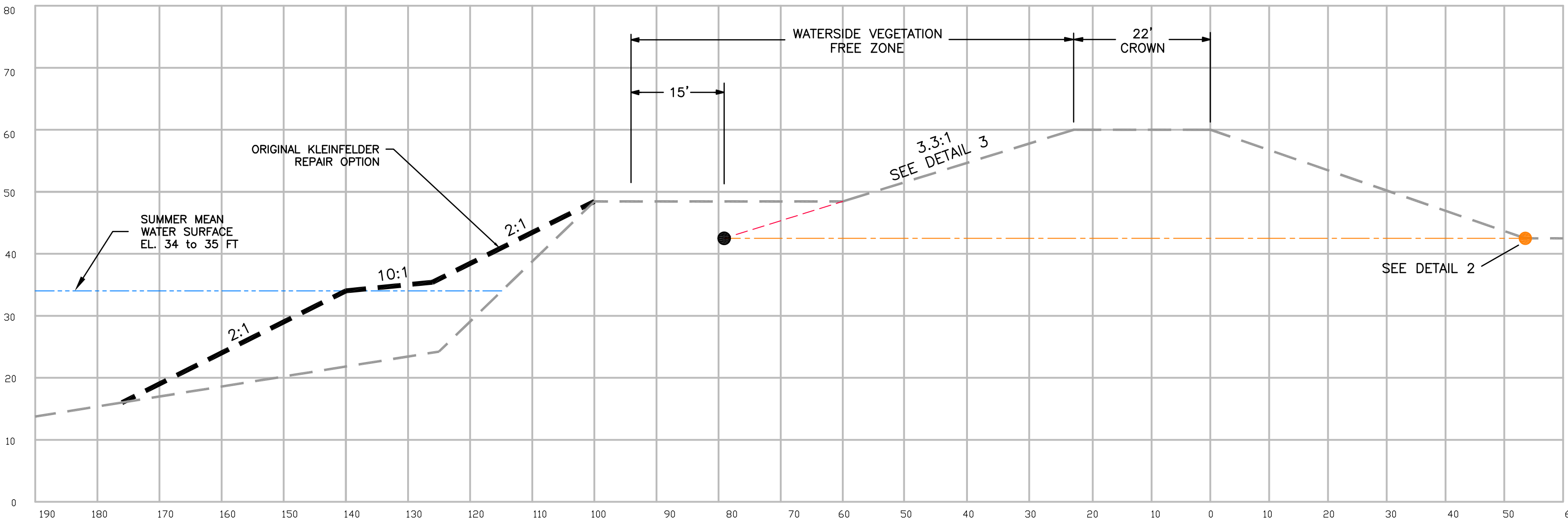
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 122.0R

Date	3/31/11
Figure	SAC 122.0R

DETAIL 1

SACRAMENTO RIVER 122.3R



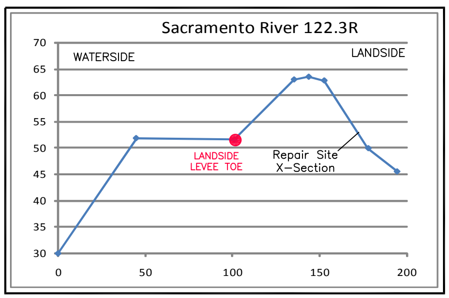
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	30.1
44.8	51.9
101.1	51.6
135.4	63.0
143.8	63.5
152.7	62.8
178.0	50.0
194.5	45.6

KEY DATA FOR DETERMINING LANDSIDE TOE

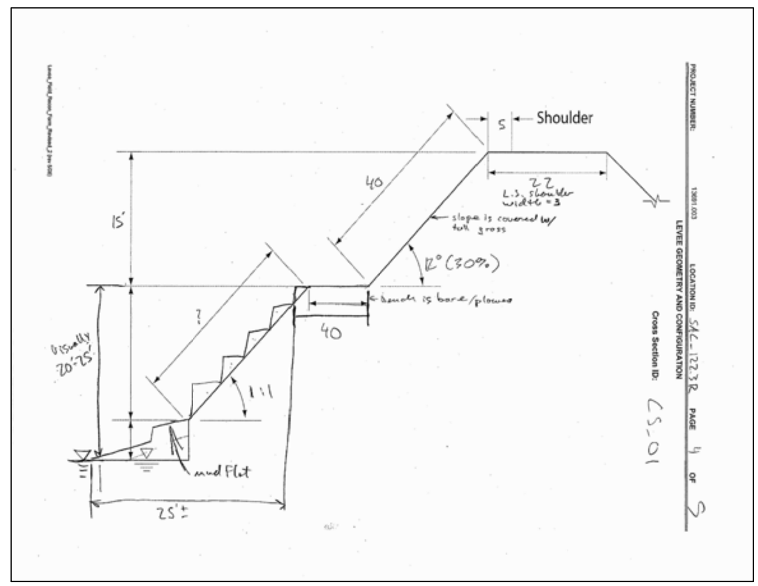
Comp Study Levee Crown Elevation	63.1
Comp Study Landside Toe Elevation	45.6
Comp Study Difference	17.5

Alternatives Report Analysis Levee Crown Elevation	60.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	42.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

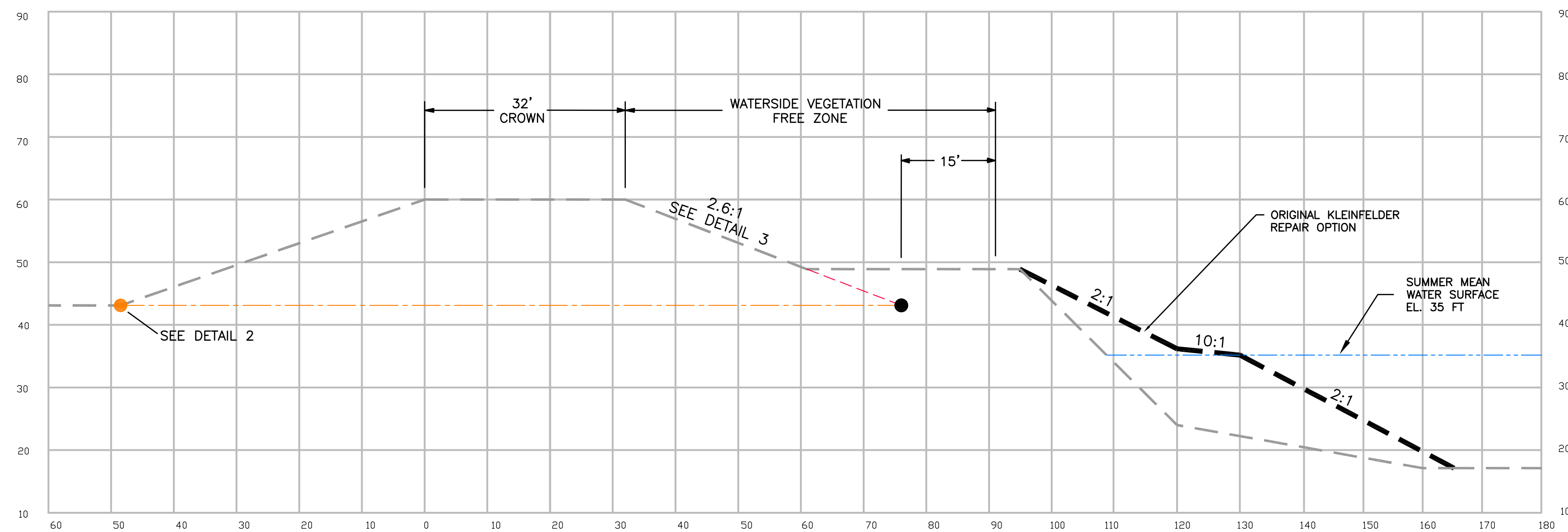
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 122.3R

Date	3/31/11
Figure	SAC 122.3R

DETAIL 1

SACRAMENTO RIVER 123.3L



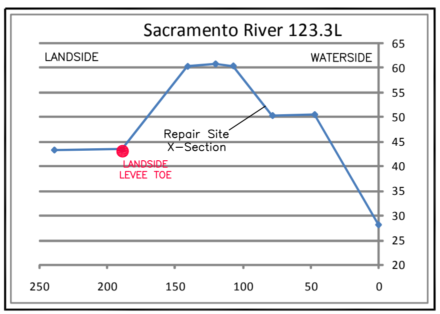
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	28.1
47.0	50.5
78.1	50.3
107.0	60.4
120.1	60.8
140.6	60.3
189.1	43.4
238.9	43.3

KEY DATA FOR DETERMINING LANDSIDE TOE

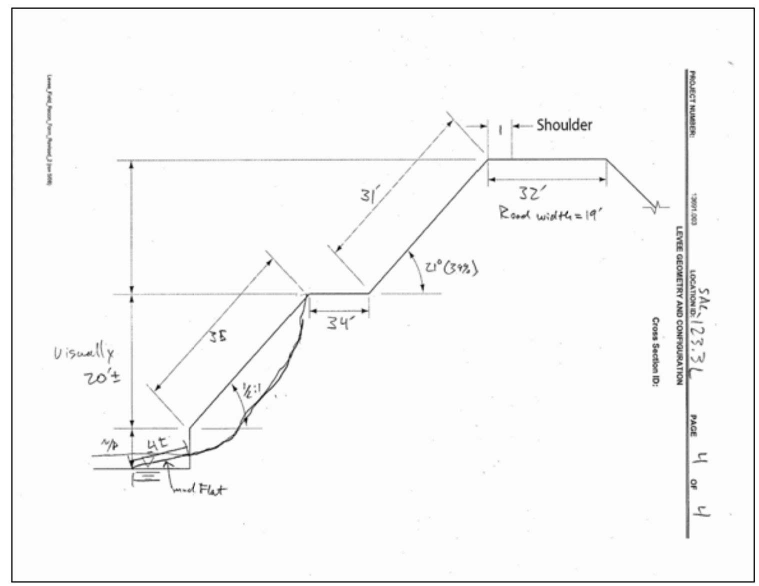
Comp Study Levee Crown Elevation	60.3
Comp Study Landside Toe Elevation	43.4
Comp Study Difference	16.9

Alternatives Report Analysis Levee Crown Elevation	60.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	43.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

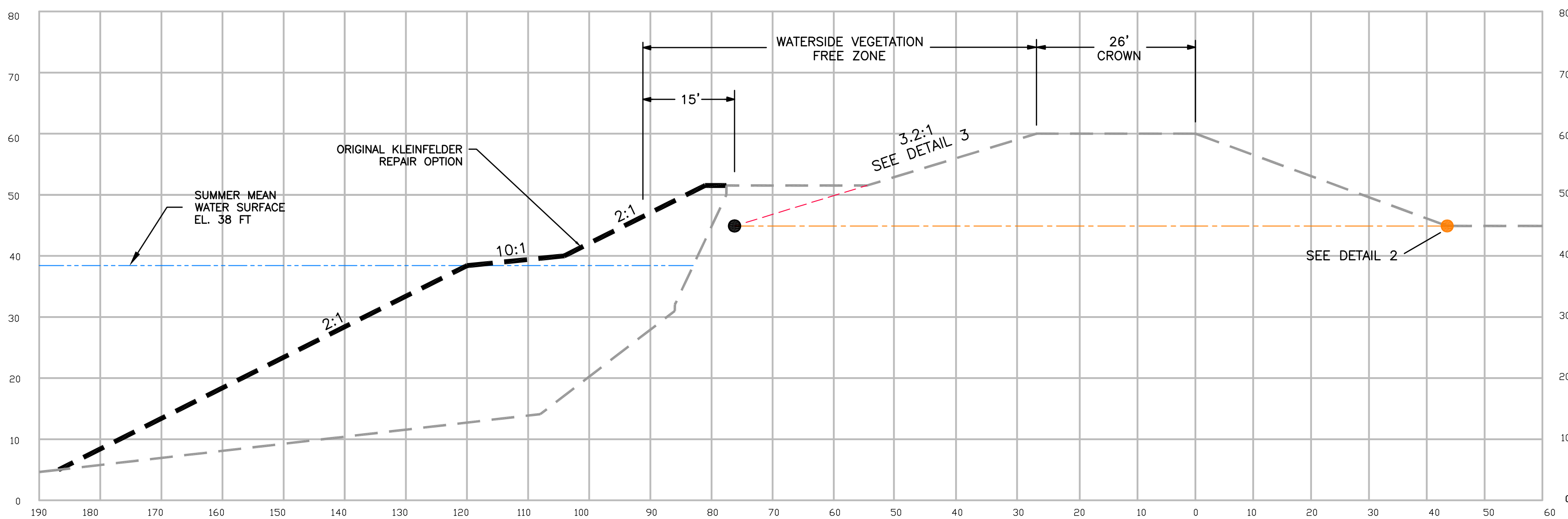
SACRAMENTO RIVER ~ 123.3L

Date 3/31/11

Figure SAC 123.3L

DETAIL 1

SACRAMENTO RIVER 123.7R



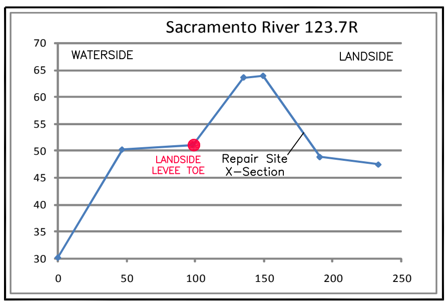
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	30.2
46.7	50.3
97.9	51.2
135.1	63.7
149.3	64.0
190.5	48.9
233.1	47.5

KEY DATA FOR DETERMINING LANDSIDE TOE

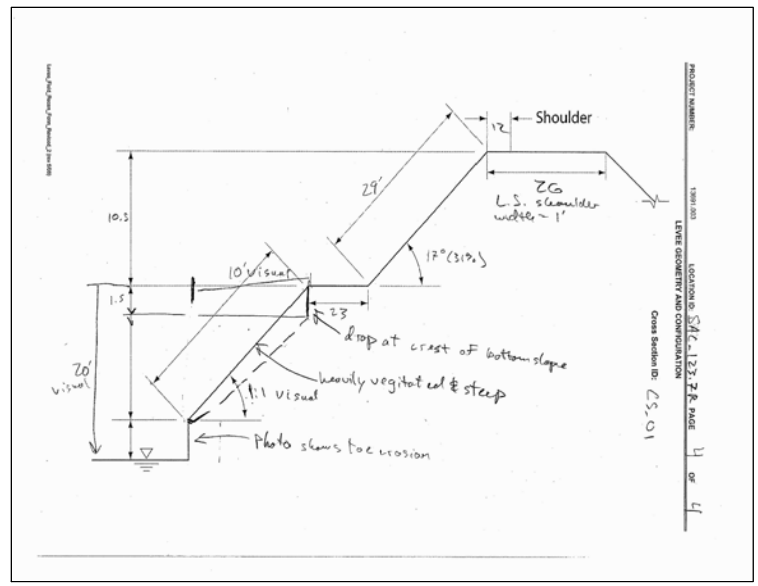
Comp Study Levee Crown Elevation	64.0
Comp Study Landside Toe Elevation	48.9
Comp Study Difference	15.1

Alternatives Report Analysis Levee Crown Elevation	60.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	44.9

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

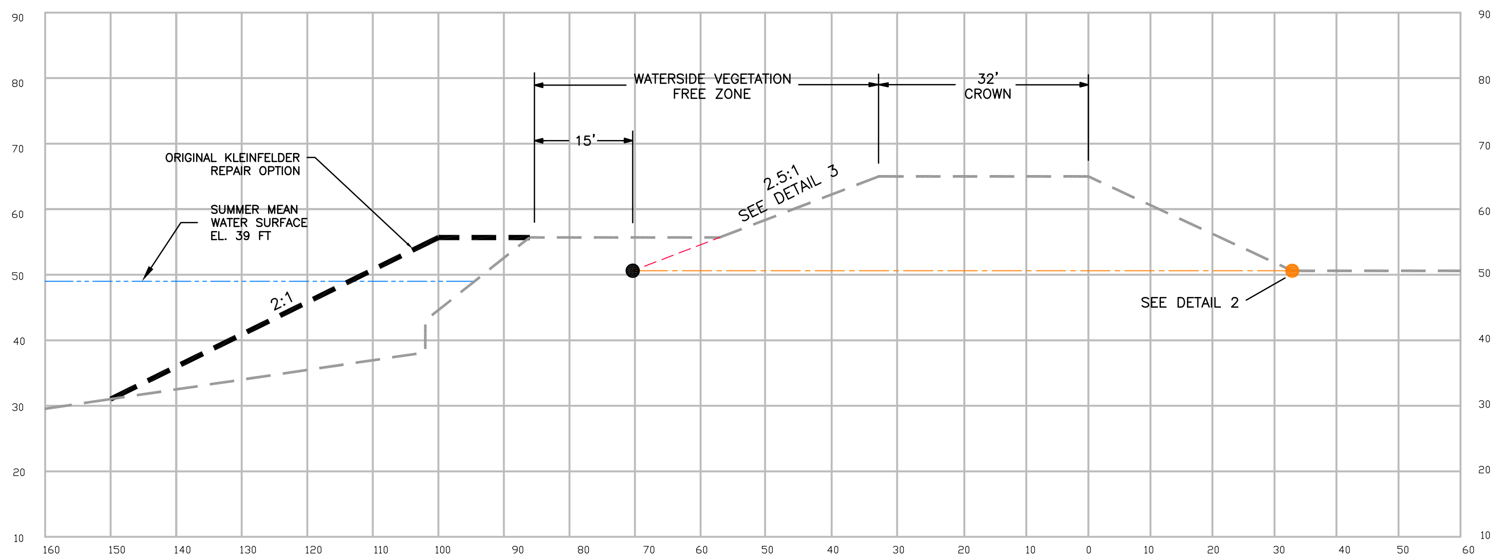
SACRAMENTO RIVER ~ 123.7R

Date 3/31/11

Figure SAC 123.7R

DETAIL 1

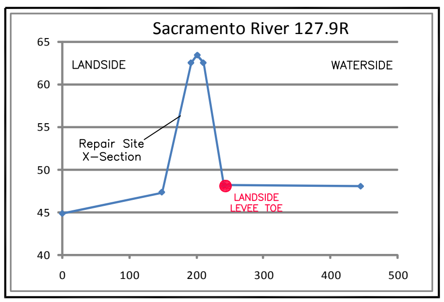
SACRAMENTO RIVER 127.9R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points

Horizontal Distance to Data Point	Elevation at Data Point
0.0	44.9
148.2	47.4
191.6	62.6
201.1	63.5
210.1	62.6
241.2	48.2
444.6	48.1

KEY DATA FOR DETERMINING LANDSIDE TOE

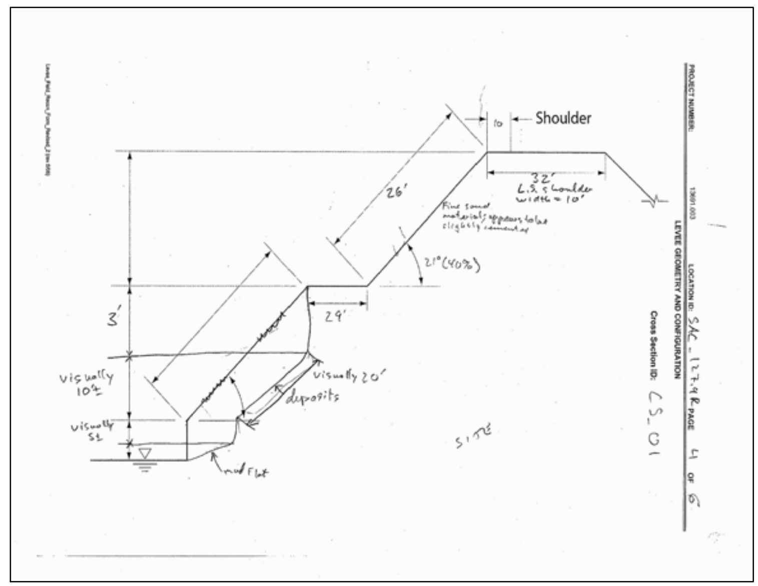
Comp Study Levee Crown Elevation	62.6
Comp Study Landside Toe Elevation	48.2
Comp Study Difference	14.4

Alternatives Report Analysis Levee Crown Elevation	65.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	50.6

DETAIL 3

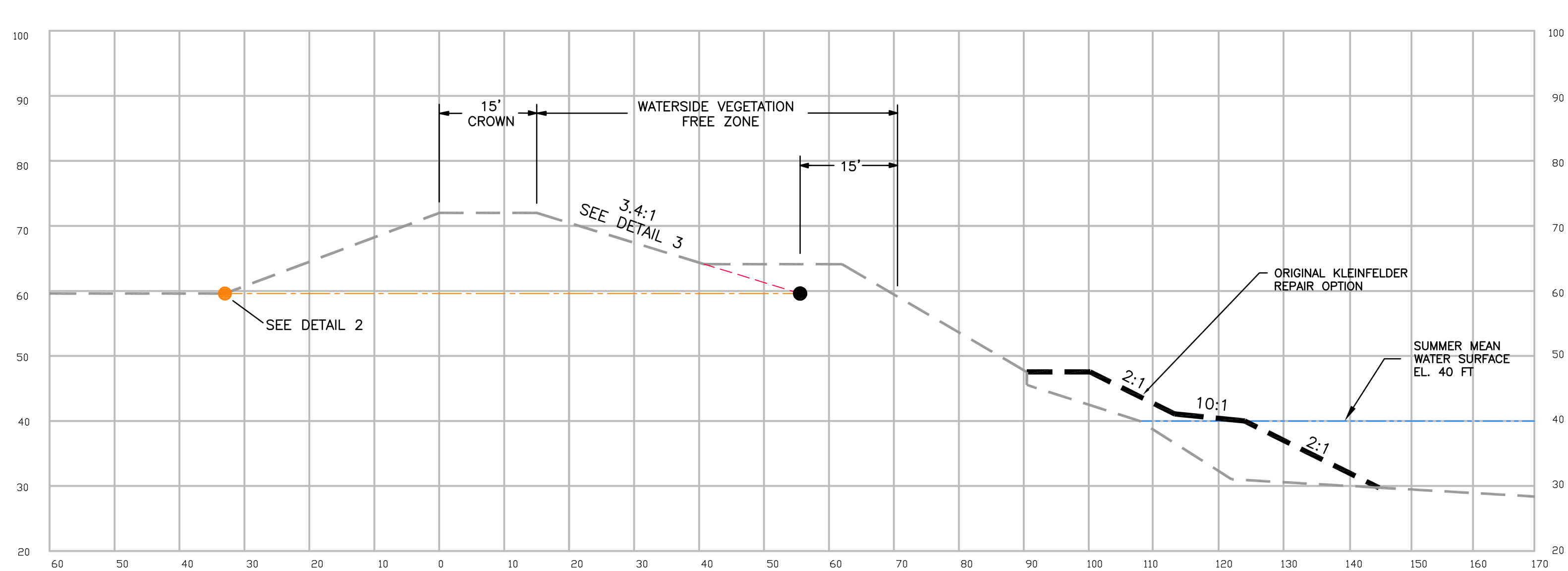
ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	SACRAMENTO RIVER ~ 127.9R	Date 3/31/11 Figure SAC 127.9R

DETAIL 1

SACRAMENTO RIVER 131.8L



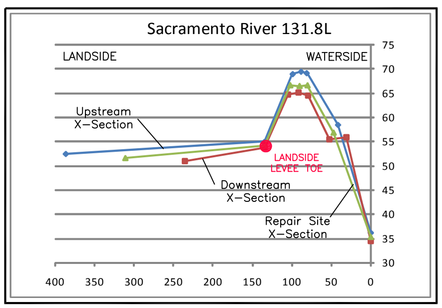
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	35.4
47.1	57.0
80.1	66.8
90.3	66.7
102.0	66.8
135.0	54.4
310.9	51.7

KEY DATA FOR DETERMINING LANDSIDE TOE

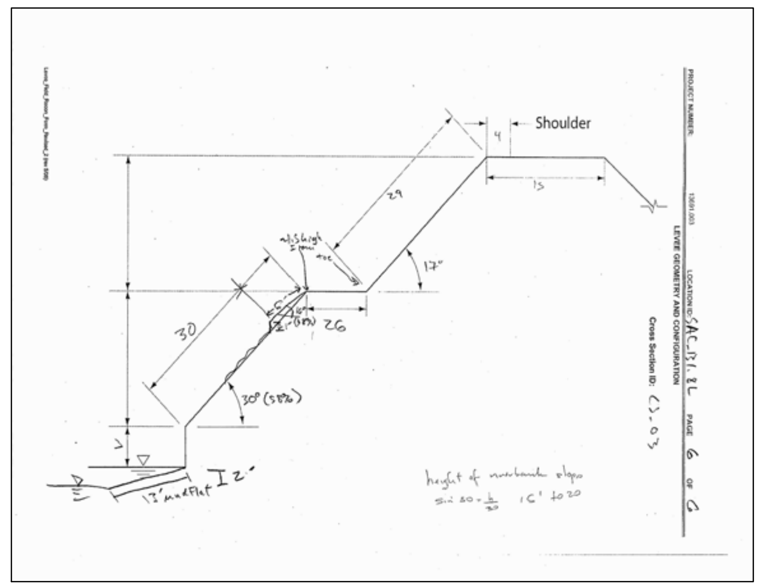
Comp Study Levee Crown Elevation	66.8
Comp Study Landside Toe Elevation	54.4
Comp Study Difference	12.4

Alternatives Report Analysis Levee Crown Elevation	72.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	59.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



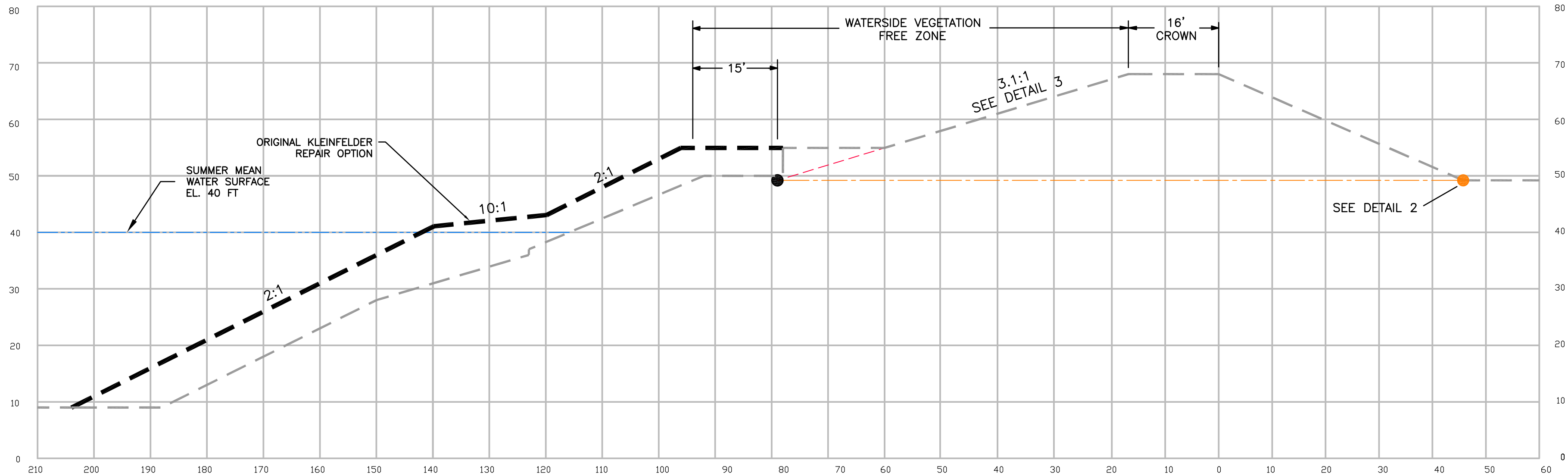
Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	SACRAMENTO RIVER ~ 131.8L	Date 3/31/11 Figure SAC 131.8L

DETAIL 1

LEGEND

EXISTING LEVEE SURFACE	WATER SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE	PROJECTED WATERSIDE SLOPE
PROJECTED LANDSIDE LEVEE TOE	

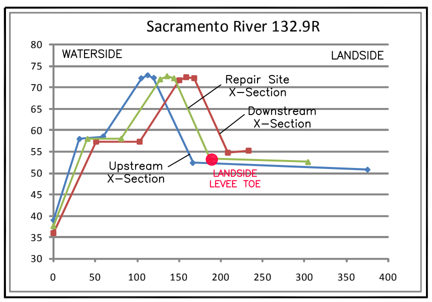
SACRAMENTO RIVER 132.9R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points

Horizontal Distance to Data Point	Elevation at Data Point
0.0	37.8
40.7	58.1
81.0	58.1
127.5	72.0
135.7	72.7
144.0	72.3
187.3	53.4
304.1	52.7

KEY DATA FOR DETERMINING LANDSIDE TOE

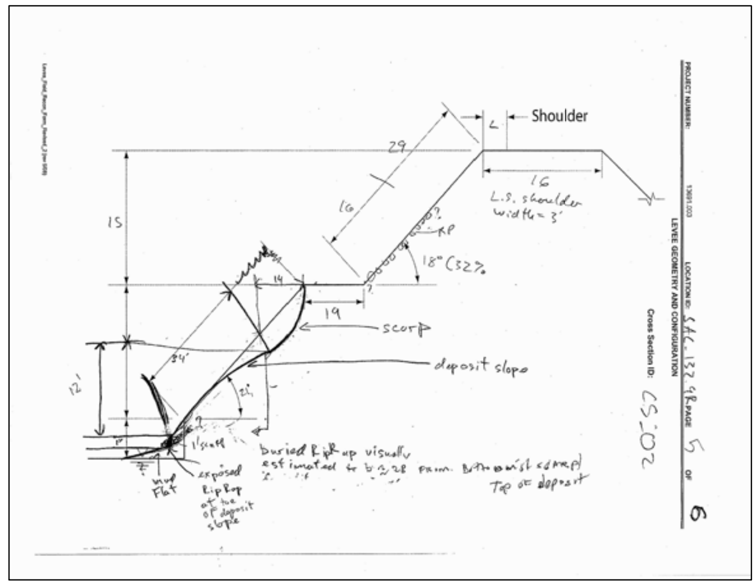
Comp Study Levee Crown Elevation	72.3
Comp Study Landside Toe Elevation	53.4
Comp Study Difference	18.8

Alternatives Report Analysis Levee Crown Elevation	68.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	49.2

DETAIL 3

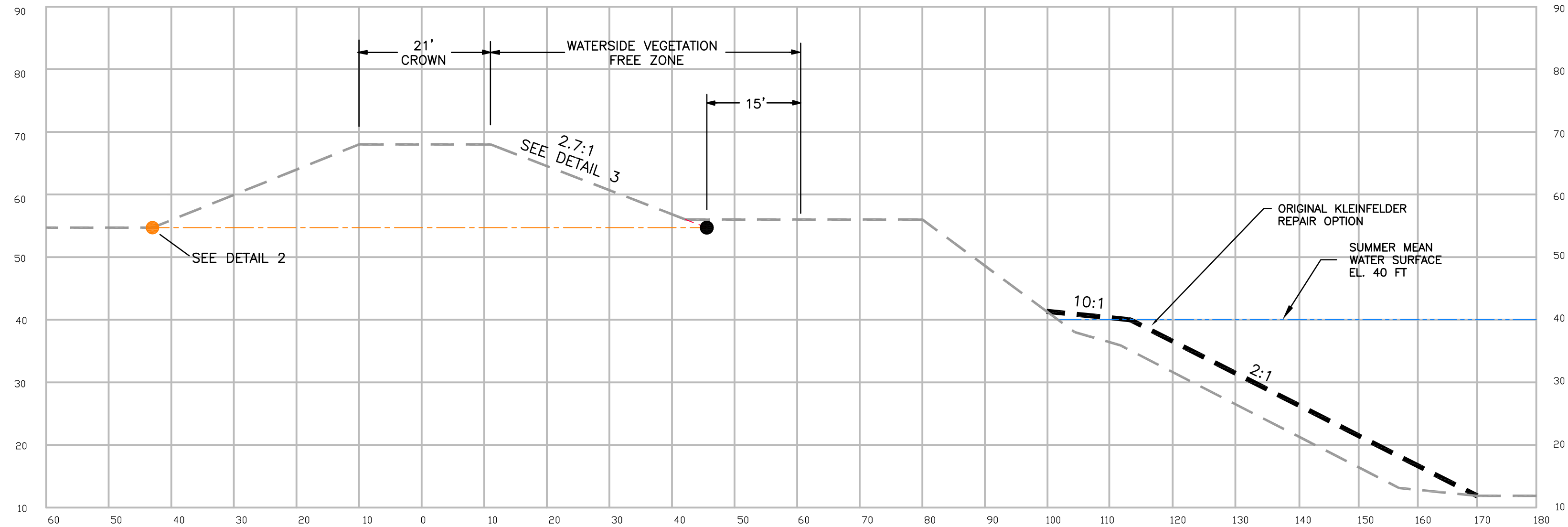
ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	SACRAMENTO RIVER ~ 132.9R
Date: 3/31/11	Figure: SAC 132.9R		

DETAIL 1

SACRAMENTO RIVER 133.0L



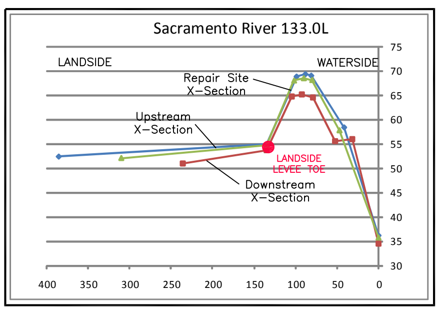
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	35.8
47.1	57.8
80.1	68.2
90.3	68.5
102.0	68.1
135.0	54.7
310.9	52.2

KEY DATA FOR DETERMINING LANDSIDE TOE

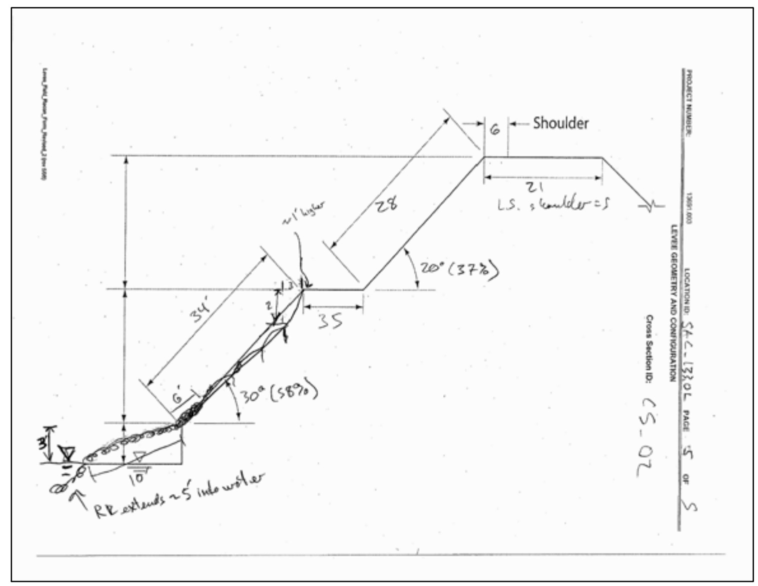
Comp Study Levee Crown Elevation	68.1
Comp Study Landside Toe Elevation	54.7
Comp Study Difference	13.3

Alternatives Report Analysis Levee Crown Elevation	68.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	54.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

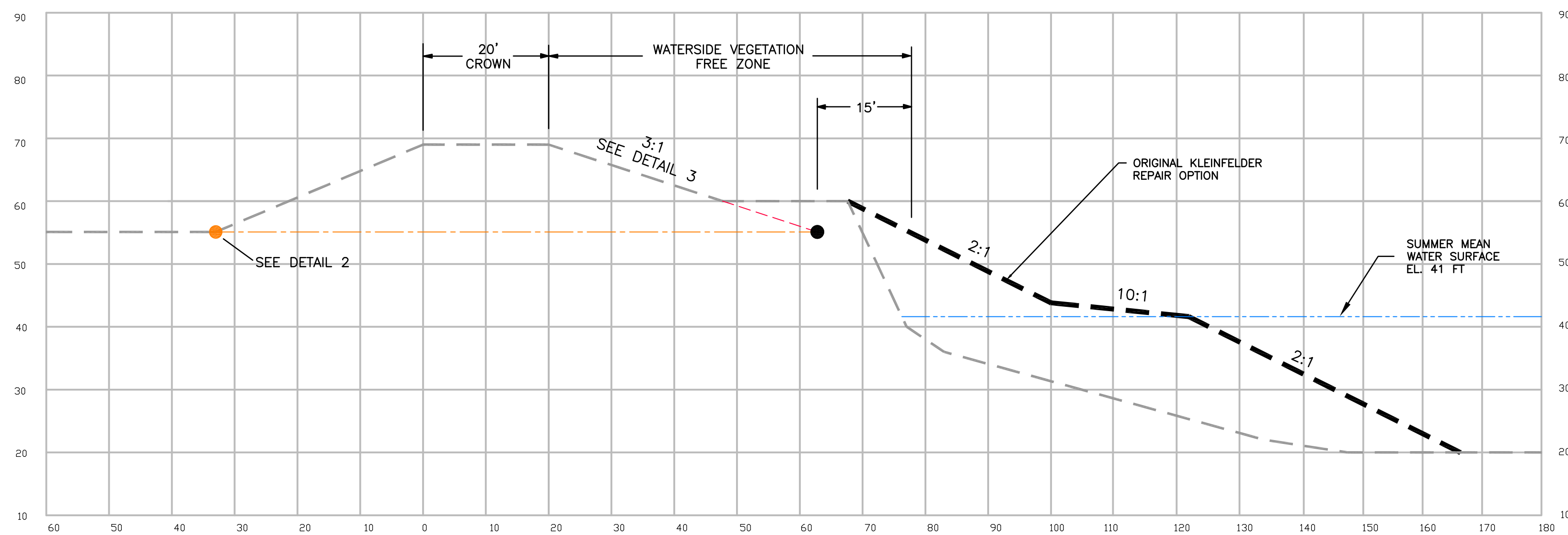
SACRAMENTO RIVER ~ 133.0L

Date 3/31/11

Figure SAC 133.0L

DETAIL 1

SACRAMENTO RIVER 133.8L



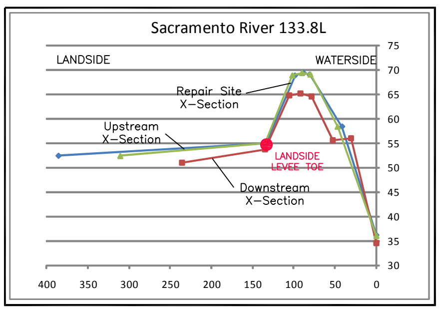
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	36.2
47.1	58.4
80.1	69.1
90.3	69.4
102.0	68.9
135.0	55.0
310.9	52.5

KEY DATA FOR DETERMINING LANDSIDE TOE

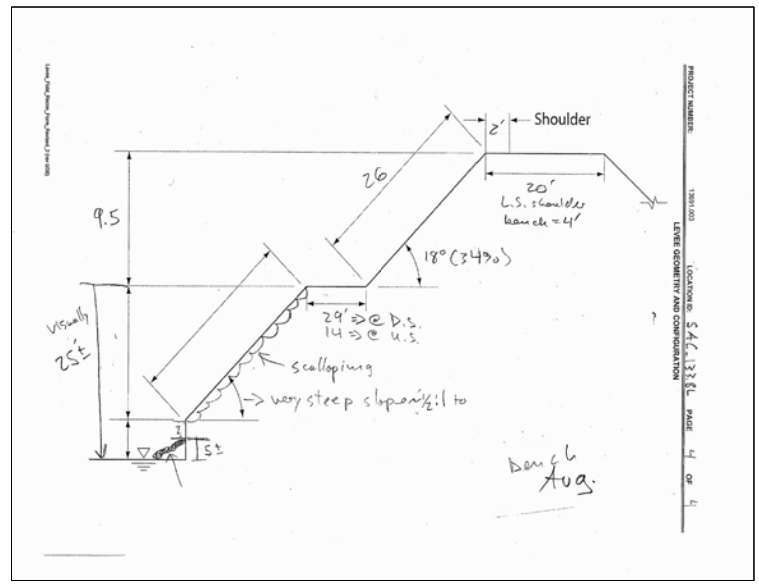
Comp Study Levee Crown Elevation	68.9
Comp Study Landside Toe Elevation	55.0
Comp Study Difference	13.9

Alternatives Report Analysis Levee Crown Elevation	69.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	55.1

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

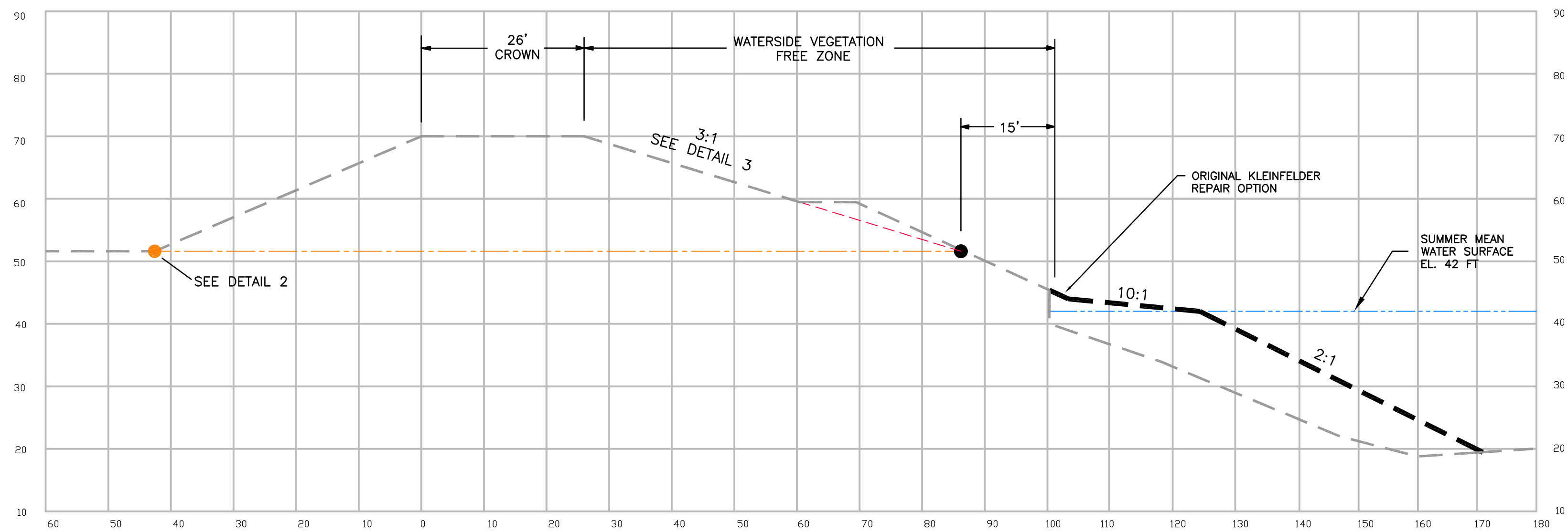
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 133.8L

Date	3/31/11
Figure	SAC 133.8L

DETAIL 1

SACRAMENTO RIVER 136.6L



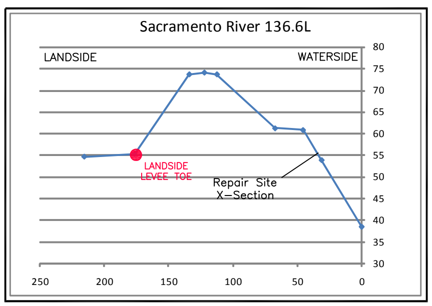
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	38.6
31.1	53.9
45.6	60.8
67.3	61.2
112.5	73.6
122.3	74.0
134.0	73.6
176.6	55.3
215.7	54.7

KEY DATA FOR DETERMINING LANDSIDE TOE

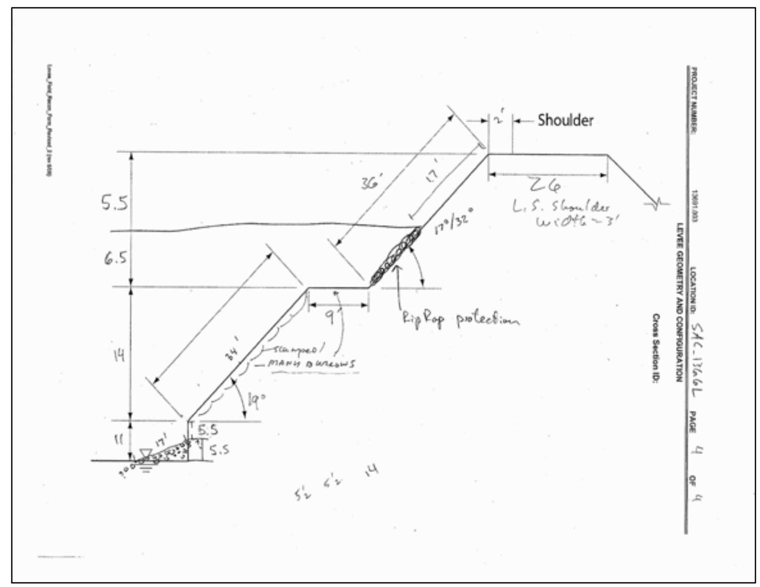
Comp Study Levee Crown Elevation	73.7
Comp Study Landside Toe Elevation	55.3
Comp Study Difference	18.4

Alternatives Report Analysis Levee Crown Elevation	70.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	51.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

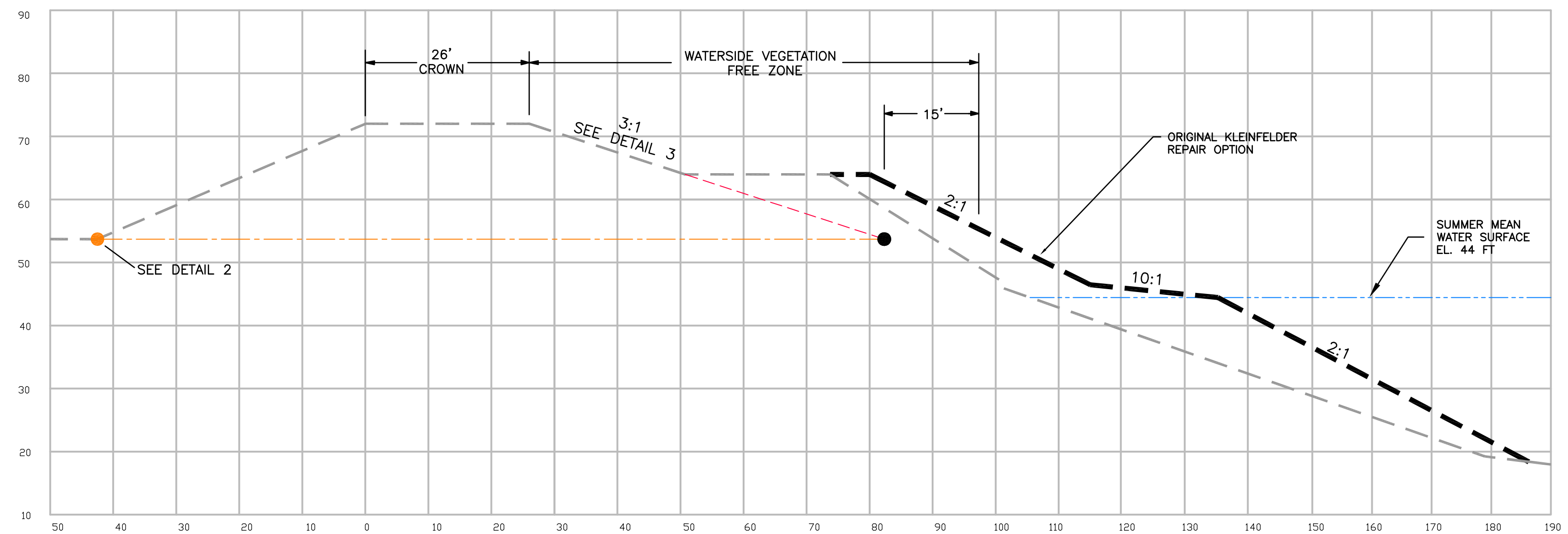
SACRAMENTO RIVER ~ 136.6L

Date: 3/31/11

Figure: SAC 136.6L

DETAIL 1

SACRAMENTO RIVER 138.1L



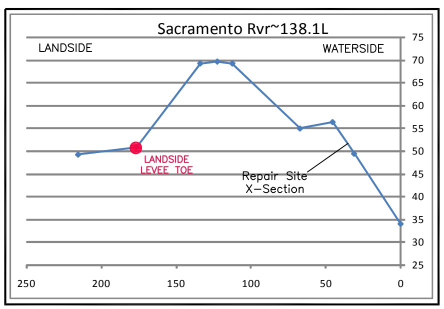
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	34.1
31.1	49.4
45.4	56.3
67.2	54.9
112.3	69.1
122.4	69.5
133.8	69.1
176.3	50.8
215.3	49.2

KEY DATA FOR DETERMINING LANDSIDE TOE

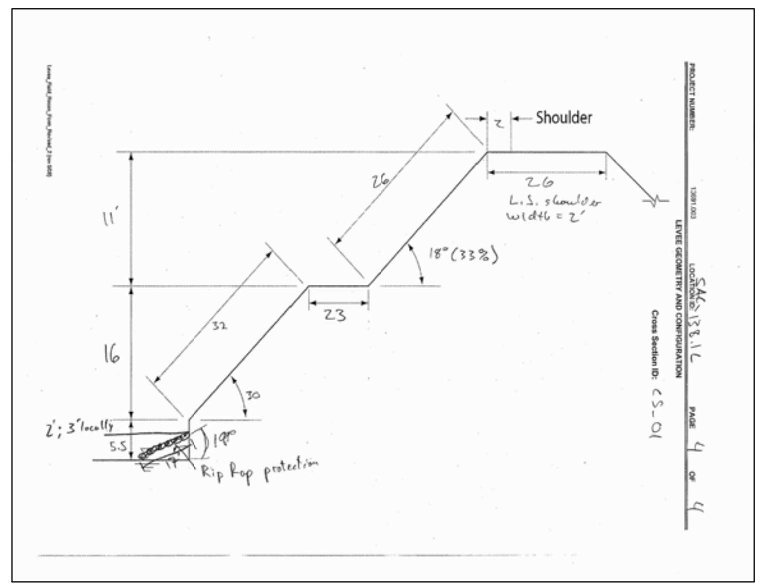
Comp Study Levee Crown Elevation	69.1
Comp Study Landside Toe Elevation	50.8
Comp Study Difference	18.3

Alternatives Report Analysis Levee Crown Elevation	72.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	53.7

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

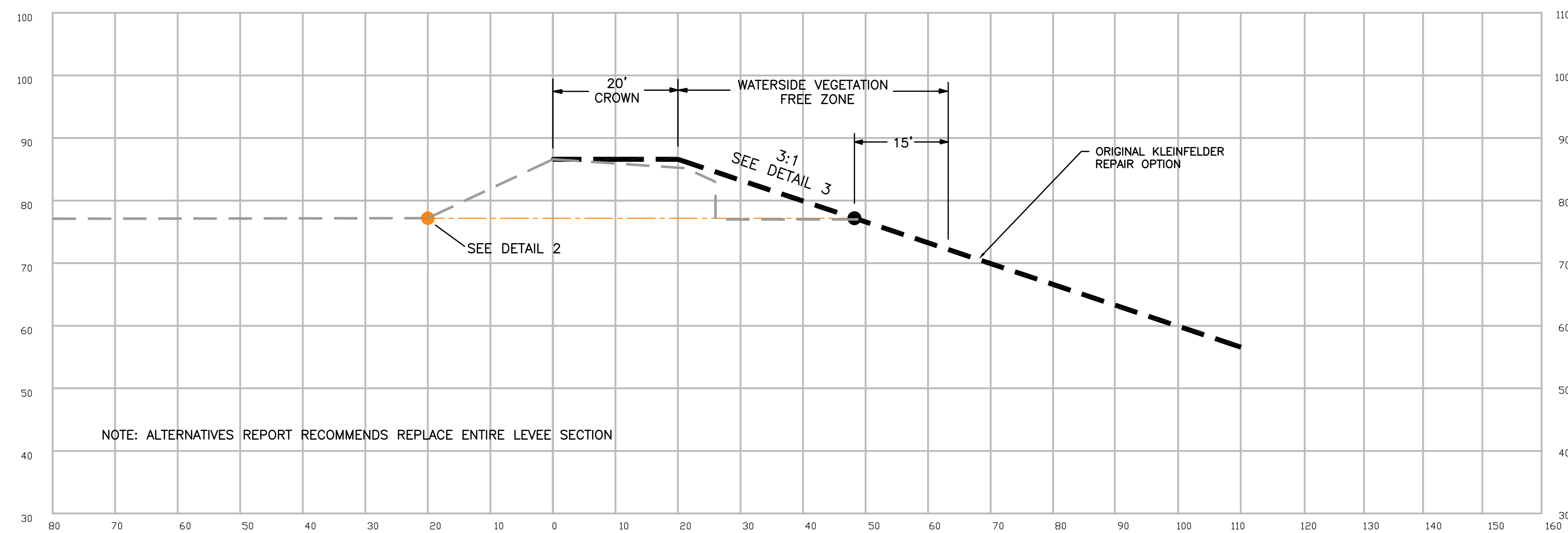
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 138.1L

Date	3/31/11
Figure	SAC 138.1L

DETAIL 1

YUBA RIVER LEVEE 2.3L



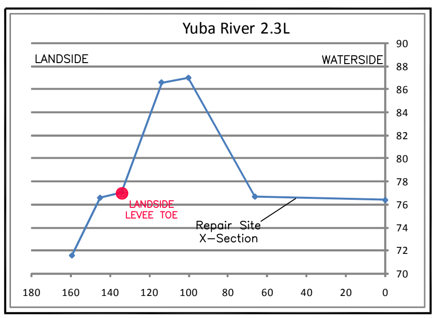
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	76.4
66.2	76.7
100.0	87.0
113.7	86.6
133.9	77.1
144.9	76.6
159.2	71.6

KEY DATA FOR DETERMINING LANDSIDE TOE

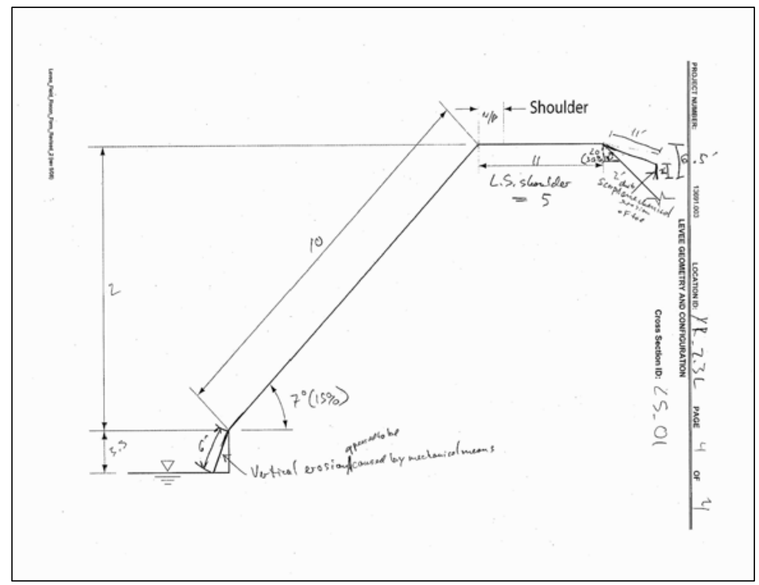
Comp Study Levee Crown Elevation	86.6
Comp Study Landside Toe Elevation	77.1
Comp Study Difference	9.5

Alternatives Report Analysis Levee Crown Elevation	87.5

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	78.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
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HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

YUBA RIVER ~ 2.3L

Date 3/31/11

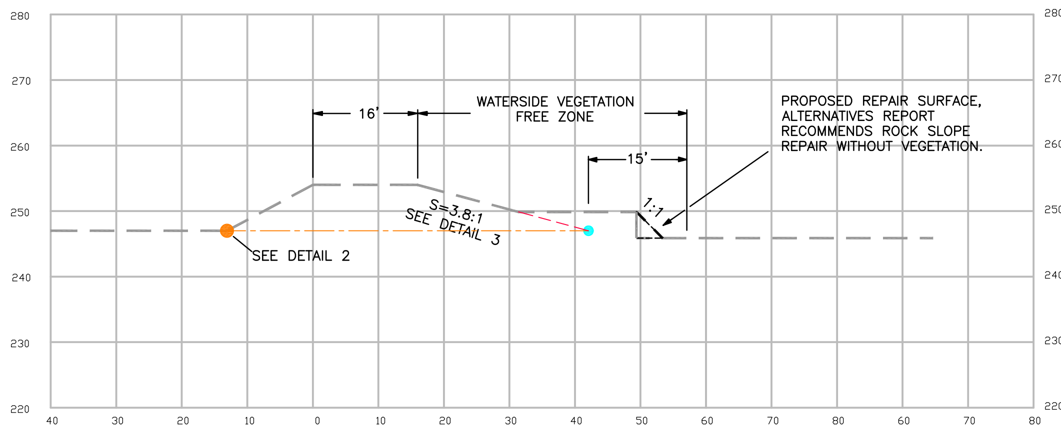
Figure YR 2.3L

DETAIL 1

LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

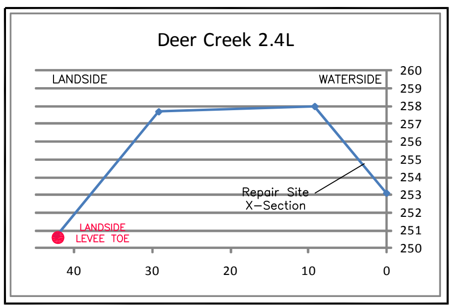
DEER CREEK 2.4L



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	253.1
9.2	258.0
29.2	257.7
42.3	250.7

KEY DATA FOR DETERMINING LANDSIDE TOE

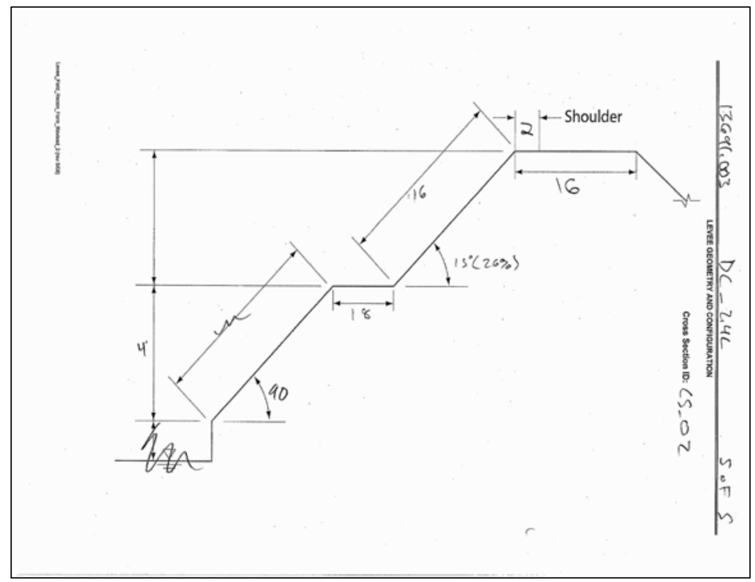
Comp Study Levee Crown Elevation	257.7
Comp Study Landside Toe Elevation	250.7
Comp Study Difference	7.0

Alternatives Report Analysis Levee Crown Elevation	254.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	247.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

DEER CREEK LEVEE ~ 2.4L

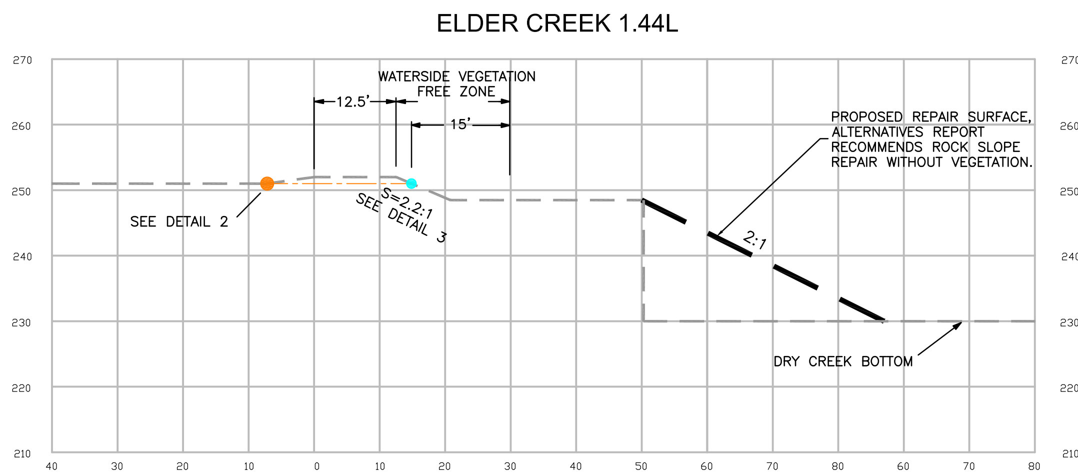
Date 3/31/11

Figure DC 2.4L

DETAIL 1

LEGEND

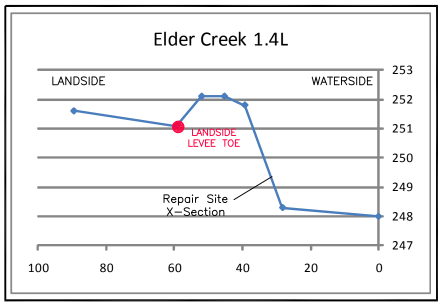
- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	248.0
28.2	248.3
39.3	251.8
45.3	252.1
52.0	252.1
59.3	251.1
89.6	251.6

KEY DATA FOR DETERMINING LANDSIDE TOE

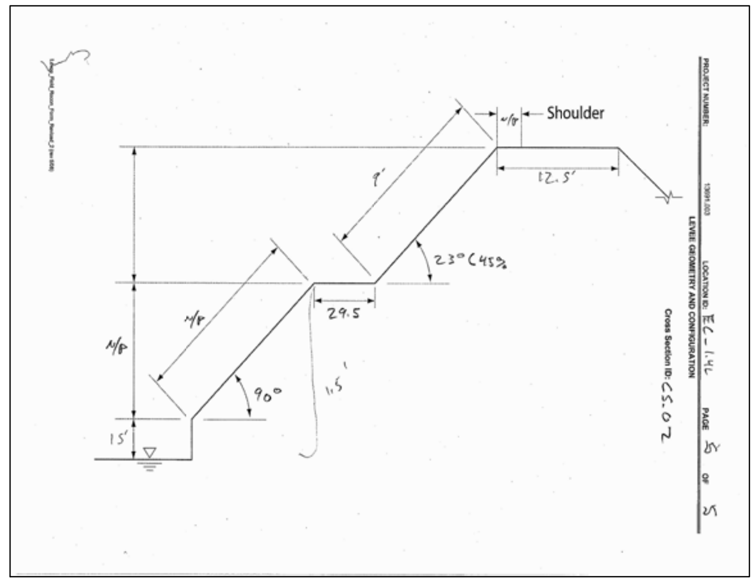
Comp Study Levee Crown Elevation	252.1
Comp Study Landside Toe Elevation	251.1
Comp Study Difference	1.0

Alternatives Report Analysis Levee Crown Elevation	252.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	251.0

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

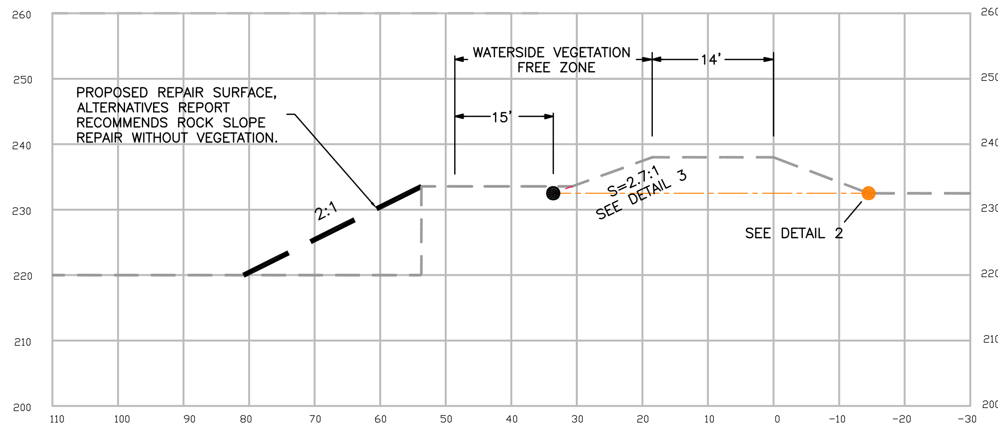
ELDER CREEK ~ 1.4L

Date	3/31/11
Figure	EC 1.4L

DETAIL 1

LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE

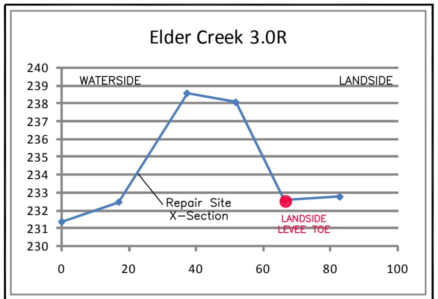
ELDER CREEK 3.0R



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	231.4
17.0	232.5
37.3	238.6
51.8	238.1
66.3	232.6
82.8	232.8

KEY DATA FOR DETERMINING LANDSIDE TOE

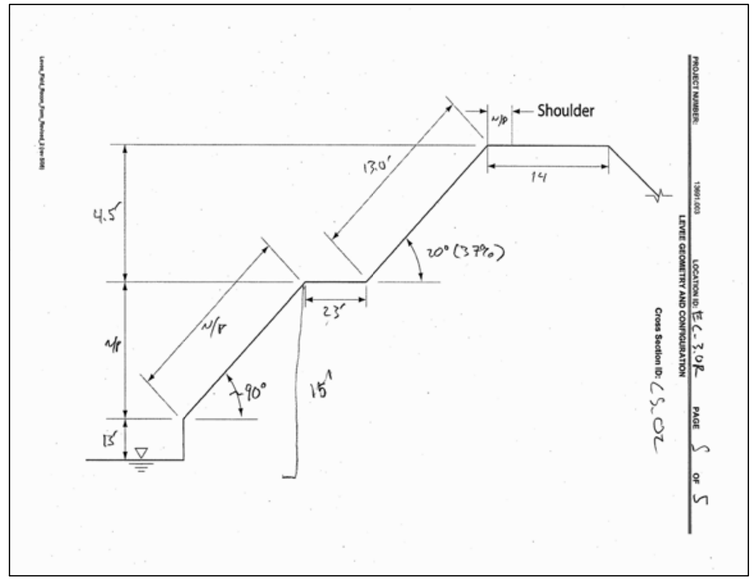
Comp Study Levee Crown Elevation	238.1
Comp Study Landside Toe Elevation	232.6
Comp Study Difference	5.5

Alternatives Report Analysis Levee Crown Elevation	238.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	232.5

DETAIL 3

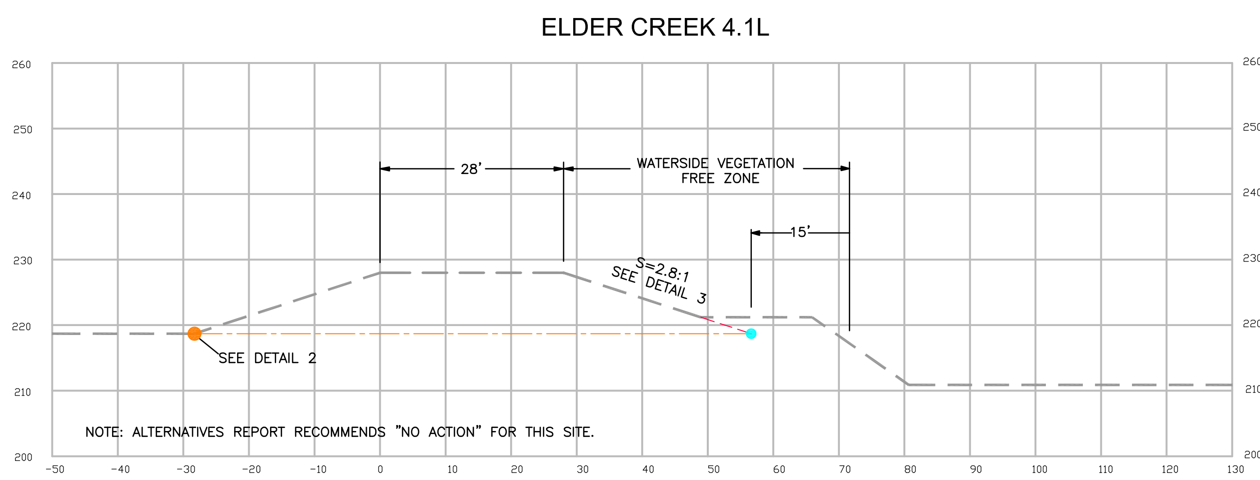
ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	ELDER CREEK ~ 3.0R
Date: 3/31/11	Figure: EC 3.0R		

DETAIL 1

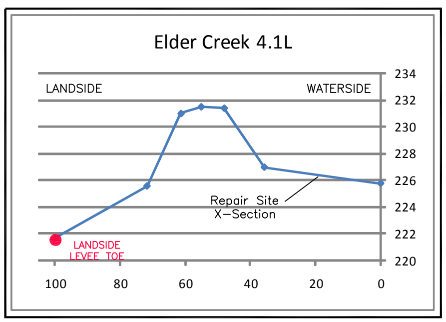
LEGEND
EXISTING LEVEE SURFACE
ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
PROJECTED LANDSIDE LEVEE TOE
WATER SURFACE
PROJECTED WATERSIDE SLOPE



DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	225.8
35.8	227.0
48.1	231.4
55.2	231.5
61.4	231.0
71.9	225.6
100.3	221.7

KEY DATA FOR DETERMINING LANDSIDE TOE

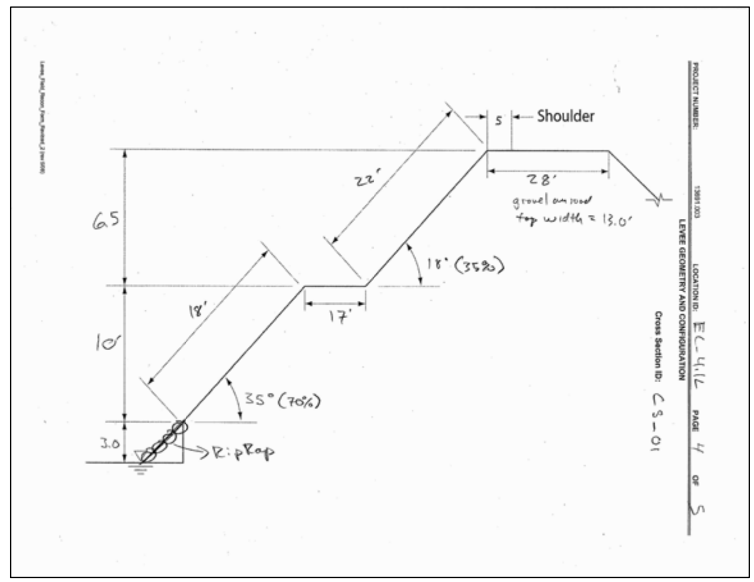
Comp Study Levee Crown Elevation	231.0
Comp Study Landside Toe Elevation	221.7
Comp Study Difference	9.3

Alternatives Report Analysis Levee Crown Elevation	228.0

Landside Toe Calculated by: (Alt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	218.7

DETAIL 3

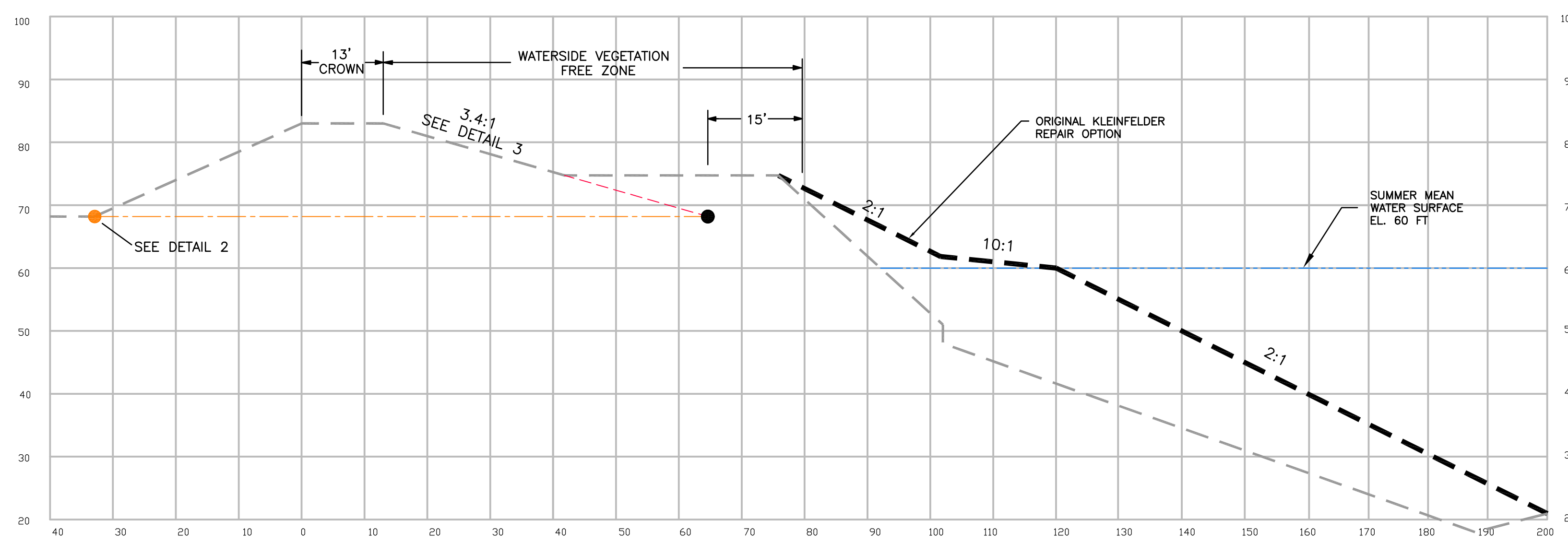
ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project Phase II Post Authorization Change Programmatic Plan Framework Memorandum	HDR Engineering, Inc.	Drawn By: E. Smith Checked By: R. Little QA/QC Review: D. Teak	ELDER CREEK ~ 4.1L	Date 3/31/11 Figure EC 4.1L

DETAIL 1

SACRAMENTO RIVER 152.8L



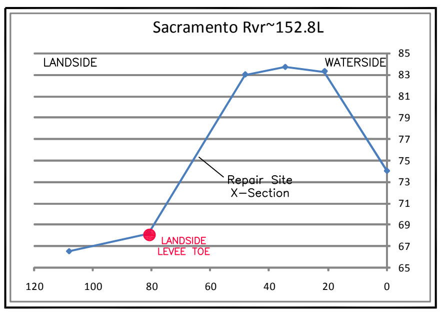
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	74.0
21.2	83.3
34.6	83.7
48.2	83.0
81.1	68.2
108.1	66.5

KEY DATA FOR DETERMINING LANDSIDE TOE

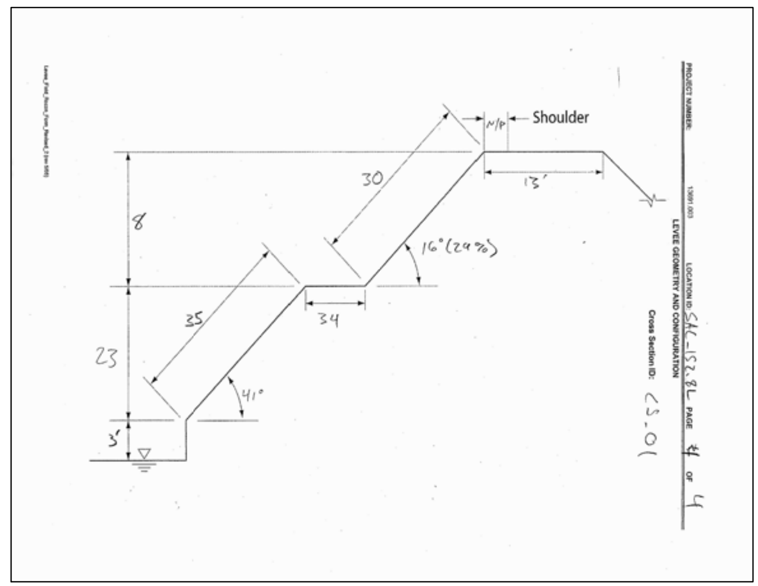
Comp Study Levee Crown Elevation	83.0
Comp Study Landside Toe Elevation	68.2
Comp Study Difference	14.8

Alternatives Report Analysis Levee Crown Elevation	83.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	68.2

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

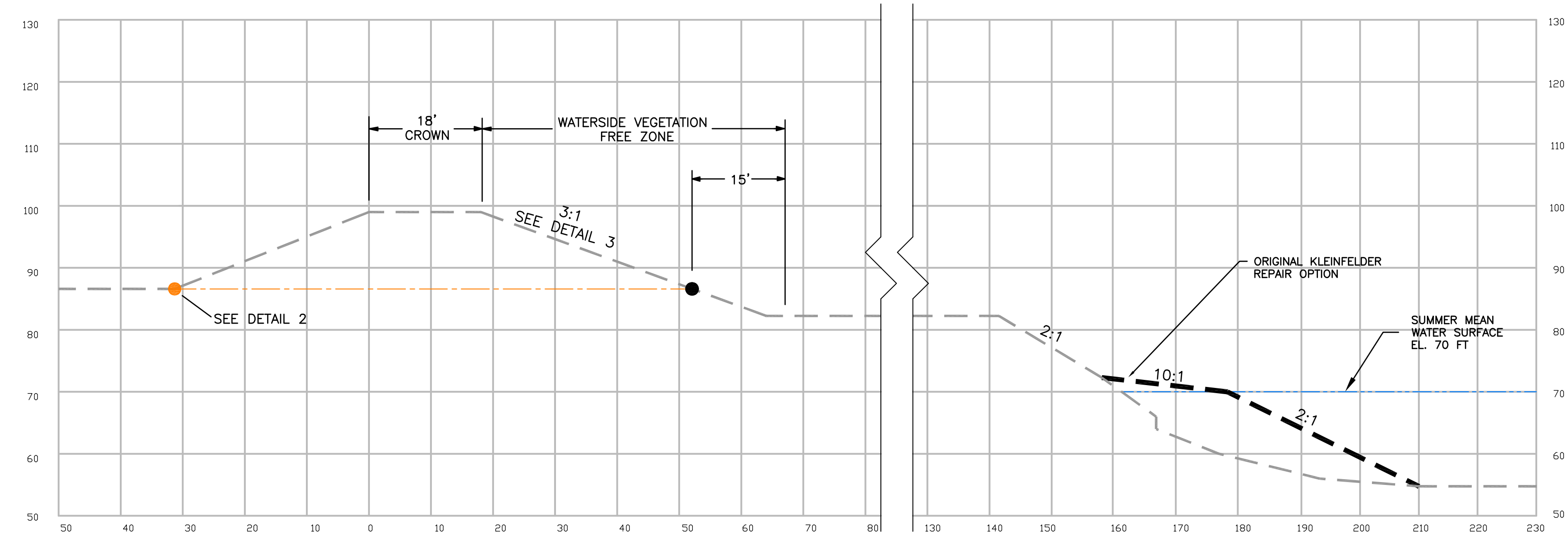
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 152.8L

Date	3/31/11
Figure	SAC 152.8L

DETAIL 1

SACRAMENTO RIVER 163.0L



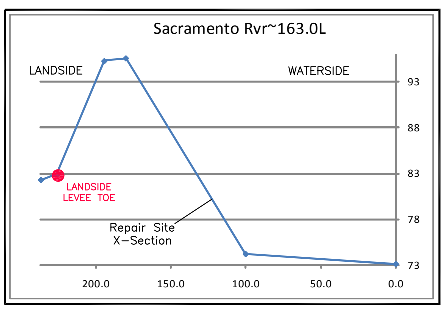
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	73.1
100.2	74.2
180.2	95.6
194.6	95.3
225.9	82.9
236.8	82.3

KEY DATA FOR DETERMINING LANDSIDE TOE

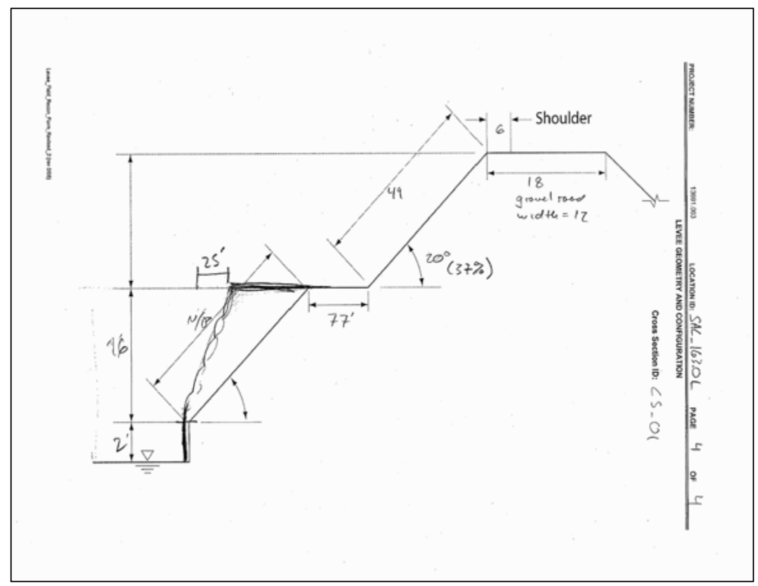
Comp Study Levee Crown Elevation	95.3
Comp Study Landside Toe Elevation	82.9
Comp Study Difference	12.4

Alternatives Report Analysis Levee Crown Elevation	99.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	86.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

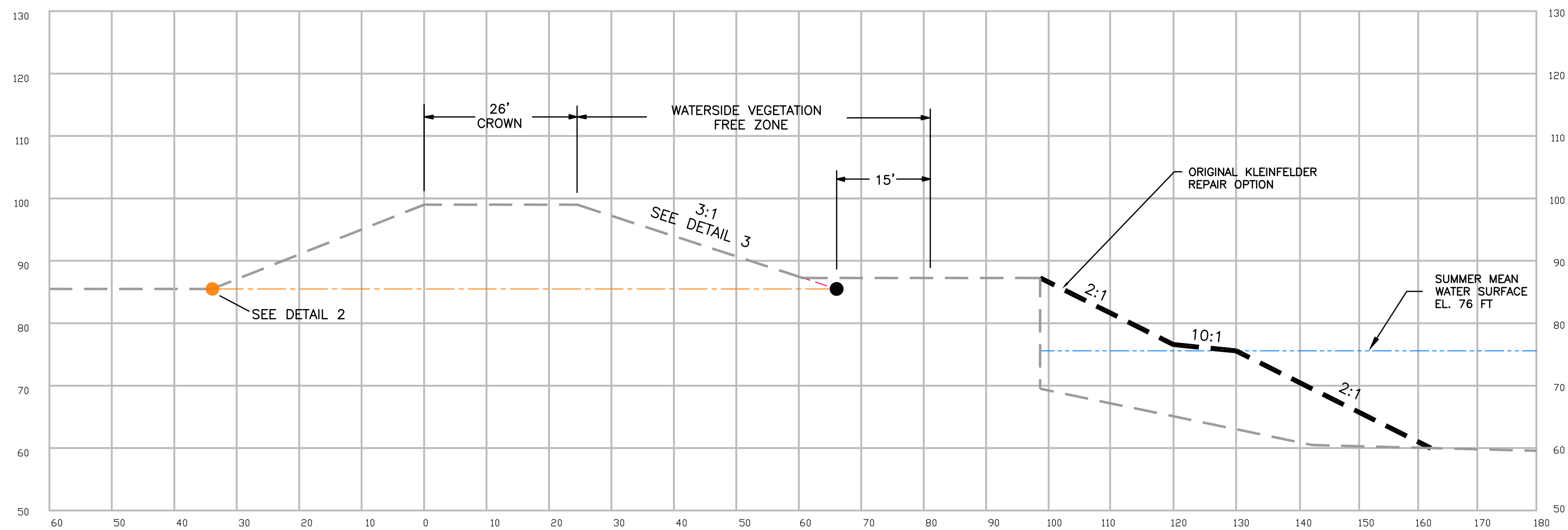
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 163.0L

Date	3/31/11
Figure	SAC 163.0L

DETAIL 1

SACRAMENTO RIVER 168.3L



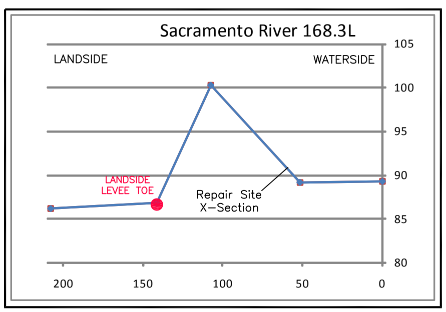
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	89.3
51.7	89.2
55.8	100.3
33.9	86.8
66.3	86.2

KEY DATA FOR DETERMINING LANDSIDE TOE

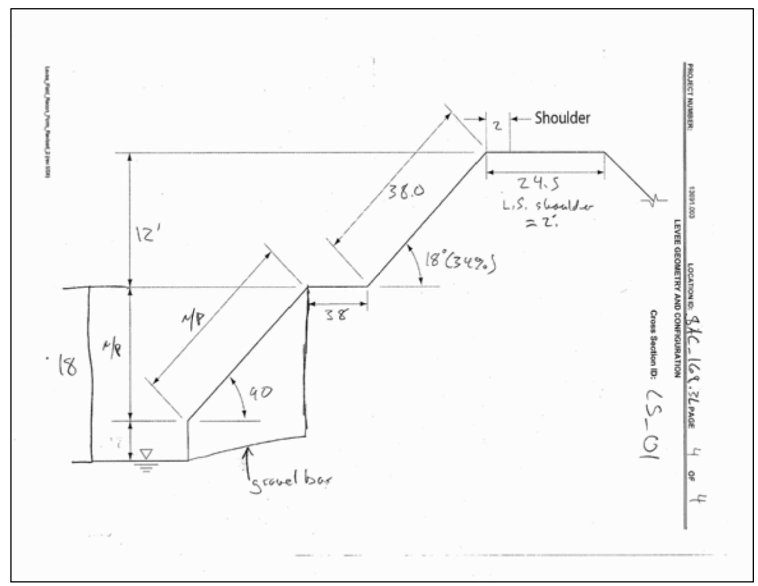
Comp Study Levee Crown Elevation	100.3
Comp Study Landside Toe Elevation	86.8
Comp Study Difference	13.5

Alternatives Report Analysis Levee Crown Elevation	99.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	85.5

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

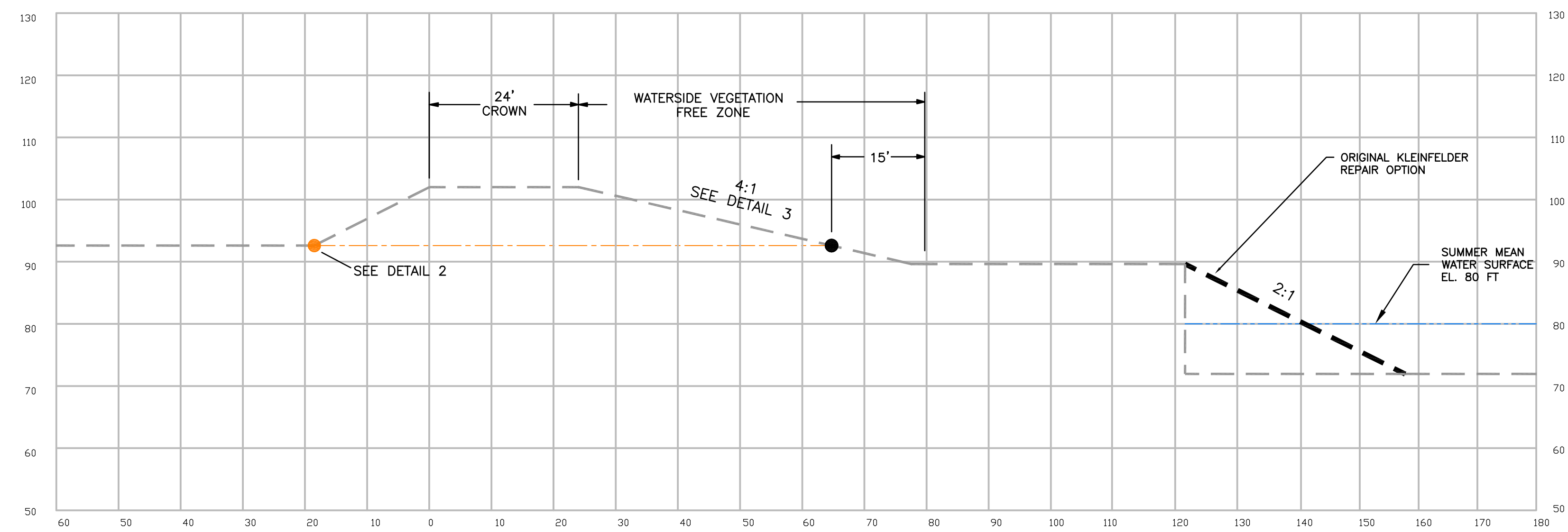
Drawn By:	E. Smith
Checked By:	R. Little
QA/QC Review:	D. Teak

SACRAMENTO RIVER ~ 168.3L

Date	3/31/11
Figure	SAC 168.3L

DETAIL 1

SACRAMENTO RIVER 172.0L



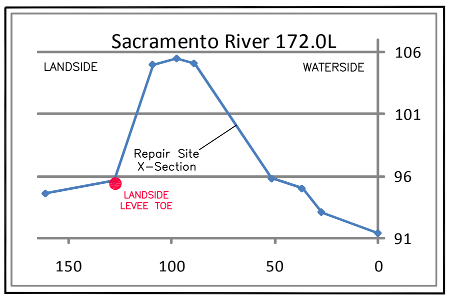
LEGEND

- EXISTING LEVEE SURFACE
- ALTERNATIVES REPORT PROPOSED REPAIR SURFACE
- PROJECTED LANDSIDE LEVEE TOE
- WATER SURFACE
- PROJECTED WATERSIDE SLOPE

DETAIL 2

ESTABLISH LANDSIDE TOE

CROSS-SECTION FROM DWR COMPREHENSIVE STUDY



Comp Study Data Points	
Horizontal Distance to Data Point	Elevation at Data Point
0.0	91.4
27.4	93.1
36.8	95.0
51.4	95.8
89.0	105.1
97.3	105.5
109.0	105.0
127.5	95.6
160.8	94.6

KEY DATA FOR DETERMINING LANDSIDE TOE

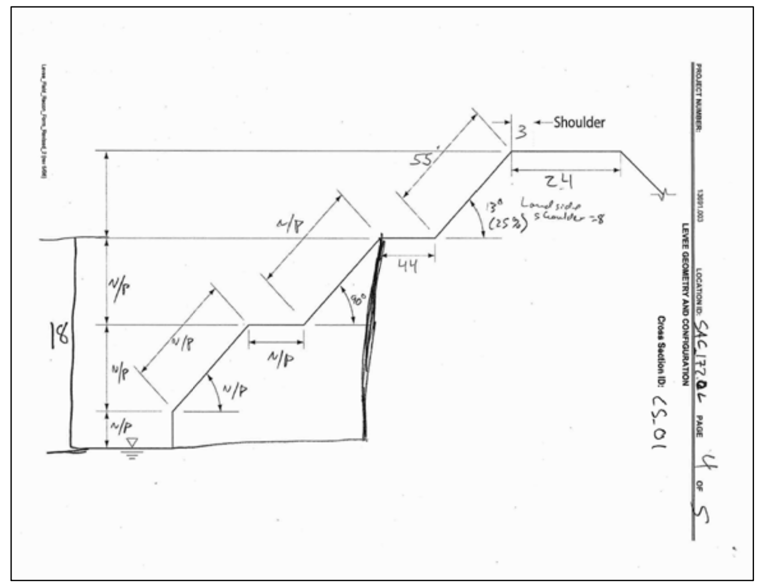
Comp Study Levee Crown Elevation	105.0
Comp Study Landside Toe Elevation	95.6
Comp Study Difference	9.4

Alternatives Report Analysis Levee Crown Elevation	102.0

Landside Toe Calculated by: (ALt. Report Crown Elev.) - (Comp Study Difference)	
Determined Landside Toe	92.6

DETAIL 3

ALTERNATIVES REPORT (80,000LF) FIELD NOTES



Sacramento River Bank Protection Project
Phase II Post Authorization Change
Programmatic Plan Framework Memorandum

HDR Engineering, Inc.

Drawn By: E. Smith
Checked By: R. Little
QA/QC Review: D. Teak

SACRAMENTO RIVER ~ 172.0L

Date 3/31/11

Figure SAC 172.0L

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Subappendix 3. Geotechnical

Sacramento River Bank Protection Project
Geotechnical Appendix
23 August 2011

1. Introduction. The Sacramento River Bank Protection Project (SRBPP) is authorized to protect the river banks of the Sacramento River Flood Control Project (SRFCP) from erosion. The majority of the river banks along the SRFCP consist of unconsolidated materials that are erosive in nature.

2. Background. In the late 1800s the flood capacity of the Sacramento River and its tributaries was greatly reduced due to debris from hydraulic mining. This also impaired navigation on the Sacramento River and its tributaries. Therefore, one design feature of the SRFCP was to encourage removal of debris by increasing flow velocity to induce scour. This was accomplished by reducing river meander at key locations by setting levees near the river banks. Currently, the majority of debris, including natural sediments, had been removed by scoured. The river continues to actively erode the banks as it continues to adjust to natural and human-caused events.

The SRBPP was originally authorized in 1960 to repair eroded river banks within the SRFCP and has included subsequent authorizations and phases. The original Phase II authorization was in 1974 and is nearing completion. Congress has authorized an additional 80,000 linear feet of erosion control work for Phase II per the Water Resources Development Act (WRDA) 2007.

3. Erosion Protection. The SRBPP Phase II is authorized to protect the banks (river banks and levees if no river bank exists) within the SRFCP system from erosion. This will be accomplished by either: 1) repair of existing bank by placement of erosion resistant materials or 2) widen the waterside berm by setting the levee back and allow the river to erode the bank as part of the rivers natural meandering process.

This Engineering Document Report (EDR) is programmatic. Therefore, geotechnical analysis and design will be conceptual and will be based on available geotechnical information and geotechnical engineering judgment.

Subsequent to this programmatic EDR, site-specific geotechnical analysis will be performed during site-specific EDRs and site-specific Design Document Reports (DDR). The complexity of the geotechnical analysis will be dependent on the site specific conditions.

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Subappendix 4. Hydrology

Sacramento River Bank Protection Project
Phase II

Post-Authorization Change

Hydrology
Appendix

March 2011

STATEMENT OF TECHNICAL REVIEW
COMPLETION OF DISTRICT QUALITY CONTROL REVIEW

The District has completed the Phase II Post-Authorization Change Hydrology Appendix for the Sacramento River Bank Protection Project. Notice is hereby given that (1) a Quality Assurance review has been conducted as defined in the Quality Assurance Plan and (2) a district level technical review that is appropriate to the level of risk and complexity inherent in the project, has been conducted as defined in the project's Quality Management Plan. During the district level technical review, compliance with established policy principles and procedures, utilizing justified and valid assumptions, was verified. This included review of: assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the result, including whether the product meets the customer's needs consistent with law and existing Corps policy. The district level technical review was accomplished by a senior hydraulic engineer. All comments resulting from QA have been resolved.

The project hydrology covered under this quality control certification includes a description, with documentation, of the Comprehensive Study methodology used to develop frequency estimates and balanced 30-day hydrographs used to develop hydraulics information for the Sacramento River Bank Protection Project.

Steven F. Holmstrom

Steven F. Holmstrom, P.E.
DQC Reviewer, Sacramento District

6/8/2011
Date

Laurine L. White

Laurine L. White
Hydrologist, Sacramento District

8 June 2011
Date

CERTIFICATION OF DISTRICT QUALITY ASSURANCE REVIEW

I certify that an independent technical review at the District Quality Control level of the project indicated above has been completed and that all technical issues have been identified and resolved. I certify that the quality control process at the District level has been completed.

John M. High

John M. High
Chief, Hydrology Section

6/8/2011
Date

Sacramento River Bank Protection Project Phase II
Post-Authorization Change
Hydrology Technical Documentation

EXECUTIVE SUMMARY

Scope. This Attachment (hydrology documentation) describes the development of the existing conditions synthetic hydrology for the Sacramento River Bank Protection Project. The project uses the existing hydrology for the Sacramento and San Joaquin River Basins Comprehensive Study (Comp Study). Hydrology documentation includes (1) Yuba River Basin Project General Reevaluation Report (Yuba GRR), Appendix A, "Synthetic Hydrology and Reservoir Operations Technical Documentation," dated April 2004, revised 2008, and (2) Hydrology Technical Documentation, Appendix B1 and B2, for the "Post-Authorization Change Report and Interim General Reevaluation Report, American River Watershed Common Features Project (ARCF GRR), Natomas Basin, Sacramento and Sutter Counties, California," dated August 2010. Documentation referenced here, but not included, is the Comp Study Technical Studies Documentation, Appendices B and C, dated December 2002.

Background. The Sacramento River Flood Control Project is a system of levees, weirs, pumping plants, and bypasses designed to safely convey Sacramento River and tributary flood flows. There are approximately 1,300 miles of project levees in this system, as shown on Figures 1 and 2. The Sacramento River Bank Protection Project (SRBPP) is a Federal program for inspecting the levees and associated natural banks and berms, identifying and ranking erosion problems, and providing remedial fixes. Phase I of the SRBPP was constructed from 1963 to 1975, and consisted of 430,000 linear feet of bank protection. Due to continued erosion problems, SRBPP Phase II was authorized in 1974 to repair an additional 405,000 linear feet of bank protection. The Water Resources Development Act of 2007 authorized an additional 80,000 linear feet of bank protection as part of the Phase II effort.

Comprehensive Study Methodology. The SRBPP is using existing conditions Comp Study hydrology, which is anticipated to be adequate for determining water surface profiles for the levee reaches included in the SRBPP. The existing hydrology for the SRBPP is based upon the storm centering method described in the Comp Study Technical Studies Documentation, Appendices B and C. Appendix B describes the development of unregulated synthetic hydrographs for specific flood frequencies at particular watershed locations, while Appendix C presents the transformation of the unregulated conditions synthetic hydrology to regulated conditions. The Yuba GRR Hydrology Appendix, included in the attached documentation, presents a shorter description of the Comp Study methodology in Chapter 2. The Comp Study synthetic hydrology represents the best available information for the sources of flooding against the levees in the SRBPP. The Common Features hydraulic model (HEC-RAS) was used to route the upstream synthetic flood hydrographs through the open channels, weirs, bypasses and storage areas to develop the water surface profiles down the Sacramento River and its tributaries. Comp Study hydrology has also been used for regional studies, such as the American River Common Features, Yuba River Basin, Sutter Basin, Marysville, and West Sacramento studies.

Synthetic Flood Centerings. Two Comp Study mainstem flood centerings (Ord Ferry and Latitude of Sacramento) and ten tributary flood centerings, including Shanghai-Yuba, were investigated in the development of existing conditions hydrology for the Sacramento watershed covered by the SRBPP levees. ARCF GRR Hydrology Appendix B1, Synthetic Hydrology Technical Documentation discusses the three flood centerings: the Latitude of Sacramento mainstem, the Shanghai-Yuba, and the tributary American River, used to develop hydrographs for the ARCF GRR hydrology. The Comp Study Technical Studies Documentation, Appendix B, discusses the other mainstem flood centering (Ord Ferry) and the rest of the tributary flood centerings.

Synthetic Flood Reservoir Operations. The Comp Study Technical Studies Documentation, Appendix C, discusses the reservoir operations involved in the transformation process of converting the unregulated flood hydrographs to regulated hydrographs. Operation of the reservoirs is as described in Appendix C, with the exception of Folsom Dam and Lake. ARCF GRR Appendix B2, American River Hydrology and Folsom Dam Reservoir Operations, discusses the changes to the American River flood hydrographs and in the operation of Folsom Dam. The concurrent American River flows in the Comp Study centerings include existing conditions operations for Folsom Dam (SAFCA diagram) with a 145,000 cfs maximum objective release and a future condition Joint federal Project (JFP) with a maximum objective release of 160,000 cfs. Development of a new Water Control Diagram is in progress that may change the future condition flows, although the maximum objective release is not expected to change.

Upstream Conditions Assumption. The assumption for upstream conditions is that levees upstream will not fail but will be overtopped as the water surface exceeds the top of levee. This condition was used in earlier studies.

Basis for SRBPP Flood Stages. Hydrology from the 2002 Comp Study, the 2004 Yuba Basin Project, and Folsom Dam modifications from the 2010 ARCF GRR was used by Hydraulic Design Section to develop stages for this analysis. The Comp Study uses the “Composite Floodplain” concept, which recognizes that the stages generated through modeling are not created by a single flood event, but by a combination of several events, each of which shapes the stage at different locations. The stages for the levee stretches shown on Figures 1 and 2 are based on the combination of the two mainstem and ten tributary centerings that resulted in the maximum stage possible at all locations.

In future, the Comp Study Hydrology may be used with UNET modeling to determine boundary conditions for site specific 2D models for hydraulic analysis and design.

Hydrology for Sea Level Change Analysis Report. The 50% and 1% chance flood hydrographs down the Yolo Bypass and Sacramento River from the Comp Study hydrology were used for the Common Features hydraulic model used for the SRBPP Sea Level Change Analysis Report prepared by the Corps Hydraulic Design Section. Inflow assumptions for the Yolo Bypass model included a constant 1,000 cfs flow contribution down the Willow Slough Bypass and 100 cfs flow apiece for Haas, Cache, and Lindsey sloughs.

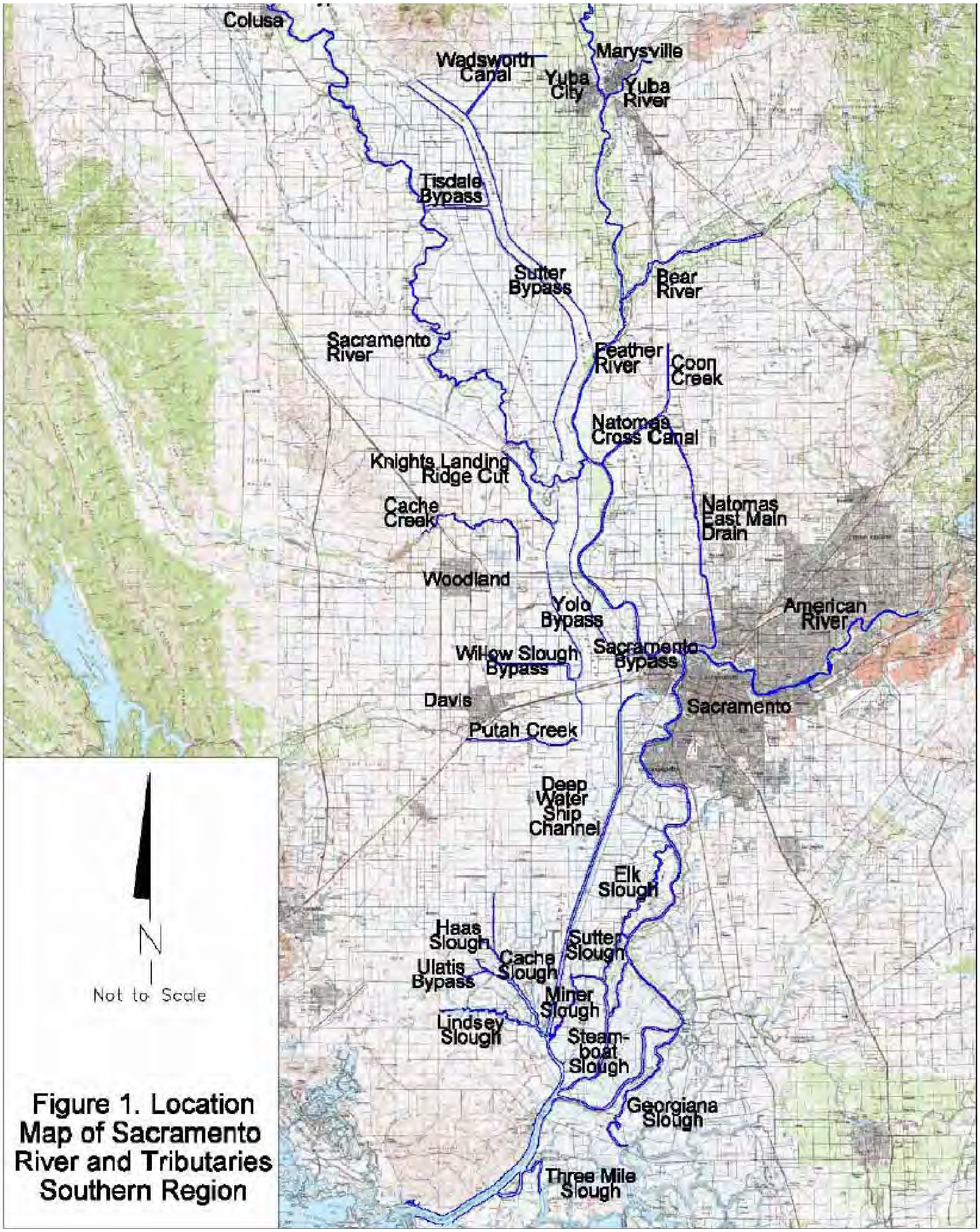

Figure 1. Location Map of Sacramento River and Tributaries Southern Region

Source: Ayers Associates, Inc. *2007 – Field Reconnaissance Report, Erosion Site Inventory and Priority Ranking*, December 18, 2007

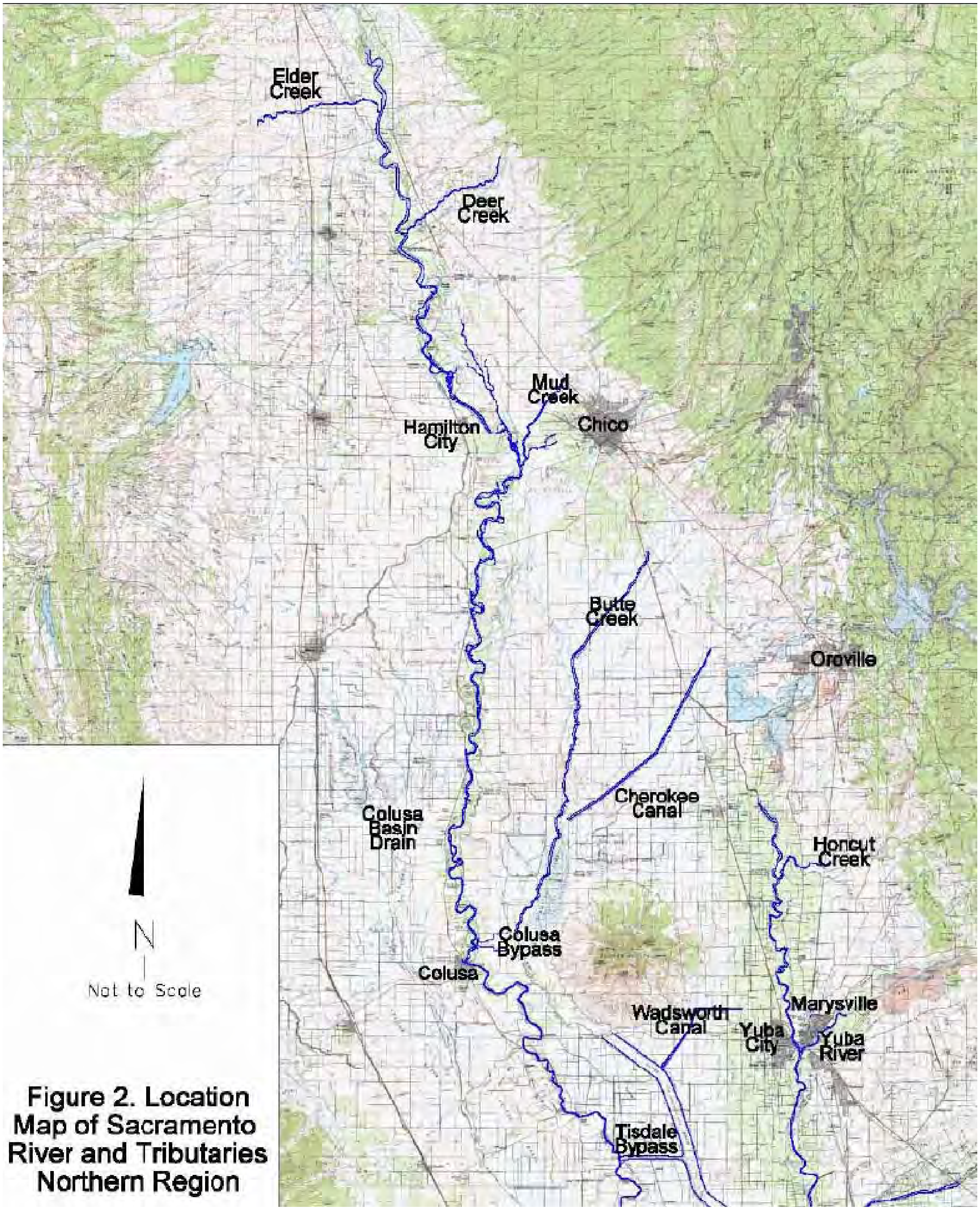

Figure 2. Location Map of Sacramento River and Tributaries Northern Region

Source: Ayers Associates, Inc. *2007 – Field Reconnaissance Report, Erosion Site Inventory and Priority Ranking*, December 18, 2007

The attached hydrology documentation is included below as follows:

Yuba River Basin Project General Reevaluation Report Appendix A, revised June 2008

Post-Authorization change Report and Interim General Reevaluation Report, American River Watershed Common Features Project, Natomas Basin, Sacramento and Sutter Counties, California, Appendix B (Appendices B1 and B2) – Hydrology Technical Documentation, dated August 2010

The Comprehensive Study Technical Documentation is available on the internet at URL: http://130.165.3.37/reports.html.

Yuba River Basin Project
General Reevaluation Report

Appendix A

Synthetic Hydrology and Reservoir Operations
Technical Documentation

April 2004
(Corrected June 2008)

U.S. Army Corps of Engineers
Sacramento District

Corrections

The April 2004 version of this report contained an error in the labeling of Tables 2 and 3 (here corrected to 1 and 2). In this June 2008 version, Table 1 is now correctly labeled Feather River Above Shanghai Bend Storm Centering A *with a Specific Centering on the Yuba River*, and Table 2 is labeled Feather River Above Shanghai Bend Storm Centering B *with a Specific Centering Above Oroville*. The italicized portions of each label were previously reversed.

The New Bullards Bar release schedule has also been added, as Table 6.

WATER MANAGEMENT SECTION
CERTIFICATION FOR INDEPENDENT TECHNICAL REVIEW

Yuba River Basin Project General Reevaluation Report
Appendix A, Synthetic Hydrology and Reservoir Operations
Technical Documentation, Sacramento District
April 2004, Revised June 2008

GENERAL FINDINGS

Compliance with clearly established policy, principles, and procedures, utilizing clearly justified and valid assumptions, has been verified for the subject project. This includes assumptions; methods, procedures and materials used in the analyses; the appropriateness of data used and level of data obtained; and the reasonableness of the results, including whether the product meets the customers' needs consistent with law and existing Corps criteria and policy.

I certify that an independent technical review of the project indicated above has been completed and all technical issues have been identified and resolved. I recommend certification that the quality control process has been completed.

In accordance with CESPD R 11 10-1-8, South Pacific Division Quality Management Plan, May 2000, this letter certifies that the without-project hydrology is appropriate as the basis for use in the hydraulic analysis for the Yuba River Basin Project General Reevaluation.

Laurine L. White — 17 July 2008

Laurine L. White
Hydrologist, SPK

Date

James Chieh — 17 July 2008

James Chieh
Independent Technical Reviewer

Date

Edwin Townsley — 7/17/08

Edwin Townsley
Chief, Water Management Section, SPK

Date

SYNTHETIC HYDROLOGY & RESERVOIR OPERATIONS TECHNICAL DOCUMENTATION

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CHAPTER 1

INTRODUCTION

AUTHORITY

The Yuba River Basin, California Final Feasibility Report and Appendices dated April 1998 and approved by Chief of Engineers on November 25, 1998, was authorized by the Water Resources Development Act of 1999. Since the final Yuba River Basin Project was authorized, geotechnical investigations and new hydrology have identified previously unknown levee foundation problems in portions of the specifically authorized project. The preliminary design to effectively maintain the level of protection described in the Feasibility Report will cause the cost of the project to exceed the Section 902 cost limit of the Water Resources Development Act of 1986 for the specifically authorized project. Since flooding is still a significant problem for the affected communities along the Yuba and Feather Rivers, the Reclamation Board has requested that the Corps initiate a re-evaluation of the project. The reevaluation will not be limited to the elements of the authorized project, and new alternatives will be examined.

STUDY AREA

The study area is located in Yuba County about 50 miles north of Sacramento in northern California. The area encompasses the lower Yuba River basin and part of the Feather River basin and includes parts of the eastern Sacramento Valley and Sierra foothills. Elevations in the Yuba River basin range from 30 feet above sea level near the Feather River to over 9,100 feet in the Sierra Nevada. Located in the upper basin are the three forks of the Yuba River. New Bullards Bar Reservoir is located on the north fork, and the other two forks contain a number of much smaller reservoirs. Urban areas include Marysville, Linda, and Olivehurst. The areas of interest for the LRR are the levees surrounding the City of Marysville, 6.1 miles of levee on the left bank of the Yuba River upstream with the confluence with the Feather River, and approximately 10 miles of the left bank of the Feather River downstream of the confluence with the Yuba River.

PURPOSE OF DOCUMENTATION

This appendix documents the hydrology and reservoir operation modeling efforts conducted in support of the Yuba River Basin GRR. This work included both the use of existing technical information obtained from other studies, such as the Comprehensive Study, and new hydrologic analysis. The hydrology developed from the models was used in HEC-RAS by the Hydraulic Design section to 1) define water surface profiles---profiles that will be used to evaluate possible improvements to existing levees and to design new setback levees, and 2) to provide frequency-discharge-stage information required for evaluation of project performance at index locations.

REFERENCES

1. U.S. Army Corps of Engineers. 1999. Rain Flood Flow Frequency Analysis, Feather and Yuba Rivers, California. Sacramento District. Sacramento, California.
2. U.S. Army Corps of Engineers. 2003. Sacramento and San Joaquin River Basins Comprehensive Study, Reservoir Simulation Model User's Guide. Sacramento District. Sacramento, California.
3. U.S. Army Corps of Engineers. 2002. Sacramento and San Joaquin River Basins Comprehensive Study; Technical Studies Documentation, Appendix B, Synthetic Hydrology Technical Documentation. Sacramento District. Sacramento, California.
4. U.S. Army Corps of Engineers. 2002. Sacramento and San Joaquin River Basins Comprehensive Study; Technical Studies Documentation, Appendix C, Reservoir Operations Modeling. Sacramento District. Sacramento, California.

CHAPTER 2

FEATHER RIVER HYDROLOGY & RESERVOIR OPERATION MODELING

GENERAL

The hydrologic analysis for this region focused on the development of a storm that is centered on the Feather River. The Comprehensive Study developed tributary storm centerings on the Feather River at Oroville Dam and the Yuba River at Marysville. However, in order to determine the maximum inundation areas along the lower reaches of the Feather and Yuba rivers, another storm centered at both Shanghai Bend (near the confluence of the Yuba River with the Feather River) and at Verona (near the confluence of the Feather River with the Sacramento River) was needed. Comprehensive Study methods were adopted to derivate this new storm centering.

Reservoir modeling for the Feather and Yuba rivers was done with ResSim, the new software package developed by HEC in support of the Corps Water Management System (CWMS). Resulting regulated hydrographs from the ResSim model were used as input into the hydraulic model (HEC-RAS) to determine river stages and floodplain delineation. The hydrograph "handoff" locations included the Feather River at Oroville, Yuba River at Englebright, Bear River near Wheatland, and locations on other smaller tributaries (Honcut Creek, Deer Creek on the Yuba River, Dry Creek on the Yuba River, and Dry Creek on the Bear River). The analysis discussed in this chapter was conducted in support of three major studies in the area including the Yuba River Basin Project, the Sutter County Feasibility Study, and the Lower Feather Floodplain Mapping Study.

HYDROLOGIC ANALYSIS

Hypothetical Storm Pattern Generation

The intent of this hydrologic analysis is to prepare a hypothetical storm pattern and flood hydrographs that can be fed into reservoir system and hydraulic models for each frequency event (50-, 10-, 4-, 2-, 1-, 0.8-, 0.67-, 0.57-, 0.5-, and 0.2-percent chance exceedences). In order to define floodplains for the entire reach of the Feather River, synthetic storms centered over this area were developed. The Comprehensive Study includes a number of synthetic storms that produce large floods along the Feather and Yuba rivers, including storms centered at Oroville Dam on the Feather River, Marysville on the Yuba River, and at the Latitude of Sacramento (Reference 3). However, in order to determine the maximum inundation areas along the lower reaches of the Feather and Yuba rivers, another storm centered both at Shanghai Bend (near the confluence of the Yuba River with the Feather River) and at Verona (near the confluence of the Feather River with the Sacramento River) was needed.

Large floods at Shanghai Bend result from the combination of high flows from both the Yuba River and Upper Feather River. Historically, large events occurring at Shanghai Bend have resulted from rare events occurring on the Upper Feather River (above Oroville) and also on the Yuba River, with one of these rivers having a slightly rarer event than the other. For example, in 1997 a slightly less frequent event occurred at Oroville than on the Yuba River at Marysville and in 1965, Marysville experienced a less frequent event than at Oroville. However, in both of these years, large floods occurred at Shanghai Bend. Because of the possibility that either scenario could happen, two different hypothetical storm patterns were produced. These storm patterns are shown in Tables 1 and 2. Table 1 shows the storm patterns (actually, flood patterns expressed as percent chance exceedence floods) for the Yuba River centering. The synthetic exceedence frequencies are assigned to each tributary in column 1 in such a way that the regulated and routed hydrographs for the Feather River, Yuba River, and Deer Creek have the volumes for a flood series centered at Shanghai Bend downstream of the Feather-Yuba confluence. The specific storm centerings (Storm Centering A) are on the two Yuba River index points; the concurrent storms are on the Feather River at Oroville.

TABLE 1
Feather River Above Shanghai Bend Storm Centering A
With a Specific Centering on the Yuba River

Index Point	Percent Chance Exceedence						
	50	**10**	**4**	**2**	**1**	**0.5**	**0.2**
Sacramento R at Shasta	101.01	20.20	8.08	5.77	2.89	1.44	0.58
Clear Cr at Whiskeytown	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Cow Cr nr Millville	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Cottonwood Cr nr Cottonwood	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Battle Cr blw Coleman FH	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Mill Cr nr Los Molinos	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Elder Cr nr Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Thomes Cr at Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Deer Cr nr Vina	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Big Chico Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Stony Cr at Black Butte	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Butte Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Feather R. at Oroville	54.95	10.87	4.35	2.17	1.06	0.53	0.21
Yuba R. at New Bullards Bar	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Yuba R nr Marysville	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Deer Cr nr Smartsville	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Bear R nr Wheatland	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Cache Cr at Clear Lake	153.85	30.77	12.31	6.15	3.08	1.54	0.62
Cache Cr at Indian Valley	153.85	30.77	12.31	6.15	3.08	1.54	0.62
American R at Folsom	76.34	15.27	6.11	3.05	1.53	0.76	0.31
Putah Cr at Berryessa	153.85	30.77	12.31	6.15	3.08	1.54	0.62

Note – The seven frequency storms centered at Shanghai Bend and Verona are the bold values located in the column headers. The concurrent frequency values for each index location are given below each column header. For example, a 2.89% chance exceedence event occurs on the Sacramento River above Shasta Dam during the 1% chance exceedence event centered at Shanghai Bend and Verona.

TABLE 2
Feather River Above Shanghai Bend Storm Centering B With a Specific Centering Above Oroville

Index Point	Percent Chance Exceedence									
	50	**10**	**4**	**2**	**1**	**0.80**	**0.67**	**0.57**	**0.50**	**0.20**
Sacramento R at Shasta	101.01	20.20	8.08	5.77	2.89	2.31	1.92	1.65	1.44	0.58
Clear Cr at Whiskeytown	344.83	68.97	27.59	19.70	9.85	7.88	6.57	5.63	4.93	1.97
Cow Cr nr Millville	196.08	39.22	15.69	11.20	5.60	4.48	3.73	3.20	2.80	1.12
Cottonwood Cr nr Cottonwood	344.83	68.97	27.59	19.70	9.85	7.88	6.57	5.63	4.93	1.97
Battle Cr blw Coleman FH	196.08	39.22	15.69	11.20	5.60	4.48	3.73	3.20	2.80	1.12
Mill Cr nr Los Molinos	76.34	15.27	6.11	4.36	2.18	1.74	1.45	1.25	1.09	0.44
Elder Cr nr Paskenta	140.85	28.17	11.27	8.05	4.02	3.22	2.68	2.30	2.01	0.8
Thomes Cr at Paskenta	140.85	28.17	11.27	8.05	4.02	3.22	2.68	2.30	2.01	0.8
Deer Cr nr Vina	76.34	15.27	6.11	4.36	2.18	1.74	1.45	1.25	1.09	0.44
Big Chico Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.74	1.45	1.25	1.09	0.44
Stony Cr at Black Butte	140.85	28.17	11.27	8.05	4.02	3.22	2.68	2.30	2.01	0.8
Butte Cr nr Chico	76.34	15.27	6.11	4.36	2.18	1.74	1.45	1.25	1.09	0.44
Feather R. at Oroville	50.00	10.00	4.00	2.00	1.00	0.80	0.67	0.57	0.5	0.2
Yuba R. at New Bullards Bar	58.82	10.42	4.76	2.04	1.04	0.84	0.71	0.61	0.54	0.22
Yuba R nr Marysville	58.82	10.42	4.76	2.04	1.04	0.84	0.71	0.61	0.54	0.22
Deer Cr nr Smartsville	125.00	25.00	10.00	5.00	2.50	2.00	1.67	1.43	1.25	0.5
Bear R nr Wheatland	125.00	25.00	10.00	5.00	2.50	2.00	1.67	1.43	1.25	0.5
Cache Cr at Clear Lake	153.85	30.77	12.31	6.15	3.08	2.46	2.05	1.76	1.54	0.62
Cache Cr at Indian Valley	153.85	30.77	12.31	6.15	3.08	2.46	2.05	1.76	1.54	0.62
American R at Folsom	76.34	15.27	6.11	3.05	1.53	1.22	1.02	0.87	0.76	0.31
Putah Cr at Berryessa	153.85	30.77	12.31	6.15	3.08	2.46	2.05	1.76	1.54	0.62

Note – The seven frequency storms centered at Shanghai Bend and Verona are the bold values located in the column headers. The concurrent frequency values for each index location are given below each column header. For example, a 2.89% chance exceedence event occurs on the Sacramento River above Shasta Dam during the 1% chance exceedence event centered at Shanghai Bend and Verona.

There are only subtle differences between these two storm patterns. These differences lie within the index locations on the Feather and Yuba rivers. For storm centering A, exceedence frequency values generated at Shanghai Bend and the Latitude of Verona are the same as the frequency assigned to the Yuba River. However, for storm centering B, the Yuba River experiences a more frequent event, and the Feather River at Oroville is assigned the same exceedence frequency value that is produced at Shanghai Bend and the Latitude of Verona. In other words, storm centering A has more emphasis on the Yuba River, and storm centering B has more emphasis on the Feather River.

In developing these storm centerings, the guidelines for preparation of mainstem centerings developed for the Comprehensive Study were followed (Reference 3). Shanghai Bend and the Latitude of Verona are the bull's eyes of the storm. That is, no other location within the Sacramento River Basin experiences a larger flood than at Shanghai Bend and the Latitude of Verona for the 10 hypothetical storms (50-, 10-, 4-, 2-, 1-, 0.8-, 0.67-, 0.57-, 0.5-, and 0.2- percent chance exceedences). First, the distribution of storm intensity for the Upper Feather and Yuba River basins was developed. Initial exceedence frequency values were assigned to the Yuba River and Feather River index locations. Hydrographs were then constructed at these tributary locations and routed through the system to Shanghai Bend. Duration maxima (peak, 1-, 3-, 7-, 15-, and 30-day) were computed for the hydrographs at Shanghai Bend and compared with the average flows from the frequency curves. The initial pattern was then increased or decreased and the comparison process was repeated until results agreed reasonably with the unregulated rain flood frequency curves.

Once this portion of the pattern was set, the same process was followed for the Latitude of Verona index location. The storm pattern for the rest of the tributary index locations were based upon the average of the Feather and Yuba River storm centerings generated for the Comprehensive Study (Reference 3). This pattern was iteratively adjusted by a fixed percentage until the duration maxima (1-, 3-, 7-, 15-, and 30-day) computed at the Latitude of Verona agreed reasonably with the unregulated rain flood frequency curve at this index location.

Hydrograph Construct

The hydrographs generated at each tributary index location are hypothetical hourly hydrographs made up of six 5-day waves. The translation from a frequency to a hypothetical 30-day flood series is described in Plate 2. This process includes: 1) obtaining the average flood flow rates from the unregulated frequency curves 2) separating these average flows into wave volumes, and 3) distributing volumes into the 6-wave series. This process is performed only at the tributary locations. Mainstem flood hydrographs are the result from the routed contributions of upstream tributaries. Please refer to Reference 3 for further explanation of this process.

The frequency curves used in this process were obtained from the Comprehensive Study (Reference 3), except for the Shanghai Bend unregulated flow frequency curve. This curve was adopted from the 1999 FEMA report entitled, “Rain Flood Flow Frequency Analysis, Feather and Yuba Rivers” (Reference 1). No adjustments were made to any of the frequency curves except for the peak curve for Shanghai Bend. According to Reference 1, the peak mean for the unregulated flow frequency curve at Shanghai Bend was proportioned based on the relationship of the peak and 1-day means at Oroville, since no peak unregulated data at Shanghai Bend was available. However, the peak mean value on the Shanghai Bend flow frequency curve does not represent this relationship. Therefore, the peak mean value of 4.977 was replaced with the correct value of 4.951. This frequency curve with the modified statistics is presented in Plate 3.

The 1997 flood was chosen as the pattern for the five-day wave patterns. These wave patterns were constructed by adjusting regulated gage records for the 1997 flood event in accordance with changes in upstream storage. Natural series were computed for all tributaries locations except the Sacramento River at Shasta Dam, Feather River at Oroville, and Deer Creek near Smartsville. At these sites, insufficient data at headwater reservoirs precluded the accurate computation of natural flows; regulated flows were used as pattern hydrographs. All patterns remained unchanged except for the Yuba River. The shape that was used to form the pattern hydrograph for the North, Middle,

and South forks of the Yuba River was the 1997 inflow hydrograph to New Bullards Bar Reservoir. The top of this hydrograph is fairly flat, resulting in a peak of only about 7% higher than the maximum 24-hour average flow. Other historical events reveal a percentage that is much higher. For example, the 1986 and 1995 storms resulted in peaks 27% and 30% higher than the maximum 24-hour average flows.
The use of this 1997 shape posed a problem when trying to match the peak flow frequency curve at Marysville. In order to produce results that agreed reasonably with the unregulated rain flood peak frequency curve at Marysville, the pattern had to be manipulated, resulting in a peak increase of 25%. The timing of the peak was not changed and the volumes of the other durations were not affected significantly.

RESERVOIR OPERATIONS MODELING

Methodology

The reservoir modeling for the Feather River was accomplished using the new ResSim modeling package. The Sacramento District contracted with HEC to convert the Comprehensive Study HEC-5 models to ResSim for the Sacramento and San Joaquin watersheds in support of the District's CWMS modeling effort. The spatial extent of this model is shown in Plate 4.

The intent of this conversion was to replicate the results of the Comprehensive Study HEC-5 models using ResSim; therefore, all hydrologic routing parameters and methods, starting storage assumptions, and operational rules found in the Comprehensive Study HEC-5 models were incorporated into the ResSim model.

HEC is still in the process of developing ResSim models for some of the river basins; however, the ResSim model covering the Feather and Yuba River basins has been completed. All of the reservoirs included in both the headwater and lower basin Comprehensive Study HEC-5 models for the Feather and Yuba River basins are included in this ResSim model. See Table 3 for a complete listing of these reservoirs.

TABLE 3
Modeled Reservoirs in the Feather and Yuba River Basins

Reservoir	Tributary	Owner	Storage Capacity (ac-ft)	Drainage Area (sq mi)
Feather River				
Mountain Meadows	Hamilton Creek	PGE	24,800	158
Almanor	Nfk Feather Creek	PGE	1,308,000	503
Butt Valley	Butte Creek	PGE	49,800	86.2
Antelope	Indian Creek	DWR	22,566	71
Bucks Lake	Bucks Creek	PGE	103,000	29.5
Frenchman	Last Chance Creek	DWR	55,477	82
Lake Davis	Big Grizzly Creek	DWR	83,000	44
Little Grass Valley	Sfk Feather River	OWID	93,010	27.3
Sly Creek	Lost Creek	OWID	65,050	23.9
Oroville	Feather River	DWR	3,538,000	3,611
Yuba above Marysville				
New Bullards Bar	Nfk Yuba River	YCWA	960,000	489
Jackson Meadows	Mfk Yuba River	NID	52,500	37.11
Bowman	Canyon Creek	NID	64,000	28.91
Fordyce	Fordyce Creek	PGE	48,900	30
Spaulding	Sfk Jackson Creek	PGE	74,773	118
Scotts Flat	Deer Creek	NID	49,000	20
Merle Collins	Dry Creek	BVID	57,000	72.3

Model Changes

A number of modifications were made to the ResSim model delivered to the Sacramento District by HEC prior to use in the Sutter County Feasibility Study and the Lower Feather Floodplain Mapping Study. For both studies, starting storages for all but two headwater reservoirs were set at gross pool because storage capability below the normal pool elevation of dams operated primarily for purposes other than flood control should not be considered because the availability of such storage is uncertain. The storage for both Bucks Lake and Lake Almanor has never exceeded gross pool; therefore, the maximum storage that has occurred at the lakes for the months of December-March was used as the starting storage. Even though the model simulations began with the majority of the reservoirs at gross pool, effects of peak attenuation for many locations along the Feather and Yuba Rivers was still evident due to surcharge effects (Table 4).

TABLE 4

Effects of Headwater Regulation

Location	Annual Percent Chance Exceedence	Unregulated Peak Flow (cfs)	Regulated Peak Flow (cfs)	% Peak Reduction Due to Regulation
MF + SF of Yuba	50%	8,800	6,300	28.1
	10%	38,800	34,100	12.2
	4%	58,600	52,400	10.5
	2%	76,400	68,500	10.3
	1%	96,200	87,300	9.3
	0.5%	117,800	107,200	9.0
	0.2%	149,200	137,000	8.2
Deer Creek	50%	2,400	2,200	5.9
	10%	4,900	4,600	5.9
	4%	7,300	6,800	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.5%	11,400	10,700	5.7
	0.2%	13,000	12,400	4.9
Dry Creek	50%	2,400	2,200	5.9
	10%	4,900	4,600	5.9
	4%	7,300	6,800	5.9
	2%	8,700	8,200	5.9
	1%	10,100	9,500	5.9
	0.5%	11,400	10,700	5.7
	0.2%	13,000	11,600	10.9
Oroville Inflow	50%	51,700	47,300	8.5
	10%	153,700	135,900	11.6
	4%	225,100	200,700	10.8
	2%	284,100	253,100	10.9
	1%	349,600	311,500	10.9
	0.5%	419200	373800	10.9
	0.2%	520,300	464,600	10.7

Notes:
% Peak Reduced = ((Maximum Unregulated Inflow)-(Maximum Regulated Inflow))/(Maximum Unregulated Inflow) X 100%
Values are from model simulations of the Feather River Storm Centering A

No changes were made to the Oroville or New Bullards Bar release schedule; those schedules are included in this report as Tables 5 and 6, respectively.

TABLE 5
Oroville Release Schedule

Actual or Forecasted Inflow (Whichever is Greater) (cfs)	Flood Control Space Used (acre-ft)	Required Releases (cfs)
0 – 15,000	0 – 5,000	Power demand
0 – 15,000	Greater than 5,000	Inflow
15,000 – 30,000	0 – 30,000	Lesser of 15,000 or maximum inflow
0 – 30,000	Greater than 30,000	Maximum inflow for flood
30,000 – 120,000	N/A	Lesser of maximum inflow or 60,000
120,000 – 175,000	N/A	Lesser of maximum inflow or 100,000
Greater than 175,000	N/A	Lesser of maximum inflow or 150,000

TABLE 6
New Bullards Bar Release Schedule

Actual Inflow (cfs)	Flood Control Space Used (ac-ft)	Required Releases (cfs)
0 – 50,000	0 – 170,000	Inflow
50,000 – 120,000	0 – 170,000	Inflow
Greater than 120,000	0 – 170,000	Inflow up to 180,000

Note – Emergency spillway release diagram used when the combination of the rate of rise and pool elevation dictate.

Both the Comprehensive Study HEC-5 model and the original ResSim model developed by HEC did not incorporate the forecasted inflow component of this release schedule. For example, releases would be restricted to 60,000 cfs until an actual inflow exceeded 120,000 cfs. At this time releases would begin to ramp up to the next specified flow value in the schedule (100,000 cfs for this example). In reality, releases would begin to ramp up to 100,000 cfs much earlier than this if a forecasted inflow greater than 120,000 cfs was known. All events greater than the 10% flood have peak flows greater than the largest value in the release schedule (175,000 cfs); so, for these events, Oroville releases were modeled to allow releases to ramp up freely to the maximum objective flow of 150,000 cfs at a rate of 5,000 cfs an hour.

Another change to the ResSim model involved travel times. Total travel time from Oroville Dam down to Yuba City was increased from 8 hours to 16 hours, which is consistent with the published travel times used by the Department of Water Resources and is in better agreement with what has been observed.

Lastly, changes were made to the model to incorporate a forecast uncertainty component to the local flow. The original models assumed complete certainty in local flow contributions downstream of a reservoir. This assumption yields high operational efficiency when operating for downstream flow criteria. In reality, however, local flow contributions could be greater or less than what was forecasted. Because of the possibility that local flows could be more than what is forecasted, reservoir releases are typically less than what the calculated releases would be based on the forecasted information. The magnitude of forecast uncertainty can vary from basin to basin and also from storm to storm. The Corps standard is to incorporate a 20% uncertainty in local flow contributions when operating for downstream flow targets. This uncertainty percentage was modeled in ResSim by reducing all downstream flow targets by 20% of the local flow contributing to that specific location. These modifications are listed in Table 7.

TABLE 7
Downstream Flow Target Reductions

Reservoir	Downstream Location	Target Flow (cfs)	Reduced Target Flow (cfs)
Oroville	Yuba City	180,000	174,000
	Below Yuba R. Confluence	300,000	280,000
	Below Bear R. Confluence	320,000	312,000
New Bullards Bar	Marysville	120,000/180,000	106,000/154,000

Model runs were also simulated assuming complete certainty in local flow contributions for all frequency events. Results from both scenarios were compared for each flood event. The scenario producing the larger flows was selected for defining baseline conditions. Generally, the complete certainty scenario was selected for events in which the reservoirs were able to satisfy downstream flow criteria, and the 20% uncertainty scenario was selected for those events in which the downstream flow criteria were exceeded.

Operational Risk

Computation of expected annual damages and annual exceedence probabilities for comparison of plan performance requires definition of the with- and without-project conditions. For every proposed alternative, the flood damage reduction potential depends on the performance as designed. No matter how well a project is designed, the performance is never a certainty. The Corps Engineering Manual entitled Risk-Based Analysis for Flood Damage Reduction Studies (EM 1110-2-1619) provides guidance and procedures for how to account for risk and uncertainty in flood damage reduction studies. Chapter 7 of the EM specifically addresses procedures for describing uncertainty of reservoir performance. Reservoir operational performance is dependent on a multitude of factors that are variable from storm to storm. Such factors include starting reservoir storages, operational response time, and forecasting accuracy. In Chapter 7, recommended procedures to account for such uncertainty are outlined in 4 main steps: 1) identify critical, uncertain factors that would affect peak outflow; 2) identify combinations of the factors to define a best-case, most-likely case, and a worst-case operation scenario; 3) select a probability distribution to represent the likelihood of the resulting scenarios based on expert subjective judgment; 4) compute outflows for a range of inflow peaks of known exceedence probabilities for all three cases. The resulting probabilistic description of uncertainty should then be included in sampling procedures described in Chapter 2 of EM 1110-2-1619. A significant amount of time and money would be needed in order to perform such an analysis for a system as complex as the Yuba-Feather. Therefore, a more simplistic approach was taken for this study: the starting storage changes and target flow reductions described above were included in the ResSim model to account for operational uncertainty.

Results

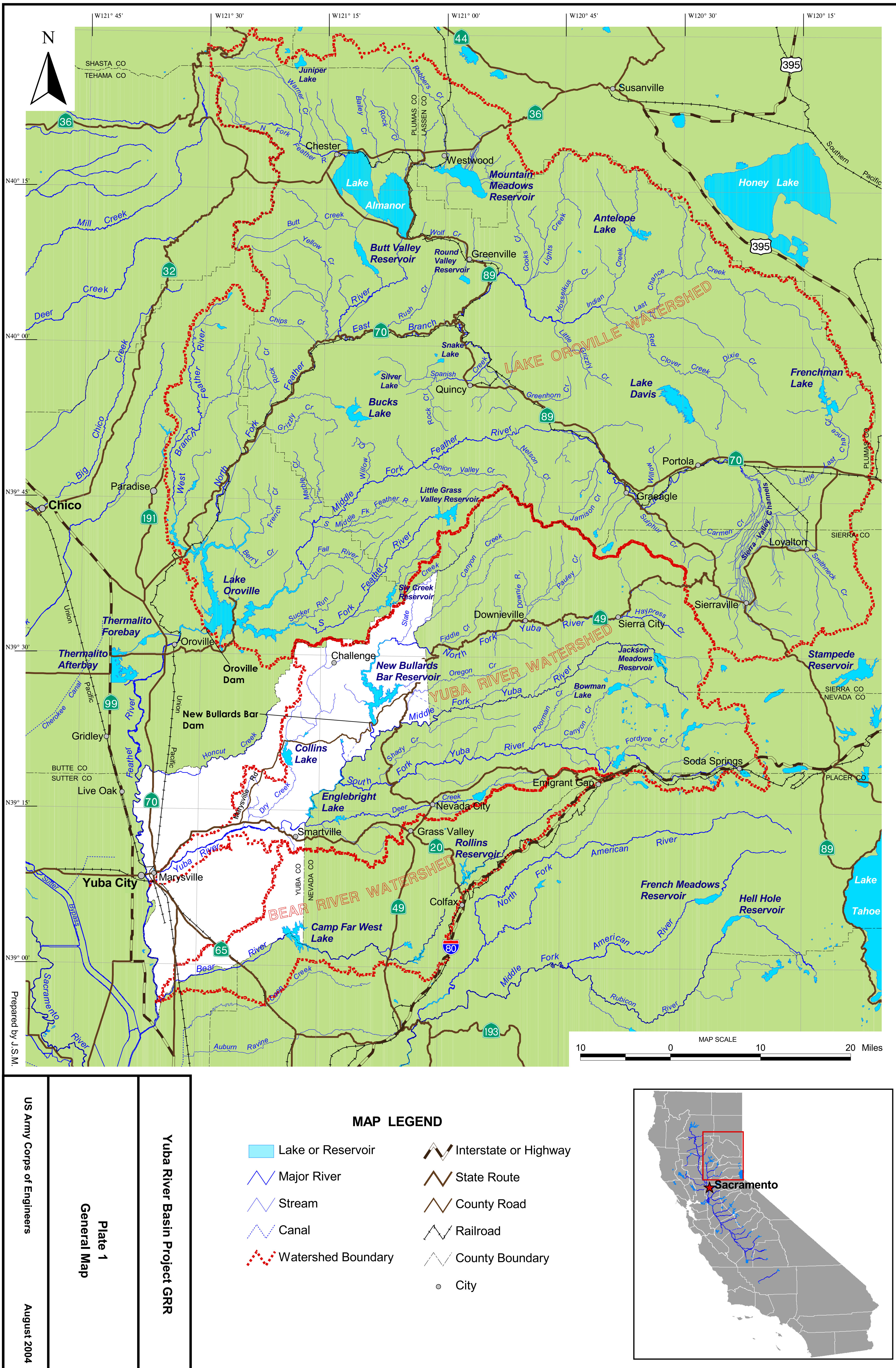
Discussion of results will focus on the area in which the synthetic storms are centered, the Feather-Yuba system, even though the spatial extent of the storms covered the entire Sacramento River Basin.

Seven reservoirs were modeled within the Yuba River Basin. New Bullards Bar, located on the North Fork of the Yuba River, is the only reservoir that has dedicated flood space. New Bullards Bar, which contains 170,000 acre-feet of flood space, operates to flow targets at Marysville. The flow criteria at Marysville is 180,000 cfs except when the Feather River is experiencing high flows. When the flows in the Feather River upstream of the Yuba River confluence are high, the flow target at Marysville is reduced to 120,000 cfs. This adjustment is made to assure that 300,000 cfs is not exceeded at the confluence of the Yuba River with the Feather River. New Bullards Bar is able to maintain its objective flow of 50,000 cfs for all events through the 2-percent chance exceedence event. For events larger than the 2-percent chance exceedence event, New Bullards Bar outflow exceeds 50,000 cfs. However, the 300,000 cfs flow target at the confluence is still met for the 0.8-percent chance exceedence event. Operation plots of New Bullards Bar are presented in Plates 15-24.

The other six reservoirs modeled in the Yuba Basin, known as headwater reservoirs, are much smaller and do not have any dedicated flood space. However, they still contribute to attenuating peak flows. Average peak flows along the Middle and South forks of the Yuba River were attenuated by 8.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

A total of 9 headwater reservoirs were modeled in the watershed above Oroville. Only 20% of the natural flow hydrograph at Oroville was routed through these headwater reservoirs. However, these reservoirs still had a significant impact on attenuating flows into Oroville. Average peak inflows to Oroville were reduced by 10.8% for the 1-, 0.5-, and 0.2-percent chance exceedence events.

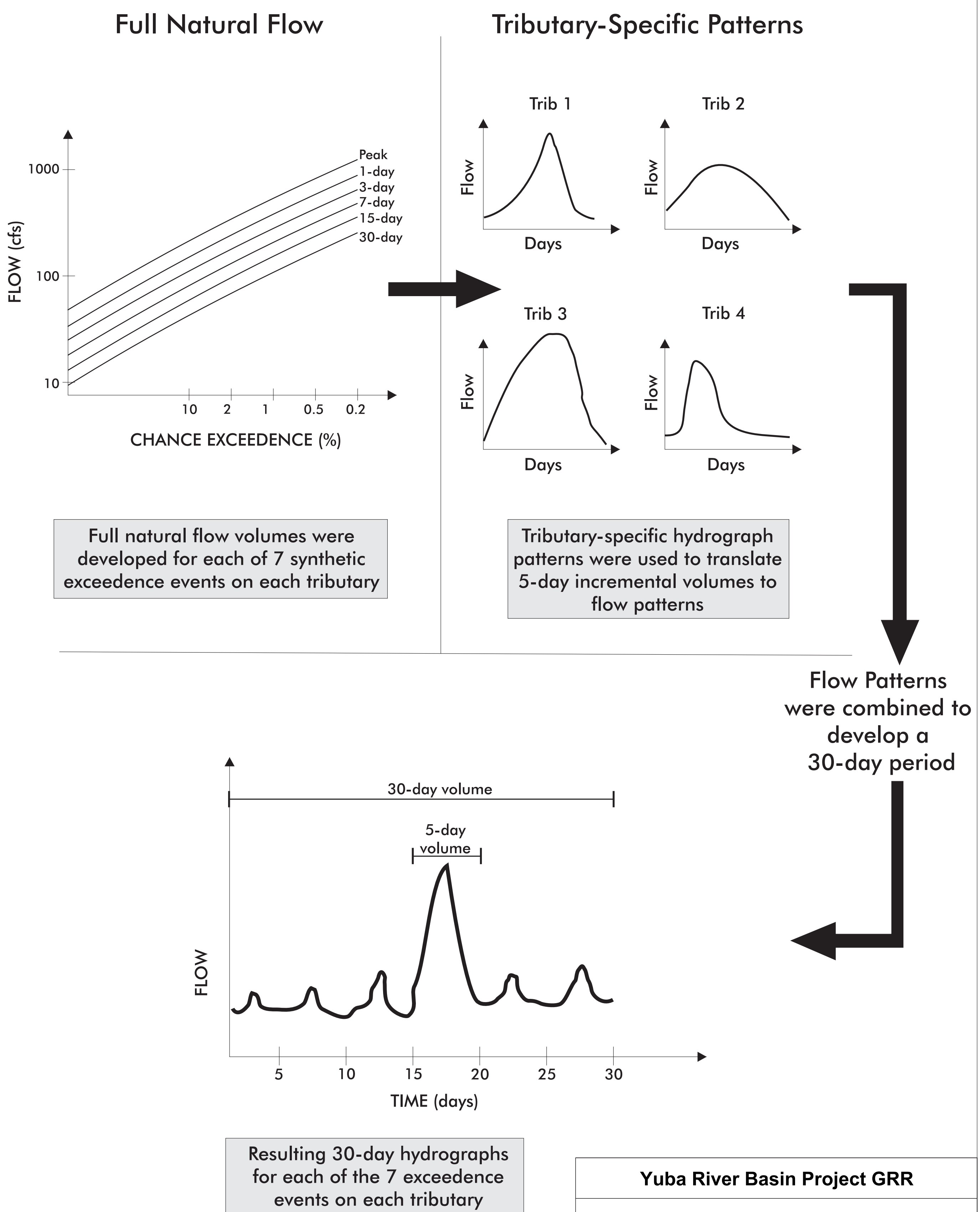
Oroville Reservoir has a maximum flood space reservation of 750,000 acre-feet, and is required to maintain flow targets at multiple downstream locations. It is also required to maintain flows at or below 180,000 cfs above the Yuba River confluence, 300,000 cfs below the Yuba River confluence, and 320,000 cfs below the Bear River confluence. These criteria were met for all events up to and including the 1-percent chance exceedence event. During the less frequent events (0.8-percent chance exceedence event and rarer) releases are triggered by the Emergency Spillway Release Diagram (ESRD). However, the ESRD does not require releases to go above the objective flow of 150,000 cfs until the 0.5-percent chance exceedence event. For the events between the 1- and 0.5-percent exceedence events the objective flow is not exceeded, but downstream flow targets are. The flow target of 320,000 cfs downstream of the Bear River confluence is exceeded during the 0.8-percent chance exceedence event because Oroville ESRD operational criteria cause releases to be increased during a time in the event in which releases should continue to be reduced to meet the flow target. Flow targets are exceeded below the Yuba River confluence and also below the Bear River confluence for all events rarer than the 0.8-percent chance exceedence event. Operation plots of Oroville are presented in Plates 5-14.



Yuba River Basin Project GRR

Plate 1
General Map

US Army Corps of Engineers **August 2004**

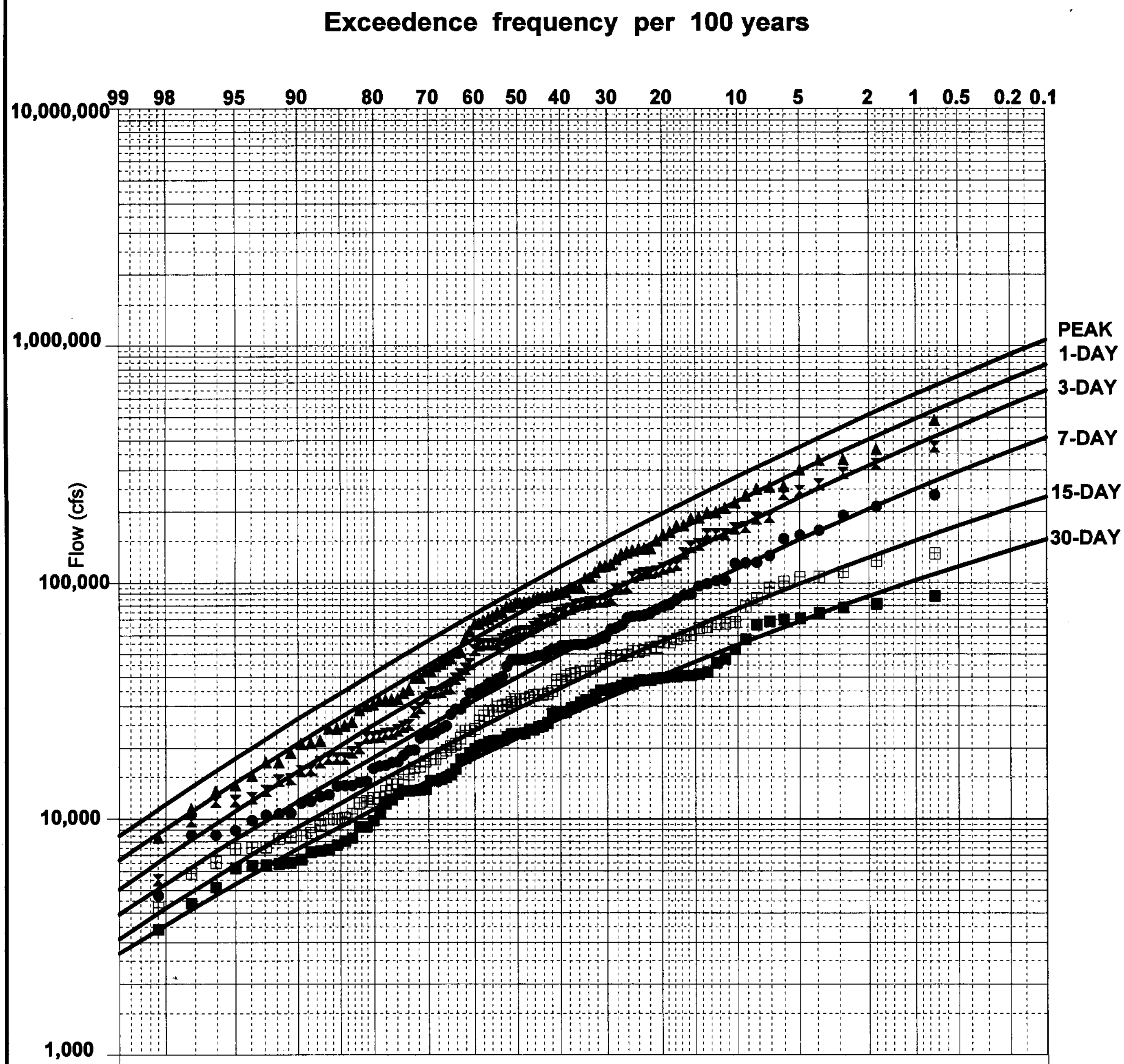


Yuba River Basin Project GRR

Plate 2
Hydrograph Construction

US Army Corps of Engineers **August 2004**

prepared by B.J.W.



ADOPTED CURVE STATISTICS

Curve	Mean	Std. Dev.	Skew
PEAK	4.951	0.402	-0.3
1-DAY	4.847	0.402	-0.3
3-DAY	4.733	0.404	-0.3
7-DAY	4.582	0.387	-0.3
15-DAY	4.443	0.363	-0.4
30-DAY	4.321	0.340	-0.4

NOTES:

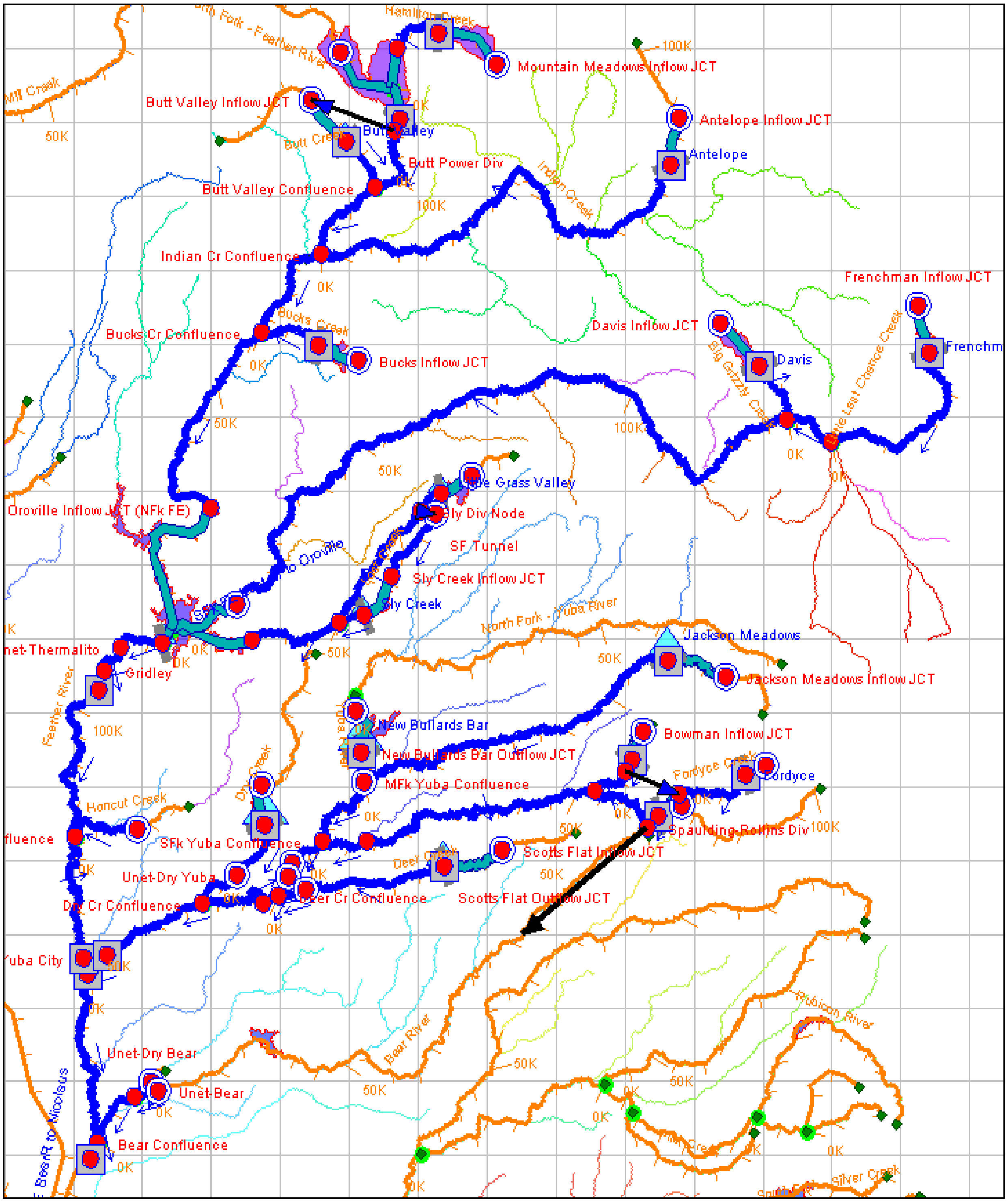
1. Median Plotting Positions
2. Drainage Area: 5313 sq. mi.
3. 94 years of record (1904 to 1997)

MODIFIED BY BJW MAY 02

Yuba River Basin Project GRR

Plate 3
Rain Flood Flow Frequency Curves
Feather River at Shanghai Bend
Unregulated Conditions

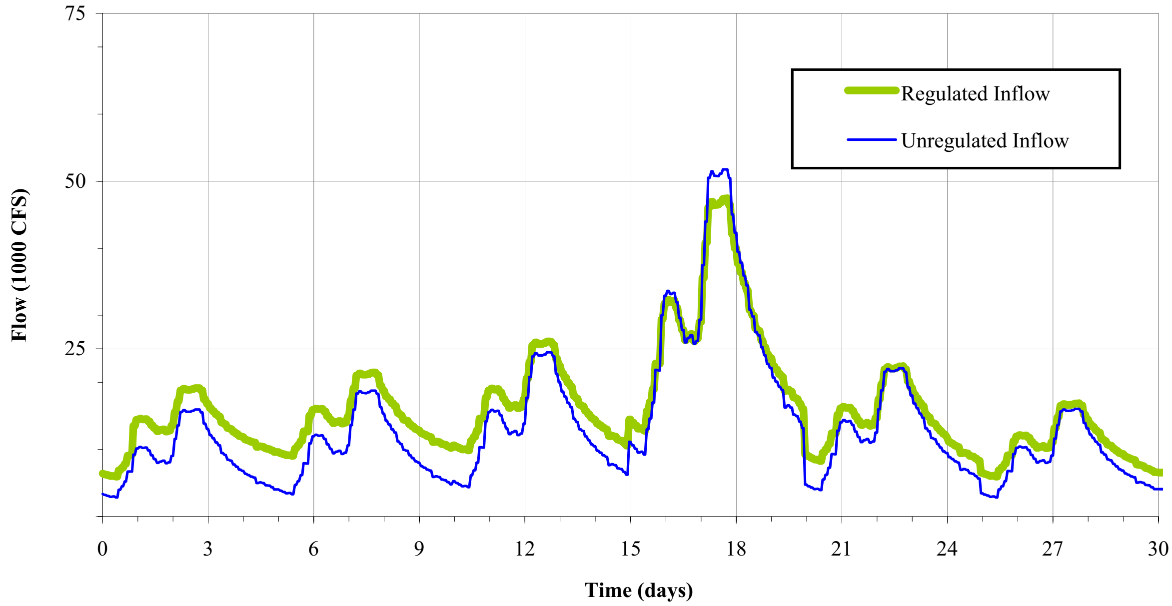
US Army Corps of Engineers August 2004



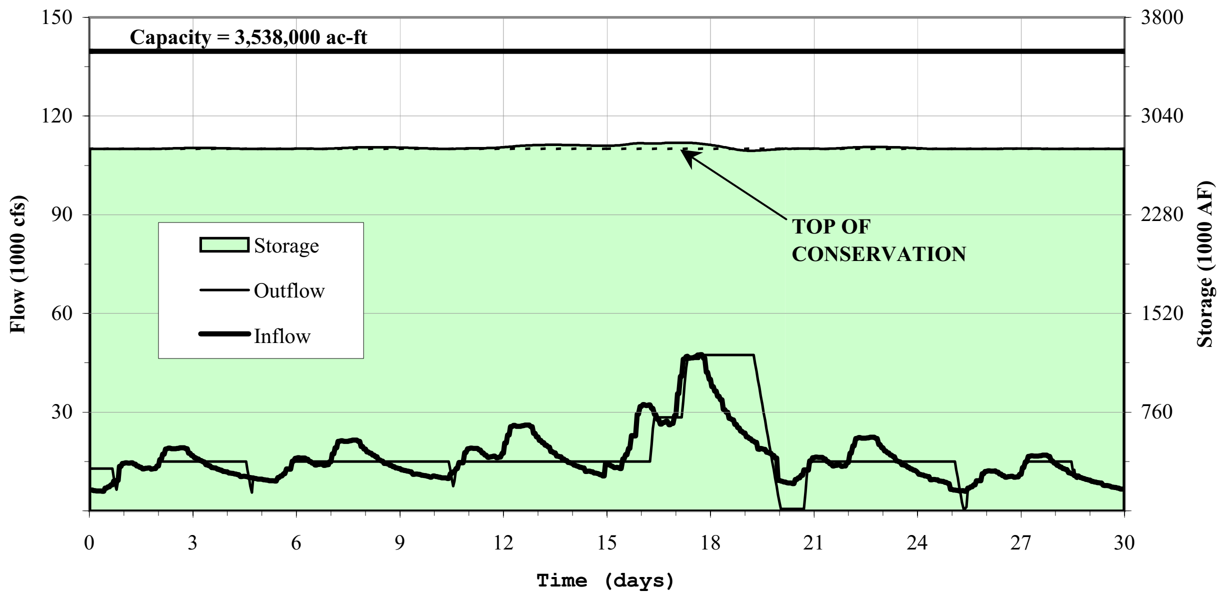
Yuba River Basin Project GRR	
Plate 4 **ResSim Model Schematic**	
US Army Corps of Engineers	August 2004

prepared by B.J.W.

FEATHER RIVER STORM CENTERING A
Oroville Inflow (50% Chance Exceedence Event)
Regulated and Unregulated Inflow



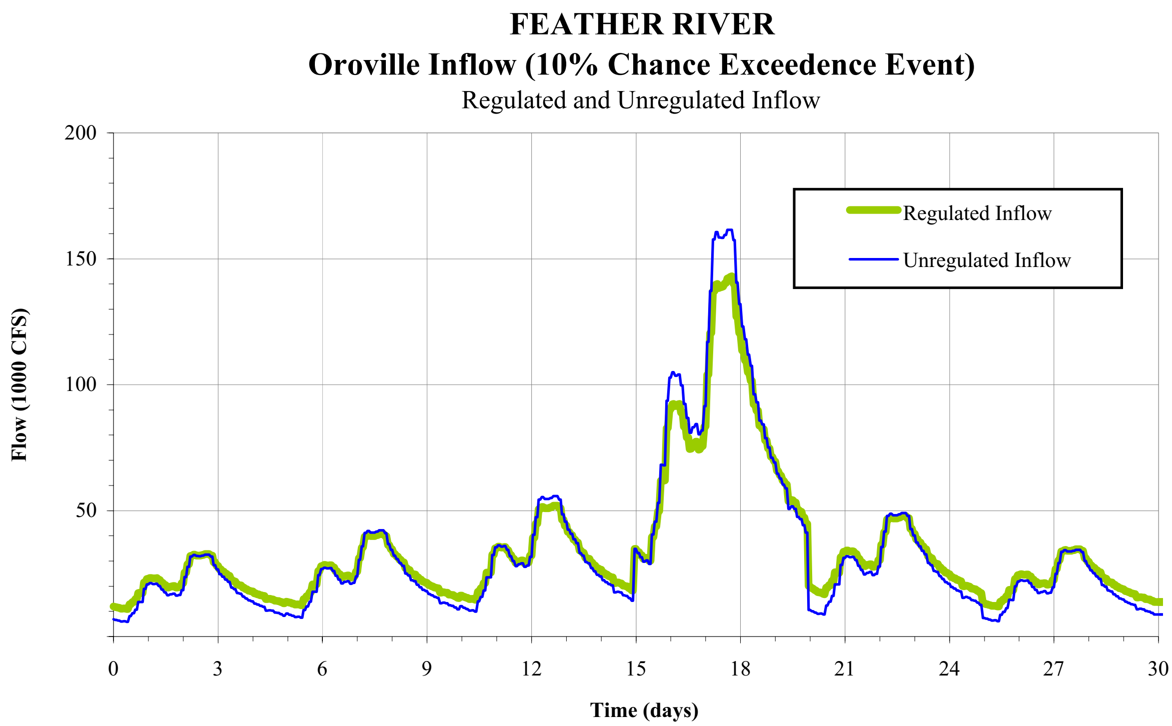
Oroville Operations (50% Chance Exceedence Event)

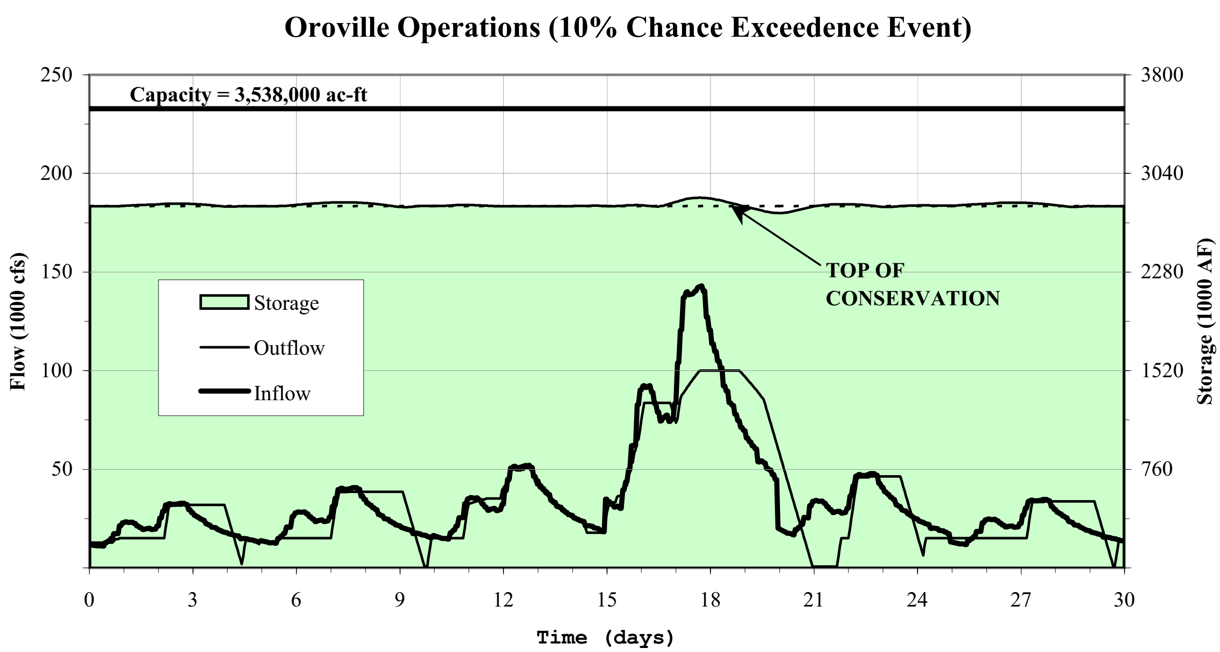


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 5 Reservoir Simulation Hydrographs Oroville (50% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.



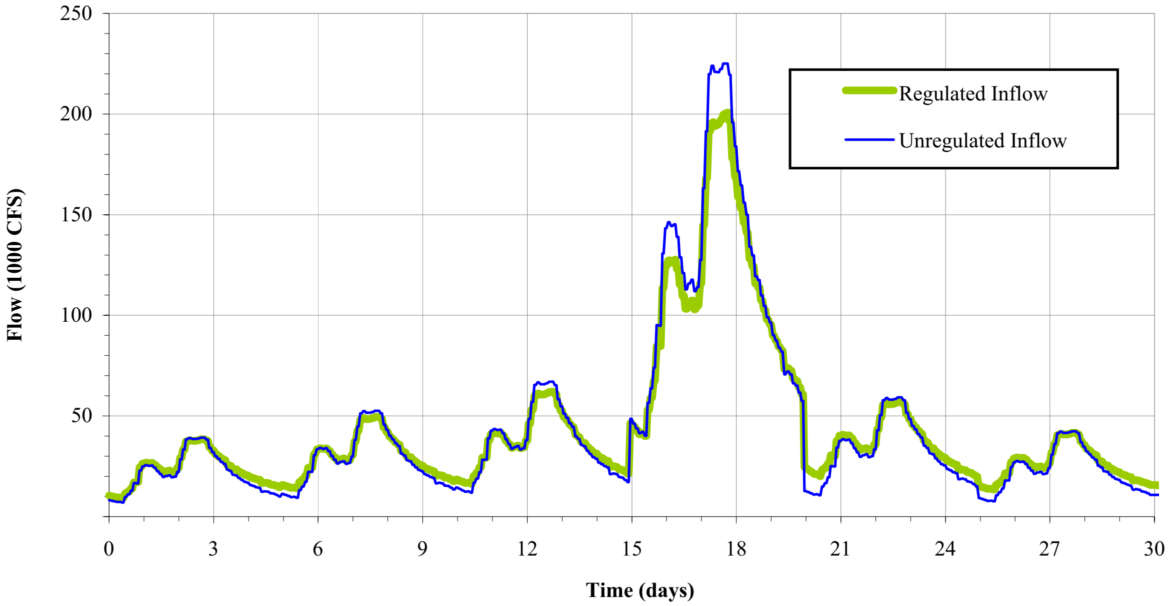


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

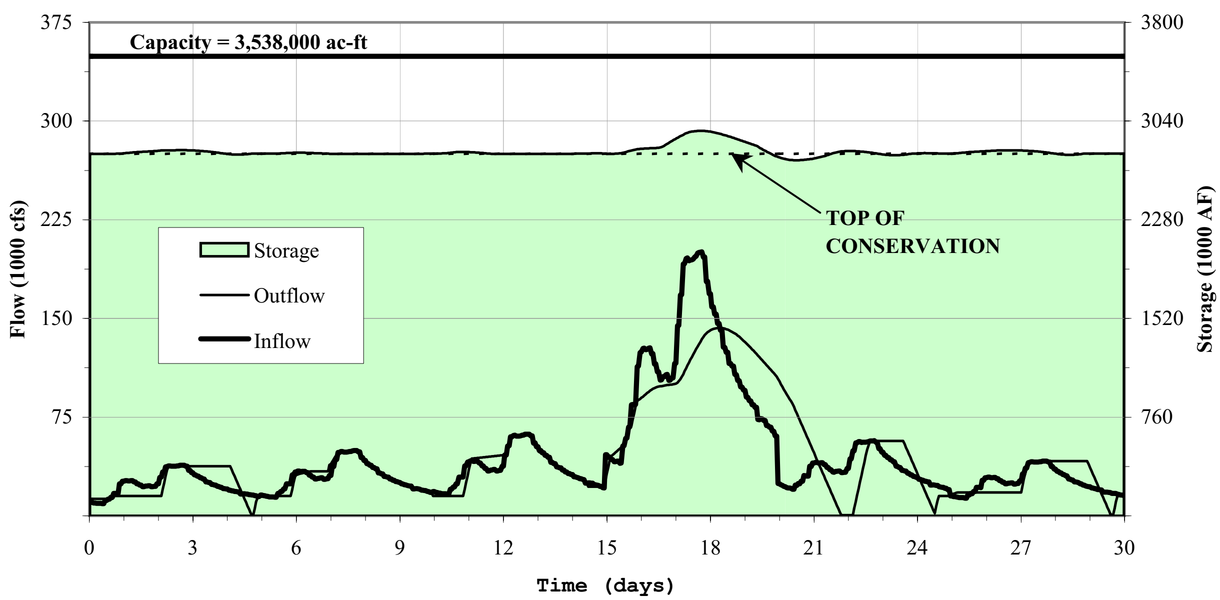
Yuba River Basin Project GRR	
Plate 6 Reservoir Simulation Hydrographs Oroville (10% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.

FEATHER RIVER
Oroville Inflow (4% Chance Exceedence Event)
Regulated and Unregulated Inflow



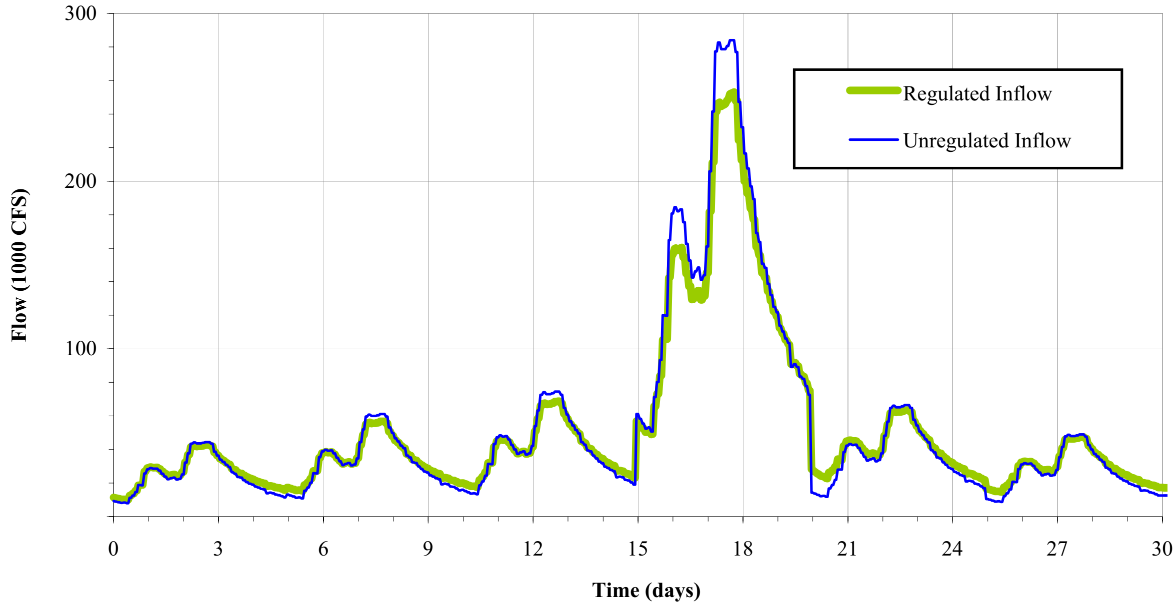
Oroville Operations (4% Chance Exceedence Event)



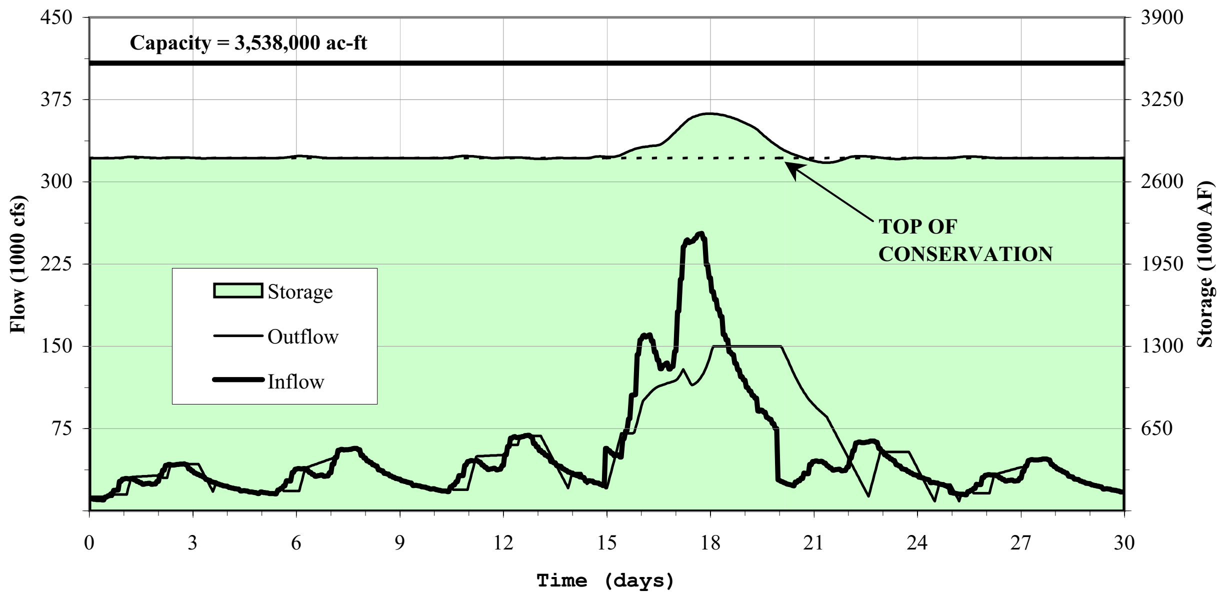
Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 7 Reservoir Simulation Hydrographs Oroville (4% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

FEATHER RIVER
Oroville Inflow (2% Chance Exceedence Event)
Regulated and Unregulated Inflow



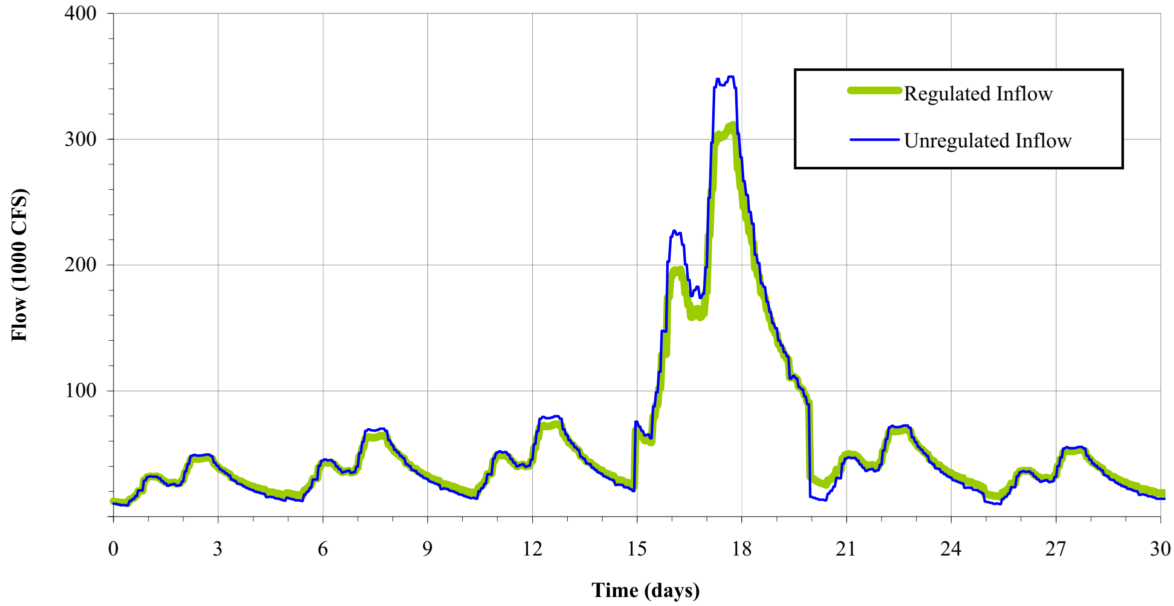
Oroville Operations (2% Chance Exceedence Event)



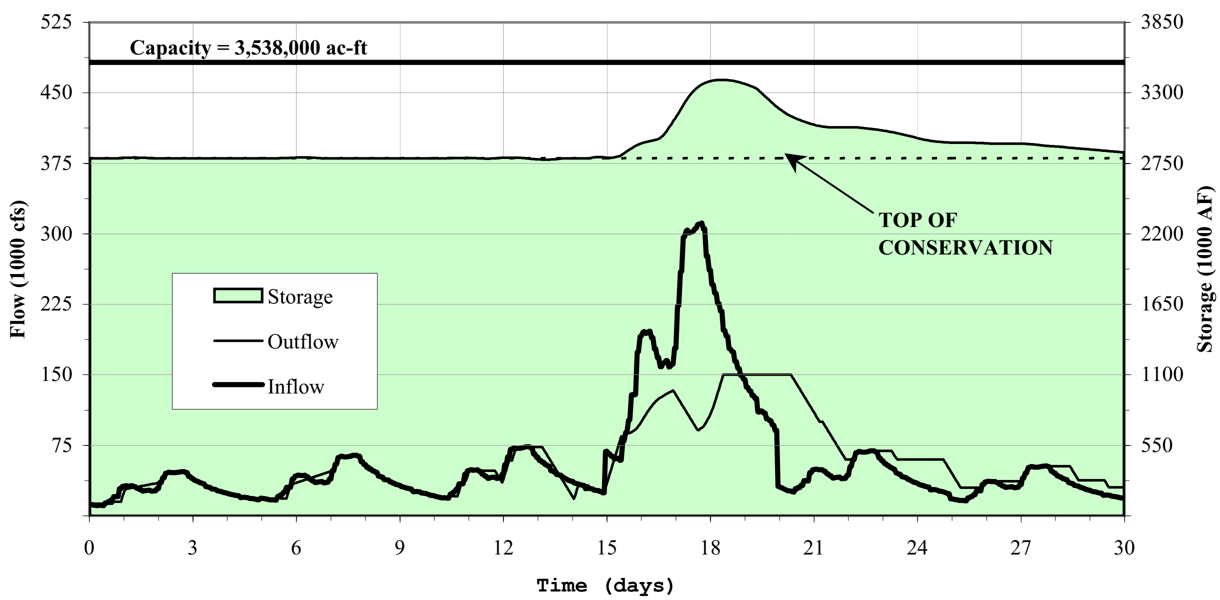
Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 8 Reservoir Simulation Hydrographs Oroville (2% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

FEATHER RIVER
Oroville Inflow (1% Chance Exceedence Event)
Regulated and Unregulated Inflow

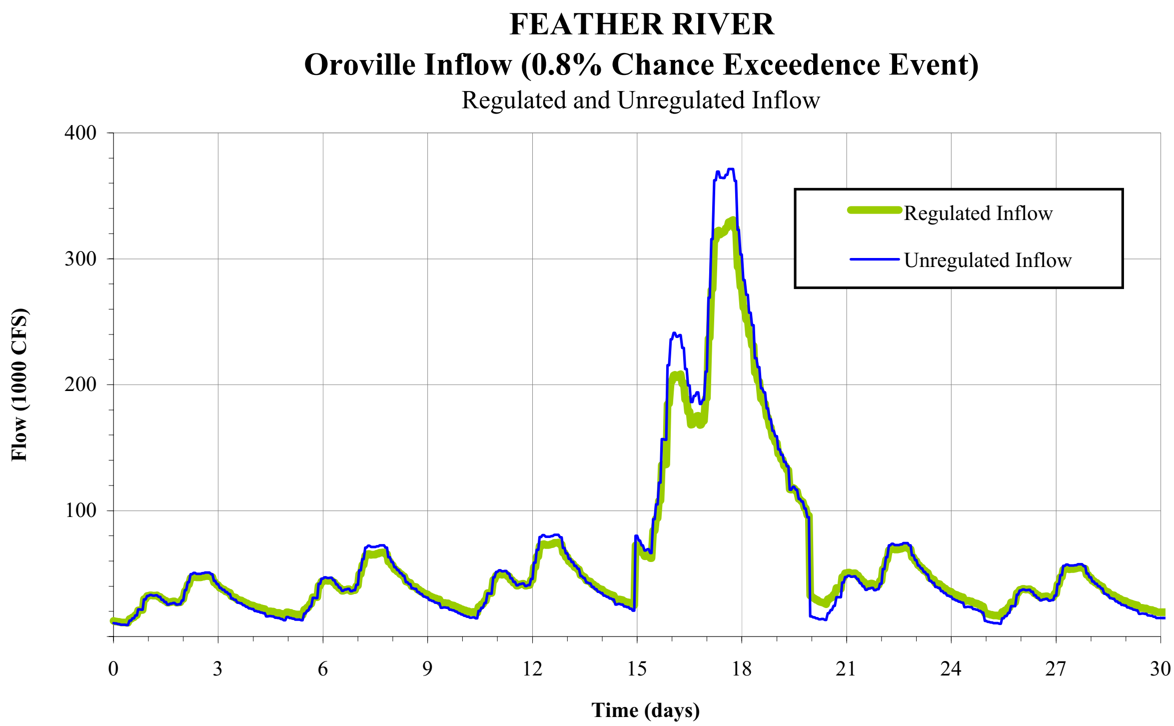


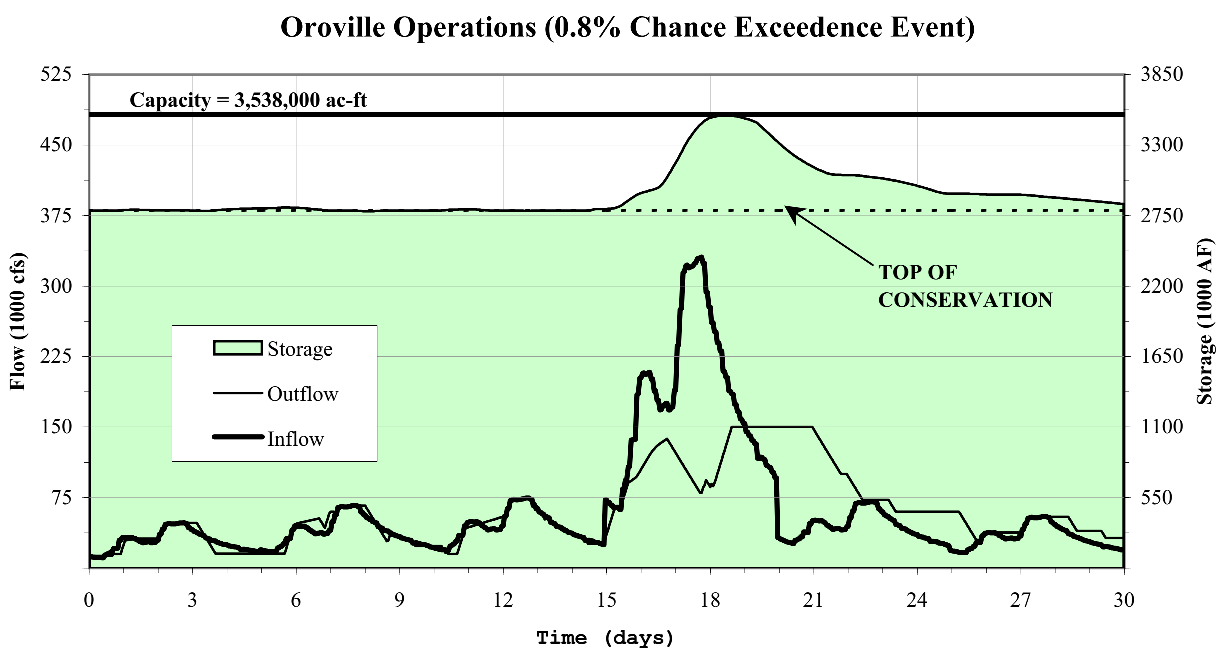
Oroville Operations (1% Chance Exceedence Event)



Yuba River Basin Project GRR	
Plate 9 Reservoir Simulation Hydrographs Oroville (1% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed



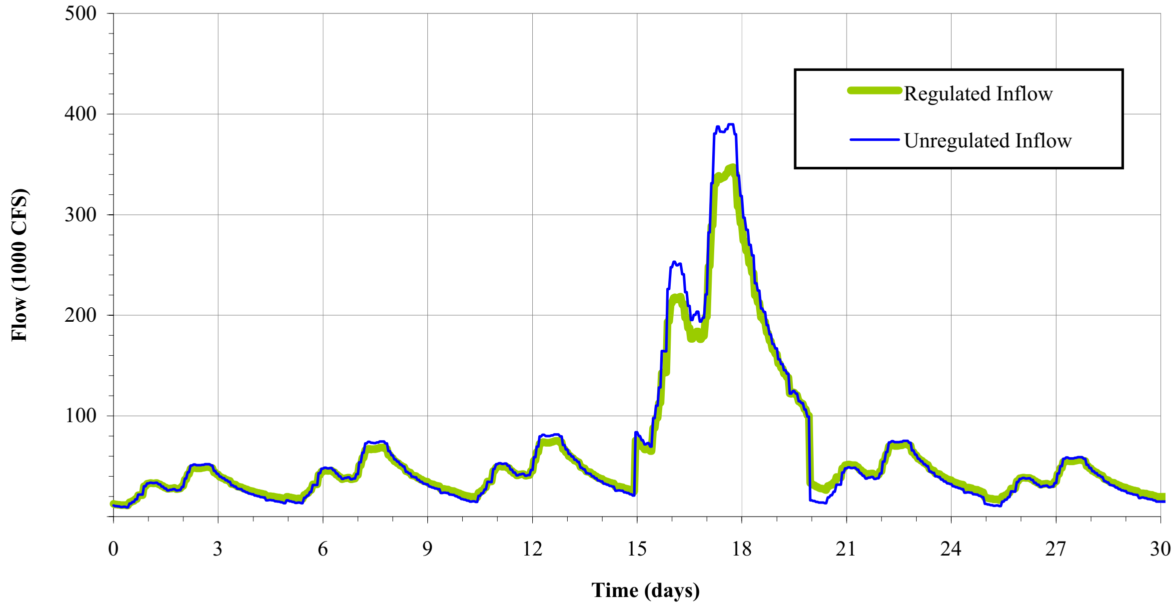


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

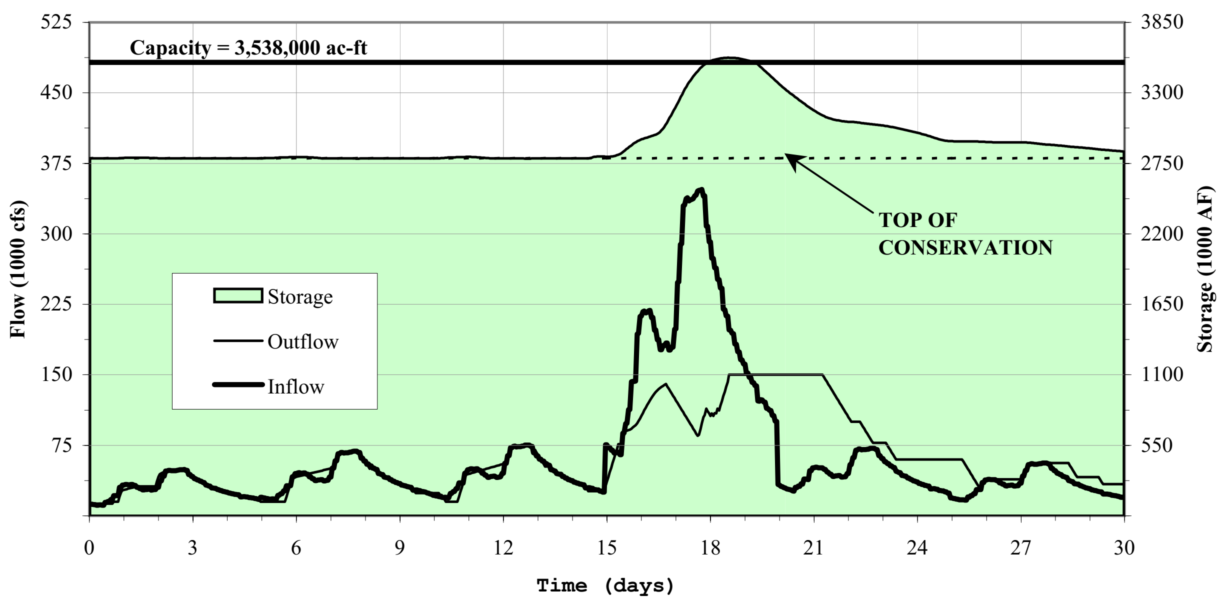
Yuba River Basin Project GRR	
Plate 10 **Reservoir Simulation Hydrographs** **Oroville** **(0.8% Chance Exceedence Event)**	
US Army Corps of Engineers	**August 2004**

prepared by B.J.W.

FEATHER RIVER
Oroville Inflow (0.67% Chance Exceedence Event)
Regulated and Unregulated Inflow



Oroville Operations (0.67% Chance Exceedence Event)

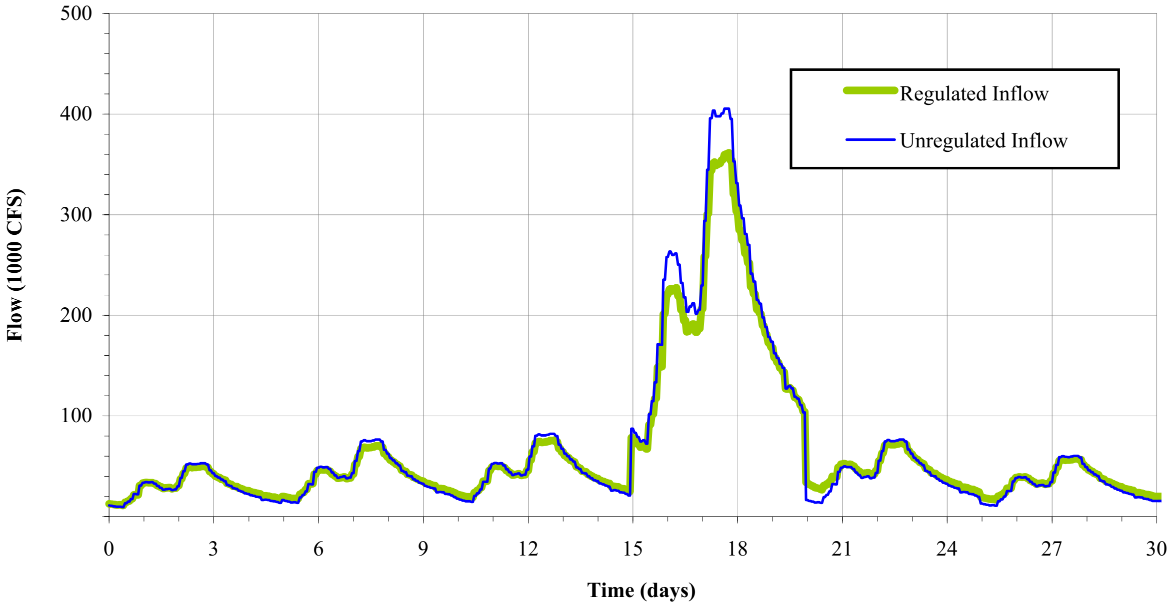


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

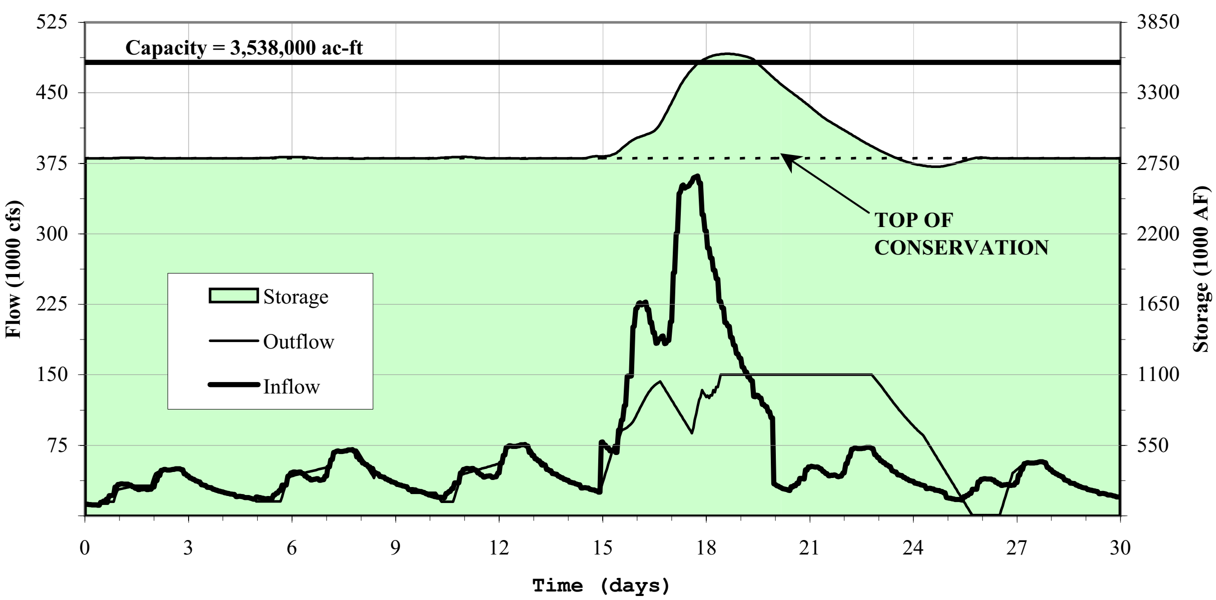
Yuba River Basin Project GRR	
Plate 11 **Reservoir Simulation Hydrographs** **Oroville** **(0.67% Chance Exceedence Event)**	
US Army Corps of Engineers	**August 2004**

prepared by B.J.W.

FEATHER RIVER
Oroville Inflow (0.57% Chance Exceedence Event)
Regulated and Unregulated Inflow



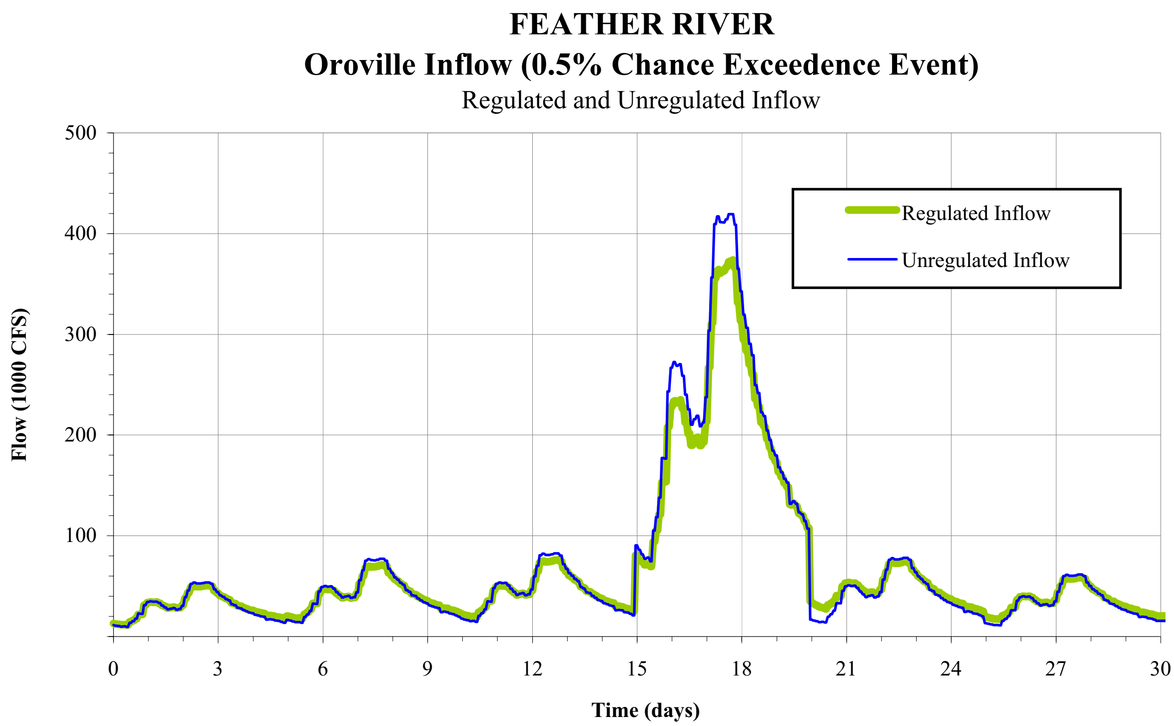
Oroville Operations (0.57% Chance Exceedence Event)

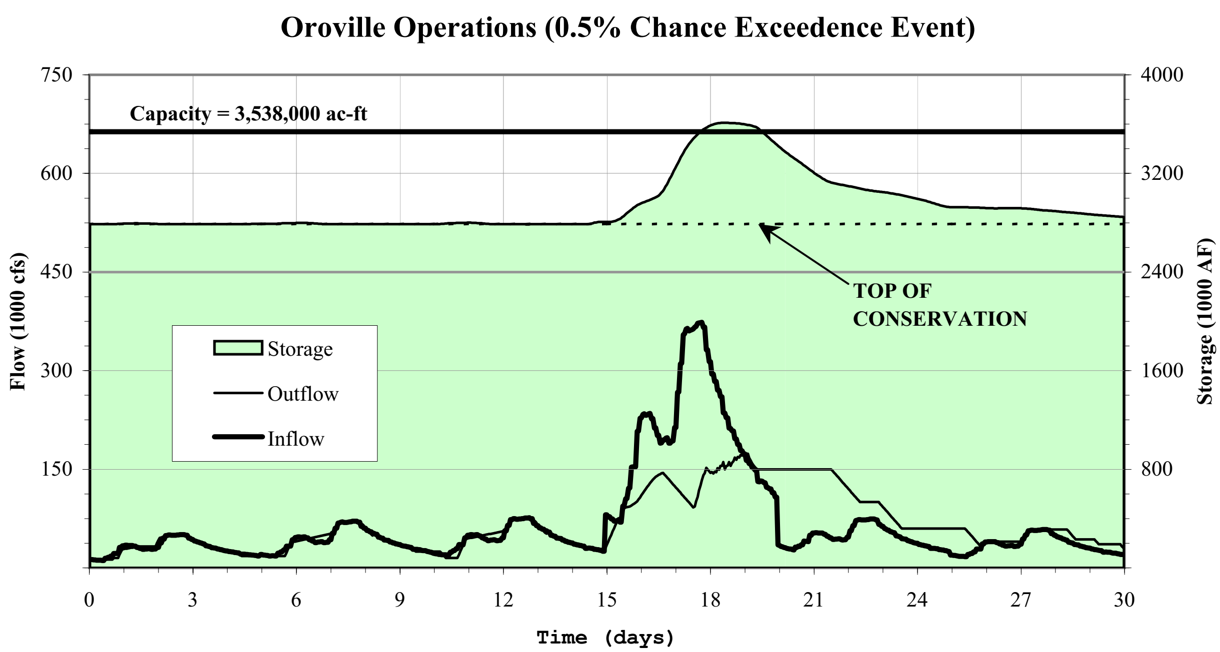


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 12 Reservoir Simulation Hydrographs Oroville (0.57% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.



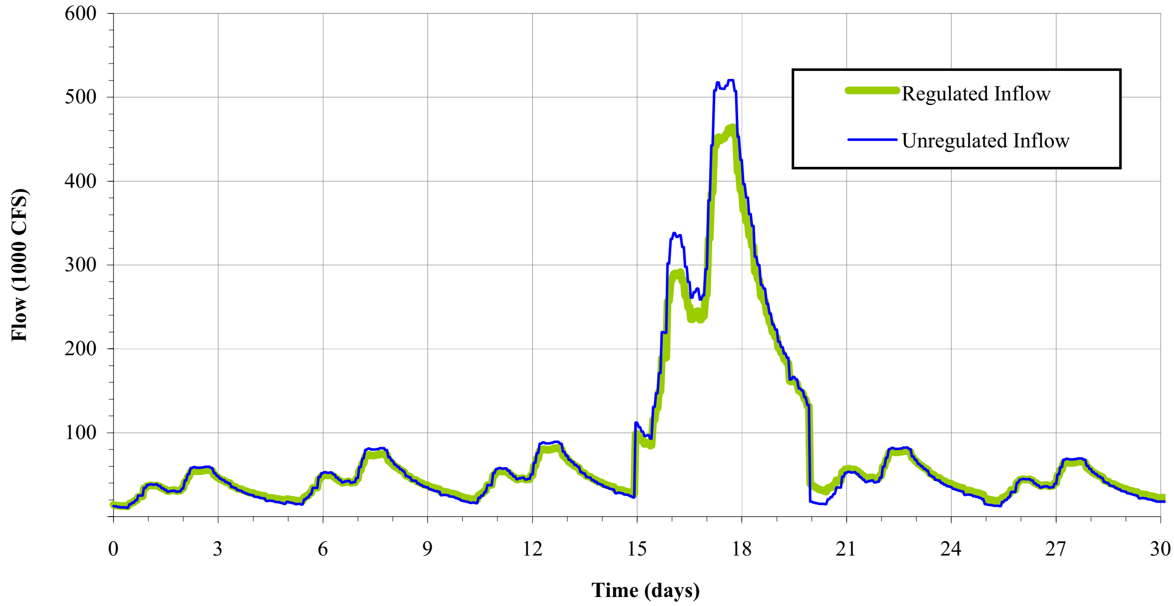


Notes:
1) Results are from Feather River Storm Centering A
2) 20% uncertainty in local flow assumed

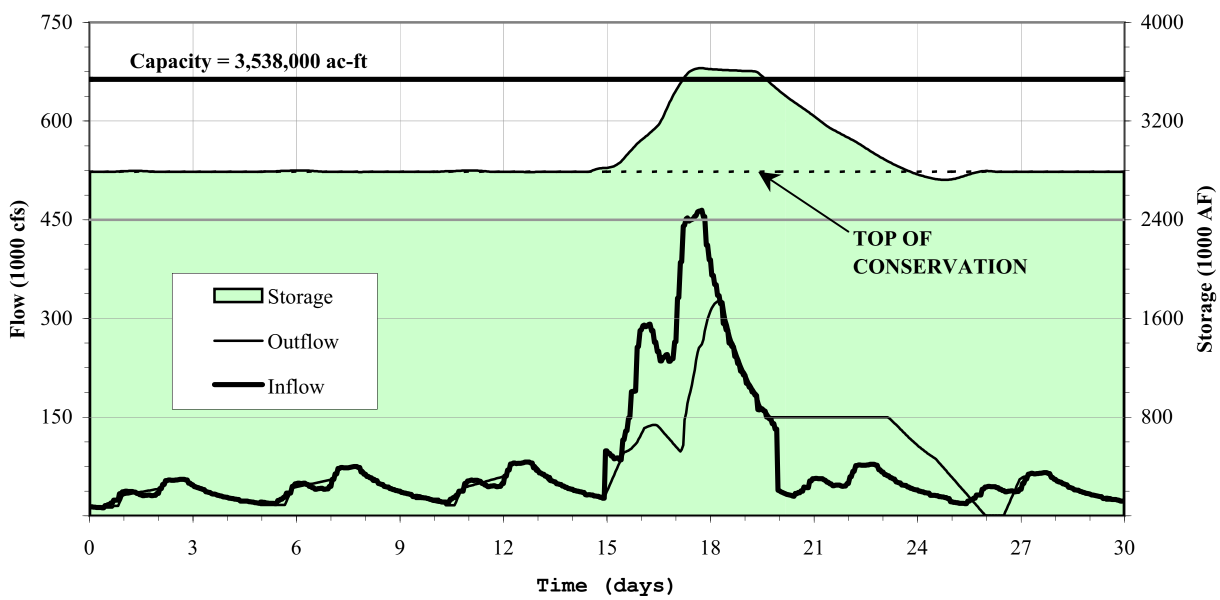
Yuba River Basin Project GRR	
Plate 13 Reservoir Simulation Hydrographs Oroville (0.5% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.

FEATHER RIVER
Oroville Inflow (0.2% Chance Exceedence Event)
Regulated and Unregulated Inflow



Oroville Operations (0.2% Chance Exceedence Event)

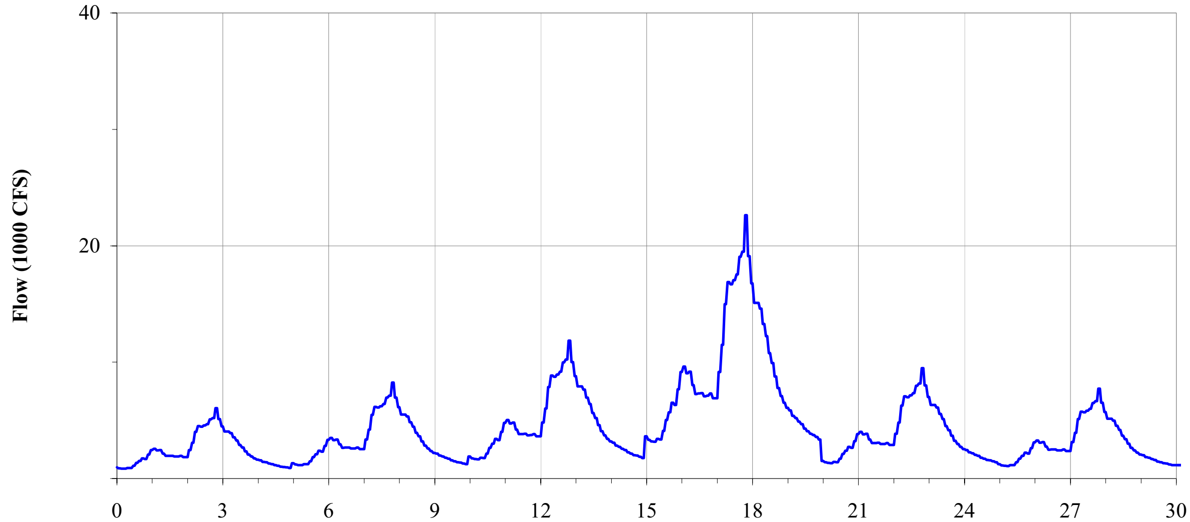


Notes:
1) Results are from Feather River Storm Centering A
2) 20% uncertainty in local flow assumed

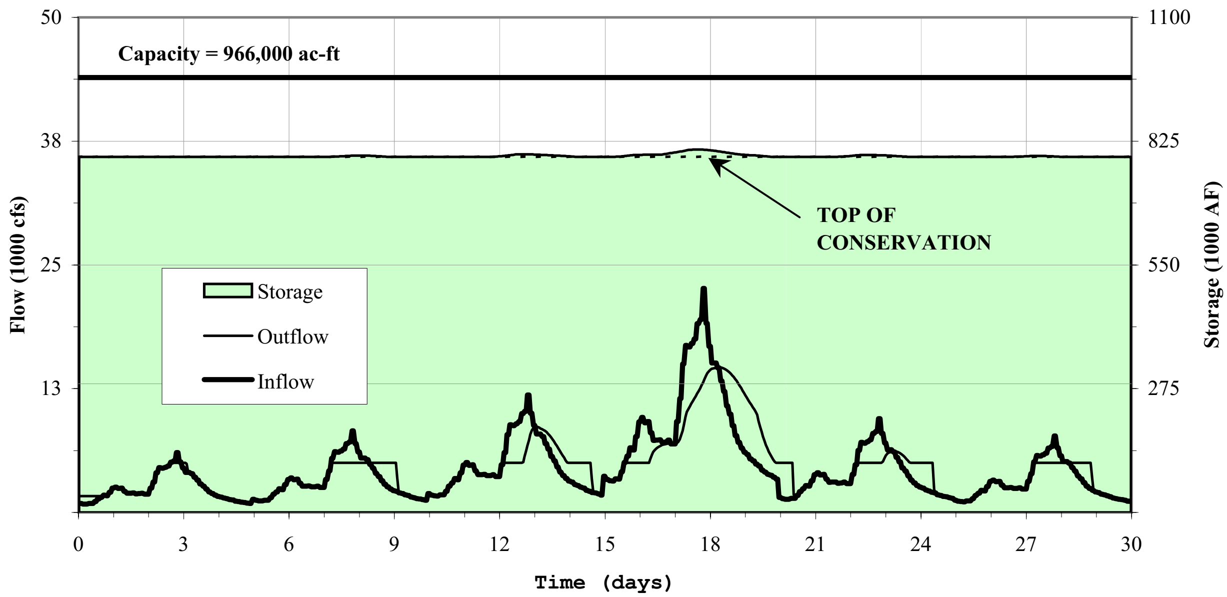
Yuba River Basin Project GRR	
Plate 14 **Reservoir Simulation Hydrographs** **Oroville** **(0.2% Chance Exceedence Event)**	
US Army Corps of Engineers	**August 2004**

prepared by B.J.W.

NORTH YUBA RIVER
New Bullards Bar Inflow (50% Chance Exceedence Event)
Regulated and Unregulated Inflow
Note: This reservoir has no major headwater reservoirs



New Bullards Bar Operations (50% Chance Exceedence Event)

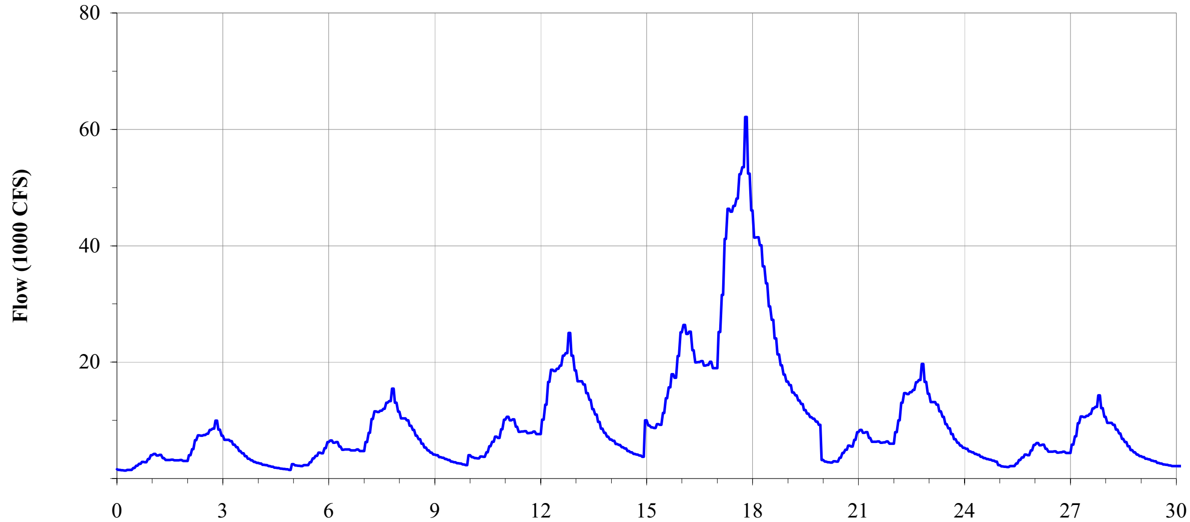


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

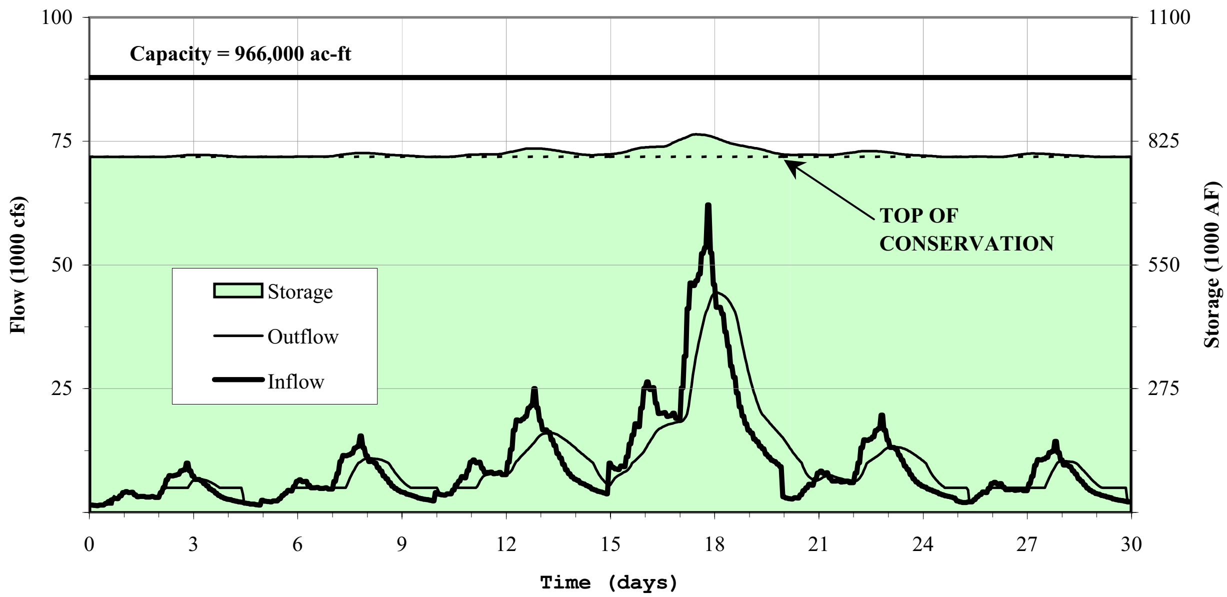
Yuba River Basin Project GRR	
Plate 15 Reservoir Simulation Hydrographs New Bullards Bar (50% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.

NORTH YUBA RIVER
New Bullards Bar Inflow (10% Chance Exceedence Event)
Regulated and Unregulated Inflow
Note: This reservoir has no major headwater reservoirs



New Bullards Bar Operations (10% Chance Exceedence Event)



Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

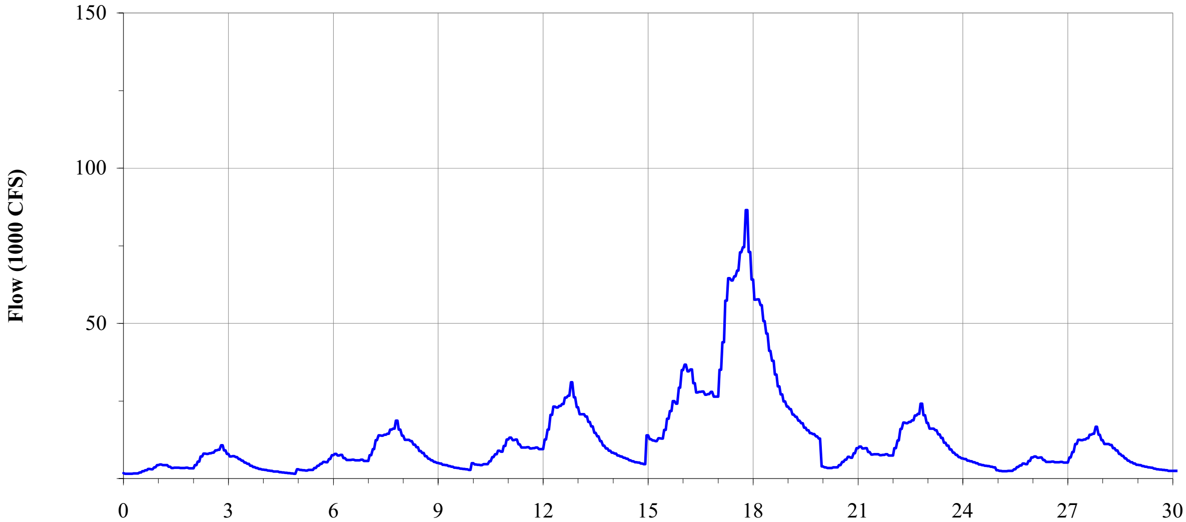
Yuba River Basin Project GRR	
Plate 16 Reservoir Simulation Hydrographs New Bullards Bar (10% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.

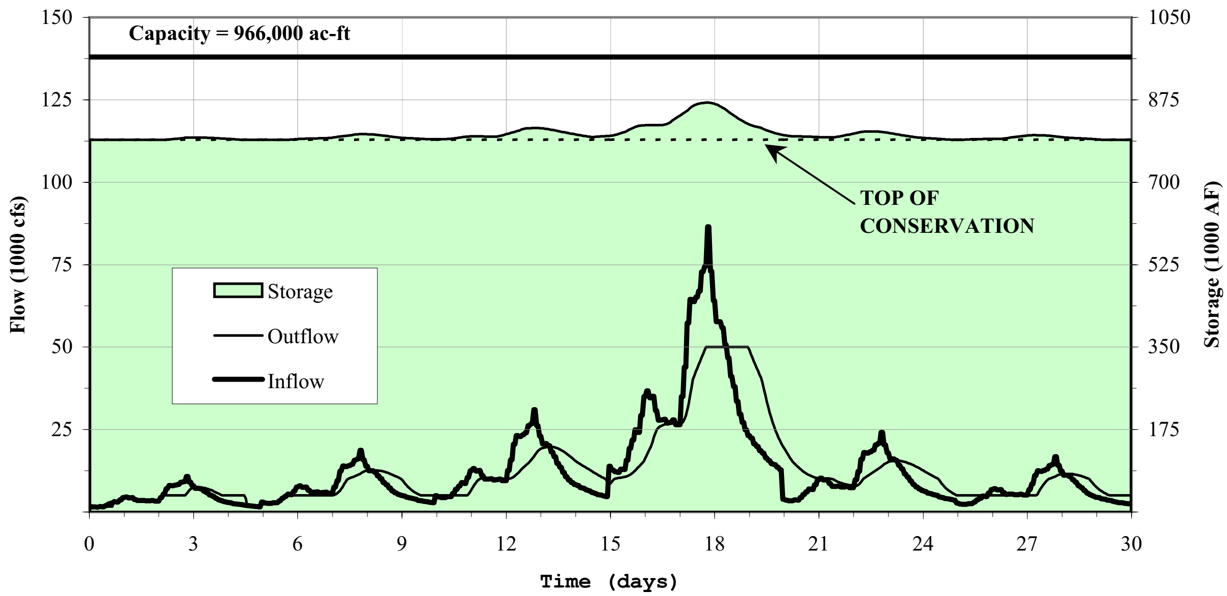
NORTH YUBA RIVER
New Bullards Bar Inflow (4% Chance Exceedence Event)

Regulated and Unregulated Inflow

Note: This reservoir has no major headwater reservoirs



New Bullards Bar Operations (4% Chance Exceedence Event)



Notes:

1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 17 Reservoir Simulation Hydrographs New Bullards Bar (4% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

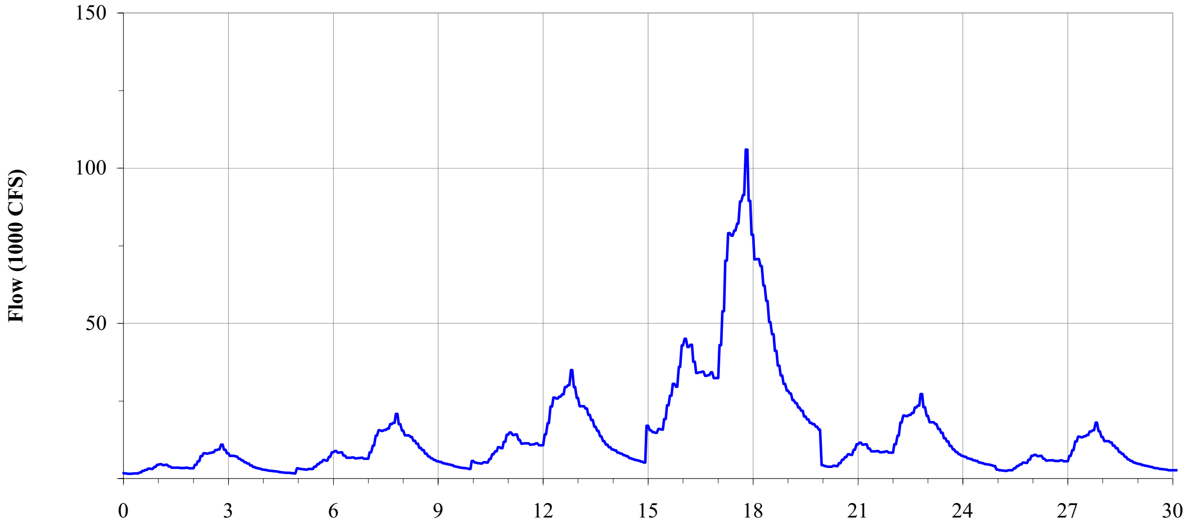
prepared by B.J.W.

NORTH YUBA RIVER

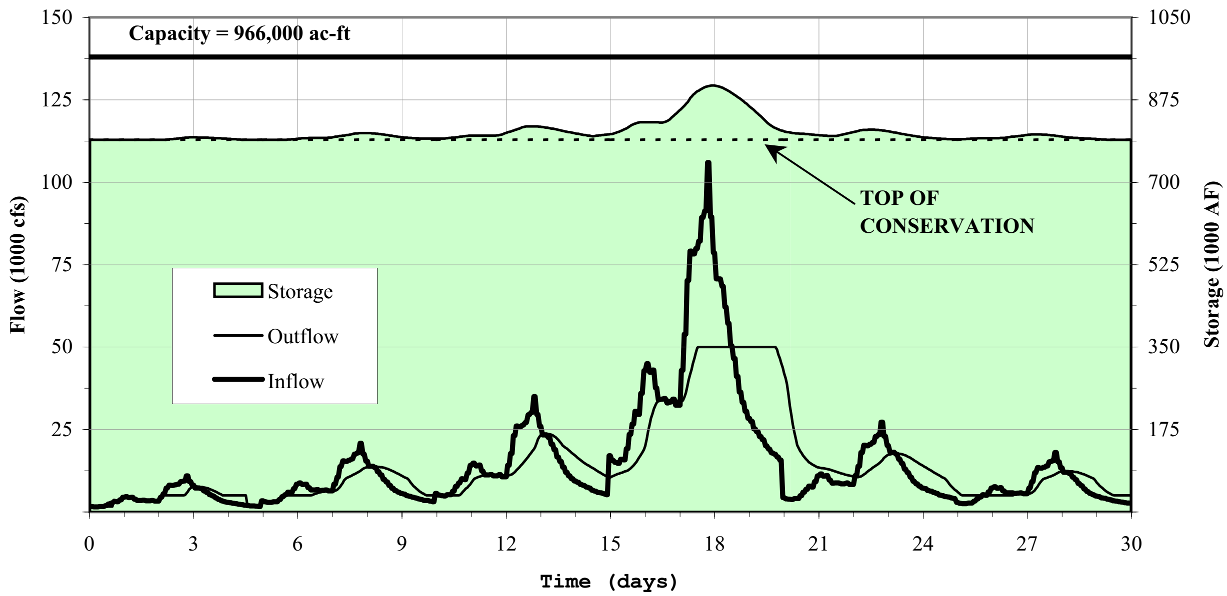
New Bullards Bar Inflow (2% Chance Exceedence Event)

Regulated and Unregulated Inflow

Note: This reservoir has no major headwater reservoirs



New Bullards Bar Operations (2% Chance Exceedence Event)

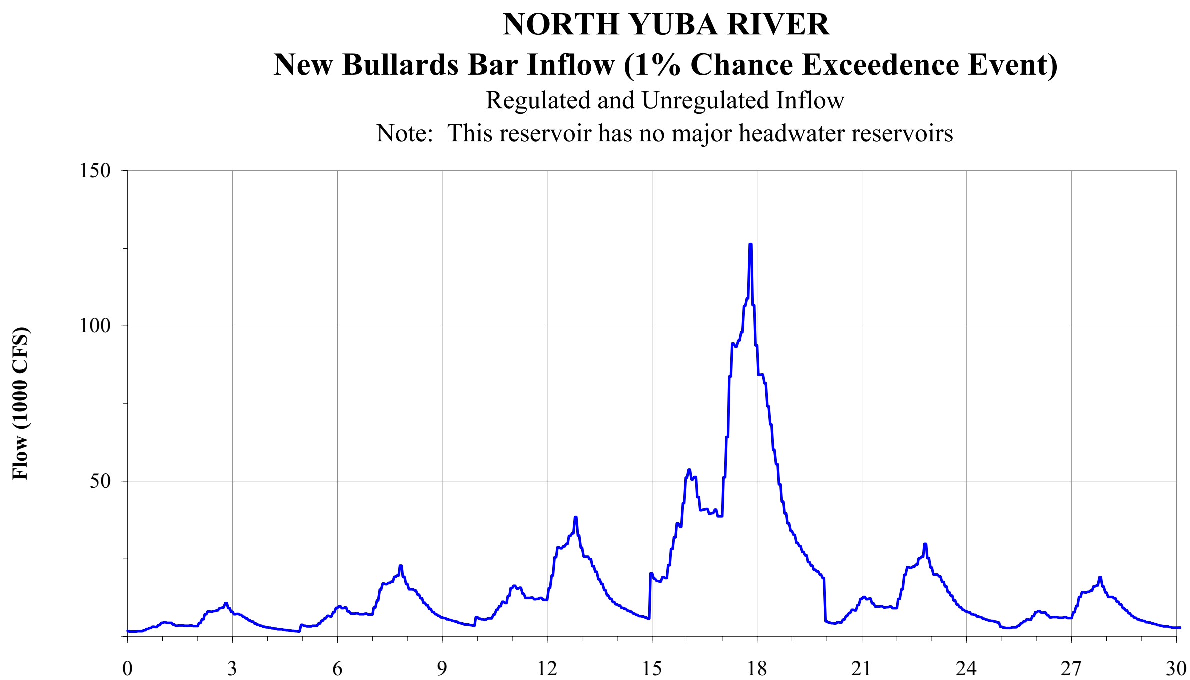


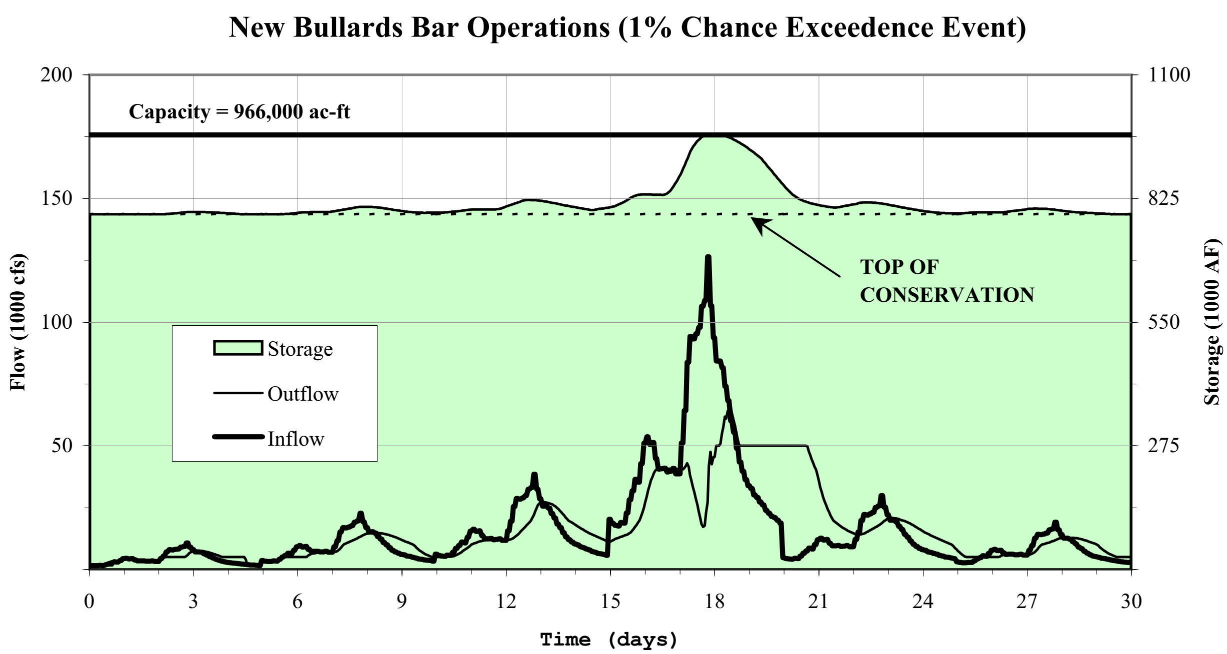
Notes:

1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 18 **Reservoir Simulation Hydrographs** **New Bullards Bar** **(2% Chance Exceedence Event)**	
US Army Corps of Engineers	**August 2004**

prepared by B.J.W.



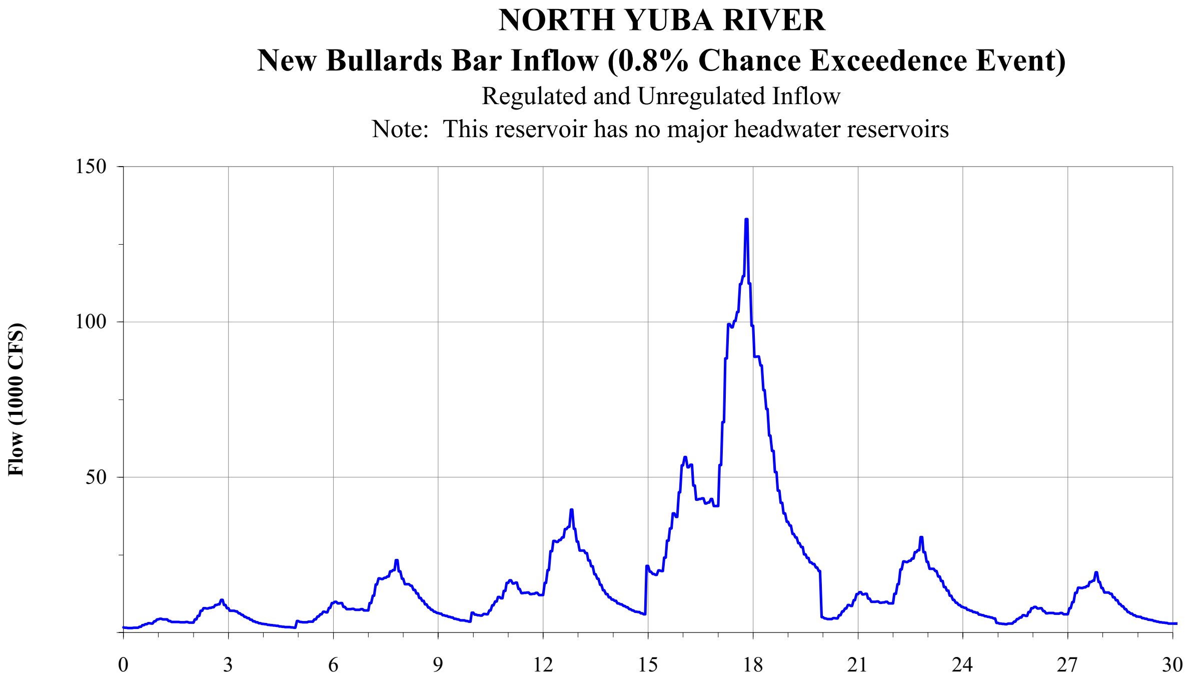


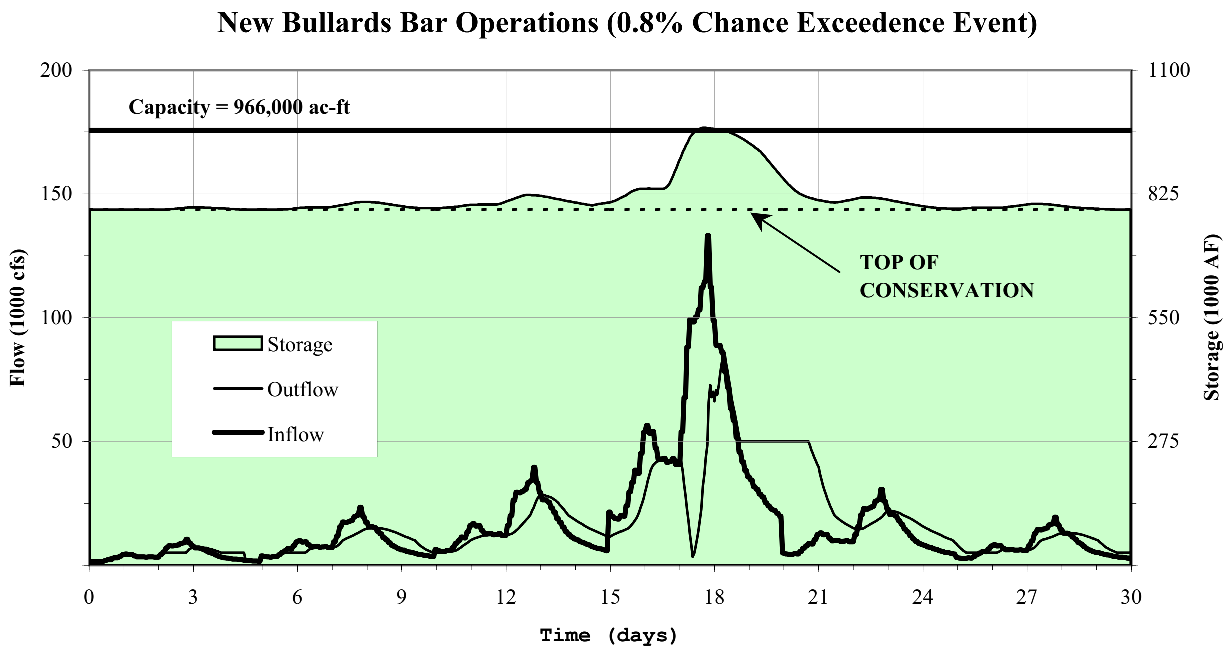
Notes:

1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 19 Reservoir Simulation Hydrographs New Bullards Bar (1% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.

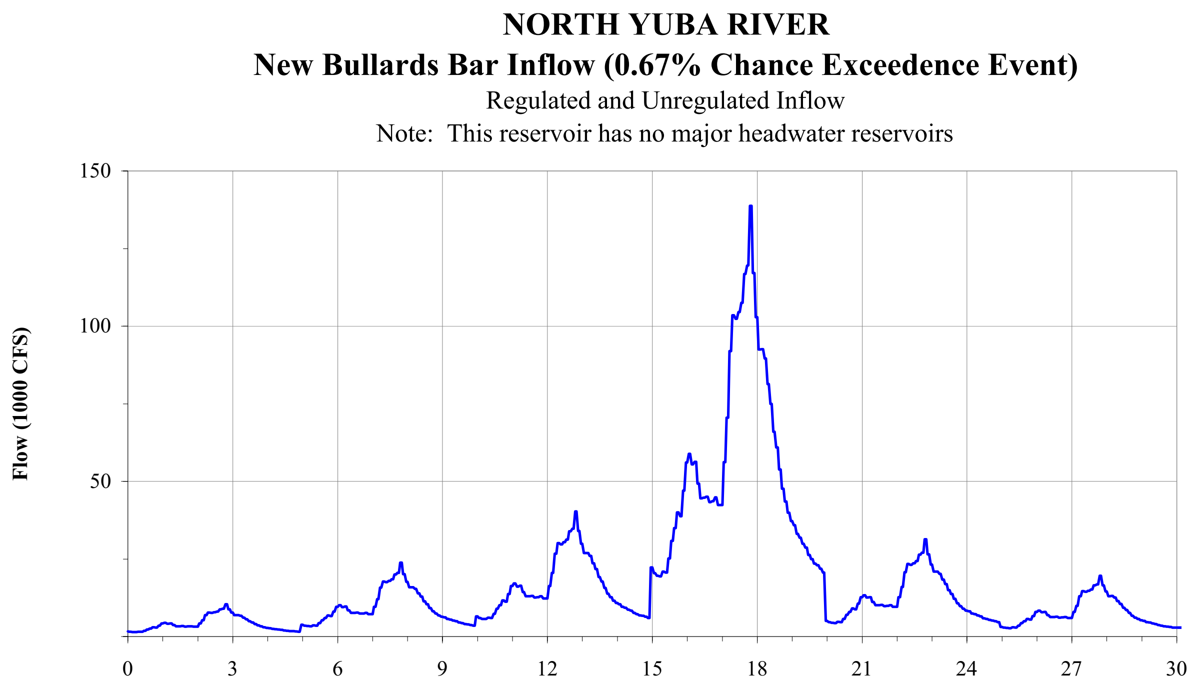


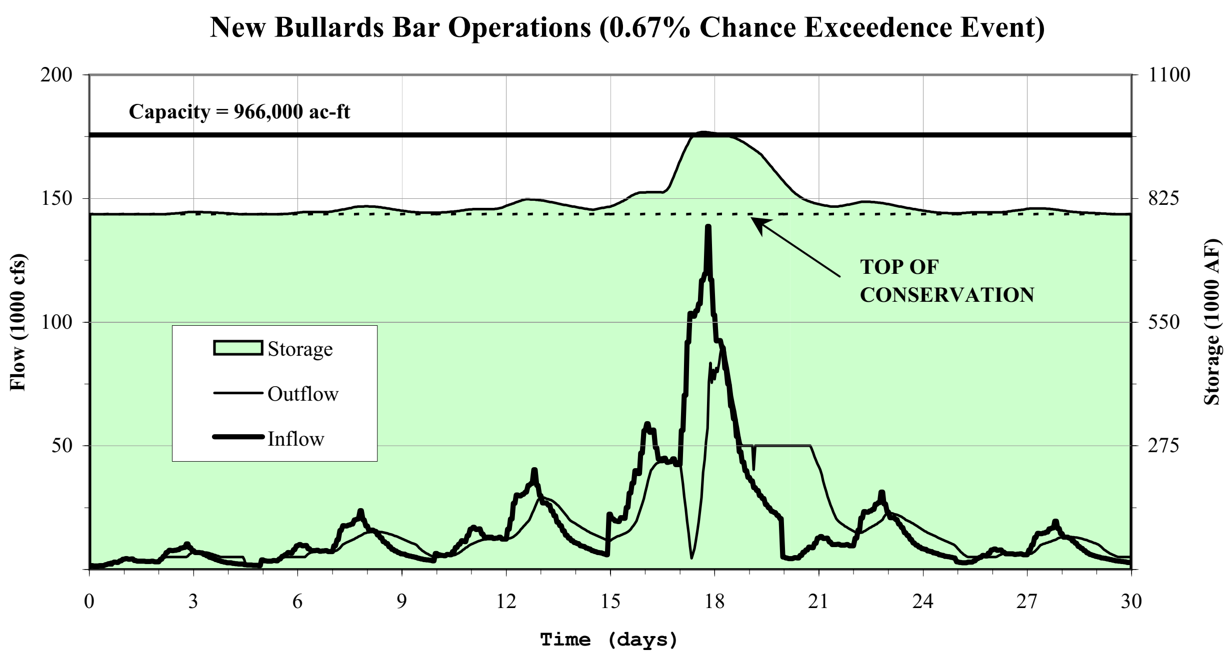


Yuba River Basin Project GRR	
Plate 20 **Reservoir Simulation Hydrographs** **New Bullards Bar** **(0.8% Chance Exceedence Event)**	
US Army Corps of Engineers	**August 2004**

Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

prepared by B.J.W.

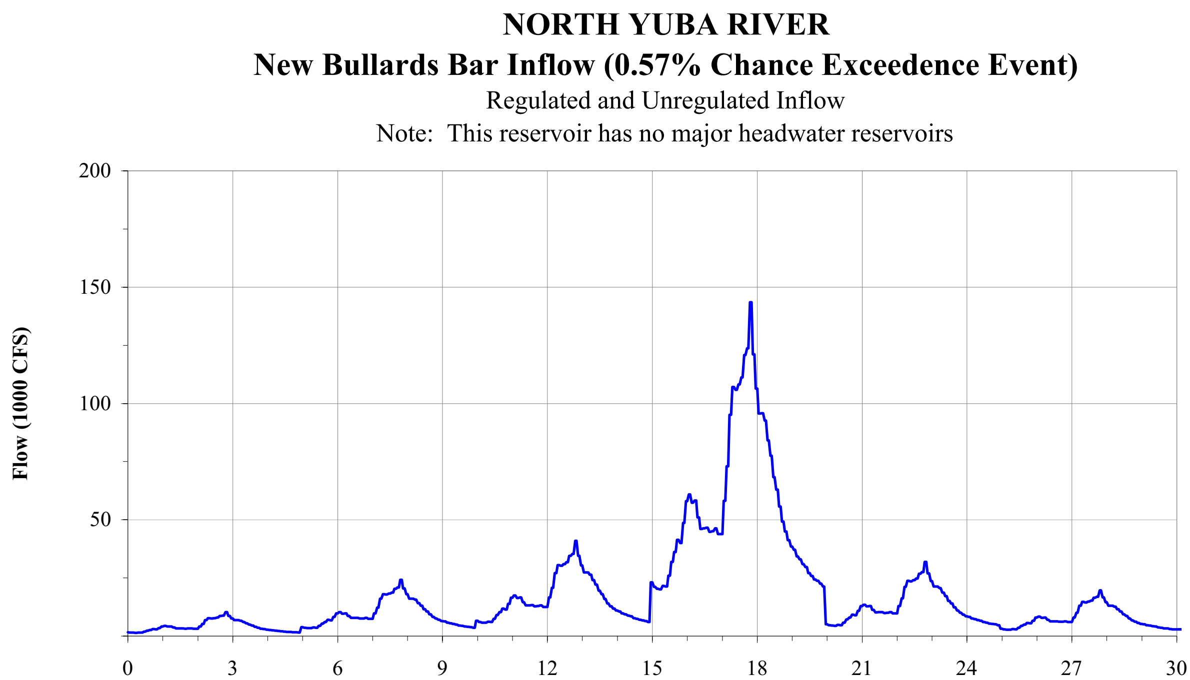


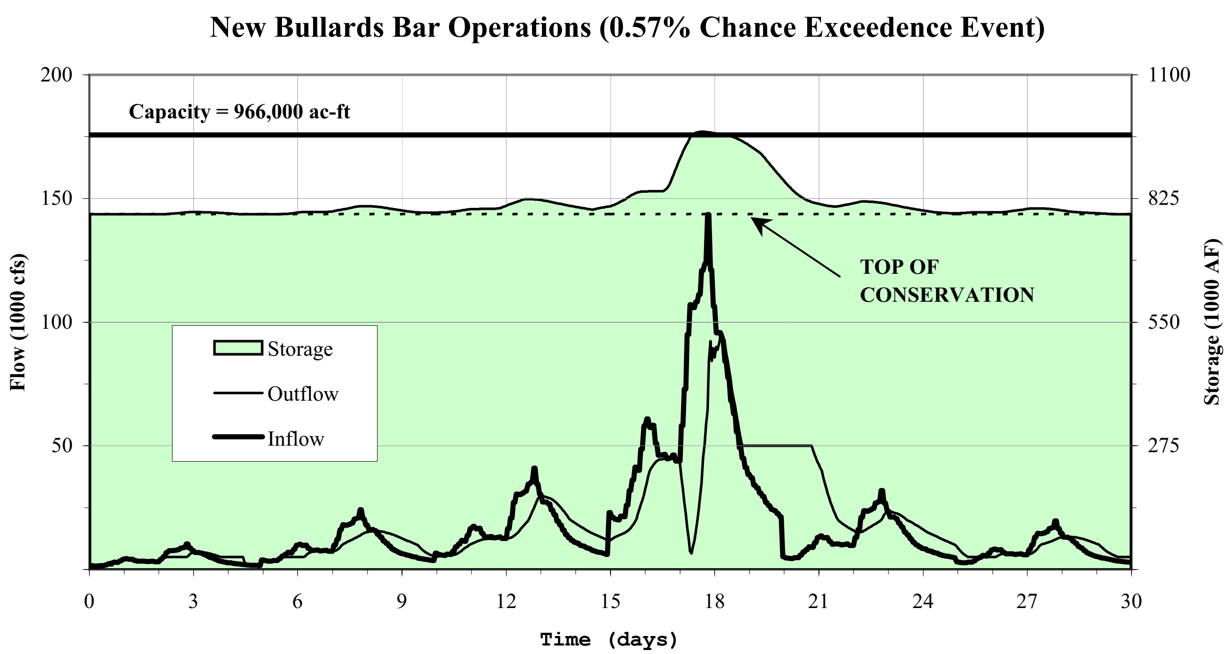


Notes:
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

Yuba River Basin Project GRR	
Plate 21 Reservoir Simulation Hydrographs New Bullards Bar (0.67% Chance Exceedence Event)	
US Army Corps of Engineers	August 2004

prepared by B.J.W.





Notes:

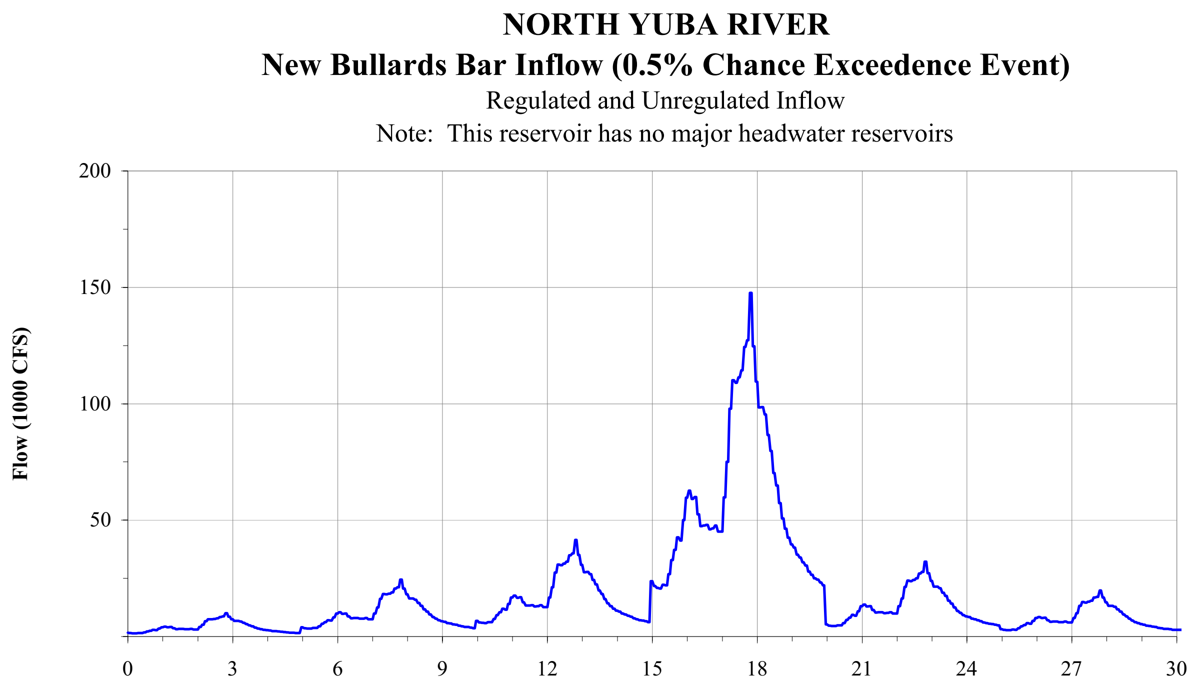
1) Results are from Feather River Storm Centering A
2) Complete certainty in local flow assumed

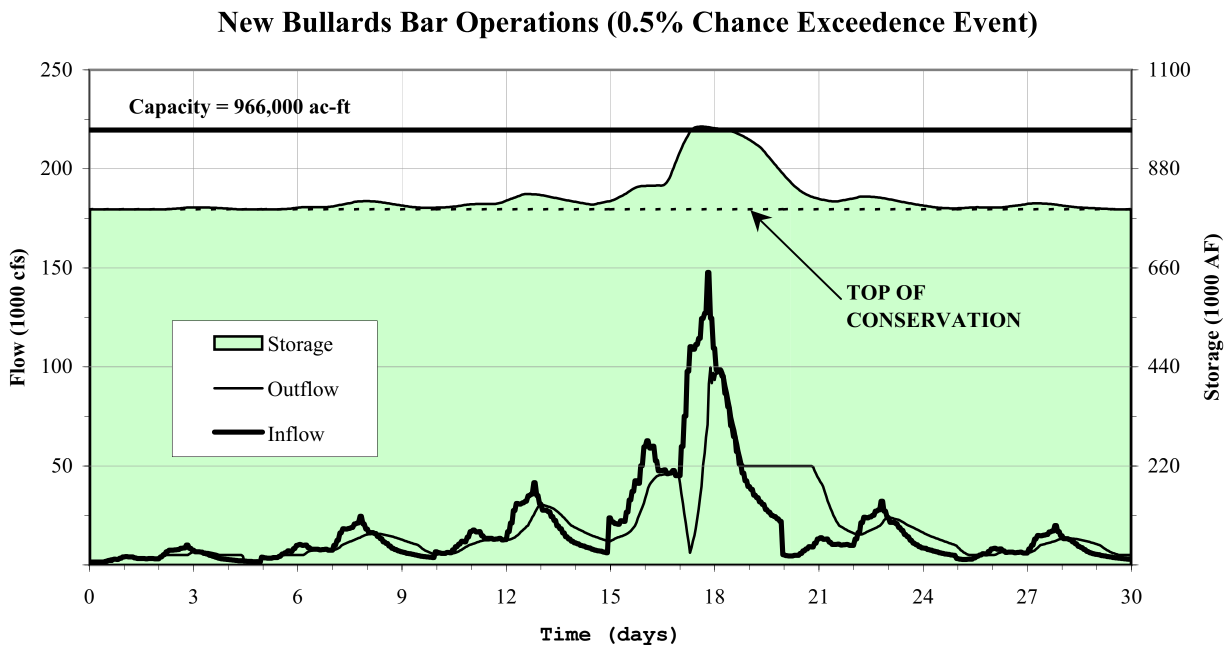
Yuba River Basin Project GRR

Plate 22
Reservoir Simulation Hydrographs
New Bullards Bar
(0.57% Chance Exceedence Event)

US Army Corps of Engineers **August 2004**

prepared by B.J.W.





Notes:
1) Results are from Feather River Storm Centering A
2) 20% uncertainty in local flow assumed

Yuba River Basin Project GRR

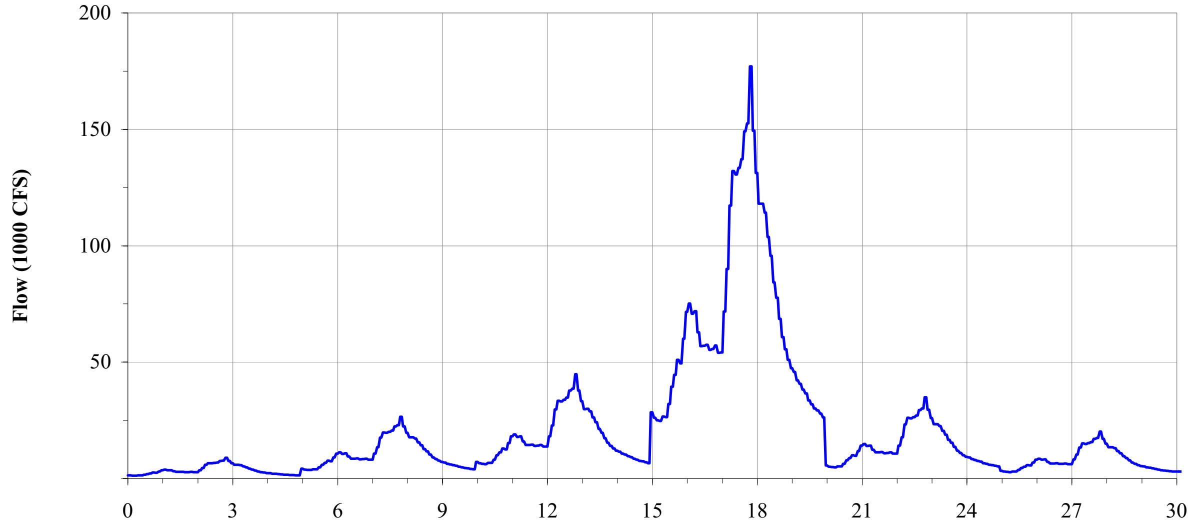
Plate 23
Reservoir Simulation Hydrographs
New Bullards Bar
(0.5% Chance Exceedence Event)

US Army Corps of Engineers **August 2004**

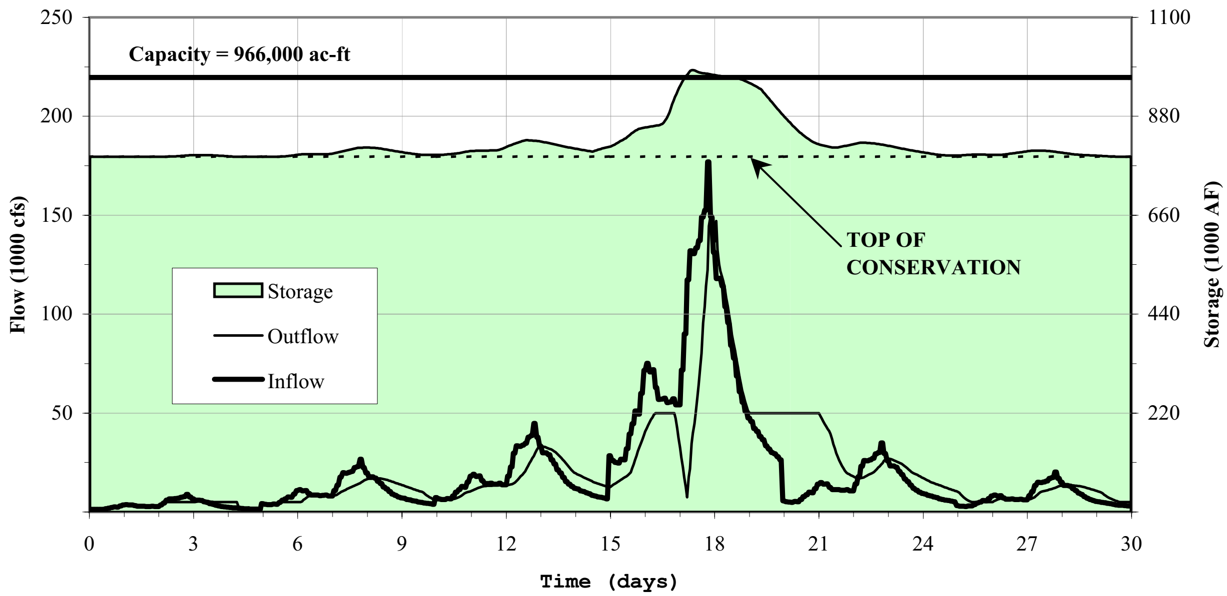
prepared by B.J.W.

NORTH YUBA RIVER
New Bullards Bar Inflow (0.2% Chance Exceedence Event)
Regulated and Unregulated Inflow

Note: This reservoir has no major headwater reservoirs



New Bullards Bar Operations (0.2% Chance Exceedence Event)



Notes:
1) Results are from Feather River Storm Centering A
2) 20% uncertainty in local flow assumed

Yuba River Basin Project GRR

Plate 24
Reservoir Simulation Hydrographs
New Bullards Bar
(0.2% Chance Exceedence Event)

US Army Corps of Engineers **August 2004**

prepared by B.J.W.

American River Watershed Project

Post-Authorization Change Report
And Interim General Reevaluation Report

American River Watershed

Common Features Project
Natomas Basin
Sacramento and Sutter Counties, California

SAFCA
Sacramento Area Flood Control Agency

Central Valley Flood Protection Board
Public Safety and Flood Management
State of California

US Army Corps of Engineers ®
Sacramento District

Appendix B – Hydrology Technical Documentation

August 2010

Appendix B

Appendix B1 – Synthetic Hydrology Technical Documentation

Appendix B2 – American River Hydrology and Folsom Dam Reservoir Operations

US Army Corps of Engineers
Sacramento District

American River Watershed
Common Features Project
Natomas Post-Authorization Change Report

Appendix B1
Synthetic Hydrology Technical Documentation

September 2008

AMERICAN RIVER WATERSHED COMMON FEATURES PROJECT
NATOMAS POST-AUTHORIZATION CHANGE REPORT
SYNTHETIC HYDROLOGY TECHNICAL DOCUMENTATION

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Note: Cover photo shows the mouth of the Natomas Cross Canal under the Garden Highway.

AMERICAN RIVER WATERSHED COMMON FEATURES PROJECT
NATOMAS POST-AUTHORIZATION CHANGE REPORT
SYNTHETIC HYDROLOGY TECHNICAL DOCUMENTATION

1.0 Documentation for Synthetic Flood Centerings

This chapter cites the documentation used to develop the hydrographs provided to Hydraulic Design Section as input for its calibrated HEC-RAS 4.0 model – the model used to develop water surface profiles for existing conditions (year 2007). Multiple flood centerings were tested to assure that the controlling hydrologic events were used for the hydraulic analysis. Each centering consisted of flow hydrographs developed for the specific frequency events: 50-, 10-, 4-, 2-, 1-, 0.5-, and 0.2 percent exceedence floods (8-Flood Series). The three flood centerings tested were the Sacramento Mainstem, Shanghai Bend-Yuba River, and the American River. The study area includes the Sacramento River from the Natomas Cross Canal down to Freeport and the American River from Folsom Dam down to its confluence with the Sacramento River, as well as the Natomas tributary drainage to the Natomas Cross Canal and to Steelhead Creek. **Plate 1**, the general map, shows the watersheds for the four Natomas tributaries to Steelhead Creek, the five Natomas tributaries to the Natomas Cross Canal, the American River south of the Natomas tributaries, the Feather River at its confluence with the Sacramento River, and the Sacramento River from upstream of Feather River down to its confluence with the American River. **Plate 2** shows where the hydraulic model input locations are for the five hydrographs contributing to the Natomas Cross Canal and the four hydrographs contributing to Steelhead Creek. Steelhead Creek is also known as the Natomas East Main Drainage Canal (NEMDC). The hydrographs are for an unsteady state simulation.

The three different flood centerings mentioned above are being tested in the hydraulic model to see which one produces the highest stages in which locations of the study area. Under certain conditions the American River is the controlling flood event for Steelhead Creek. The Shanghai Bend centering or the Sacramento Mainstem centering may be the controlling flood event for the Natomas Cross Canal. However, which flood centering series will produce the most critical flooding at which locations will not be known without hydraulic analysis.

1.1 <u>Sacramento Mainstem Centering</u>. The flood centering hydrographs were created using the methodology developed in the Comprehensive Study (the “Sacramento and San Joaquin River Basins Comprehensive Study,” Technical Studies Documentation, dated December 2002, abbreviated here as Comp Study and described in **Reference 1**). The Comprehensive Study models were developed for use in regional, broad concept studies, such as the Sacramento Common Features General Reevaluation study. **Reference 1, Appendix B**: “Synthetic Hydrology Technical Documentation,” describes the development of the unregulated flood hydrographs.

Unregulated flow frequency curves were developed at key mainstem and tributary locations in the Sacramento River basin. The unregulated frequency curves plot historic flood peaks and volumes with the statistical distributions of unimpaired flows (with no reservoir influence). The frequency curves display volumes, or average flow rates, for different time durations over a range of annual exceedence probabilities. These curves are used to translate: 1) hydrographs to frequencies; and 2) frequencies to flood volumes. As part of the Comprehensive Study (Comp Study), flow frequency curves were developed for 1-, 3-, 7-, 15-, and 30-day durations. A routing model was developed to route the unregulated daily flows from the tributary locations to downstream locations for use in constructing mainstem “index” frequency curves. Mainstem locations include the Sacramento River at the Latitude of Sacramento (including flows down the Yolo Bypass) and the Feather River downstream of the Yuba River (at Shanghai Bend). The maximum flows for each winter at the mainstem locations were used to develop flow frequency curves (for 1-, 3-, 7-, 15-, and 30-day durations) for those mainstem locations. No synthetic precipitation events were needed for the hydrology. This paragraph and the paragraphs below explain the development of the synthetic flood centerings for the latitude of Sacramento; the flood centerings for Shanghai Bend were developed similarly.

Based on analysis of historic floods over the Sacramento watershed, synthetic mainstem flood centerings were developed to stress widespread valley areas. The flow frequency curves for the Latitude of Sacramento (used for the Sacramento Mainstem Centering) provide the hypothetic flood volumes that the basin will produce during simulations of each of the eight synthetic exceedence frequency flood events (50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2percent). The role of the mainstem centering is to distribute these flood volumes back into the basin, tributary by tributary, in accordance with patterns visible in historic flood events. **Reference 1, Appendix C**: “Reservoir Operations Modeling, Existing Design Operations and Reoperation Analysis,” describes the development of the reservoir operations models to route the unregulated hydrographs through the headwater and major flood management reservoirs for input into the hydraulic model.

The Sacramento Mainstem flood hydrographs were developed using the flood patterns shown on **Table 1** to produce flood runoff hydrographs centered at the Latitude of Sacramento. **Table 1** shows the set of synthetic exceedence frequencies assigned to the set of tributaries listed in column 1 such that the regulated and routed hydrographs have the volumes for a flood series centered at the Latitude of Sacramento. The hydrographs have a duration of 30 days, with six 5-day waves. The pattern hydrograph used for the 5-day waves at each upstream tributary is that of the unregulated flood hydrograph for 30 December 1996 to 3 January 1997 (New Year 1997 flood) at that tributary index point. This flood pattern was used because, of the large historical floods over the Sacramento Basin, it is the flood event for which hourly hydrographs were available for the largest number of upstream tributary gages used for the Comp Study. The American River flood hydrographs are different from those used in the Comp Study. See **Section 1.3** for an explanation of the changes made for the American River centering.

Table 1
Sacramento River Mainstem Synthetic Flood Centering

Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	84.42	17.03	8.09	4.41	2.21	1.13	0.44
Clear Cr. at Whiskeytown	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Cow Cr. near Millville	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Cottonwood Cr. near Cottonwood	80.91	17.03	10.79	6.47	3.24	1.66	0.65
Battle Cr. Below Coleman FH	80.91	16.18	9.71	5.39	2.70	1.38	0.60
Mill Cr. near Los Molinos	80.91	16.18	9.71	4.22	2.35	1.23	0.51
Elder Cr. near Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Thomes Cr. at Paskenta	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Deer Cr. near Vina	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Big Chico Cr. near Chico	88.26	16.18	9.71	4.22	2.35	1.23	0.51
Stony Cr. at Black Butte	88.26	19.42	10.79	4.85	2.70	1.38	0.58
Butte Cr. near Chico	66.70	13.63	6.08	2.75	1.38	0.71	0.30
Feather River at Oroville	53.60	11.78	4.42	2.41	1.20	0.62	0.24
Yuba R. at New Bullards Bar	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Yuba R. at Englebright	55.09	12.52	4.86	2.10	1.05	0.54	0.21
Deer Cr. near Smartsville	55.12	12.52	4.86	2.10	1.05	0.54	0.21
Bear River near Wheatland	53.60	11.13	4.42	2.10	1.05	0.54	0.21
Cache Cr. at Clear Lake	52.19	12.52	6.95	4.45	2.22	1.14	0.45
N.F. Cache Cr. at Indian Vy.	52.19	12.52	6.95	4.45	2.22	1.14	0.45
American River at Folsom	55.09	12.52	4.86	2.51	1.26	0.64	0.25
Putah Cr. at Berryessa	52.19	12.52	6.95	4.45	2.22	1.14	0.45

The process of preparing flood hydrographs begins by using unregulated frequency curves to translate all of the exceedence frequencies in the synthetic patterns to average flow rates. The unregulated frequency curves were prepared using 1-, 3-, 7-, 15-, and 30-day durations. Values for the 5-, 10-, 20-, and 25-day durations were obtained through interpolation. The values from the frequency curves represent the average flow anticipated over a specific time interval. For instance, the 5-day value is the average flow expected during the highest 5-days of flooding during any of the eight synthetic exceedence events. Likewise the 10-day value is the average over the highest 10 days of flooding. Flood volumes were computed by multiplying the average flows by their respective durations. These values represented the total volumes of water anticipated during the highest 5, 10, 15, 20, 25, or 30 days of flows. Furthermore, these flood volumes were portioned into time segments by subtracting volumes of the shorter durations from the next longer duration. For example, the 5-day volume was subtracted from the 10-day volume and the remainder was equal to the amount of flood volume that is produced by the tributary between the 5-day and 10-day maximum periods. This procedure was repeated for the 10-, 15-, 20-, 25-, and 30-day durations and resulted in a set of eight synthetic exceedence frequency flood volumes produced by the tributary.

The basic pattern of all synthetic flood hydrographs was a 30-day hourly time series consisting of 6 waves, each 5 days in duration. Volumes were ranked and distributed into the basic pattern. The highest wave volume was always distributed into the fourth, or main, wave.

The second and third highest volumes preceded and followed the main wave, respectively. The fourth highest volume was distributed into the second wave and the fifth highest was distributed into the final of the six waves. The sixth and smallest wave volume was distributed into the first wave of the series. The shape of each wave is identical and the magnitude is determined by the total volume that the wave must convey. The process of converting flow frequency curves into the synthetic series of 30-day hydrographs is depicted on **Plate 3**.

There are several reasons for using a 30-day duration for the synthetic flood hydrographs. The Sacramento River watershed is so large that 5 days is not long enough for a flood wave to travel from the most distant headwater down to the mouth of the Sacramento River. The multi-wave flood hydrograph includes the smaller antecedent waves from storms that prime the watershed for the highest wave. Also, the multi-wave hydrograph is needed to (1) provide the extra flood volume needed to simulate reservoir operation during an extended period of wet weather, and (2) fill the floodplains with enough flood volume to run levee failure scenarios.

Figure 1 shows an example of the 30-day hydrograph with the 5-day waves, for unregulated and regulated conditions. The figure shows the 1 percent exceedence hydrographs, for unregulated and regulated conditions, for the Sacramento River at the confluence with the Feather River, for the Sacramento Mainstem Centering. The hydrograph for unregulated conditions is not a true representation of the hydrograph with six 5-day waves; it is the result from routed contributions of upstream tributaries. See **Figure 2** for an example of a tributary hydrograph with six 5-day waves – the Comp Study hydrograph for Folsom Lake inflow.

Figure 1

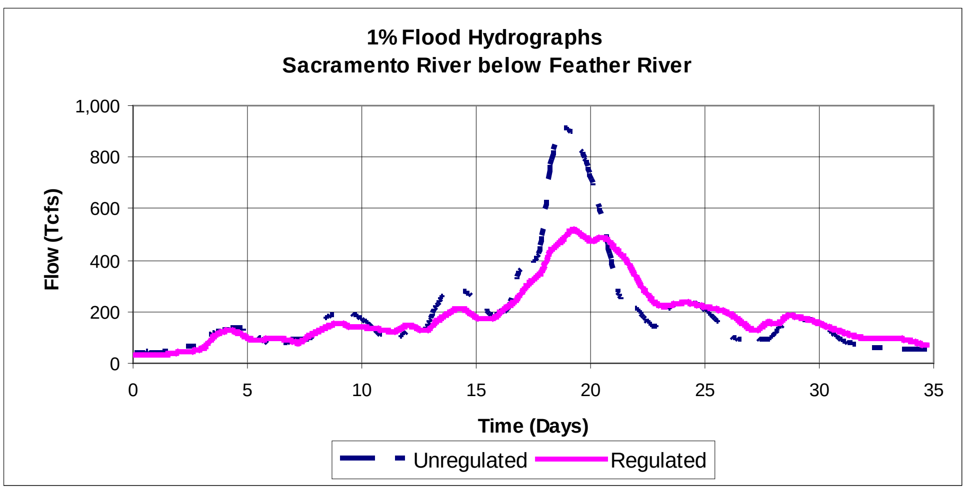
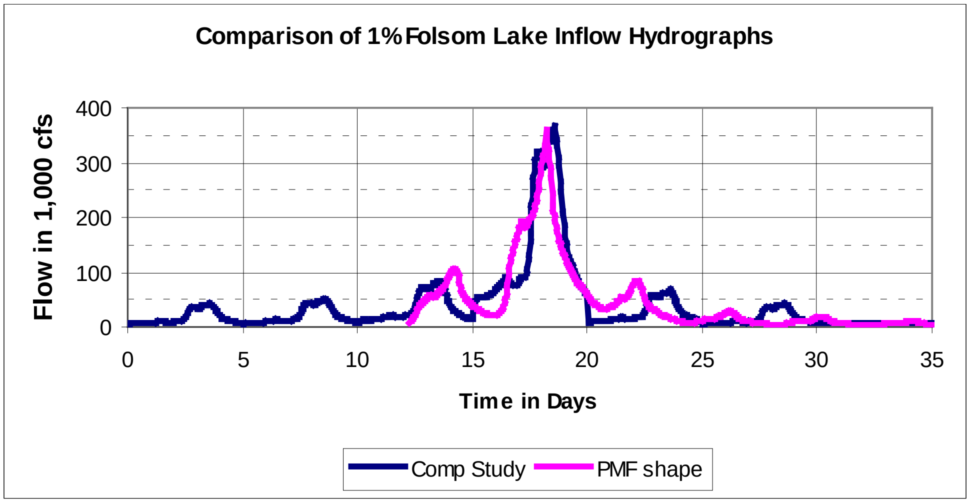


Figure 2



1.2 <u>Shanghai Bend-Yuba River Centering</u>. This flood centering, with a specific centering on the Yuba River and slightly more frequent concurrent event on the Feather River above Oroville, produces the maximum inundation areas along the lower reaches of the Feather and Yuba rivers. It also produces the maximum inundation area at Verona, near the confluence of the Feather River with the Sacramento River. This flood centering was not developed as part of the original Comp Study, but the Comp Study methodology described in **Reference 1** was used to develop the storm centering and flood hydrographs, which were routed through the reservoir system. **Reference 2**, the "Yuba River Basin Project General Reevaluation Report," App. A, Synthetic Hydrology and Reservoir Operations Technical Documentation, dated August 2004, corrected June 2008, documents the hydrology and modeling efforts conducted for the Feather and Yuba rivers using the Comp Study methodology. **Table 2** shows the flood patterns for the Shanghai Bend-Yuba River centering. The American River flood hydrographs are different from those used in the Comp Study. See **Section 1.3** for an explanation of the changes made.

Table 2
Feather River above Shanghai Bend Synthetic Flood Centering A
With a Specific Centering on the Yuba River

Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	101.01	20.20	8.08	5.77	2.89	1.44	0.58
Clear Cr. at Whiskeytown	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Cow Cr. near Millville	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Cottonwood Cr. near Cottonwood	344.83	68.97	27.59	19.70	9.85	4.93	1.97
Battle Cr. Below Coleman FH	196.08	39.22	15.69	11.20	5.60	2.80	1.12
Mill Cr. near Los Molinos	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Elder Cr. near Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Thomes Cr. at Paskenta	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Deer Cr. near Vina	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Big Chico Cr. near Chico	76.34	15.27	6.11	4.36	2.18	1.09	0.44
Stony Cr. at Black Butte	140.85	28.17	11.27	8.05	4.02	2.01	0.80
Butte Cr. near Chico	76.34	15.27	6.11	4.36	3.18	1.09	0.44
Feather River at Oroville	54.95	10.87	4.35	2.17	1.06	0.53	0.21
Yuba R. at New Bullards Bar	50.00	10.00	4.00	2.00	1.00	0.5	0.20
Yuba R. at Englebright	50.00	10.00	4.00	2.00	1.00	0.5	0.20
Deer Cr. near Smartsville	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Bear River near Wheatland	125.00	25.00	10.00	5.00	2.50	1.25	0.50
Cache Cr. at Clear Lake	153.85	30.77	12.31	6.15	3.08	1.54	0.62
N.F. Cache Cr. at Indian Vy.	153.85	30.77	12.31	6.15	3.08	1.54	0.62
American River at Folsom	76.34	15.27	6.11	3.05	1.53	0.76	0.31
Putah Cr. at Berryessa	153.85	30.77	12.31	6.15	3.08	1.54	0.62

1.3 American River Centering. The flood patterns for the American River specific tributary centering are shown on **Table 3**. The concurrent flood hydrographs for this centering were developed using the Comp Study methodology and hydrograph shapes, based on the January 1997 New Years flood event. However, the American River specific flood hydrographs were developed using a different shape and different volumes**.** For consistency with the ongoing American River Watershed Study, the Folsom Dam inflow hydrograph shape used for the American River Common Features GRR is based upon the Probable Maximum Flood (PMF) for Folsom Dam. Use of this PMF-shape flood hydrograph predates the Comp Study. Development of the revised Folsom Dam PMF is discussed in **Reference 3**, “Folsom Dam and Lake Revised PMF Study,” American River Basin, California, Hydrology Office Report, dated October 2001. The PMF was computed using the most recent Probable Maximum Precipitation criteria, presented in **Reference 4**, “Hydrometeorological Report No. 59, Probable Maximum Precipitation for California,” U.S. Dept. of Commerce, NOAA, U.S. Dept of the Army Corps of Engineers, Feb 1999).

Table 3
American River Tributary Synthetic Flood Centering

Index Point	Percent Chance Exceedence						
	50%	10%	4%	2%	1%	0.50%	0.20%
Sacramento River at Shasta	250.00	50.00	20.00	10.00	5.00	2.50	1.00
Clear Cr. at Whiskeytown	555.56	111.11	44.44	22.22	11.11	5.56	2.22
Cow Cr. near Millville	178.57	35.71	14.29	7.14	3.57	1.79	0.71
Cottonwood Cr. near Cottonwood	555.56	111.11	44.44	22.22	11.11	5.56	2.22
Battle Cr. below Coleman FH	178.57	35.71	14.29	7.14	3.57	1.79	0.71
Mill Cr. near Los Molinos	121.95	24.39	9.76	4.88	2.44	1.22	0.49
Elder Cr. near Paskenta	138.89	27.78	11.11	5.56	2.78	1.39	0.56
Thomes Cr. at Paskenta	138.89	27.78	11.11	5.56	2.78	1.39	0.56
Deer Cr. near Vina	121.95	24.39	9.76	4.88	2.44	1.22	0.49
Big Chico Cr. near Chico	138.89	27.78	11.11	5.56	2.78	1.39	0.56
Stony Cr. at Black Butte	121.95	24.39	9.76	4.88	2.44	1.22	0.49
Butte Cr. near Chico	138.89	27.78	11.11	5.56	2.78	1.39	0.56
Feather River at Oroville	92.59	18.52	7.41	3.7	1.85	0.93	0.37
Yuba R. at New Bullards Bar	69.44	13.89	5.56	2.78	1.39	0.69	0.28
Yuba R. at Englebright	69.44	13.89	5.56	2.78	1.39	0.69	0.28
Deer Cr. near Smartsville	116.28	23.26	9.30	4.65	2.33	1.16	0.47
Bear River near Wheatland	116.28	23.26	9.30	4.65	2.33	1.16	0.47
Cache Cr. at Clear Lake	192.31	38.46	15.38	7.69	3.85	1.92	0.77
N.F. Cache Cr. at Indian Vy.	192.31	38.46	15.38	7.69	3.85	1.92	0.77
American River at Folsom	50.00	10.00	4.00	2.00	1.00	0.50	0.20
Putah Cr. at Berryessa	192.31	38.46	15.38	7.69	3.85	1.92	0.77

Also, the American River Watershed Study unregulated flow frequency curves for the American River were revised when the period of record was updated through 2004. See **Reference 5**, "Rain Flood Flow Frequency Analysis, American River California," Office Report, U.S. Army Corps of Engineers, Sacramento District, dated August 2004. Revision of the flood frequency curves changed the flood volumes used for the American River hydrographs for the 8-Flood Series. **Figure 2** is a graphical presentation of the flood inflow hydrographs to Folsom Lake, comparing the Comp Study 1 percent flood with the PMF-shape 1 percent flood. The graph presents the maximum 72-hour period as coincident for the two flood hydrographs for days 17 through 19.

Because the PMF-shape hydrographs for the Folsom Lake inflow are different from the Comp Study hydrographs, a volume comparison was made between the hydrographs for various exceedence events. This comparison was made to ensure that use of the PMF-shape hydrographs would not cause problems and inconsistencies. **Table 4** presents a volume comparison between the two different hydrograph shapes for the American River flood series above Folsom Dam. The table shows that the differences in volume are minor.

Table 4
Hydrograph Volume Comparison for
Inflow Hydrographs to Folsom Lake

% Event Flood	1-Day Volume (in day cfs)	3-Day Volume (in day cfs)	7-Day Volume (in day cfs)
10% (PMF Shape)	101,000	71,000	43,000
10% (Comprehensive Study)	113,000	70,000	46,000
% Difference	12%	-1%	7%
4% (PMF Shape)	156,000	110,000	66,000
4% (Comprehensive Study)	174,000	108,000	67,000
% Difference	10%	-2%	1%
2% (PMF Shape)	207,000	145,000	87,000
2% (Comprehensive Study)	229,000	142,000	86,000
% Difference	10%	-2%	-1%
1% (PMF Shape)	266,000	187,000	112,000
1% (Comprehensive Study)	292,000	181,000	107,000
% Difference	9%	-3%	-5%
0.5% (PMF Shape)	334,000	235,000	141,000
0.5% (Comprehensive Study)	363,000	226,000	131,000
% Difference	8%	-4%	-8%
0.2% (PMF Shape)	440,000	309,000	185,000
0.2% (Comprehensive Study)	475,000	300,000	169,000
% Difference	7%	-3%	-9%

The flow comparison is presented in Table 4 in "% Difference", which shows how much the Comprehensive Study hydrograph volume differs from the PMF shape hydrograph volume. Hydrographs are for unregulated inflow conditions.

The PMF-shape hydrographs were routed through Folsom Dam for three without-project alternatives. In preparation for routing the PMF-shape hydrographs through Folsom Dam, the maximum 72-hour period of the PMF-shape was lined up to occur at the same time as the Comp Study American River hydrograph. See **Figure 2** above. For the PMF-shape hydrographs, the maximum 3-day flow occurs closer to the beginning of the hydrograph. As a result, outflow from Folsom Dam for the PMF-shape hydrographs does not begin until 6 p.m. of day 12 after the start of the Comp Study hydrographs for the other Sacramento River tributaries. A constant flow of 2,000 cfs was used for outflow from Folsom Dam for days 1 through 6pm of day 12 for the PMF shape flood hydrographs.

2.0 Development of Historical Flood Hydrographs for Natomas Tributaries

Historical flow hydrographs for the Natomas tributaries were developed as upstream boundary conditions on the Natomas Cross Canal and Steelhead Creek (also known as Natomas East Main Drainage Canal), for testing of the hydraulic model. The upstream boundary locations for the Natomas tributaries are shown on **Plate 2.** Six large historical flood events were chosen for which Natomas tributary flood hydrographs would be developed. The six flood events are 15 - 19 February 1986, 8 - 12 January 1995, 29 December 1996 - 3 January 1997, 22 - 26 January 1997, 2 - 6 February 1998, and 30 December 2005 - 3 January 2006. The selection of flood events was based on the amount of available precipitation data and whether any flow data, either a hydrograph or mean day flow, were available for the Dry Creek at Roseville gaging station. Hydrographs for the six floods on the Sacramento, Feather, and American rivers were available for use in the hydraulic model. The effect of any additional contribution from the Natomas tributaries could then be tested in the model. Also, from the frequency analysis presented in the Natomas General Reevaluation Report Hydrology Appendix (**Reference 6**), frequencies could be assigned to these flood events for the Natomas tributaries, which could then be compared with the magnitudes of these events on the mainstem Sacramento and American rivers for the Coincident Frequency Analysis.

This chapter discusses the computation of historical flood hydrographs first for the Steelhead Creek tributaries and then for the Natomas Cross-Canal tributaries. The historical flood hydrographs were easier to develop for Steelhead Creek because calibrated HEC-1 models had been developed in previous studies for the tributaries, an extensive network of precipitation gages covers the watershed, and hydrographs or mean day flows exist for the six flood events for the Dry Creek at Roseville gage. A mean day flow record is available for four of the six floods at the Arcade Creek near Del Paso Heights gage. **Table 5** shows what flow data are available for which storm events. Station locations are shown on **Plate 1**.

Table 5

Available Flow Data for 6 Historical Flood Events

Stream---> Gage Location--->	Dry Cr Royer Park	Dry Cr Vernon St.	Magpie Cr Del Paso Hghts	Arcade Cr Del Paso Hghts
CDEC Code or USGS Number	CDEC RYP	CDEC VRS	USGS 11447330	CDEC ACK
FLOOD EVENT	D.A. (sq.mi.) 58.63*	D.A. (sq.mi.) 77.75*	D.A. (sq.mi.) 2.30*	D.A. (sq.mi.) 31.83*
15-19 February 1986	N/A	Hydrograph	N/A	N/A
8-12 January 1995	N/A	Hydrograph	N/A	N/A
29 Dec 96 - 3 Jan 97	N/A	Mean Day	Mean Day	Mean Day
22-26 January 1997	N/A	Mean Day	Mean Day	Mean Day
2-6 February 1998	N/A	Mean Day	N/A	Mean Day
30 Dec 05 - 3 Jan 06	hydrograph	Hydrograph	N/A	Mean Day

N/A = Not Available

* = drainage area in HEC-1 model, not drainage area associated with DWR or USGS gage

Some of the precipitation gages used for the December 2005 storm isohyetal map were not available for the earlier flood events. These are mostly the stations on the Wunderground Web site and are not included in **Table 6**. **Table 6** below lists the National Climatic Data Center (NCDC) stations and California Data Exchange Center (CDEC) stations used to develop the storm isohyetal maps for one or more of the six historical flood events. **Table 6** also lists the station precipitation amounts for the 6 storms. **Plate 4** shows the locations of the precipitation gages listed in **Table 6** and the streamflow gages listed in **Table 5**.

Table 6

Precipitation Gages - Storm Totals for 6 Historical Storm Events

STATION	DATA SOURCE	CDEC STATION CODE	STORM EVENT AND PRECIPITATION (INCHES)					
			1986 15-19 FEB	1995 8-12 JAN	1996 - 97 29 DEC - 2 JAN	1997 22-26 JAN	1998 2-6 FEB	2005 - 06 30 DEC - 3 JAN
Arcade Cr-Winding Way	CDEC	AMC	N/A	N/A	** 3.93	** 6.34	** 5.79	** 4.93
Arden	CDEC	ARW	** 9.09	5.74	** 3.34	** 5.59	** 5.00	4.49
Auburn	NCDC	---	12.83	8.96	7.28	7.95	5.70	N/A
Auburn Dam Ridge	CDEC	ADR	N/A	N/A	** 6.93	** 7.84	** 5.55	4.60
CSUS	CDEC	CSU	N/A	N/A	N/A	N/A	N/A	4.80
Camp Far West	CDEC	CFW	N/A	N/A	N/A	N/A	N/A	4.63
Caperton Reservoir	CDEC	CPR	N/A	N/A	** 4.65	** 5.67	** 5.63	** 4.64
Chicago	CDEC	CHG	** 7.96	N/A	3.82	5.75	2.68	4.69
Cresta Park	CDEC	CRP	9.37	N/A	3.86	6.50	4.88	4.49
Englebright Dam	CDEC	ENG	N/A	5.48	6.20	6.56	4.83	N/A
Folsom Dam	CDEC	FLD	9.53	N/A	2.13	3.58	3.03	4.72
Folsom WTP	CDEC	FWP	N/A	N/A	N/A	N/A	5.94	N/A
Grass Valley #2	NCDC	---	** 14.9	9.51	14.73	10.77	8.69	N/A
Grass Valley	CDEC	GVY	N/A	N/A	N/A	N/A	N/A	10.72
Hurley	CDEC	HUR	N/A	N/A	2.78	3.56	3.91	4.55
Lincoln	CDEC	LCN	N/A	** 5.19	N/A	3.46	** 5.15	4.34
Loomis Observatory	CDEC	LMO	N/A	N/A	3.74	6.38	4.89	3.89
Navion	CDEC	NVN	** 9.54	N/A	N/A	6.07	5.94	N/A
Newcastle-Pineview Sch.	CDEC	NCS	N/A	N/A	** 4.96	** 6.74	** 5.94	4.93
Orangevale	CDEC	ORN	** 6.67	N/A	3.94	5.67	6.26	4.85
Rancho Cordova	CDEC	RNC	7.76	N/A	3.54	5.50	5.24	4.61
Represa	NCDC	---	7.03	5.24	3.52	4.47	4.53	3.89
Rio Linda	CDEC	RLN	** 7.28	N/A	** 2.92	** 4.77	** 5.32	** 3.90
Roseville City Hall	#	---	9.34	N/A	N/A	N/A	N/A	N/A
Roseville Fire Stn	CDEC	RSV	N/A	N/A	3.62	** 5.63	N/A	3.76
Roseville WTP	CDEC	RTP	** 8.76	N/A	** 4.30	** 6.30	** 5.95	** 5.01
Royer Park	CDEC	RYP	N/A	N/A	** 3.86	** 6.50	** 6.10	** 4.08
Sac Exec AP	NCDC	---	6.72	5.11	2.79	5.65	4.69	4.70
Sac Metro AP	CDEC	SMF	N/A	4.30	5.51	5.74	3.70	3.56
Sacramento 5 ESE	NOAA	---	7.68	5.89	2.22	4.71	4.54	5.02
Sacramento City	#	---	8.12	N/A	N/A	N/A	N/A	N/A
Sacramento Post Office	CDEC	SPO	N/A	5.89	2.46	4.75	4.60	N/A
Sierra College	#	---	9.05	N/A	N/A	N/A	N/A	N/A
Sunrise Blvd	#	---	6.82	N/A	N/A	N/A	N/A	N/A
Van Maren	CDEC	VNM	** 8.90	N/A	** 3.98	** 5.95	** 5.98	N/A
Wheatland 2NE	NCDC	---	4.90	4.40	N/A	N/A	N/A	N/A

N/A = Not Available or Missing Record

** = Recording Rain Gage pattern used to distribute this storm in HEC-1 Model

= Data from Dry Creek Basin Hydrology Report dated April 1988

2.1 Steelhead Creek Historical Flood Hydrographs.

a. December 2005 Flood. The December 2005 – January 2006 rainflood event was used to validate the HEC-1 models for Dry and Arcade creeks in **Reference 6**, the Natomas GRR Hydrology Appendix, dated October 2006. **Plate 5** shows the December 2005 – January 2006 storm isohyetal map, and **Figure 3** shows the comparison between the observed and computed hydrographs for Dry Creek at Vernon Street. The HEC-1 model was used to compute flood hydrographs at the streamgage locations, route the flows down to the downstream index locations, add the local flow above Steelhead Creek, and compute flood hydrographs for Upper NEMDC and Old Magpie Creek above and below their respective pumping stations. The computed flood hydrographs for Dry Creek at Steelhead Creek, Arcade Creek at Steelhead Creek, Upper NEMDC above and below the NEMDC Stormwater Pumping Station, and Old Magpie Creek above and below Pump 157, were provided to Hydraulic Design Section as historical flood input for this flood event. The pumping station locations are shown on **Plate 1**.

Figure 3 presents the flood hydrograph from the HEC-1 run for Dry Creek at Roseville compared with the observed hydrograph. **Table 7** presents a comparison for the peak, and 1-, 3-, and 5-day volumes between the computed hydrographs and the observed hydrographs for the Dry Creek and Arcade Creek gaging stations.

Figure 3

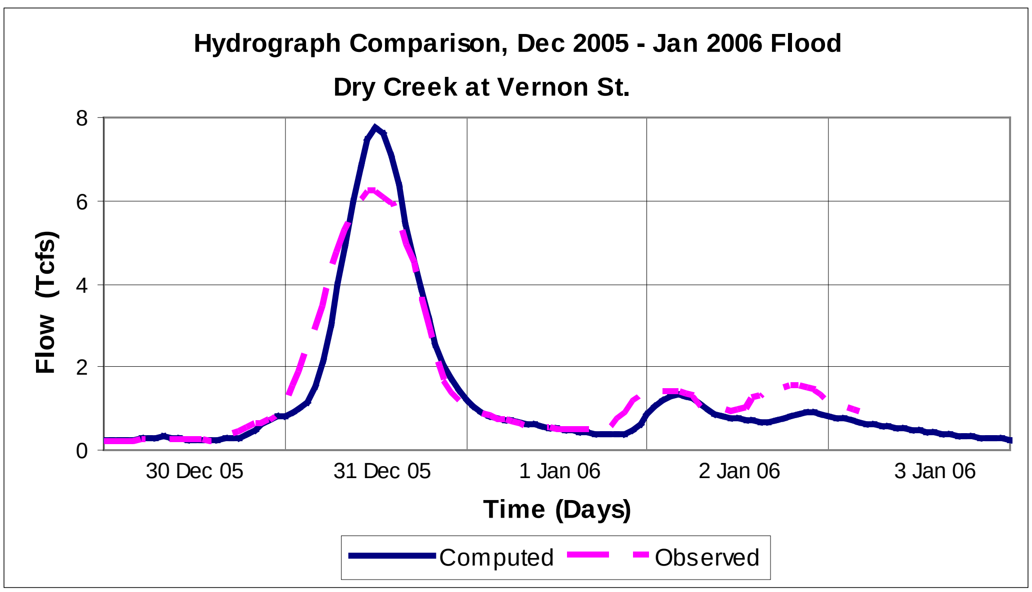


Table 7
30 December 2005 - 3 January 2006 Flood Volume Comparison
For Three Steelhead Creek Tributary Streamflow Gaging Stations

Hydrograph	Peak (cfs)	1-Day Vol. (avg cfs)	3-Day Vol. (avg cfs)	5-Day Vol. (avg cfs)
Dry Creek at Royer Park				
Observed Hydrograph	5,240	3,040	1,620	------
2006 HEC-1 Run	6,230	2,870	1,330	916
% Difference	18.9%	-5.6%	-17.9%	------
Dry Creek at Vernon St.				
Observed Hydrograph	6,250	3,820	1,930	1,424
2006 HEC-1 Run	7,760	3,920	1,810	1,252
% Difference	24.2%	2.6%	-6.2%	-12.1%
Arcade Cr. near Del Paso Heights				
Observed Hydrograph	3,460	1,900	835	536
2006 HEC-1 Run	3,240	1,870	846	561
% Difference	-6.4%	-1.6%	1.3%	4.6%

b. February 1986 Flood**.** According to **Reference 7,** Dry Creek, Placer and Sacramento Counties, California, Hydrology Office Report, revised April 1988, runoff from a large storm event like that of February 1986, can only be estimated, due to a lack of adequate streamflow data. The Dry Creek gage does not function correctly for flows above 2,000 cfs. Peak flows above that are estimated using highwater marks and slope-area measurements by the State of California. The peak flow of 13,100 cfs and associated one-day flow of 5,800 cfs listed in **Reference 7** for the February 1986 flood for Dry Creek at the Vernon Street gage are based upon a flood reconstitution, using the HEC-1 model and rainfall recording data. The flood reconstitution HEC-1 run could not be located, but available data included the reconstituted flood hydrograph for Dry Creek at Roseville, 5-day storm totals, and rainfall recording data for several stations.

Plate 6 shows the isohyetal map created for the 15 - 19 February 1986 storm, based on the station precipitation totals listed on **Table 6**. **Plate 6** may not necessarily be an accurate isohyetal map of the storm, but it shows approximate isolines of the 5-day storm amounts used in the HEC-1 model to develop the flood hydrographs for the Natomas tributaries. Eight precipitation gages used for storm distribution patterns are identified with "**" in the February 1986 rainfall column of **Table 6**. For subbasins above the Dry Creek at Roseville gage, the base flow parameters in the HEC-1 model are:

STARTQ = 9 cfs/sq.mi.
QRCSN = -0.1
RTIOR = 1.05

No base flow was used for the lower elevation subbasins in the Steelhead Creek watershed. Loss rates used were zero initial loss and 0.10 inch per hour constant loss. The watershed was wet from three days of rain prior to 15 February, the start of the maximum five-day flow.

The HEC-1 model was run to develop flood hydrographs for this storm for the four tributaries to Steelhead Creek. **Figure 4** presents the flood hydrograph from the HEC-1 run for Dry Creek at Roseville compared with the previously reconstituted flood hydrograph from **Reference 7**. **Table 8** presents a comparison for the peak, and 1-, 3-, and 5-day volumes for the two hydrographs.

Figure 4

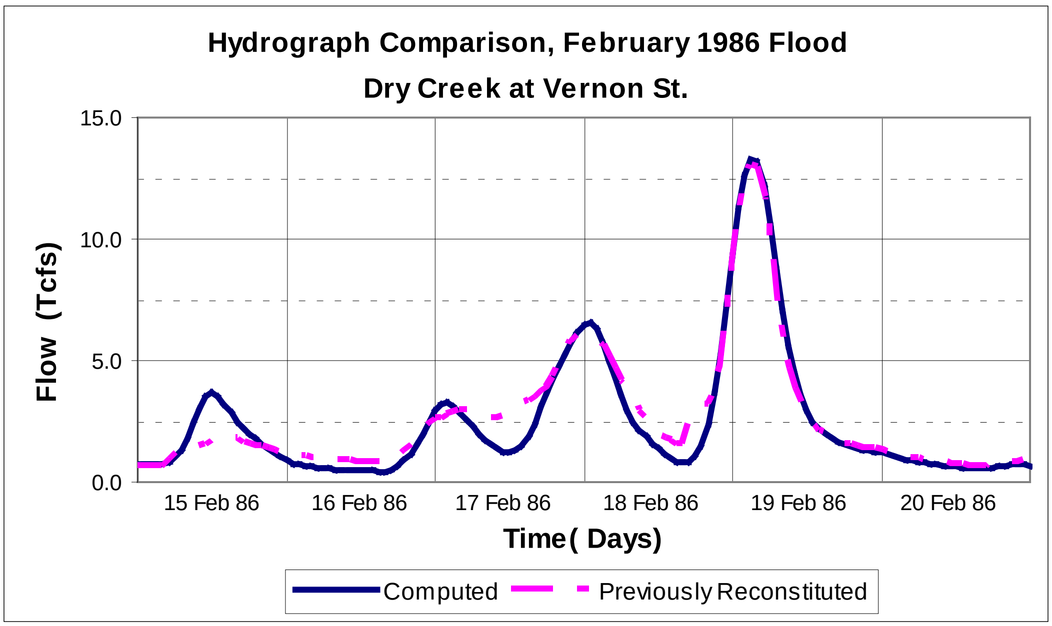


Table 8

15 – 19 February 1986 Flood Volume Comparison

Dry Creek at Roseville Gage

Hydrograph	Peak (cfs)	1-Day Vol. (avg cfs)	3-Day Vol. (avg cfs)	5-Day Vol. (avg cfs)
Ref 7 Hydrograph (1988)	13,100	5,930	4,160	2,980
2008 HEC-1 Run	13,000	5,980	3,810	2,850
% Difference	-0.8%	0.8%	-8.4%	-4.4%

c. <u>January 1995 Flood</u>. The 8 - 12 January 1995 storm had a very intense 6-hour period of rainfall the evening of 9 January that produced the peak flow of record on Dry Creek. **Reference 8**, "Use of Radar-Rainfall Estimates to Model the January 9 - 10, 1995 Floods in Sacramento, CA," paper presented October 1995, explains how data from a network of rain gages were combined with radar-rainfall estimates from the National Weather Service WSR-88D radar observations to reconstitute the flood hydrograph for Dry Creek at Roseville and estimate flood hydrographs for other locations in the watershed. The HEC-1 model used a 5-minute time increment for one hundred small subbasins above the Dry Creek at Roseville gage for a 3-day hydrograph. Each subbasin or small group of subbasins had its own rainfall distribution pattern.

The Natomas GRR study is more concerned with 5-day volumes than those of shorter duration, so the rainfall period was extended back one day, to include 8 January. The Natomas GRR HEC-1 model listed in **Reference 6,** Attachment 1 was used instead of the 5-minute HEC-1 model described in **Reference 8**. The **Reference 6** model has 28 subbasins above the Dry Creek at Roseville gage instead of the 100 subbasins in the **Reference 8** model. The nearly one hundred 5-minute rainfall distribution patterns in the **Reference 8** HEC-1 model were reduced to eight patterns to distribute the January 1995 storm for the Natomas GRR HEC-1 model. The 5-minute rainfall distribution patterns were converted to hourly increments, and extended back to 8 January using the CDEC rainfall gage for Lincoln (LCN). **Plate 7** is not an accurate isohyetal map of the storm, but it shows approximate isolines of the 5-day storm amounts used in the HEC-1 model to develop the flood hydrographs for the Natomas tributaries. The isolines were based on the station precipitation totals listed on **Table 6** and subbasin storm totals in the **Reference 8** HEC-1 model. Very little rain fell on 11-12 January. The HEC-1 model for this American River GRR study was run for a 5-day time period. For subbasins above the Dry Creek at Roseville gage, the base flow parameters in the HEC-1 model are:

STARTQ = 3 cfs/sq.mi.
QRCSN = -0.1
RTIOR = 1.10

No base flow was used for the rest of the Steelhead Creek watershed. Loss rates used were zero initial loss and 0.10 inch per hour constant loss.

The HEC-1 model was run to develop flood hydrographs for this storm for the four tributaries to Steelhead Creek. **Figure 5** presents the flood hydrograph from the HEC-1 run for Dry Creek at Roseville compared with the observed flood hydrograph shown on Figure 12 of **Reference 8**, the radar-rainfall report. The rainfall distribution patterns used in the HEC-1 model produced a hydrograph with two peaks flows, not one. The higher peak is still similar in magnitude and timing to the observed peak, and the three-day volumes are nearly the same. **Table 9** presents a comparison for the peak, and 1-, and 3-day volumes for the two hydrographs. The computed Dry Creek hydrograph has only a single peak by the time it is routed down to Steelhead Creek and added to the local flow.

Figure 5

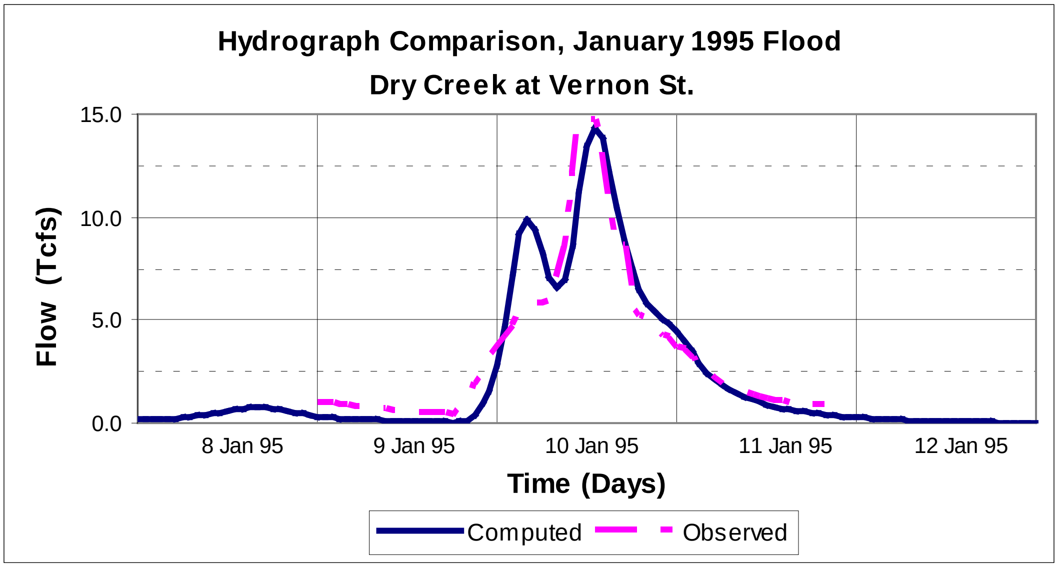


Table 9

8 – 12 January 1995 Flood Hydrograph Comparison

Dry Creek at Roseville Gage

Hydrograph	Peak (cfs)	1-Day Vol. (avg cfs)	3-Day Vol. (avg cfs)	5-Day Vol. (avg cfs)
Observed Hydrograph	14,800	7,580	3,380	------
2008 HEC-1 Run	14,400	8,390	3,360	2,120
% Difference	-2.7%	10.7%	-0.6%	------

d. <u>29 Dec 1996 – 3 Jan 1997 Flood</u>. Recording rainfall data for numerous stations were available on the CDEC website for January 1997. **Table 6** lists the storm totals for these and the daily rainfall stations. The 5-day storm period for the 1997 New Years storm is from 29 December 1996 to 2 January 1997. An isohyetal map was created, based on the storm amounts for this time period, shown on **Table 6**, and subbasin storm amounts were estimated for the HEC-1 model. Nine precipitation stations, identified with "**" in the Dec '96 – Jan '97 rainfall column of **Table 6**, were used as rainfall distribution patterns in the HEC-1 model. For subbasins above the Dry Creek at Roseville gage, the base flow parameters in the HEC-1 model are:

STARTQ = 3 cfs/sq.mi.
QRCSN = -0.1
RTIOR = 1.05

No base flow was used for the rest of the Steelhead Creek watershed. Loss rates used were zero initial loss and 0.10 inch per hour constant loss.

The HEC-1 model was run to develop flood hydrographs for this storm for the four tributaries to Steelhead Creek. These hydrographs are of greater importance than merely as reconstituted hydrographs for this flood event. The shapes of these computed hydrographs for the 5-day period 30 Dec 1996 to 3 Jan 1997 are used as the 5-day pattern hydrographs in the Coincident Frequency Analysis. The 5-day flood hydrograph patterns used in the Comprehensive Study as Sacramento River tributary input hydrographs, prior to their re-distribution to the upstream reservoirs for the Comp Study reservoir operations modeling, are either the observed or computed unregulated tributary hydrographs for that 5-day period, 30 Dec 1996 to 3 Jan 1997. With all the tributary hydrographs for the same 5-day period, timing for high flows on the Natomas tributaries should historically match their actual timing with respect to timing of the other streams, including the Sacramento River at Verona flood hydrograph for the New Year 1997 flood event.

The observed flows for this flood event at the stream gages on Dry and Arcade creeks and the flood hydrographs routed to the downstream index points showed the flood to be a 30 percent chance or more frequent event for Natomas, compared with the large, low frequency flows occurring on many other Sacramento River tributaries. It would be difficult to justify basing the shapes of floods up to the 0.2 percent event upon a 30 percent chance event, so the HEC-1 model was revised. The observed storm amounts were raised by between 15 and 45 percent, to compute a somewhat rarer flood event, on which to base the synthetic flood hydrographs. With enhanced rainfall and higher runoff, the 8-Flood Series flood patterns are based on a 15 percent chance 5-day flood event. Exceedence estimates of the 5-day volumes for the six historic floods are discussed in **Section 2.1.g**. **Plate 8** shows the revised isohyetal map with the higher rainfall amounts used to develop subbasin storm totals in the HEC-1 model to develop Natomas tributary flood hydrographs

Figure 6 presents the flood hydrograph from the HEC-1 run with the increased rainfall for Dry Creek at Roseville compared with the observed mean day flow hydrograph for the Vernon Street gage. **Figure 7** presents the flood hydrograph from the HEC-1 run for Arcade Creek near Del Paso Heights USGS gage compared with the observed mean day flow hydrograph for the gage. The bars on **Figures 5 and 6** represent the observed peak flows for Dry and Arcade creeks at their respective gaging stations. **Table 10** presents a comparison for the peak, and 1-, and 3-day volumes between the computed hydrograph and the mean day flow hydrograph published for the gage. The 5-day period, 30 December 1996 to 3 January 1997, is the period for which the computed 5-day hydrographs for Dry and Arcade creeks at their confluences with Steelhead Creek and Upper NEMDC and Old Magpie Creek above their respective pumping stations are the pattern hydrographs used for the 8-Flood synthetic series.

Figure 6

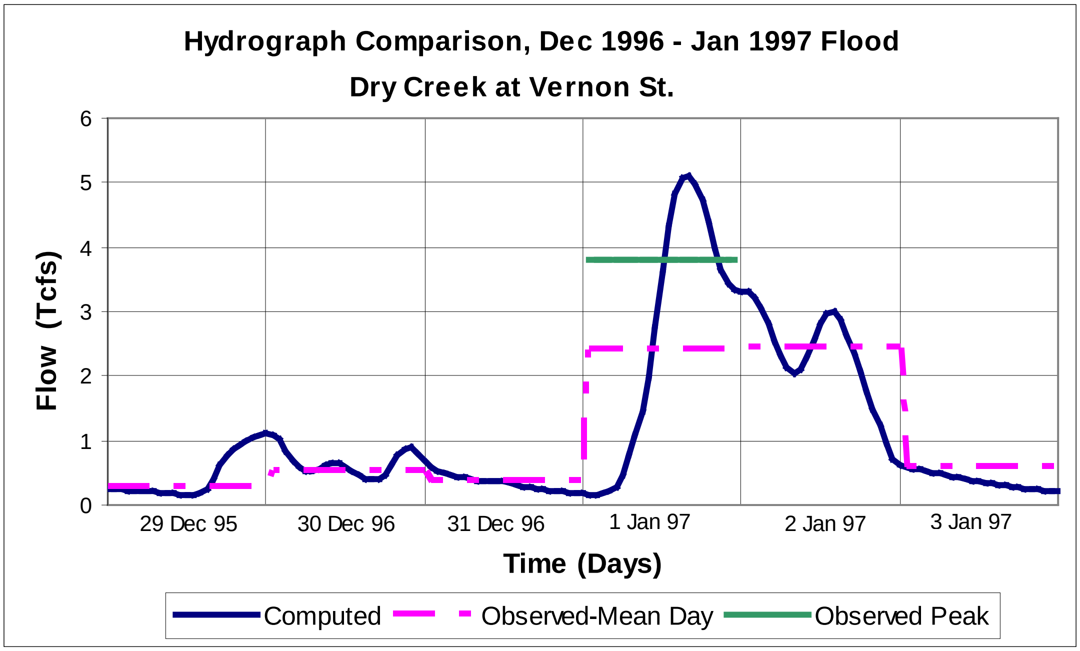


Figure 7

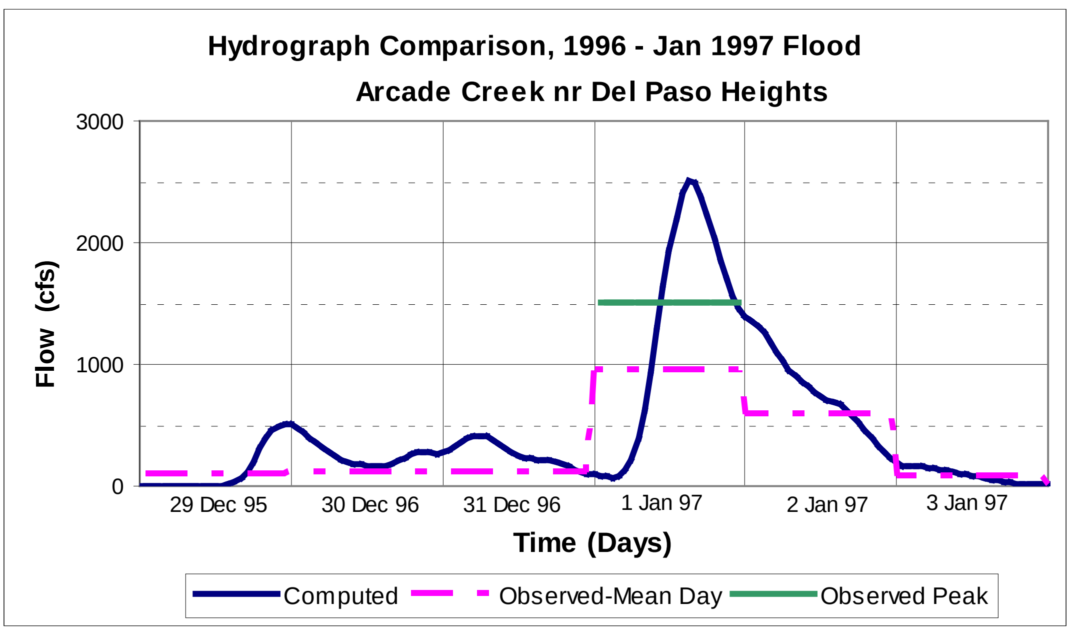


Table 10
29 December 1996 – 3 January 1997 Flood Volume Comparison
For Three Steelhead Creek Tributary Streamflow Gaging Stations

Hydrograph	Peak (cfs)	1-Day Vol. (avg cfs)	3-Day Vol. (avg cfs)	5-Day Vol. (avg cfs)
Dry Creek at Vernon St.				
Observed Hydrograph	3,800	2,440	1,810	1,262
2008 HEC-1 Run	5,120	3,470	1,770	1,303
% Difference	34.7%	42.2%	-2.2%	3.3%
Magpie Cr. near Del Paso Heights				
Observed Hydrograph	N/A	81	35	25
2008 HEC-1 Run	320	108	47	31
% Difference	------	33.3%	35.6%	22.0%
Arcade Cr. near Del Paso Heights				
Observed Hydrograph	1,510	945	551	373
2008 HEC-1 Run	2,507	1,630	778	558
% Difference	66.0%	72.5%	41.2%	49.5%

e. Mid-January 1997 Flood. The mid-January 1997 flood was not an especially rare flood event for the higher elevation tributaries to the Sacramento River. However, for the Natomas tributaries, the mid-January rainfall was greater than for the New Year 1997 storm a few weeks earlier. The greater mid-January rainfall is reflected in the higher peak flows and runoff volumes for this event on the Natomas tributaries. Compare the difference between the Dry Creek hydrographs shown on **Figure 6** and **Figure 8**. The peak flow on Arcade Creek was 150 percent of the peak flow there three weeks earlier. The rainfall from **Table 6** for the 22-26 January 1997 storm was used to develop a storm isohyetal map for the HEC-1 model. **Plate 9** may not necessarily be an accurate isohyetal map of the storm, but it shows approximate isolines of the 5-day storm amounts used in the HEC-1 model to develop the flood hydrographs for the Natomas tributaries. The observed mean day flood hydrographs for Vernon Street, Magpie Creek and Arcade Creek near Del Paso Heights were used as the observed hydrographs for the comparison between observed and computed flood hydrographs in **Table 11**. Ten precipitation stations, identified with "**" in the 22-26 January 1997 rainfall column of **Table 6**, were used as storm distribution patterns. For subbasins above the Dry Creek at Roseville gage, the base flow parameters in the HEC-1 model are:

STARTQ = 3 cfs/sq.mi.
QRCSN = -0.1
RTIOR = 1.05

No base flow was used for the rest of the Steelhead Creek watershed. Loss rates used were zero initial loss and 0.10 inch per hour constant loss.

The HEC-1 model was run to develop flood hydrographs for this storm for the four tributaries to Steelhead Creek. **Figure 8** presents the flood hydrograph from the HEC-1 run for Dry Creek at Roseville compared with the mean day hydrograph observed for the Vernon Street gage. Timing of the observed peak flows of 7,950 cfs and 7,250 cfs is based on the time that the highest stages occurred. The computed peak flows are not the same as the observed peak flows, but the observed peak flows are only one hour earlier than the computed peak flows, which is better timing than for the New Year 1997 flood hydrograph reproduction. There is not much difference between the computed and the observed 5-day flood volumes for Dry Creek. **Table 11** presents a comparison for the peak, and 1-, 3-, and 5-day volumes for the three gaging stations.

Figure 8

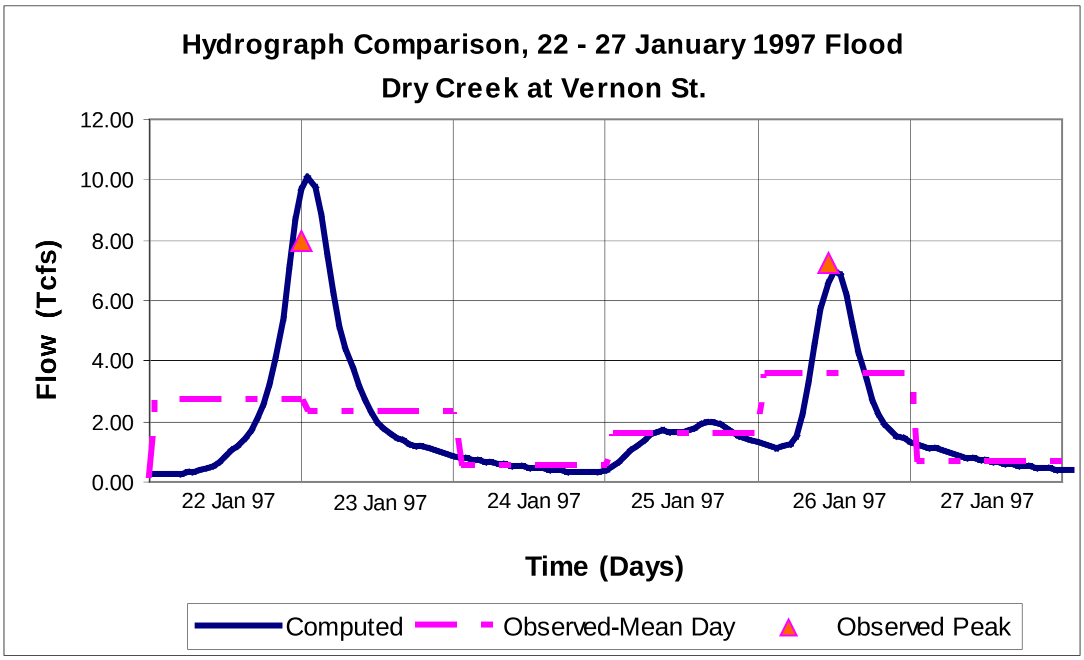


Table 11
22 - 26 January 1997 Flood Volume Comparison
For Three NEMDC Tributary Streamflow Gaging Stations

Hydrograph	Peak (cfs)	1-Day Vol. (avg cfs)	3-Day Vol. (avg cfs)	5-Day Vol. (avg cfs)
Dry Creek at Vernon St.				
Observed Hydrograph	7,950	3,550	1,886	2,142
2008 HEC-1 Run	10,060	4,810	2,200	2,204
% Difference	26.5%	35.5%	16.6%	2.9%
Magpie Cr. near Del Paso Heights				
Observed Hydrograph	560	128	47	47
2008 HEC-1 Run	570	107	45	49
% Difference	1.8%	-16.4%	-4.5%	3.2%
Arcade Cr. near Del Paso Heights				
Observed Hydrograph	2,270	1,090	591	679
2008 HEC-1 Run	3,410	1,730	714	748
% Difference	50.2%	58.7%	20.8%	10.2%

f. February 1998 Flood. Another large storm occurred over the Natomas tributaries watershed in February 1998. The storm amounts for 2 - 6 February 1998 on **Table 6** were used to create a storm isohyetal map for the event, and subbasin storm amounts were used in the HEC-1 model. **Plate 10** may not necessarily be an accurate isohyetal map of the storm, but it shows approximate isolines of the 5-day storm amounts used in the HEC-1 model to develop the flood hydrographs for the Natomas tributaries. The observed mean day flood hydrographs for the Vernon Street and Arcade Creek near Del Paso Heights gages were used for the comparison between the observed and computed flood hydrographs. Ten precipitation stations, identified with "**" in the 2-6 February 1998 rainfall column of **Table 6**, were used as storm distribution patterns. For subbasins above the Dry Creek at Roseville gage, the base flow parameters in the HEC-1 model are:

STARTQ = 3 cfs/sq.mi.
QRCSN = -0.1
RTIOR = 1.05

No base flow was used for the rest of the Steelhead Creek watershed. Loss rates used were zero initial loss and 0.10 inch per hour constant loss.

The HEC-1 model was run to develop flood hydrographs for this storm for the four tributaries to Steelhead Creek. **Figure 9** presents the flood hydrograph from the HEC-1 run for Dry Creek at Roseville compared with the mean day hydrograph observed for the Vernon Street gage. The observed peak flow at Vernon Street gage occurred two hours earlier than the computed peak flow in the HEC-1 run. There is not much difference between the computed and the observed 5-day flood volumes for the Dry and Arcade creek gages. **Table 12** presents a comparison for the peak, and 1-, 3-, and 5-day volumes for the two gaging stations.

Figure 9

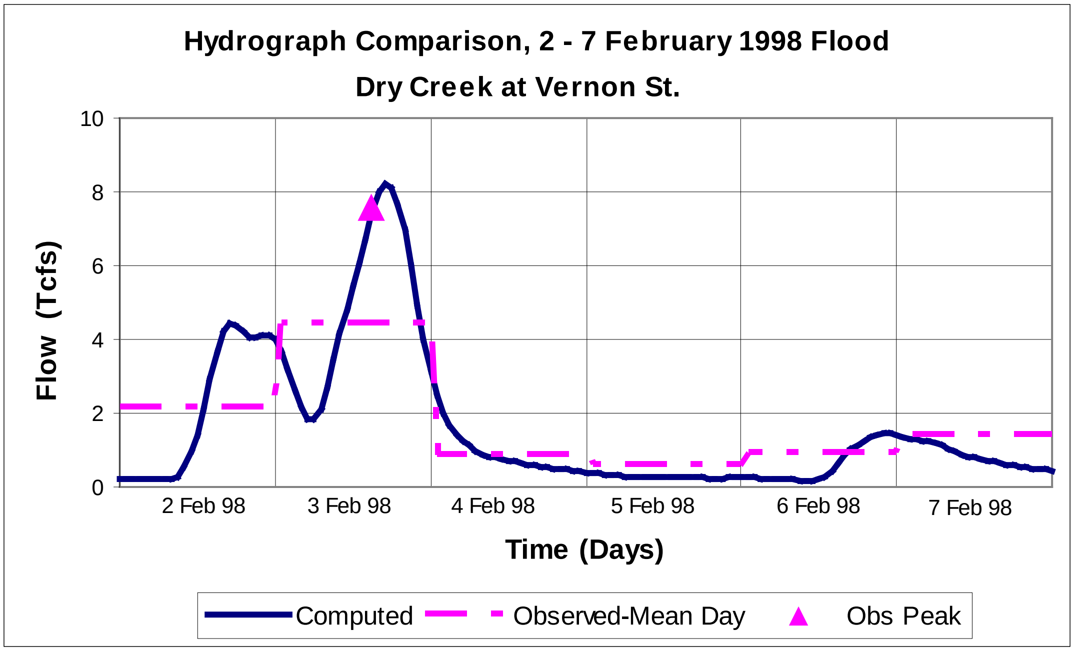


Table 12
2 - 6 February 1998 Flood Volume Comparison
For Two Steelhead Creek Tributary Streamflow Gaging Stations

Hydrograph	Peak (cfs)	1-Day Vol. (avg cfs)	3-Day Vol. (avg cfs)	5-Day Vol. (avg cfs)
Dry Creek at Vernon St.				
Observed Hydrograph	7,549	4,420	2,489	1,791
2008 HEC-1 Run	8,240	4,840	2,620	1,822
% Difference	9.2%	9.5%	5.2%	1.7%
Arcade Cr. Near Del Paso Heights				
Observed Hydrograph	3,320	1,910	1,069	715
2008 HEC-1 Run	3,190	2,100	1,120	718
% Difference	-3.9%	9.9%	4.7%	0.4%

g. 5-Day Volume Frequency Relationships. **Table 13** lists the 5-day flood volumes for the 8-Flood Series for the Steelhead Creek and Natomas Cross Canal tributaries at their downstream index points. The NEMDC Sum in **Table 13** below is the maximum 120 hours of the Steelhead Creek hydrograph developed by adding the 4 tributary hydrographs together at their respective downstream index points. The NEMDC Sum is not necessarily the sum of the four tributary hydrograph volumes, because the maximum 120 hours for the tributary hydrographs do not have the exact same starting and ending times. The 5-day volume frequency curves for Steelhead Creek and Natomas Cross Canal are shown on **Plates 11 and 12**.

Table 13

Summary Table - 8-Flood Series - Five-Day Duration Volumes

Stream at	D.A.	8-Flood Series Five-Day Volumes (in Acre-Feet)							
at Mouth	(sq.mi.)	50%	20%	10%	4%	2%	1%	0.50%	0.20%
Steelhead Cr									
Dry Cr. at NEMDC	116.48	9,250	15,450	19,800	26,600	31,000	35,600	39,800	47,200
Upper NEMDC	27.13	2,010	3,230	4,110	5,300	6,190	7,120	7,980	9,360
OldMag at NEMDC (5-DAY)	4.57	380	594	747	952	1,103	1,260	1,410	1,640
Arcade Cr. At NEMDC	40.14	3,400	5,310	6,650	8,430	9,710	11,050	12,300	14,260
NEMDC Sum	188.32	14,970	24,600	31,340	41,320	48,020	54,980	61,360	71,750
Cross Canal									
Coon Creek at WPRR	112.61	8,760	15,640	20,360	29,430	34,360	39,410	44,040	51,430
Markham Rav. at WPRR	32.36	1,840	3,310	4,370	5,660	6,700	7,760	8,810	10,480
Auburn Rav. at WPRR	79.97	6,770	11,250	14,290	19,460	22,500	25,660	28,600	33,250
Pl.Grove Cr. at WPRR	46.69	4,140	6,500	8,110	10,360	11,880	13,390	15,080	17,420
Curry Creek at WPRR	16.59	1,190	2,000	2,560	3,300	3,850	4,420	4,950	5,810
Cross Canal Sum	288.22	22,690	38,710	49,680	68,160	79,230	90,580	101,420	118,320

The 5-day volumes in **Table 13** and the volume frequency curves on **Plate 11** were used to estimate the percent exceedence of the 5-day volumes for Steelhead Creek for the six historical flood events described above. **Table 14** lists the 5-day volumes for the Steelhead Creek tributaries computed using the HEC-1 program and the storm isohyetal maps for the 6 historical floods, along with the estimated percent exceedence of the 5-day volume for Steelhead Creek hydrographs.

Table 14

5-Day Volume Frequency Relationships for Six Historical Storms

Steelhead Creek Tributaries

Steelhead Cr Index Pt	5-Day Volume (ac-ft)	5-Day Volume % Chance Event (%)	Steelhead Cr Index Pt	5-Day Volume (ac-ft)	5-Day Volume % Chance Event (%)
Feb 1986 Storm			Mid-Jan 1997 Storm		
Dry Cr. At Mouth	38,400	0.6%	Dry Cr. At Mouth	28,500	2.6%
Arcade Cr.-Del Paso Hghts	10,700	0.6%	Arcade Cr.-Del Paso Hghts	7,420	4.6%
Arcade Cr. at Mouth	12,200	0.6%	Arcade Cr. At Mouth	8,300	4.4%
Upper NEMDC abv. Pump	7,090	1.0%	Upper NEMDC abv. Pump	4,230	9.3%
Old Magpie Cr. abv. Pump	1,420	0.6%	Old Magpie Cr. Abv. Pump	810	8.0%
Steelhead Sum	58,300	0.7%	Steelhead Sum	41,600	3.6%
Jan 1995 Storm			Feb 1998 Storm		
Dry Cr. At Mouth	29,800	2.2%	Dry Cr. At Mouth	24,100	5.1%
Arcade Cr.-Del Paso Hghts	8,300	2.7%	Arcade Cr.-Del Paso Hghts	7,380	5.7%
Arcade Cr. at Mouth	9,540	2.3%	Arcade Cr. At Mouth	8,100	4.9%
Upper NEMDC abv. Pump	5,430	3.6%	Upper NEMDC abv. Pump	4,540	7.3%
Old Magpie Cr. abv. Pump	930	4.6%	Old Magpie Cr. Abv. Pump	780	9.0%
Steelhead Sum	45,700	2.4%	Steelhead Sum	37,500	5.4%
New Year 1997 Storm			New Year 2006 Storm		
Dry Cr. At Mouth	17,400	14.5%	Dry Cr. At Mouth	17,700	13.8%
Arcade Cr.-Del Paso Hghts	5,300	15.6%	Arcade Cr.-Del Paso Hghts	5,430	14.6%
Arcade Cr. at Mouth	6,100	13.5%	Arcade Cr. At Mouth	6,370	11.8%
Upper NEMDC abv. Pump	3,370	18.4%	Upper NEMDC abv. Pump	2,820	28.0%
Old Magpie Cr. abv. Pump	600	19.5%	Old Magpie Cr. Abv. Pump	700	13.0%
Steelhead Sum	27,500	14.6%	Steelhead Sum	27,600	14.4%

A sensitivity analysis of storm centerings and runoff discussed in the Natomas GRR Hydrology Appendix showed there was less than a 5 percent difference in runoff on Steelhead Creek for a 1 percent storm centering on the Steelhead drainage and a concurrent storm on Steelhead Creek with the specific centering on Cross Canal drainage. The difference in runoff was also less than 5 percent for the Natomas Cross Canal. To simplify Natomas flood centerings for the Coincident Frequency Analysis, an n-percent chance flood is assumed to be centered on the combined drainages of Steelhead Creek and Natomas Cross Canal. So, if the 5-day flood hydrograph for Steelhead Creek for the New Year 1997 flood is a 15 percent exceedence event, it is assumed to be a 15 percent exceedence event for the Natomas Cross Canal 5-day runoff volume as well. Based on the flood volumes listed in **Table 13**, the 5-day volume of the New Year 1997 flood for the Natomas Cross Canal should be about 43,300 acre-feet. Based on this combined 5-day flood volume for the Cross Canal, 5-day flood hydrographs needed to be computed for the five Cross Canal tributaries for the New Year 1997 flood, to be used in the Coincident Frequency Analysis. Computation of the Natomas Cross Canal tributary hydrographs for the New Year 1997 flood and other five historic floods is discussed in **Section 2.2**.

2.2 Natomas Cross-Canal Historical Flood Hydrographs.

a. Computing 5-Day Volumes for 6 Historical Floods on Natomas Cross Canal. There are several problems with developing historical flood hydrographs for the Natomas Cross Canal tributaries. One is the lack of precipitation stations in the Cross Canal watershed. See **Plate 2**, the watershed map showing the precipitation station locations. Also, there are no flow gages – only a few stage gages on Pleasant Grove Creek at and upstream of Fiddyment Road, and in the upper watersheds of Coon Creek and Auburn Ravine. Coon Creek and Auburn Ravine stage gage locations can be found at **Reference 9,** on the map of Sacramento County ALERT gages. The Pleasant Grove Creek stage gage locations can be found at **Reference 10**, the map of City of Roseville Flood Alert gages. The isohyetal lines on the isohyetal maps for the six historic storms (**Plates 5 through 10**) were extended from Steelhead Creek drainage north through the Cross Canal drainage.

The Civil Engineering Solutions HEC-1 models and the isohyetal maps (**Plates 5 through 10**) were used to compute preliminary runoff hydrographs for the Cross Canal tributaries for the six historical floods. The storm isohyetal maps and subbasins storm amounts for the Cross Canal tributaries were adjusted until the 5-day runoff volumes for the Cross Canal tributaries matched the percent exceedence of the 5-day Steelhead Creek tributary volumes for the same event. (See **Table 14**.) The Pleasant Grove Creek and Markham Ravine drainages are similar to Arcade Creek in east-to-west alignment, drainage area, and elevation range (below 300 feet), so that the percent exceedence event for the Arcade Creek 5-day flood volumes were used as guidance to estimate the flood volumes for those two Cross Canal tributaries. For the larger tributaries, Coon Creek and Auburn Ravine, with large contributing drainage above 300 feet (extending up to 2,000 feet for Coon Creek), the percent exceedence 5-day volumes for the six historical floods were based on the percent exceedence flood volumes for Dry Creek at Steelhead Creek. Curry Creek is adjacent to Upper NEMDC, which was used as a model in case the 5-day volumes on Curry Creek needed adjustment.

Table 15 lists the computed 5-day flood volumes from the above adjusted modeling runs for the Natomas Cross Canal tributaries, as well as the ratios of peak-to-5-day-volume for the computed hydrographs on the Steelhead Creek and Cross Canal tributaries. The HEC-1 models developed by Civil Engineering Solutions, Inc., for the Natomas Cross canal tributaries, discussed in the Natomas GRR Hydrology Appendix (**Reference 6**), assumed that future housing and urbanization projects were in place. At the present time, they have yet to be constructed. One review comment on the Hydrology Appendix was that the Cross Canal tributary peak flows computed for the Hydrology Appendix had much higher peak flows in proportion to their flood volumes and contributing drainage areas. The relationship for Cross Canal peak flows should be more in line with the ratios of peak flow to flood volume and to drainage area for the Steelhead Creek tributaries.

Table 15
Ratio of Peaks to 5-Day Volumes
for 6 Historical Floods on Natomas Tributaries

Stream at Mouth	D.A. (sq.mi.)	8-Flood Series - Peaks, Volumes and Ratios: Peak to Volume						Average Peak to Volume
		Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	
Steelhead Cr								
Dry Cr. At Steelhead Cr.	Peak (cfs)	10,040	12,080	5,110	7,830	7,350	6,900	
5-day Vol. (ac-ft)		38,400	29,800	17,400	28,500	24,100	17,700	
Drainage Area 116.48 sq.mi.	PK/Vol.	0.26	0.41	0.29	0.27	0.30	0.39	0.32
Upper NEMDC	Peak (cfs)	3,830	3,840	2,610	2,610	1,610	2,110	
5-day Vol. (ac-ft)		7,090	5,430	3,370	4,230	4,540	2,820	
Drainage Area 27.13 sq.mi.	PK/Vol.	0.54	0.71	0.77	0.62	0.35	0.75	0.62
Old Magpie Cr. above Pump	Peak (cfs)	831	918	603	673	389	573	
5-day Vol. (ac-ft)		1,420	930	600	810	780	700	
Drainage Area 4.57 sq.mi.	PK/Vol.	0.59	0.99	1.01	0.83	0.50	0.82	0.79
Arcade Cr. At Steelhead Cr.	Peak (cfs)	3,720	4,950	2,640	3,470	3,200	3,360	
5-day Vol. (ac-ft)		12,200	9,540	6,100	8,300	8,100	6,370	
Drainage Area 40.14 sq.mi.	PK/Vol.	0.30	0.52	0.43	0.42	0.40	0.53	0.43
Steelhead Cr. Sum	Peak (cfs)	14,060	17,840	8,470	11,300	11,050	10,860	
5-day Vol. (ac-ft)		58,300	45,700	27,500	41,600	37,500	27,600	
Drainage Area 188.32 sq.mi.	PK/Vol.	0.24	0.39	0.31	0.27	0.29	0.39	0.32
Cross Canal		Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	Average
Coon Creek at WPRR	Peak (cfs)	11,700	26,500	8,250	13,700	10,150	9,970	
5-day Vol. (ac-ft)		35,500	29,100	17,600	20,700	18,050	13,460	
Drainage area 112.61 sq.mi.	PK/Vol.	0.33	0.91	0.47	0.66	0.56	0.74	0.61
Markham Rav. At WPRR	Peak	6,510	4,830	2,520	4,810	2,550	4,120	
5-day Vol. (ac-ft)		8,620	4,850	3,700	5,280	5,130	3,440	
Drainage Area 32.36 sq.mi.	PK/Vol.	0.76	1.00	0.68	0.91	0.50	1.20	0.84
Auburn Rav. At WPRR	Peak (cfs)	11,700	10,200	4,290	6,840	5,490	5,700	
5-day Vol. (ac-ft)		26,450	21,000	12,500	16,360	14,100	10,200	
Drainage Area 79.97 sq.mi.	PK/Vol.	0.44	0.49	0.34	0.42	0.39	0.56	0.44
Pl.Grove Cr. At WPRR	Peak (cfs)	7,870	9,100	4,550	7,360	4,610	5,470	
5-day Vol. (ac-ft)		14,900	11,400	6,560	9,090	9,330	6,160	
Drainage Area 46.69 sq.mi.	PK/Vol.	0.53	0.80	0.69	0.81	0.49	0.89	0.70
Curry Creek at WPRR	Peak (cfs)	2,520	2,500	1,570	1,680	1,020	1,290	
5-day Vol. (ac-ft)		4,650	3,330	2,130	2,890	3,000	1,730	
Drainage Area 16.59 sq.mi.	PK/Vol.	0.54	0.75	0.74	0.58	0.34	0.75	0.62
Cross Canal Sum	Peak (cfs)	30,700	43,600	16,100	23,200	20,800	21,300	
5-day Vol. (ac-ft)		89,800	72,900	42,500	54,300	49,500	35,000	
Drainage Area 288.22 sq.mi.	PK/Vol.	0.34	0.60	0.38	0.43	0.42	0.61	0.46

Upper NEMDC (Steelhead tributary) and Curry Creek (Cross Canal tributary) are adjacent basins on the valley floor and have similar ratios of computed peak to 5-day volume for each of the six flood events. The 6-event averaged ratio of peak/5-day volume (**Table 15**, right-hand column) is the same, 0.62, for Upper NEMDC and Curry Creek.

Arcade Creek (Steelhead tributary) and Pleasant Grove Creek and Markham Ravine (Cross Canal tributaries) are similar in orientation and elevation. However, because of the highly urbanized HEC-1 models used for Pleasant Grove Creek and Markham Ravine, the 6-event averaged ratio of peak/5-day volume for Pleasant Grove Creek is 60 percent higher than for Arcade Creek and for Markham Ravine is nearly two times that of Arcade Creek.

Dry Creek (Steelhead tributary) and Coon Creek and Auburn Ravine (Cross Canal tributaries) have larger drainage areas as well as headwaters at much higher elevations than the other Natomas tributaries. Because of the highly urbanized HEC-1 models used for Auburn Ravine and Coon Creek, the 6-event averaged ratio of peak/5-day volume for Auburn Ravine is 38 percent higher than for Dry Creek and is 91 percent higher for Coon Creek than for Dry Creek.

Table 16 shows the ratios of peak-to-drainage-area for the computed hydrographs on the Steelhead Creek and Cross Canal tributaries.

Table 16
Ratio of Peaks to Drainage Areas
for 6 Historical Floods on Natomas Tributaries

Stream at Mouth	D.A. (sq.mi.)	8-Flood Series - Ratios of Peaks to Drainage Areas						Average Peak to D.A.
		Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	
Steelhead Cr								
Dry Cr. At Steelhead Cr.	Peak (cfs)	10,040	12,080	5,110	7,830	7,350	6,900	
Drainage Area (sq.mi.)								
116.48	Pk/D.A.	86.2	103.7	43.9	67.2	63.1	59.2	70.6
Upper NEMDC	Peak (cfs)	3,830	3,840	2,610	2,610	1,610	2,108	
Drainage Area (sq.mi.)								
27.13	Pk/D.A.	141.2	141.5	96.2	96.2	59.3	77.7	102.0
Old Magpie Cr. above Pump	Peak (cfs)	831	918	603	673	389	573	
Drainage Area (sq.mi.)								
4.57	Pk/D.A.	181.8	200.9	131.9	147.3	85.1	125.4	145.4
Arcade Cr. At Steelhead Cr.	Peak (cfs)	3,720	4,950	2,640	3,470	3,200	3,360	
Drainage Area (sq.mi.)								
40.14	Pk/D.A.	92.7	123.3	65.8	86.4	79.7	83.7	88.6
Steelhead Cr. Sum	Peak (cfs)	14,060	17,840	8,470	11,300	11,050	10,860	
Drainage Area (sq.mi.)								
188.32	Pk/D.A.	74.7	94.7	45.0	60.0	58.7	57.7	65.1
Cross Canal		Feb-86	Jan-95	NY 1997	MidJan 97	Feb-98	NY 2006	Average
Coon Creek at WPRR	Peak (cfs)	11,700	26,500	8,250	13,700	10,150	9,970	
Drainage Area (sq.mi.)								
112.61	Pk/D.A.	103.9	235.3	73.3	121.7	90.1	88.5	118.8
Markham Rav. At WPRR	Peak (cfs)	6,510	4,830	2,520	4,810	2,550	4,120	
Drainage Area (sq.mi.)								
32.36	Pk/D.A.	201.2	149.3	77.9	148.6	78.8	127.3	130.5
Auburn Rav. At WPRR	Peak (cfs)	11,700	10,200	4,290	6,840	5,490	5,700	
Drainage Area (sq.mi.)								
79.97	Pk/D.A.	146.3	127.5	53.6	85.5	68.7	71.3	92.2
Pl.Grove Cr. At WPRR	Peak (cfs)	7,870	9,100	4,550	7,360	4,610	5,470	
Drainage Area (sq.mi.)		14,900	11,400	6,560	9,090	9,330	6,160	
46.69	Pk/D.A.	168.6	194.9	97.5	157.6	98.7	117.2	139.1
Curry Creek at WPRR	Peak (cfs)	2,520	2,500	1,570	1,680	1,020	1,290	
Drainage Area (sq.mi.)								
16.59	Pk/D.A.	151.9	150.7	94.6	101.3	61.5	77.8	106.3
Cross Canal Sum	Peak (cfs)	30,700	43,600	16,100	23,200	20,800	21,300	
Drainage Area (sq.mi.)								
288.22	Pk/D.A.	106.5	151.3	55.9	80.5	72.2	73.9	90.0

The 6-event averaged ratio of peak/drainage area (**Table 16**, right-hand column) is nearly the same for the adjacent stream drainages, Upper NEMDC and Curry Creek, with ratios of 102 and 106.3, respectively. These basins are in close agreement for ratios of both peak to 5-day volume and peak to drainage area. The computed historical reproduction hydrographs for Curry Creek do not appear to need adjustment.

The 6-event averaged ratio of peak/drainage area for Arcade Creek is 88.6. While Markham Ravine and Pleasant Grove Creek are the tributaries to the Natomas Cross Canal most similar to Arcade Creek, the 6-event averaged ratio of peak/drainage area for Markham Ravine is 47 percent higher than for Arcade Creek and for Pleasant Grove Creek is 57 percent higher than for Arcade Creek. These higher ratios for the Cross Canal tributaries can be explained by the HEC-1 models that included future urbanization on those watersheds. The peak flows for present conditions on Markham Ravine and Pleasant Grove Creek should be lower.

The 6-event averaged ratio of peak/drainage area for Dry Creek is 70.6. The Cross Canal tributaries most similar to Dry Creek are Auburn Ravine and Coon Creek. The 6-event averaged ratio of peak/drainage area for Auburn Ravine is 31 percent higher than that for Dry Creek while the averaged ratio for Coon Creek is 68 percent higher than for Dry Creek. The peak flows for present conditions on Auburn Ravine and Coon Creek should be lower.

Based on the differences in the ratios presented in **Tables 15 and 16**, the hydrographs for Auburn Ravine, Coon Creek, Markham Ravine, and Pleasant Grove Creek were reshaped with lower peak flows. This process is explained in **Section 2.2.b**.

b. Re-shaping the Natomas Cross Canal Historical Hydrographs. Once the 5-day runoff volumes for the six historic floods on the Natomas Cross Canal tributaries were determined, the flood hydrographs were re-shaped (except for Curry Creek), with lower peak flows, more in line with the peak to volume and to drainage area ratios for the Steelhead Creek tributaries (**Tables 15 and 16** above). The same Steelhead Creek tributaries were used for the hydrograph patterns: Arcade Creek at Steelhead Creek as a pattern for Pleasant Grove Creek and Markham Ravine at their downstream WPRR index points, and Dry Creek at Steelhead Creek as a pattern for Auburn Ravine and Coon Creek at their downstream WPRR index points. The computed flood volumes for the Cross Canal tributaries remained the same, but volume lost by re-shaping for lower peak flows was offset by the addition of recession flow. The timing of the peak flows on the Cross Canal tributaries was not changed. Examples of re-shaping of the Cross Canal tributary hydrographs for the New Year 1997 flood are shown on **Figure 10**, Pleasant Grove Creek at WPRR, based on Arcade Creek, and **Figure 11**, Coon Creek at WPRR, based on Dry Creek at Steelhead Creek.

The figures show how the high peak flows on the Cross Canal tributaries were reduced by hydrograph re-shaping. Rapid hydrograph fluctuations were filled in. Recession base flow was added to the hydrographs for the Cross Canal tributaries with major contributing drainage above 300 feet (Coon Creek and Auburn Ravine). Minor waves in the flood hydrographs were not adjusted. While the Arcade Creek hydrograph appears to have base flow, the higher flow trailing after the main wave is due to water being pumped from interior drainage areas upstream of the mouth of Arcade Creek.

Figure 10

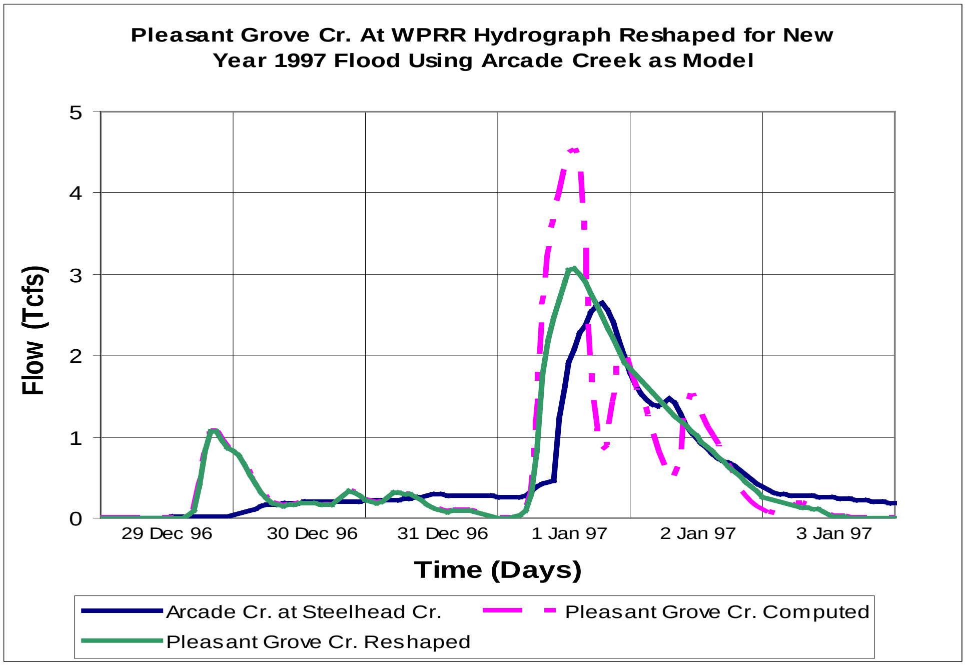
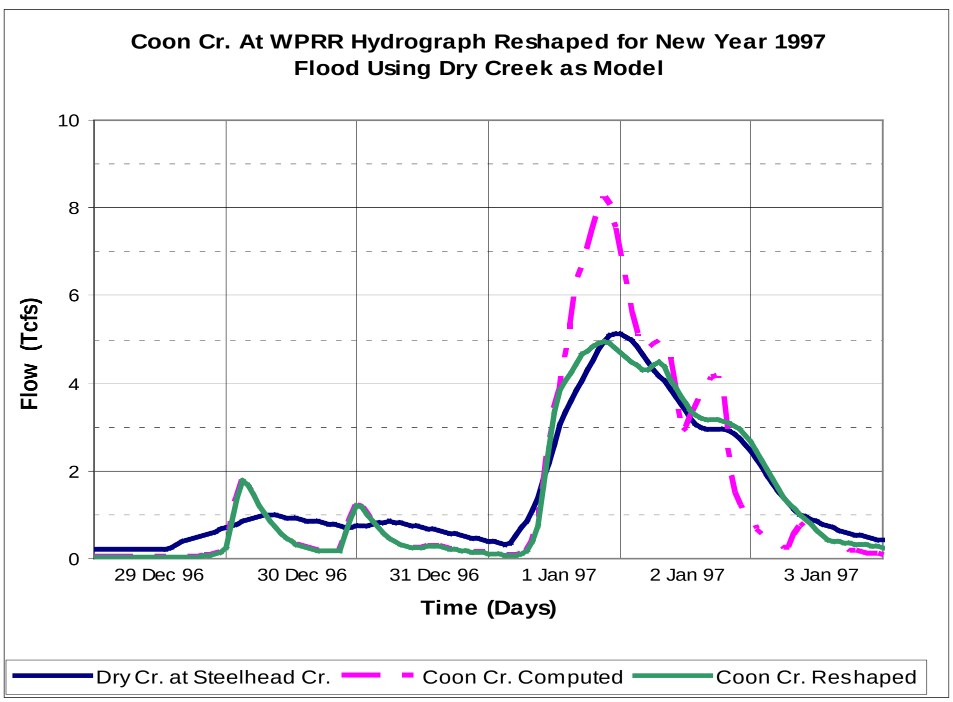
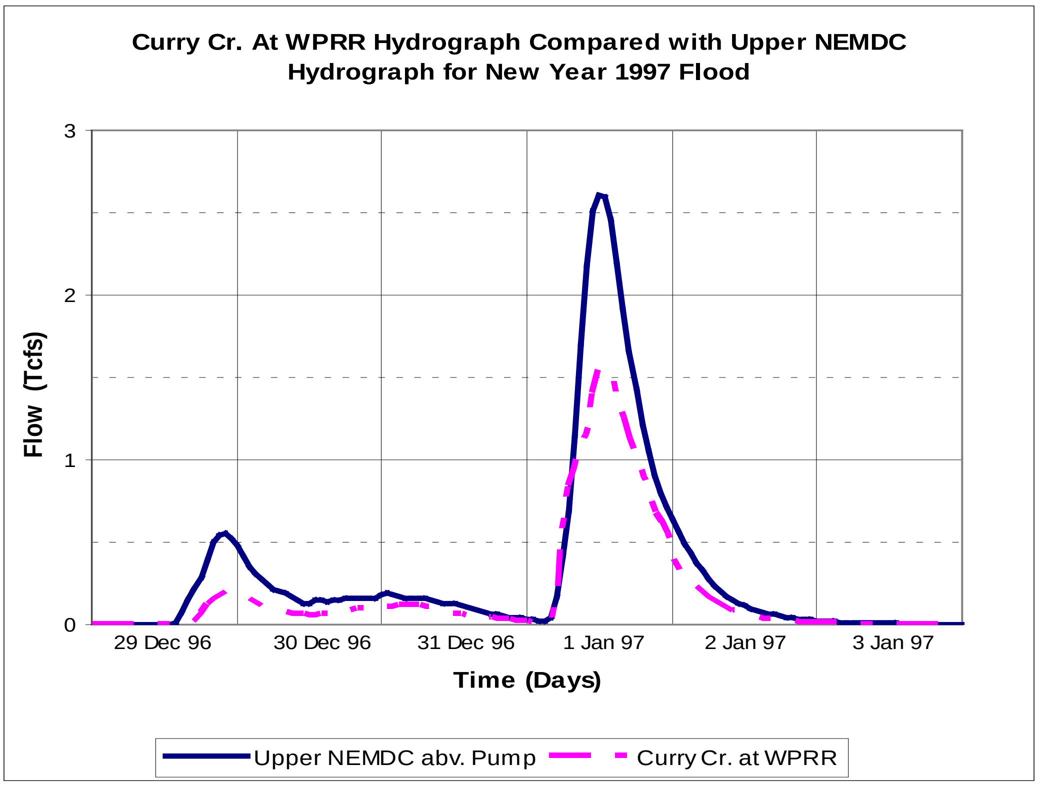


Figure 11



The smaller valley tributaries, Upper NEMDC and Old Magpie Creek, have higher peak flows in proportion to their flood volumes and drainage areas, but those peak flows would not have as much effect on the downstream Steelhead Creek hydrograph, even if they contributed directly to Steelhead Creek instead of being pumped in; their drainage areas and flood volumes are small compared with the larger tributaries, Dry and Arcade creeks. The contribution from Curry Creek to flows at the Natomas Cross Canal does not have a large effect either. The Rio Linda rainfall gage was used to distribute the precipitation over these two drainages for the six historical storms. The ratios of peak to flood volume and to drainage area for Curry Creek are very similar to the ratios for Upper NEMDC. The historical flood hydrograph for Curry Creek was not re-shaped. **Figure 12** presents the flood hydrographs for Curry Creek and Upper NEMDC for the New Year 1997 flood.

Figure 12



2.3 <u>Use of Historical Flood Hydrographs on Natomas Tributaries</u>. The Natomas tributary hydrographs for the six historic floods were provided to Hydraulic Design Section to be used for upstream boundary conditions in the hydraulic modeling. The historic flood hydrographs were at the following locations: Coon Creek at WPRR, Markham Ravine at WPRR, Auburn Ravine at WPRR, Pleasant Grove Creek at WPRR, Curry Creek at WPRR, Upper NEMDC above and below the NEMDC Stormwater Pumping Station, Dry Creek above Steelhead Creek confluence, Old Magpie Creek above and below Pump Station 157, and Arcade Creek above Steelhead Creek confluence. **Plate 13** shows the New Year 1997 computed flood hydrographs for Curry

Creek and the Steelhead Creek tributaries and the reshaped flood hydrographs for Pleasant Grove Creek, Auburn Ravine, Markham Ravine, and Coon Creek.

3.0 Development of 8-Flood Series Hydrographs for Natomas Tributaries

Development of the 8-Flood Series hydrographs for the Natomas tributaries follows Comprehensive Study methodology. The Comprehensive Study used 30-day hydrographs consisting of six 5-day waves, with the 4th wave being the highest. The process includes: 1) obtaining the average flood flow rates from the unregulated frequency curves, 2) separating these average flows into wave volumes, and 3) distributing volumes into the 6-wave series.

All of the Natomas tributaries at their respective downstream index points are unregulated. The index points for Upper NEMDC and Old Magpie Creek are upstream of their respective pumping stations. The 5-day volume frequency curves for the Natomas tributaries are shown on **Plates 11 and 12. Plates 14 and 15** present the 10-day volume frequency curves. The 5-day volumes for the 8-Flood Series for the Natomas tributaries are listed on **Table 13** in **2.1.g. Table 17** below lists the 10-day volumes for the 8-Flood Series.

Table 17

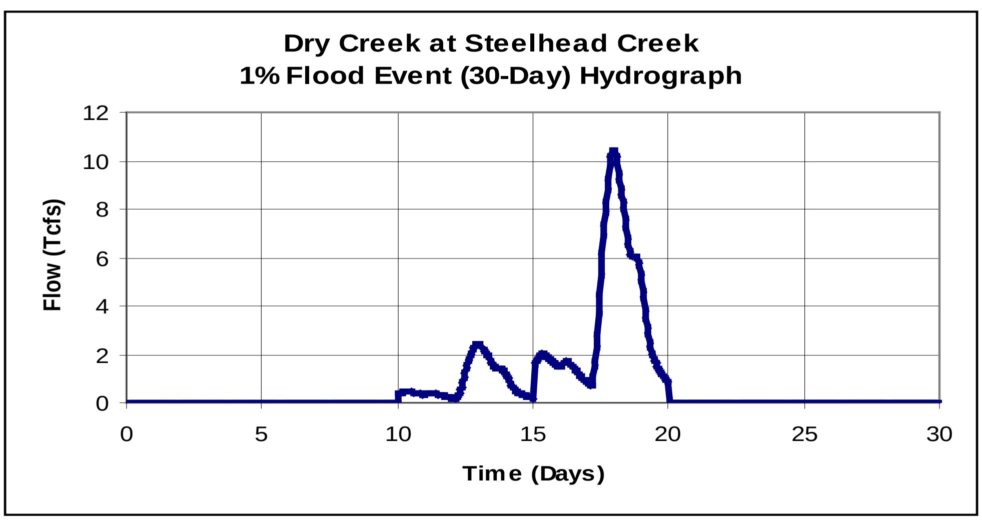
Summary Table - 8-Flood Series - Ten-Day Duration Volumes

Stream at	D.A.	8-Flood Series Five-Day Volumes (in Acre-Feet)							
at Mouth	(sq.mi.)	50%	20%	10%	4%	2%	1%	0.50%	0.20%
Steelhead Cr									
Dry Cr. at NEMDC	116.48	11,000	18,300	23,600	32,700	38,200	43,900	49,100	58,700
Upper NEMDC	27.13	2,400	3,840	4,920	6,400	7,510	8,700	9,760	11,500
OldMag at NEMDC (5-DAY)	4.57	470	724	891	1,200	1,390	1,590	1,770	2,070
Arcade Cr. at NEMDC	40.14	4,220	6,570	8,190	10,300	11,900	13,600	15,100	17,600
NEMDC Sum	188.32	18,090	29,434	37,601	50,600	59,000	67,790	75,730	89,870
Cross Canal									
Coon Creek at WPRR	112.61	10,900	19,500	25,400	38,300	44,700	51,400	57,600	67,300
Markham Rav. at WPRR	32.36	2,380	4,170	5,450	7,320	8,610	9,920	11,200	13,300
Auburn Rav. at WPRR	79.97	8,600	14,200	18,100	25,300	29,300	33,400	37,300	43,400
Pl.Grove Cr. at WPRR	46.69	5,160	8,060	10,200	13,100	15,000	17,000	19,200	22,100
Curry Creek at WPRR	16.59	1,490	2,490	3,180	4,120	4,820	5,540	6,230	7,330
Cross Canal Sum	288.22	28,530	48,420	62,330	88,140	102,430	117,260	131,530	153,430

For consistency with the Comprehensive Study, the computed New Year 1997 flood hydrographs for the Natomas tributaries at their respective downstream index points, or upstream of their respective pumping stations for Old Magpie Creek and Upper NEMDC, were used as the pattern hydrographs for the synthetic 8-Flood Series. For the Comprehensive Study, the basic pattern of all synthetic flood hydrographs was a 30-day hourly time series consisting of six waves, each 5 days in duration. Flood volumes were ranked and distributed into the basic pattern. The highest wave volume was distributed into the fourth, or main, wave. The second highest volume preceded the main wave. So, the two highest waves are in the middle ten days of the 30-day hydrograph. The upstream tributary index points used for the Comprehensive Study are listed on **Table 1**. They flow out of the mountains to the east, west, and north of the Sacramento Valley and have high flows during the rainy season. The Natomas tributaries flow out of the foothills or originate on the valley floor. Flows on these tributaries can be high during and immediately after a rainstorm. Without additional rainfall, the flows drop to base flow or to urban runoff levels. The average flows are a lot lower than for the Comp Study tributaries on **Table 1**. The Natomas tributary flows for the four smaller waves would be so minor, that zero runoff was assumed for the 30-day hydrographs except for the middle 10 days (Waves 3 and 4).

The 1 percent flood hydrograph for Dry Creek at Steelhead Creek was developed in the following way. The 5-day flood pattern hydrograph for 30 Dec 1996 to 3 Jan 1997 for Dry Creek at its downstream index point is shown on **Figure 11** and **Plate 13**. The 5-day flood volume for this pattern hydrograph is 17,400 acre-feet. The 5-day flood volume for the 1 percent flood for Dry Creek is 35,600 acre-feet. The ratio of the 1 percent event 5-day volume to the New Year 1997 5-day volume is 35,600 / 17,400 or 2.046. This ratio was applied to the hourly ordinates of the computed 5-day New Year 1997 hydrograph for Dry Creek at Steelhead Creek, to define the 1 percent flood hydrograph for Wave 4 at the Dry Creek index point. The difference between the 1 percent 5-day volume (35,600 ac-ft) for Dry Creek at Steelhead Creek index point and the 1 percent 10-day volume (43,900 ac-ft) for the Dry Creek index point is 8,300 acre-feet. The ratio of 8,300 ac-ft to the New Year 1997 5-day volume for Dry Creek at Steelhead Creek is 8,300 / 17,400, or 0.477. This ratio was applied to the New Year 1997 flood hydrograph at the Dry Creek index point, to define the hydrograph for Wave 3 of the 30-day 1 percent event flood hydrograph at the Dry Creek index point. **Figure 13** below shows the shape of the 30-day 1 percent event hydrograph for Dry Creek at Steelhead Creek, with zero flow for waves 1 – 2 and 5 – 6. Wave 4 is higher than Wave 3.

Figure 13



The rest of the floods in the 8-Flood Series for Dry Creek, as well as the hydrographs for the other eight Natomas tributaries, were developed using the same method. These hydrographs are consistent in shape and timing with the synthetic flood hydrographs for the Sacramento River tributary index points listed on **Table 1**.

The 30-day hydrographs for Upper NEMDC above the NEMDC Stormwater Pumping station and Old Magpie Creek above Pump 157 were routed through their respective pumping stations for each of the 8-Flood Series.

The Natomas tributary 30-day hydrographs for the 8-Flood Series were provided to Hydraulic Design Section for use as upstream boundary conditions for the hydraulic model. For Upper NEMDC and Old Magpie Creek, hydrographs for above and below their respective pumping stations were provided to Hydraulic Design Section.

4.0 Natomas Cross Canal (NCC) and Steelhead Creek (SHC) Coincident Frequency Study

The Comprehensive Study hydrology included coincident flood centerings for the Sacramento River tributaries large enough to have an influence on the flows downstream of their confluences with the mainstem. Flood hydrograph contributions from the tributary Natomas Cross Canal (NCC) and Steelhead Creek (SHC) are negligible in comparison with the mainstem flood flows, such that the tributary flow or stage hydrographs do not need to be considered when developing stage-frequency functions for the mainstem channels. However, the mainstem channel stages still need to be considered when developing stage-frequency functions on the tributaries. For this phase of the analysis, the Sacramento Mainstem flood series is used as the mainstem for the Natomas Cross Canal, and either the American River or the Sacramento Mainstem is used as the mainstem for the Steelhead Creek tributary, depending upon percent exceedence. For low mainstem stage conditions, Steelhead Creek flows directly to the Sacramento River rather than mingling flows with the American River.

4.1 <u>Total Probability Theorem</u>. Instead of the Comprehensive Study concurrent flood centering methodology, a total probability approach was used to evaluate coincident flood stages on the Natomas Cross Canal and Steelhead Creek. The procedure used was an extension of the Total Probability method documented in **Reference 11**, Procedures for Developing Stage-Probability Functions for Tributary Streams, prepared by David Ford Consulting Engineers (Ford) in February 2007.

Tangible benefit of a flood management project is computed, in part, as the expected value of inundation damage reduced. This computation requires a stage-frequency function at the location of interest. If that location is on a tributary stream, development of the function must account properly for the influence of the mainstem stream into which the tributary flows. A systematic, uniform approach is required for development of the stage-frequency functions for the locations of interest. The procedure begins with an assessment of the degree to which the tributary is dependent on the mainstem. An overview flowchart for the tributary analysis procedure is shown on **Plate 16**.

If the tributary is not dependent on mainstem conditions (Case 1), then the necessary information can be developed using typical riverine analyses: estimate the discharge for a specified probability, use that as the upstream boundary condition, and use a rating curve or similar control as the downstream boundary condition for the hydraulics model.

If tributary conditions are hydraulically dependent on mainstem conditions, can the frequency of the stage at the tributary location be predicted, given the mainstem conditions? If so (Case 3), then the Comprehensive Study methodology is used to develop the tributary flow-frequency function and the mainstem stage-frequency function. A channel model is developed for the reach of interest, and a resulting stage-frequency function is derived for the tributary index location.

If tributary conditions cannot be predicted reliably from mainstem conditions (Case 2), then combinations of boundary conditions are applied to the standard watershed and channel models. Using the results from analysis of tributary stages computed with varying downstream boundary conditions, the total probability equation is used to compute the desired stage-frequency function at the tributary location. The equation is:

$$F(stage_{tributary}) = \sum_{\substack{mainstem \\ conditions}} (F(stage_{tributary} \mid stage_{mainstem}) \times F(stage_{mainstem}))$$

If a correlation exists between the tributary and mainstem, but is not definitive (Case 4), then a conditional probability analysis needs to be done. Practical methods to accomplish this have yet to be developed and field-tested.

4.2 Application to Natomas Tributaries. The coincident-frequency procedures that Ford used to develop stage-frequency curves for the Natomas Cross Canal and Steelhead Creek channels are described in the memorandum, "NCC/SHC Coincident Frequency Study: Exposition of Analytical Procedures," dated September 10, 2008, prepared by David Ford Consulting Engineers (**Reference 12**). Primary technical tasks include assessing hydrologic dependence between tributary and mainstem channels and identifying flow regimes where hydrologic independence may be presumed. A secondary task is identifying timing differences between tributary and mainstem peak stages. Total probability methodology relies on historical rainfall and streamflow data. Stage records from the California Data Exchange Center (CDEC, **Reference 13**) were used for the analysis. Due to the lack of stage data on the Natomas Cross Canal, CDEC stage records for the Dry Creek gage at Vernon Street (VRS) were substituted to develop a cross-correlation with the Sacramento River at Verona (VON) records. Records for the Sacramento River at I Street (IST) and at Ord Ferry (ORD) gages were used to supplement/correct the VON stage records. Similarly, due to the unavailability of long-term records for Steelhead Creek, Arcade Creek (AMC) records were cross-correlated with American River at H-Street gage (HST) records. American River at Fair Oaks (AFO) records were used to fill in missing values in the HST record. **Table 18** summarizes the primary stream gages used for this study. Gaging station locations (except for ORD) are shown on **Plate 1**.

Table 18
CDEC Gage Records Used for Hydrologic Dependence Analysis

Gage Name	CDEC gage ID	Period of Record
Sacramento River at Verona	VON	01Jan1984 – Present
Sacramento River at I Street	IST	01Jan1984 – Present
Sacramento River at Ord Ferry	ORD	01Jan1984 – Present
American River at H Street	HST	01Jan1984 – Present
American River at Fair Oaks	AFO	02Nov1998 – Present
Dry Creek at Vernon Street	VRS	19Oct1996 – Present
Arcade Creek at Winding Way	AMC	29Oct1996 – Present

The memorandum, "Cross-Correlation Analysis Results for NCC/SHC Coincident-Frequency Study," dated April 17, 2008, prepared by David Ford Consulting Engineers (**Reference 14**), describes the methods Ford used to assess conditions of hydrologic dependence between (1) Steelhead Creek and the American River, (2) Natomas Cross Canal and the

Sacramento River, and (3) the American River and the Sacramento River. It also identifies peak-stage timing differences between each tributary and the downstream mainstem channel.

Table 19 shows the tributary/mainstem confluence water surface elevations used as input in the Hydraulic Design Section's hydraulic models for the Natomas Cross Canal (NCC) and Steelhead Creek (SHC) tributaries as a function of mainstem annual exceedence probability (AEP) stages. Water surface elevation (WSEL) values are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29). Water surface elevations on SHC and NCC in **Table 19** correspond to stages on the American River and on the Sacramento River, respectively. For the more frequent mainsteam AEP between 0.50 and 0.04, Steelhead Creek stages are affected more by stages on the Sacramento River than by flows down the American River.

An analytical approach based on historical storm event data was used to characterize tributary/mainstem dependencies. Local event Annual Exceedence Probabilities (AEPs) were assigned to individual storm events, based on precipitation records from rainfall gages close to the SHC and NCC drainages. Rainfall frequency data was provided by Rainfall Depth-Duration Frequency Analysis for California Rain Gages (**Reference 15**), assembled by retired California State Climatologist Jim Goodridge. Historical mainstem peak flows were matched to concurrent local rainfall events on an event-by-event basis. Based on local storm magnitudes, the set of historic events was partitioned into return-frequency classes. Distributions for rarer AEP events were based on projected regional meteorologic patterns. Only rainfall and flow/stage records collected after 1980 were used for the analysis. It was assumed that n-year local flow event corresponded to the n-year local rainfall event, and that mainstem/tributary conditional distribution patterns can be extrapolated for rarer events using general knowledge of regional storm patterns and local channel hydraulics.

Table 19
Applied Stage-Frequency Functions for Mainstem AEP Events

Mainstem-event AEP	Steelhead Creek (SHC) Downstream WSEL (ft. NGVD29)	Natomas Cross Canal (NCC) Downstream WSEL (ft. NGVD29)
0.500	24.09	33.08
0.200	24.80	35.10
0.010	25.70	36.34
0.040	30.71	39.34
0.020	32.65*	40.10
0.010	35.43*	41.62
0.005	37.18*	43.00
0.002	42.62*	44.35

Notes:
AEP = Annual Exceedence Probability
WSEL = Water Surface Elevation
* WSEL is stage for American River conditions. All other WSELs are stages on the Sacramento River Mainstem.

The Hydraulic Design models were used to generate peak water surface elevations for the SHC and NCC index points for various combinations of tributary discharge and fixed mainstem stage (per **Table 19**). The tributary discharge rates were characterized by local-event AEP; similarly, the downstream confluence stages were characterized by mainstem AEP. The computed NCC and SHC index point stage values corresponded to regulated mainstem conditions.

4.3 Computational Results. Ford developed stage-frequency functions for the Natomas Cross Canal and Steelhead Creek index points. **Table 20** presents the stage-frequency functions for the NCC and SHC index points based on Ford's coincident-frequency evaluation. The stage values were computed under regulated mainstem conditions. Water surface elevation (WSEL) values are referenced to the National Geodetic Vertical Datum of 1929 (NGVD29).

Table 20

Computed Stage-Frequency Functions for Local AEP Events

Local-event AEP	Steelhead Creek (SHC) Index Point WSEL (ft. NGVD29)	Natomas Cross Canal (NCC) Index Point WSEL (ft. NGVD29)
0.500	26.3	33.9
0.200	28.6	34.5
0.010	29.9	34.8
0.040	31.4	36.6
0.020	33.4	37.8
0.010	35.5	38.6
0.005	37.4	40.1
0.002	40.1	42.4

Notes:
AEP = Annual Exceedence Probability
WSEL = Water Surface Elevation
SHC index point is located at RM 3.713
NCC index point is located at RM 4.323

Stages listed in **Table 20** are based on UNET modeling, not on the latest HEC-RAS model. The above stages may change when the HEC-RAS model is used for the analyses. The memorandum, "NCC/SHC Coincident Frequency Study: Computational Results," dated September 10, 2008 prepared by Ford (**Reference 16**), provides additional details regarding the results in **Table 20** from the analyses - the special factors considered, the hydraulic profiles and probabilistic relations used in the computations, and the coincident stage-frequency functions.

Table 21 shows the combination of which mainstem flood hydrographs are being used in combination with which Natomas tributary flood hydrographs in the HEC- RAS hydraulic model. These flood hydrograph combinations are being used in preparation for the F3 Conference Milestone. Different combinations of floods may be tested for later analysis.

Preliminary analysis determined that, for the mouth of the Natomas Cross Canal, the flood stages for the Sacramento Mainstem and Shanghai-Yuba centerings were similar. So the Shanghai-Yuba flood series hydrographs are not being used in the current phase (pre-F3 Milestone) of the analysis, but will be tested later.

Table 21
Flood Hydrograph Combinations used in HEC-RAS Hydraulic Model
for Current Phase of Analysis

Sacramento Mainstem Flood-event AEP	Steelhead Creek Flood-event AEP	Natomas Cross Canal Flood-event AEP
0.500	0.500	0.500
0.200	0.500	0.500
0.010	0.200	0.200
0.040	0.010	0.010
0.020	0.040	0.040
0.010	0.020	0.020
0.005	0.010	0.010
0.002	0.005	0.005
American River Flood-event AEP	Steelhead Creek Flood-event AEP	Natomas Cross Canal Flood-event AEP
0.500	0.500	0.500
0.200	0.500	0.500
0.010	0.200	0.200
0.040	0.010	0.010
0.020	0.040	0.040
0.010	0.020	0.020
0.005	0.010	0.010
0.002	0.005	0.005

Notes: AEP = Annual Exceedence Probability

5.0 List of References

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2. Yuba River Basin Project General Reevaluation Report, Appendix A, Synthetic Hydrology & Reservoir Operations Technical Documentation. U.S. Army Corps of Engineers, Sacramento District. Aug 2004, corrected June 2008.

3. Folsom Dam and Lake Revised PMF Study, American River Basin, California, Hydrology Office Report. U.S. Army Corps of Engineers, Sacramento District. October 2001.

4. Hydrometeorological Report No. 59, Probable Maximum Precipitation for California. U.S. Department of Commerce, National Oceanic and Stmospheric administration. U.S. Army Corps of Engineers. February 1999.

5. Rain Flood Flow Frequency Analysis, American River, California, Office Report. U.S. Army Corps of Engineers, Sacramento District. August 2004.

6. Natomas General Reevaluation Report, Natomas Cross Canal and Steelhead Creek Watersheds, Placer, Sacramento, and Sutter Counties, California, Hydrology Appendix. U.S. Army Corps of Engineers, Sacramento District. October 2006.

7. Dry Creek, Placer and Sacramento Counties, California, Hydrology Office Report. U.S. Army Corps of Engineers, Sacramento District. July 1984, revised April 1988

8. "Use of Radar-Rainfall Estimates to Model the January 9-10, 1995 Floods in Sacramento, CA," by David C. Curtis, Ph.D., NEXRAIN Corporation, and John H. Humphrey, Ph.D., P.E., C.C.M., HYDMET, Inc. Paper presented October 1995

9. Sacramento County ALERT System gage map: <http://www.sacflood.org/alrtloc1.htm>.

10. City of Roseville Public Works Web page with access to maps with local gaging station locations: <http://www.roseville.ca.us/pw/engineering/floodplain_management/roseville_current_stream_levels/default.asp>.

11. Procedures for Developing Stage-Probability Functions for Tributary Streams. Prepared by David Ford Consulting Engineers, Inc. February 26, 2007.

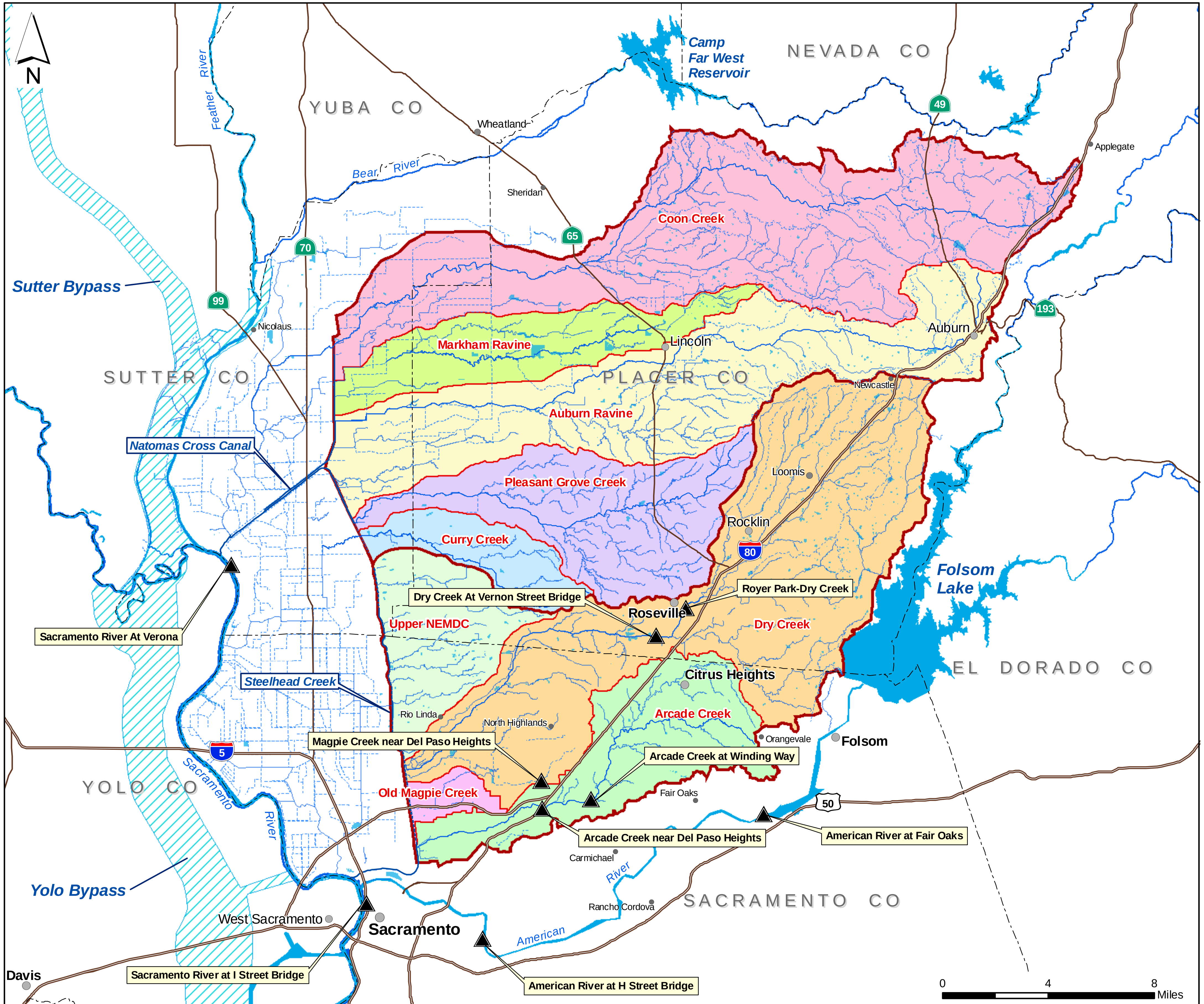
12. Memorandum: NCC/SHC Coincident-Frequency Study: Exposition of Analytical Procedures. Prepared by David Ford Consulting Engineers, Inc. September 10, 2008.

13. California Data Exchange Center (CDEC), the access point to the California Department of Water Resources' operation hydrologic data at: <http://cdec.water.ca.gov>.

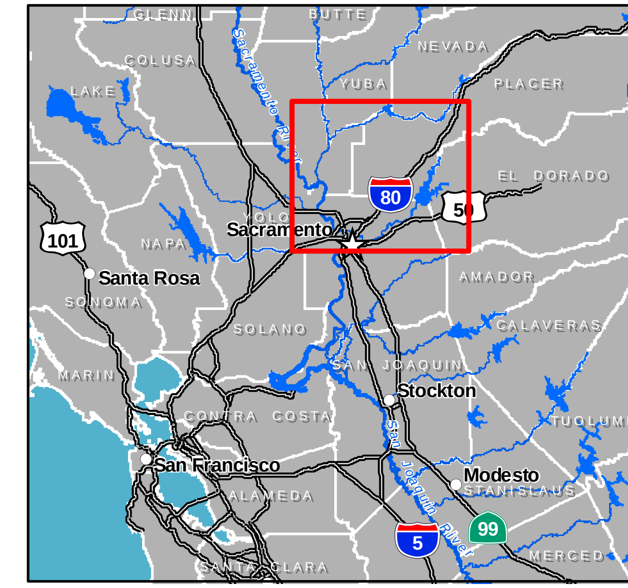
14. Memorandum: Cross-Correlation Analysis Results for NCC/SHC Coincident-Frequency Study. Prepared by David Ford Consulting Engineers, Inc. April 17, 2008.

15. Rainfall Depth-Duration Frequency Analysis for California Rain Gages. Mr. James Goodridge, retired State of California climatologist. Revised 2005.

16. Memorandum: NCC/SCH Coincident Frequency Study: Computational Results. Prepared by David Ford Consulting Engineers, Inc. September 10, 2008.



Prepared by J.S.M



Legend

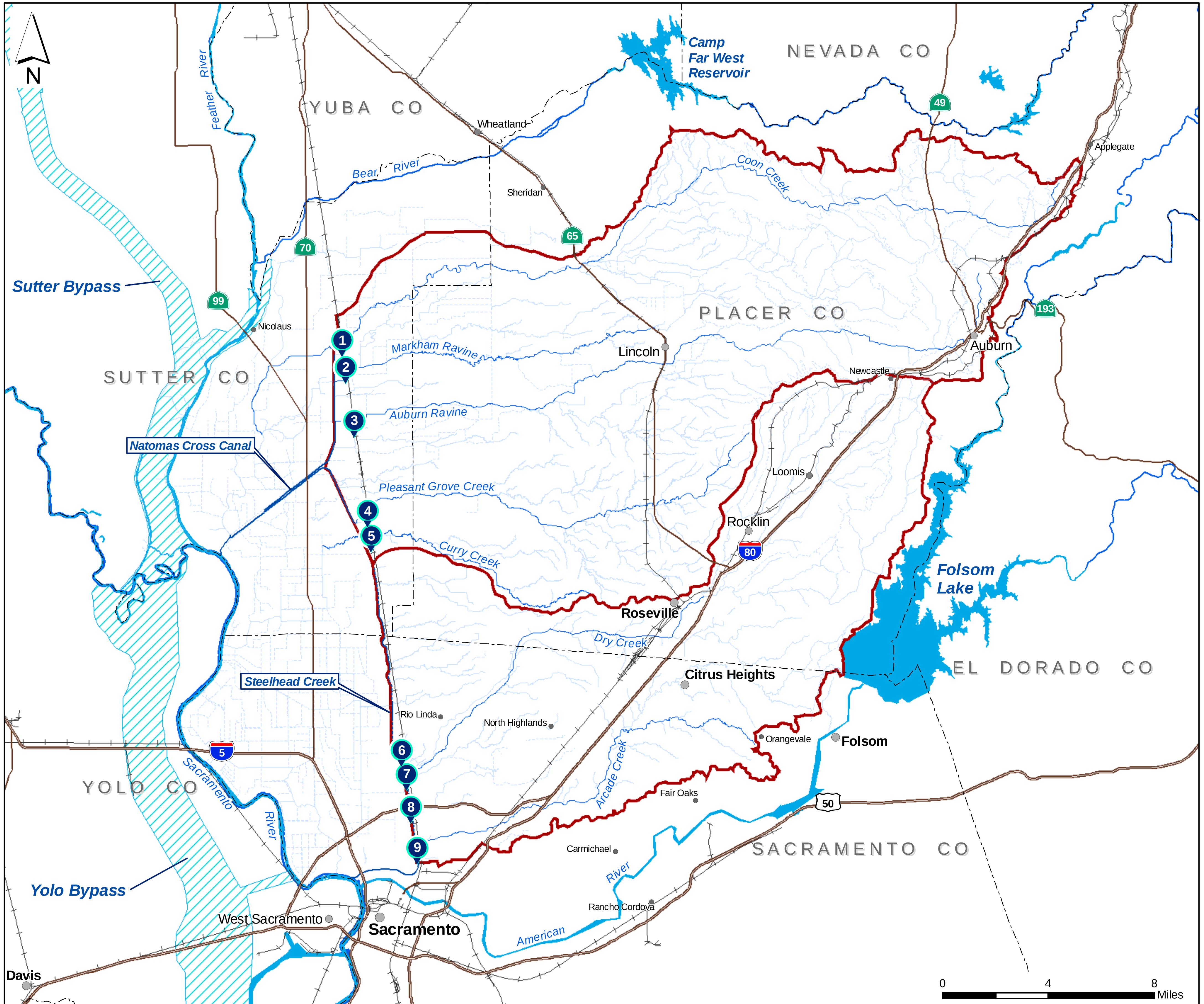
- Stream Gage
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- Canal or Ditch
- Freeway
- Highway
- County Boundary
- City or Town

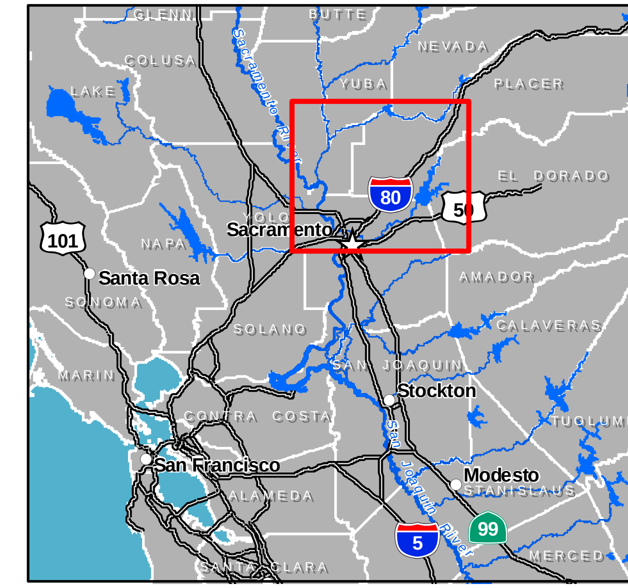
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

GENERAL MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008 PLATE 1





Legend

Watershed		Freeway	
Lake or Major River		Highway	
River or Stream		Railroad	
Canal or Ditch		County Boundary	
City or Town			

Input Sites

1 Coon Creek	6 Upper NEMDC Tribs
2 Markham Ravine	7 Dry Creek
3 Auburn Ravine	8 Old Magpie Creek
4 Pleasant Grove Creek	9 Arcade Creek
5 Curry Creek	

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

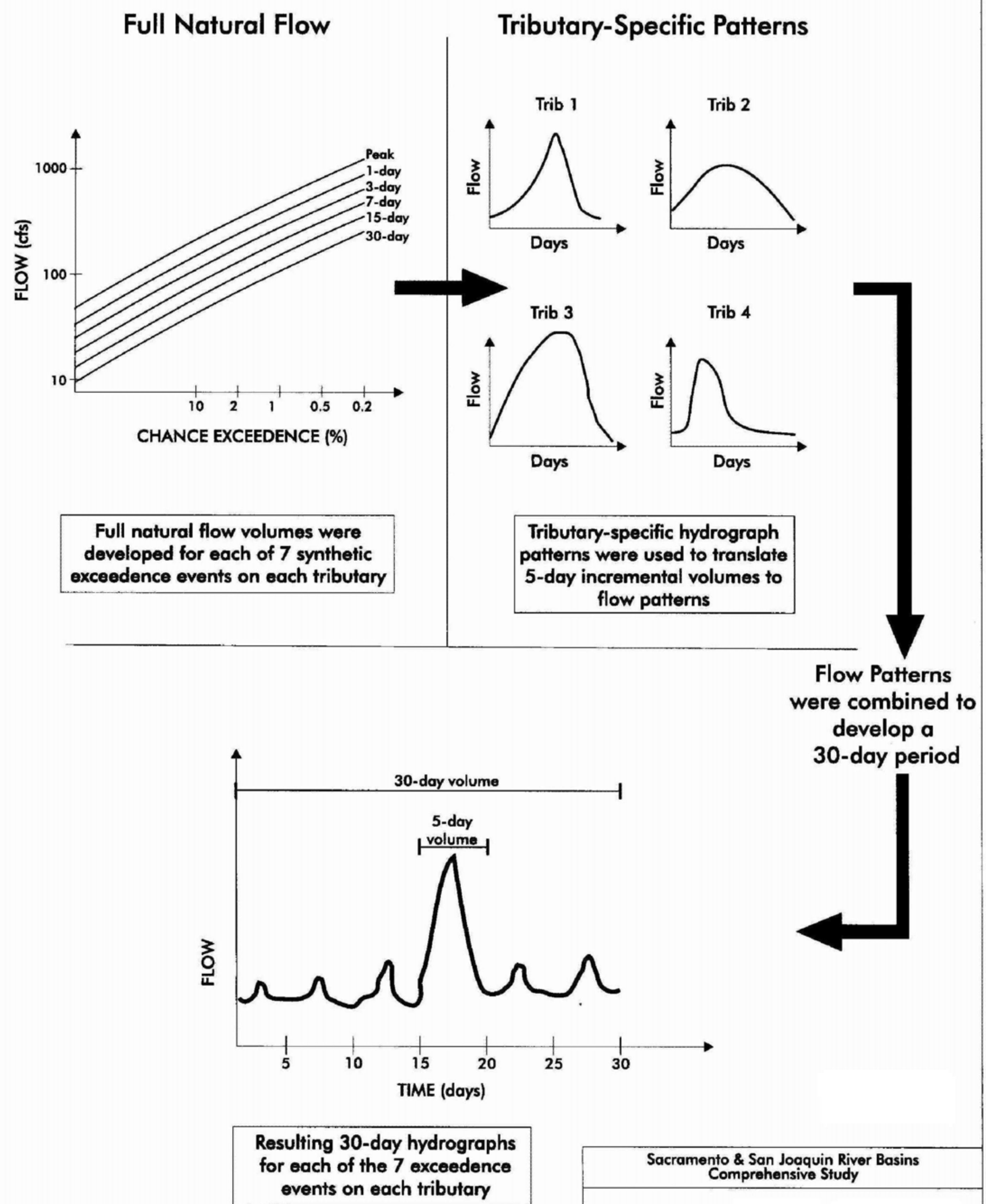
NATOMAS TRIBUTARY INPUT LOCATIONS FOR HYDRAULIC MODEL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Prepared by J.S.M

SEP 2008

PLATE 2

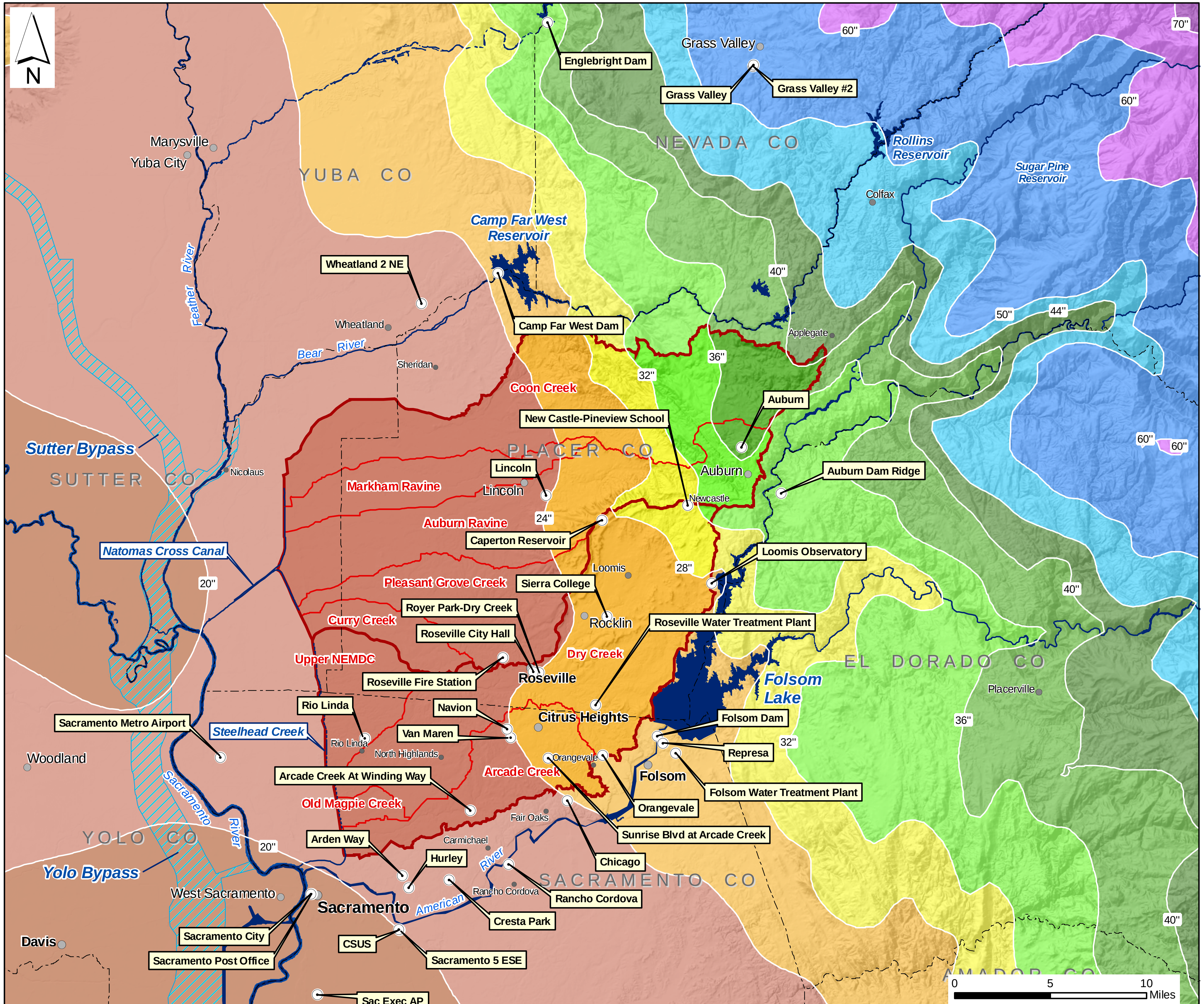


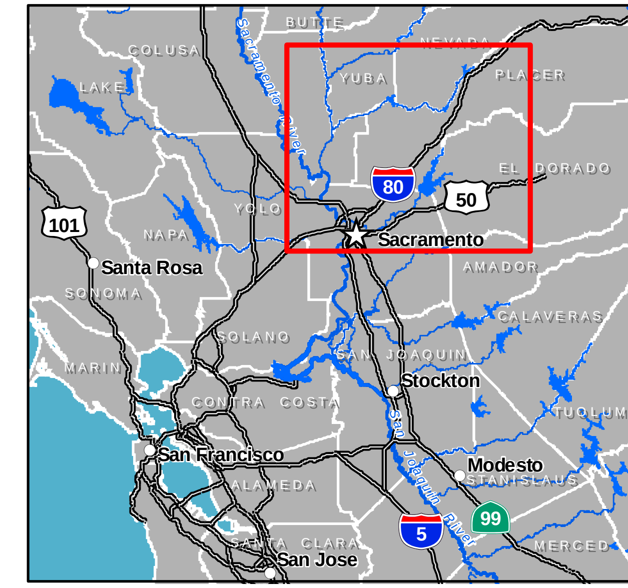
Sacramento & San Joaquin River Basins
Comprehensive Study

HYDROGRAPH CONSTRUCTION

U.S. Army Corps of Engineers
Reclamation Board, State of California

July 2002





Prepared by J.S.M

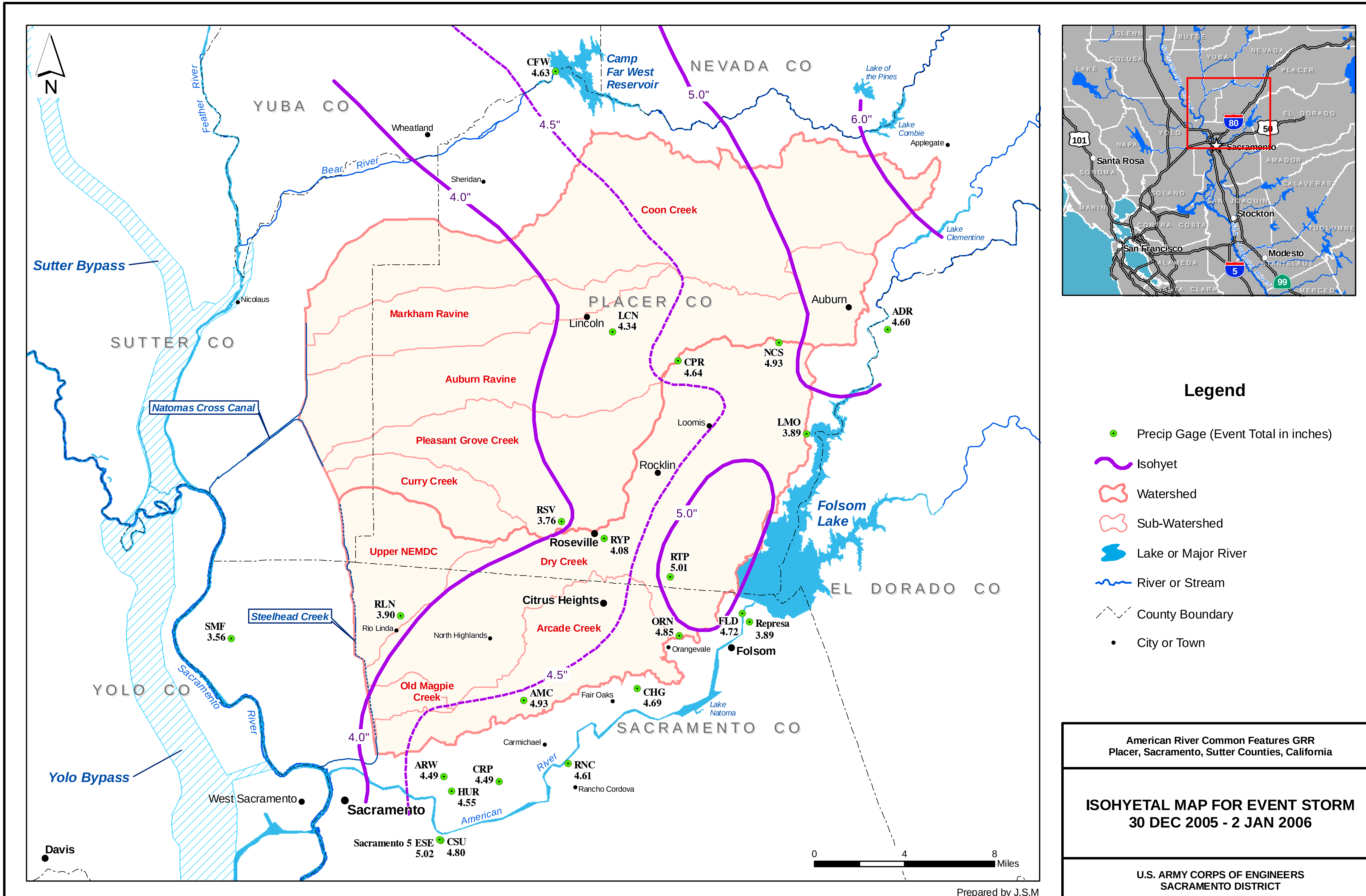
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

AVERAGE ANNUAL PRECIPITATION

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 4

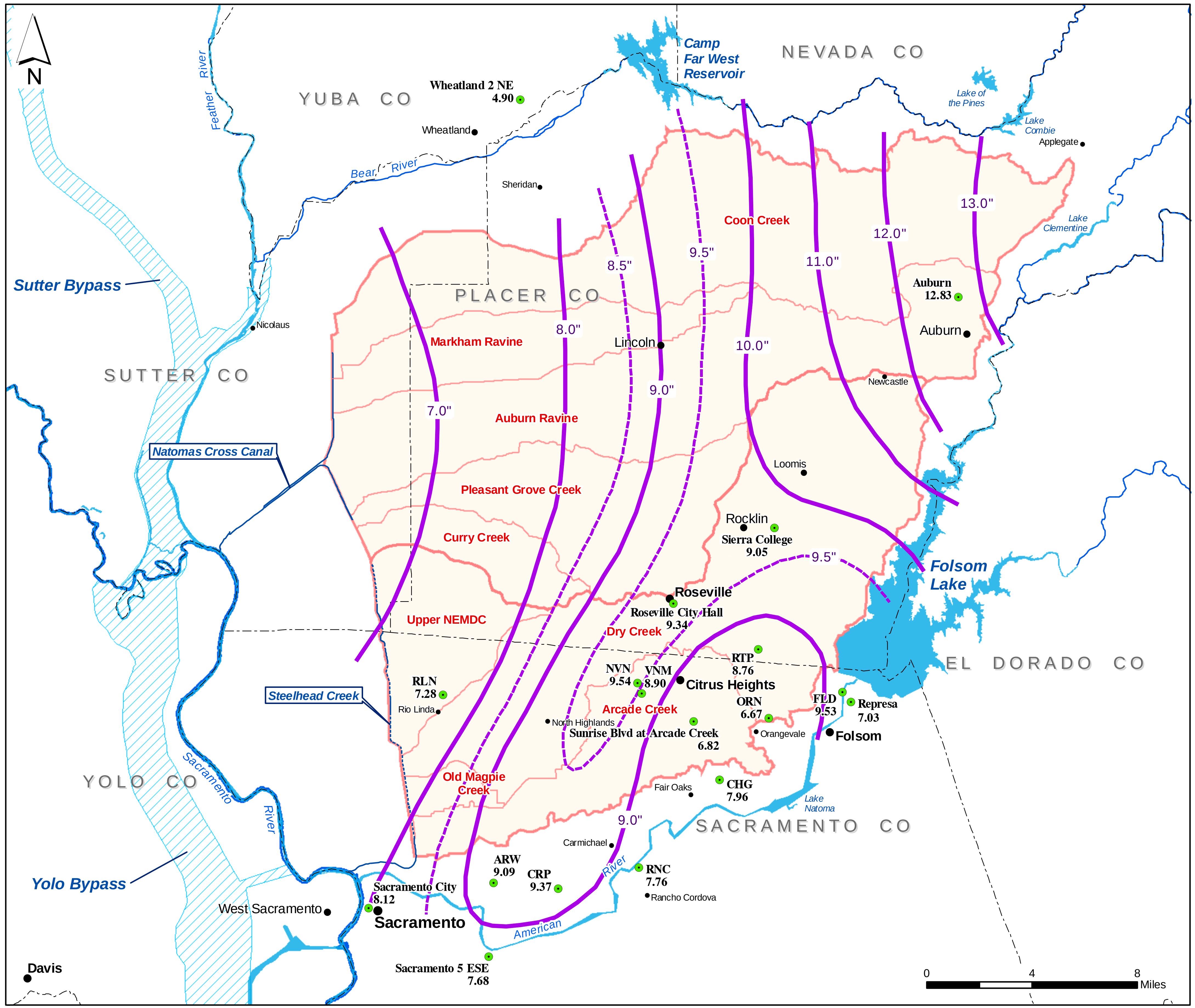


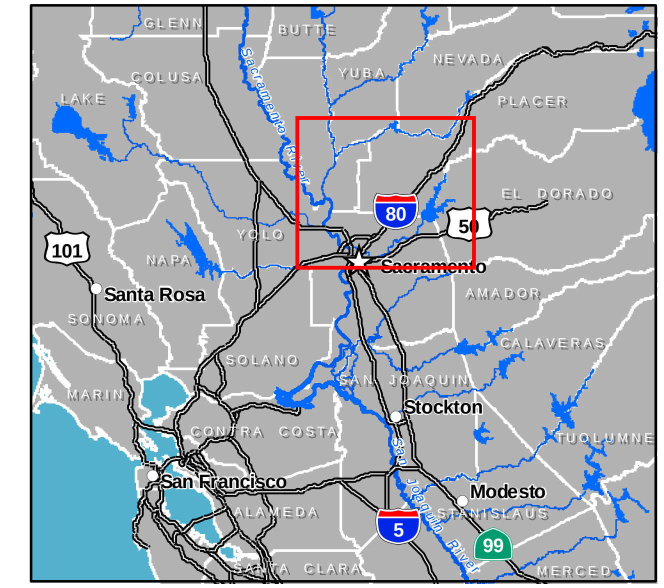
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM
30 DEC 2005 - 2 JAN 2006

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008 PLATE 5





Prepared by J.S.M

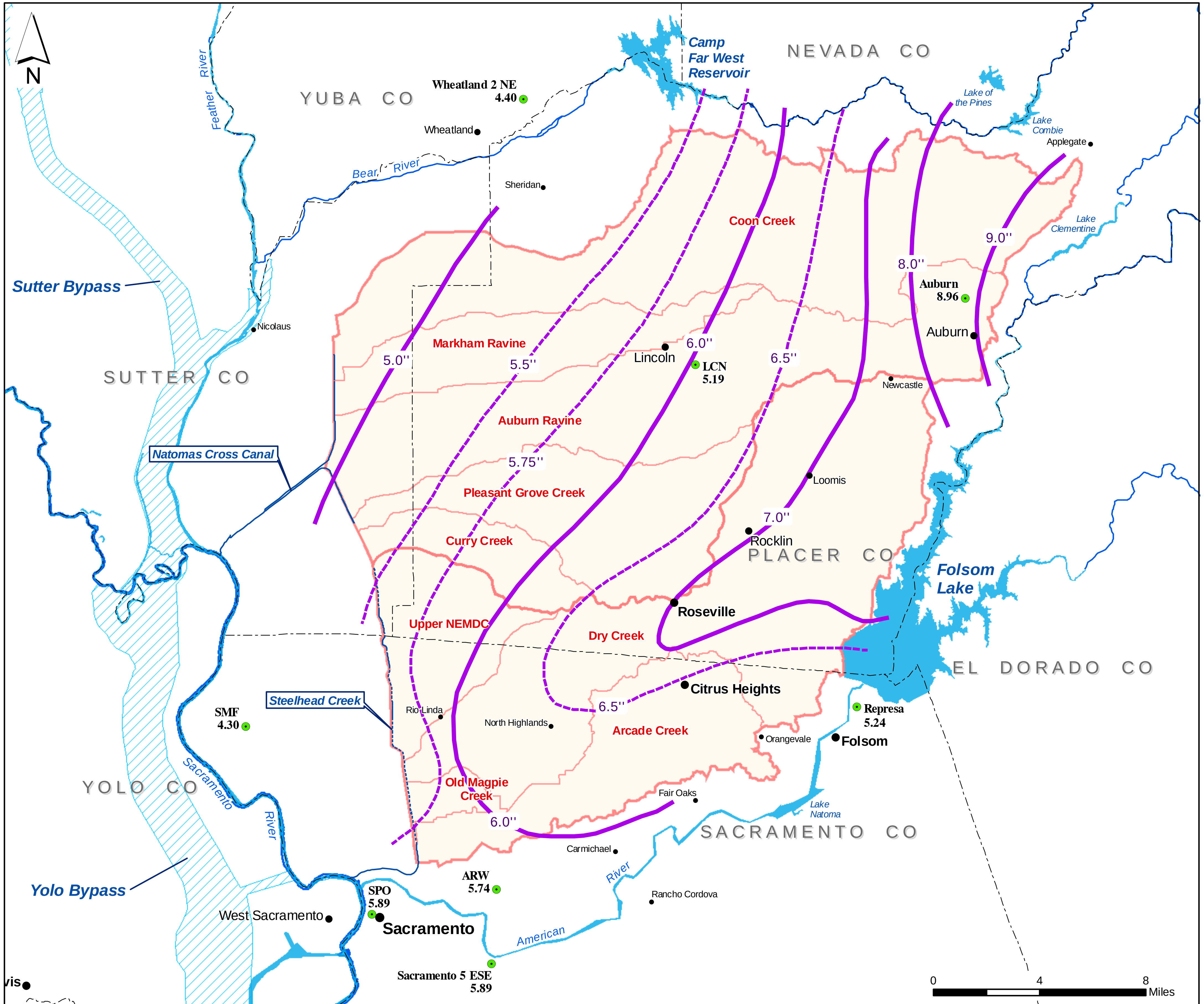
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

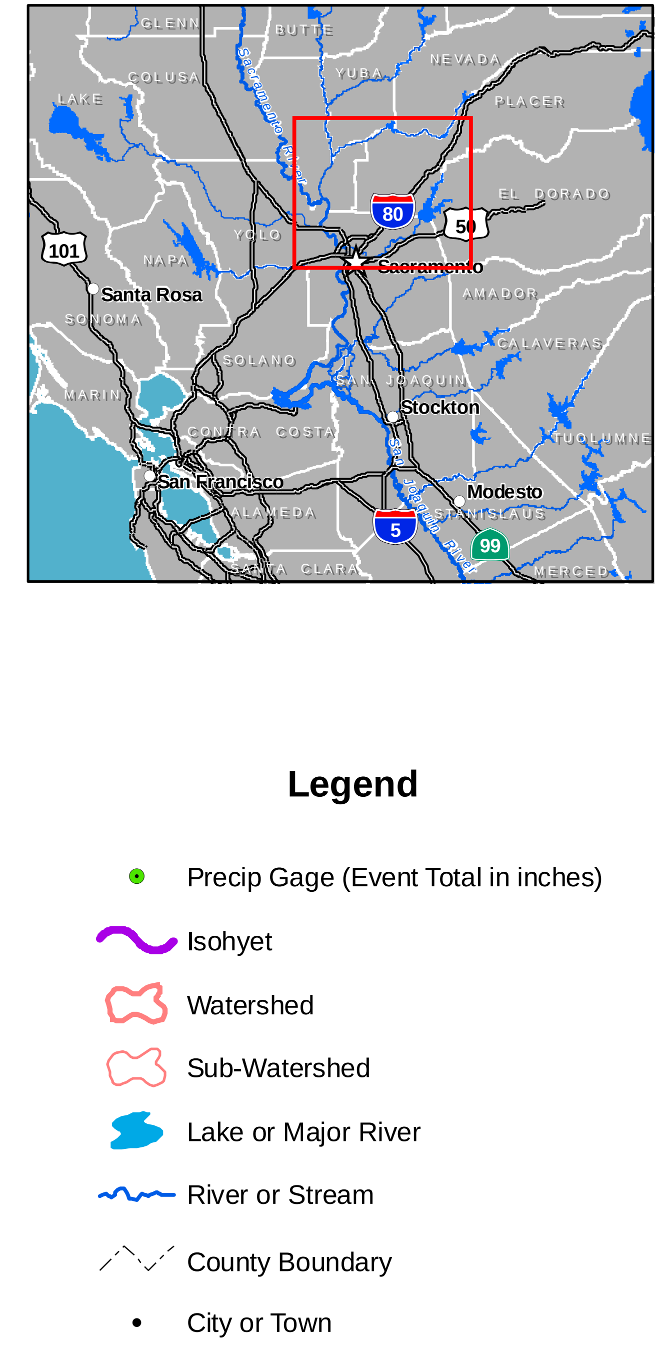
**ISOHYETAL MAP FOR EVENT STORM
15 FEB - 19 FEB 1986**

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 6





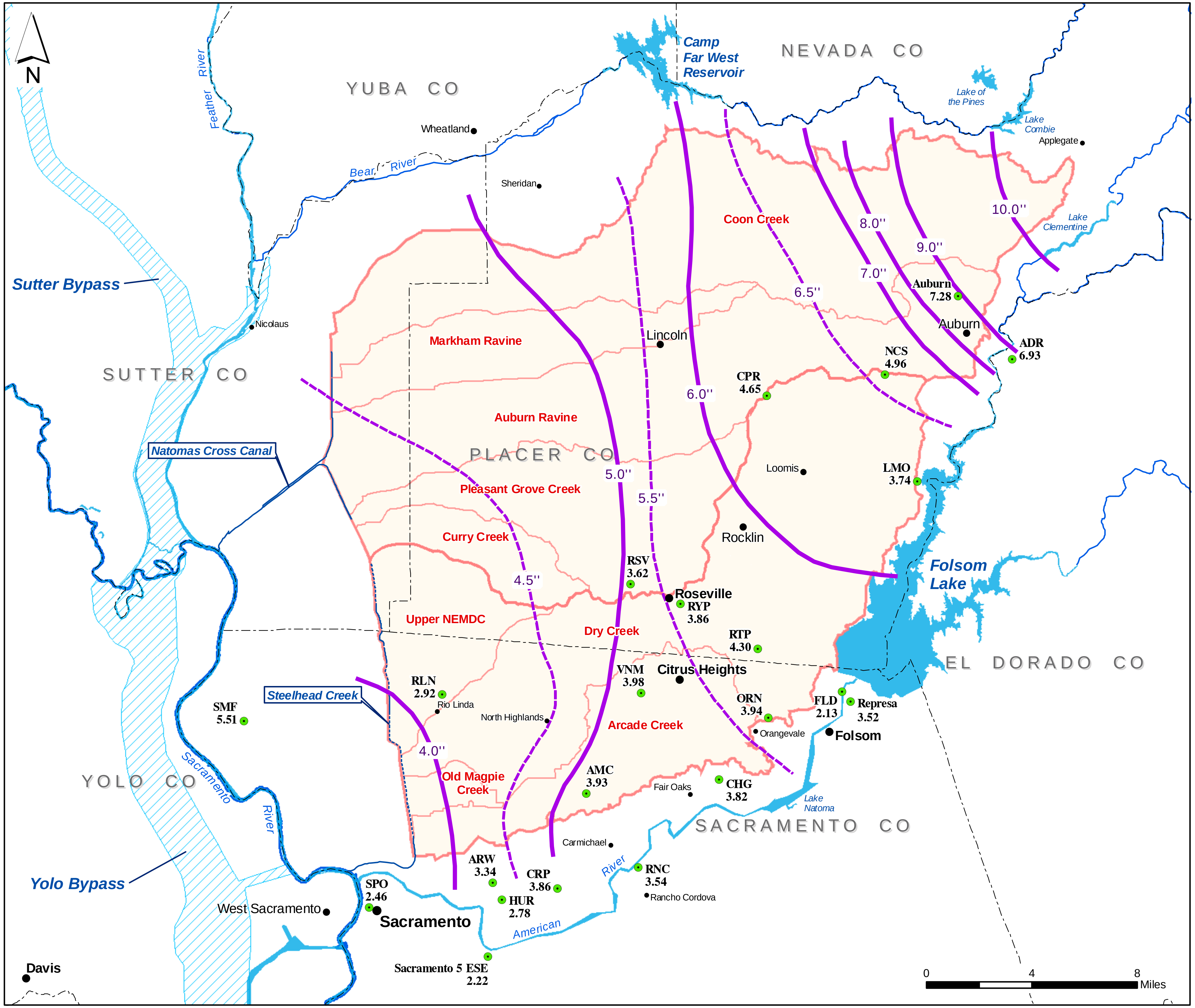
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

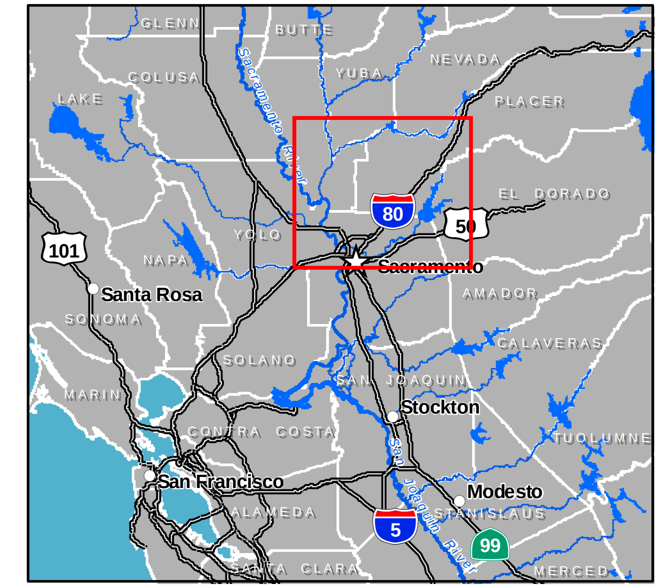
ISOHYETAL MAP FOR EVENT STORM
8 JAN - 12 JAN 1995

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 7





Legend

- Precip Gage (Event Total in inches)
- Isohyet
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- County Boundary
- City or Town

Prepared by J.S.M

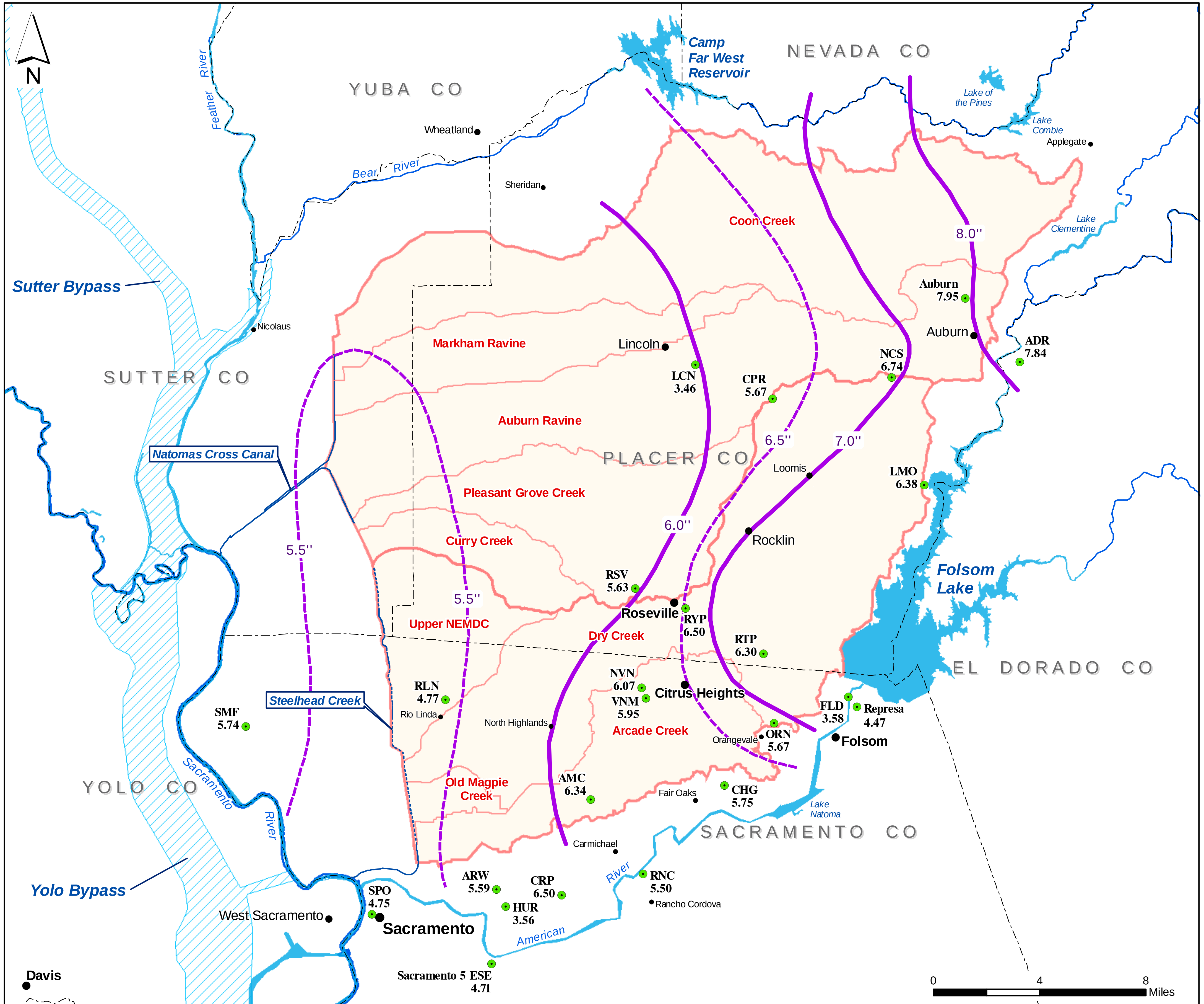
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

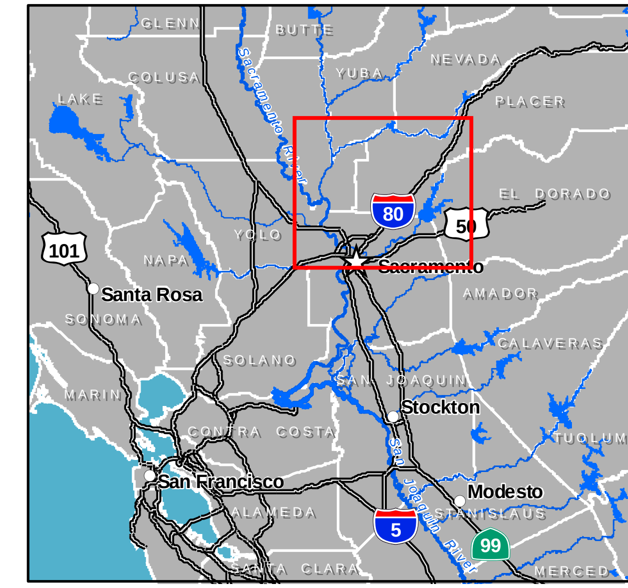
ISOHYETAL MAP FOR EVENT STORM
29 DEC 1996 - 2 JAN 1997

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 8





Prepared by J.S.M

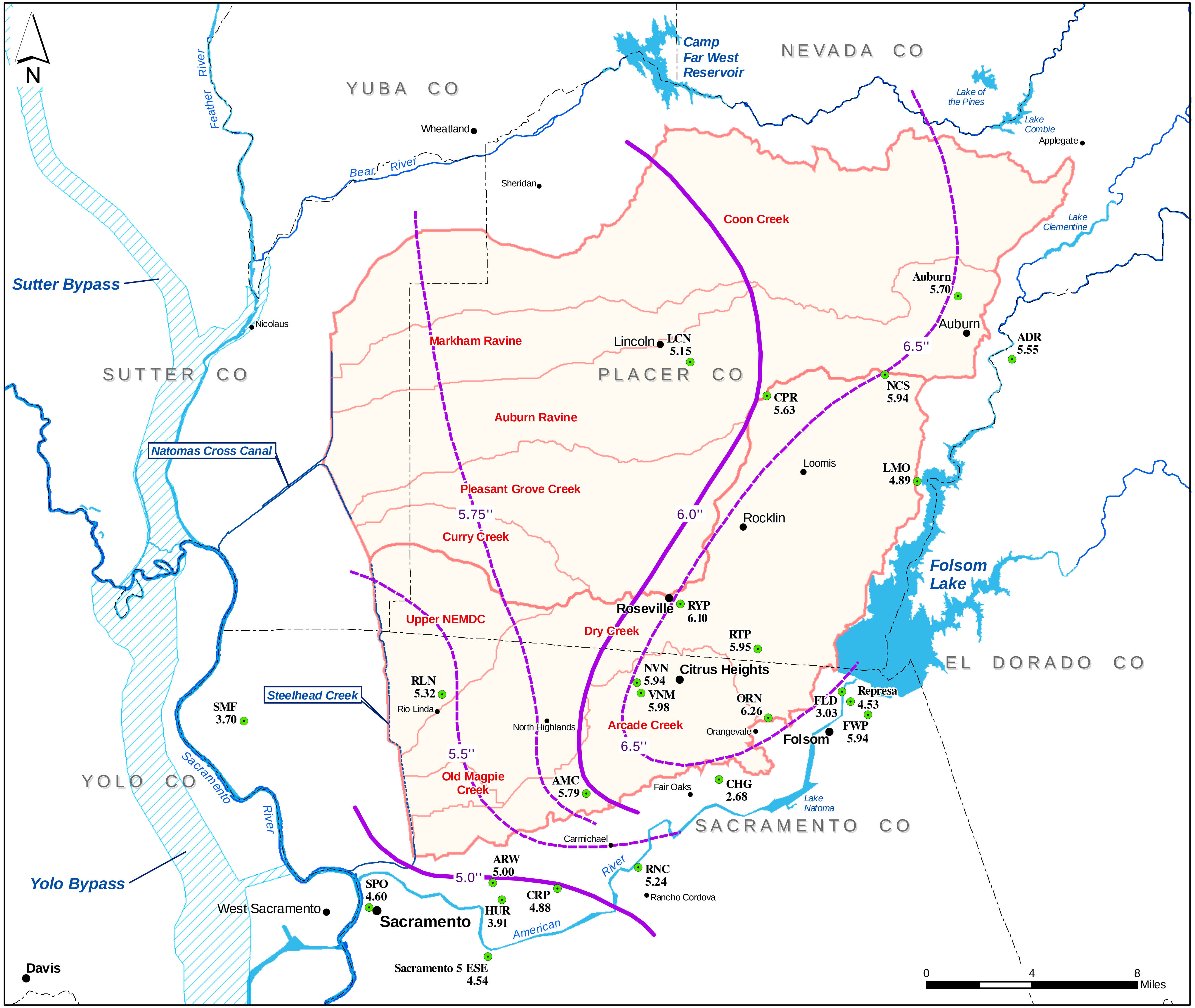
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

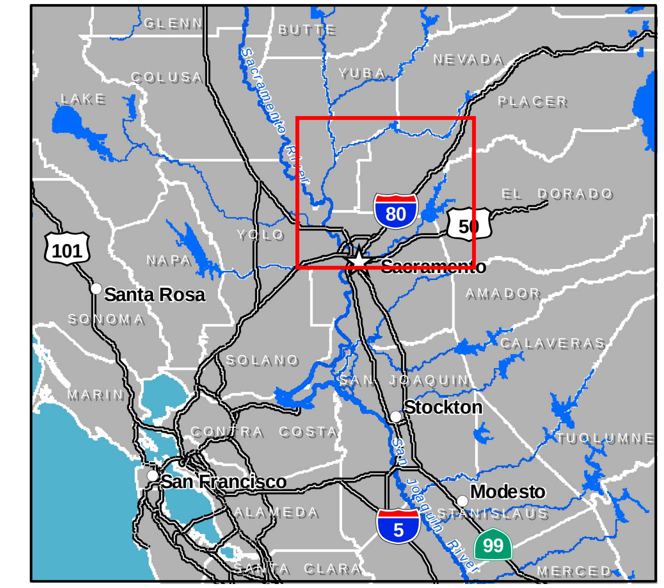
ISOHYETAL MAP FOR EVENT STORM
22 JAN - 26 JAN 1997

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 9





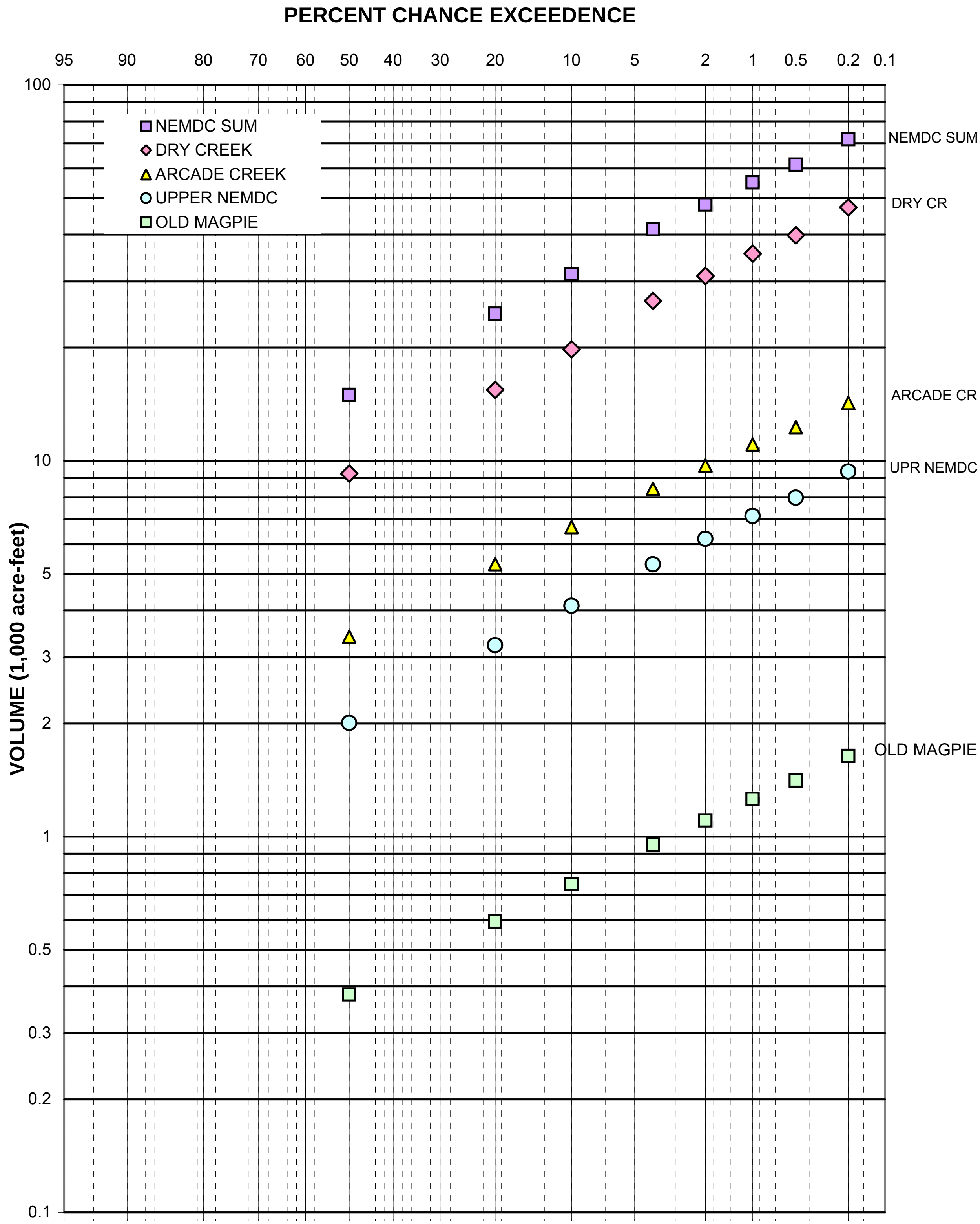
Prepared by J.S.M

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ISOHYETAL MAP FOR EVENT STORM
2 FEB - 6 FEB 1998

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008 PLATE 10



NOTES:

Dry Creek 116.48 sq. mi.

Arcade Creek 40.14 sq. mi.

Upper NEMDC 27.13 sq. mi.

Old Magpie Sum 4.57 sq. mi.

NEMDC Sum 188.32 sq. mi.

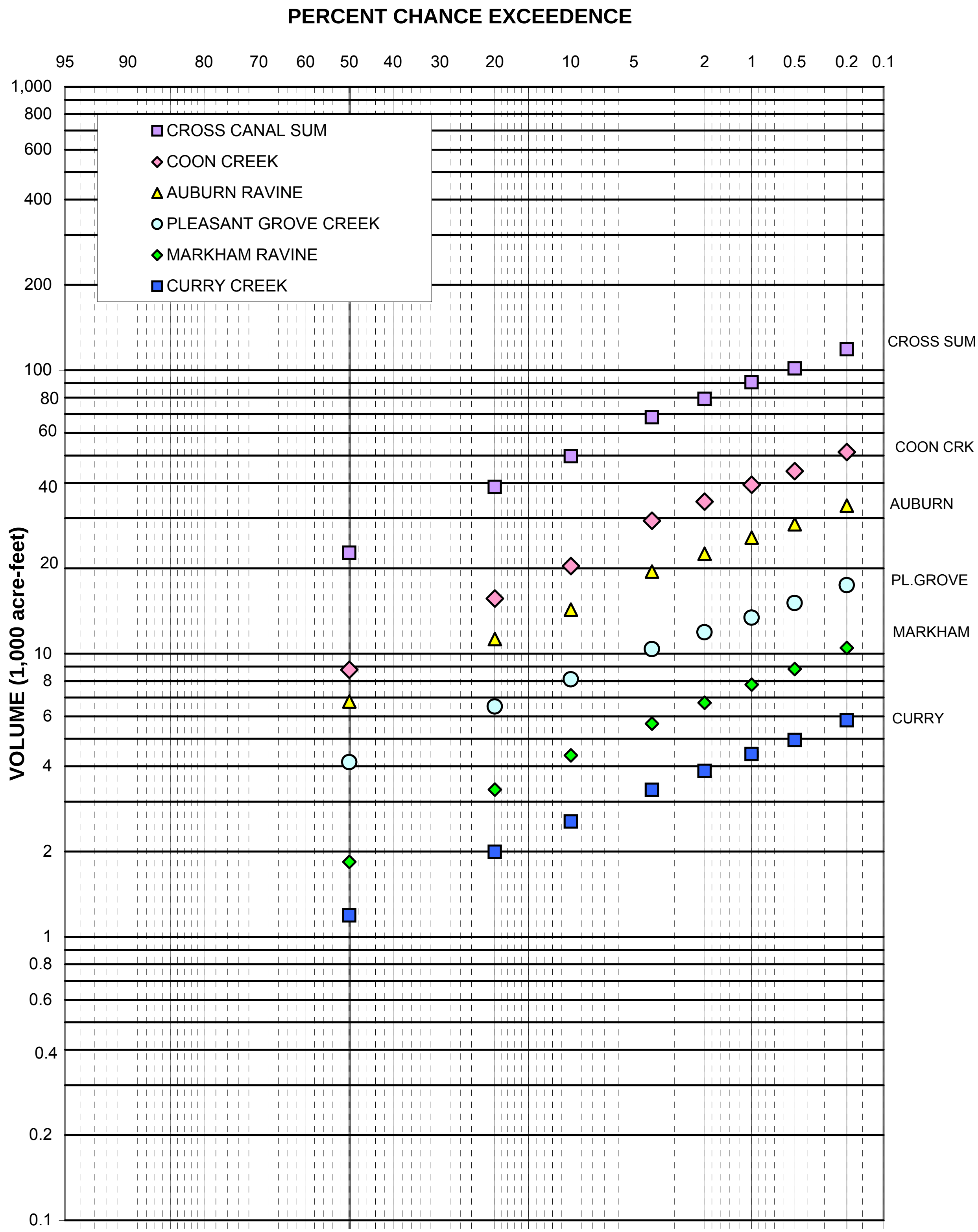
Developed by LLW and prepared by JLB

AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

5-DAY VOLUME FREQUENCY CURVES STEELHEAD CREEK DRAINAGE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008



NOTES:

Coon Creek 112.61 sq. mi.

Auburn Ravine 79.97 sq. mi.

Pleasant Grove Creek 46.69 sq. mi.

Markham Ravine 32.36 sq. mi.

Curry Creek 16.59 sq. mi.

Cross Canal Sum 288.22 sq. mi.

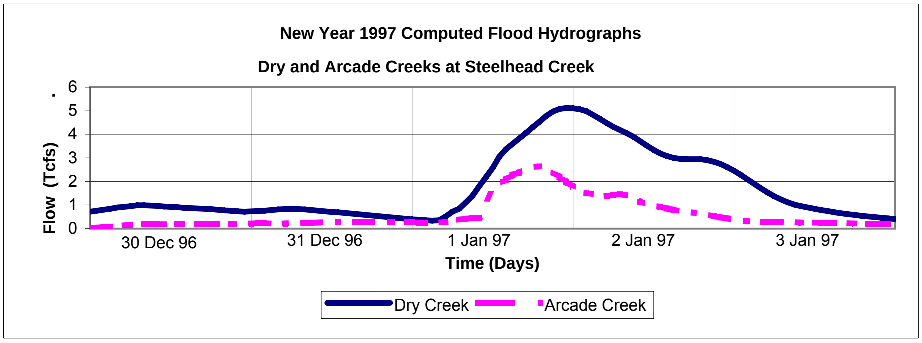
Developed by LLW and prepared by JLB

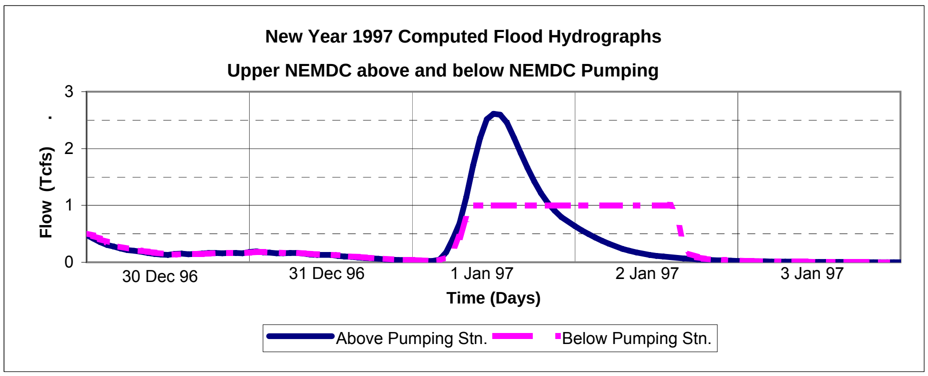
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

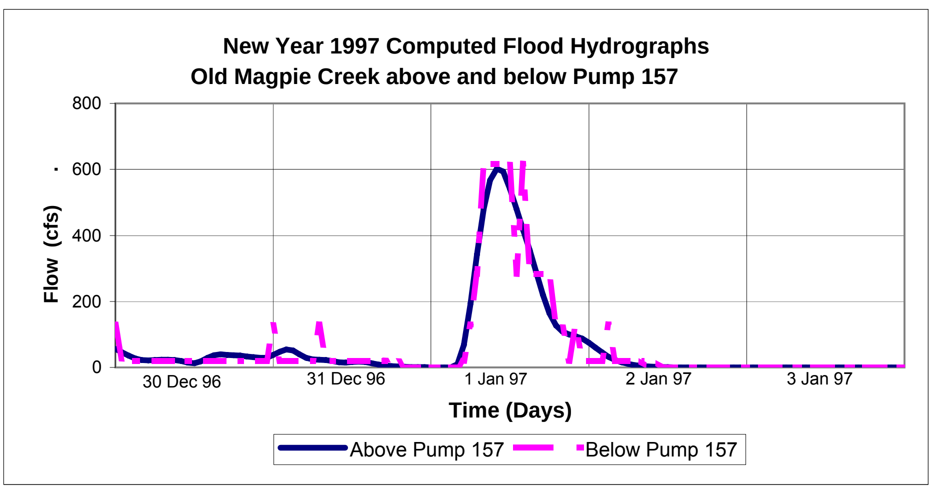
5-DAY VOLUME FREQUENCY CURVES
CROSS CANAL TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008





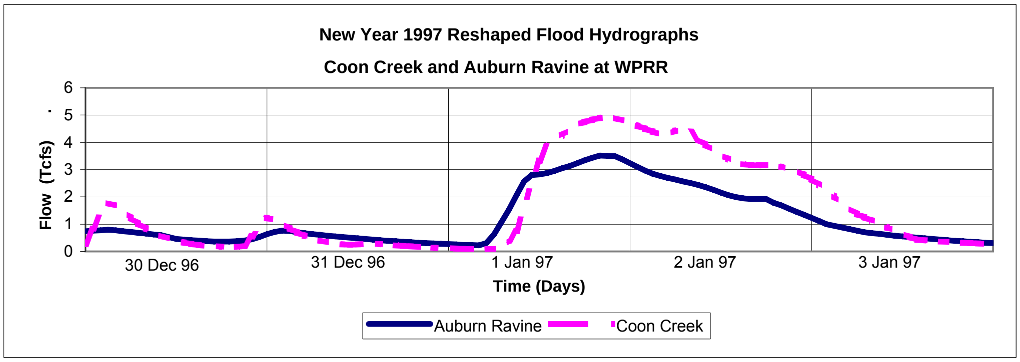


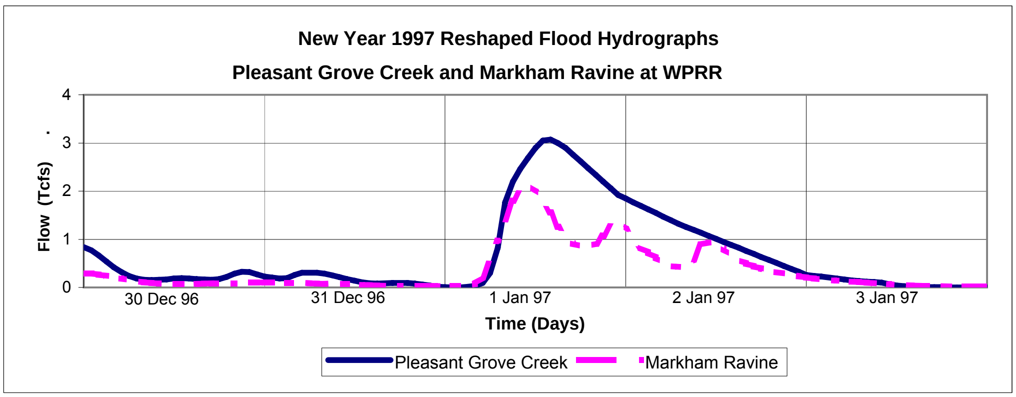
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

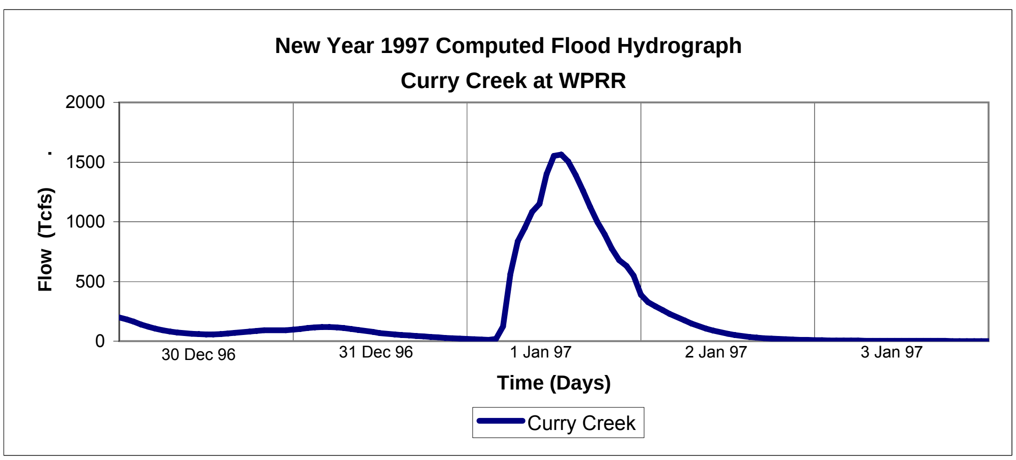
COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT STEELHEAD CREEK TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008







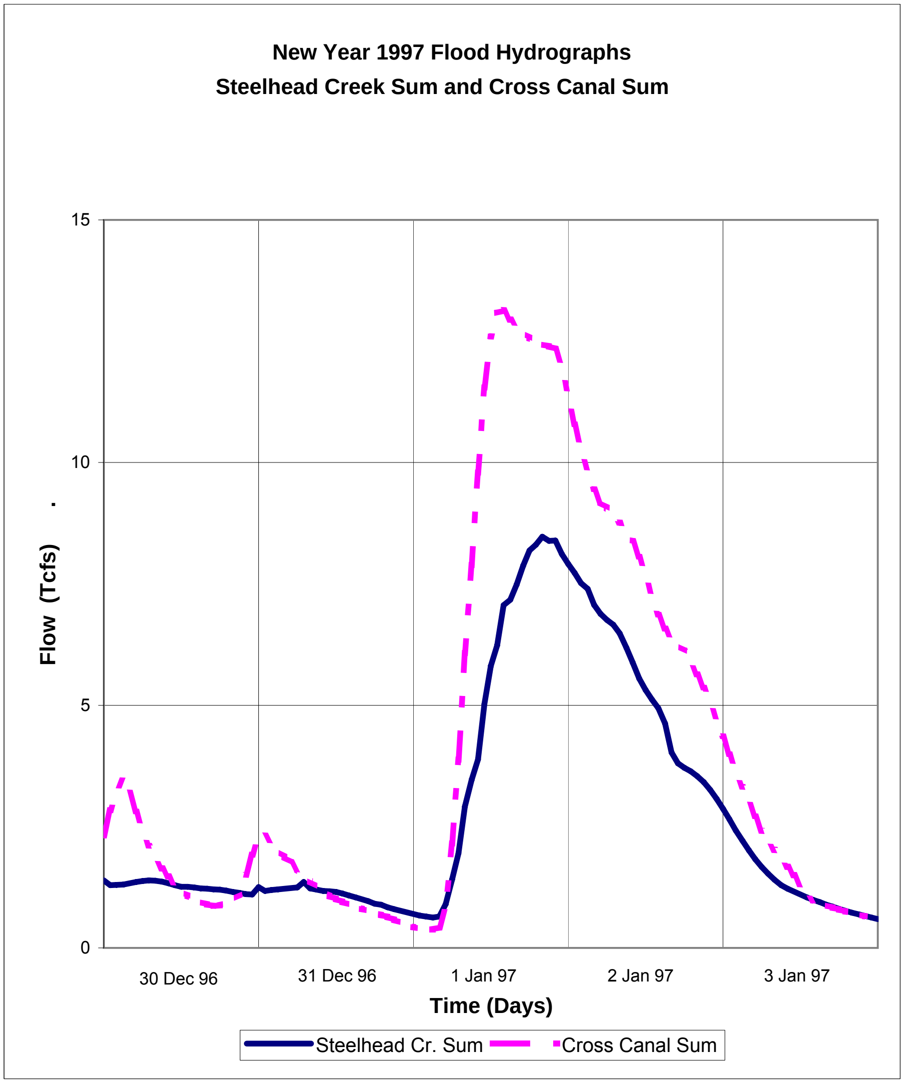
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT NATOMAS CROSS CANAL TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

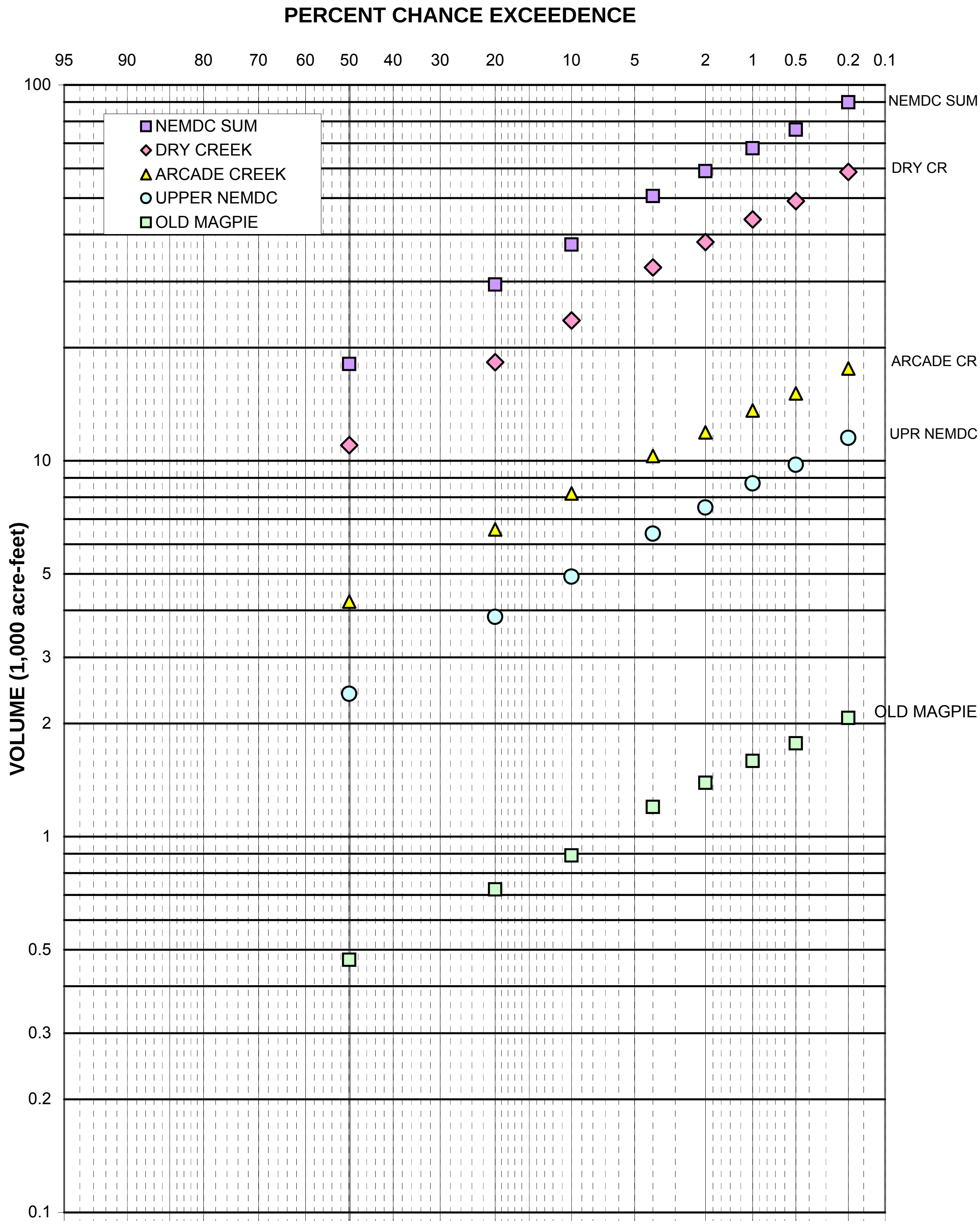
PLATE 13-B



AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT STEELHEAD CREEK SUM NATOMAS CROSS CANAL SUM

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



NOTES:

Dry Creek 116.48 sq. mi.

Arcade Creek 40.14 sq. mi.

Upper NEMDC 27.13 sq. mi.

Old Magpie Sum 4.57 sq. mi.

NEMDC Sum 188.32 sq. mi.

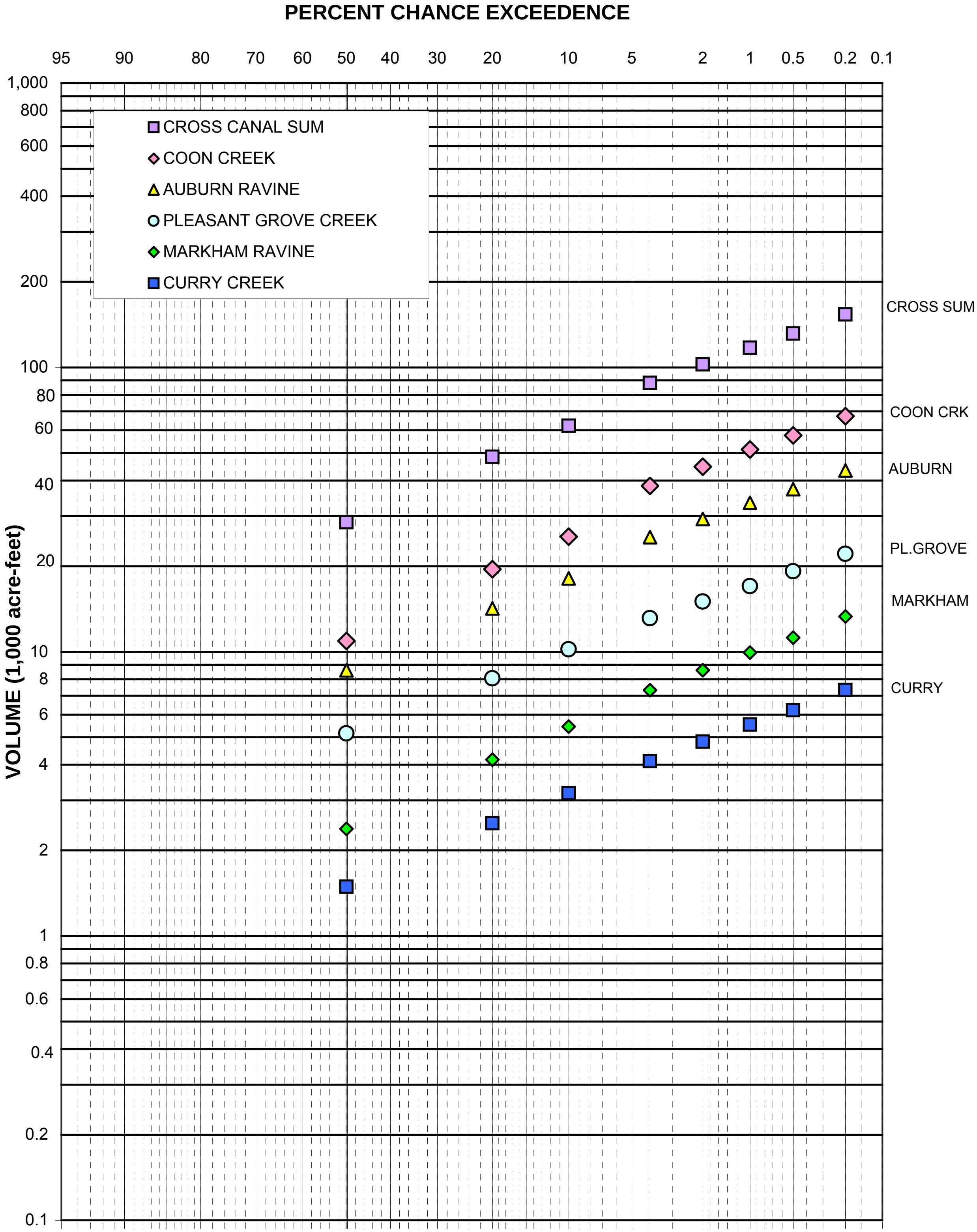
Developed by LLW and prepared by JLB

AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

10-DAY VOLUME FREQUENCY CURVES
STEELHEAD CREEK DRAINAGE

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008



NOTES:

Coon Creek 112.61 sq. mi.

Auburn Ravine 79.97 sq. mi.

Pleasant Grove Creek 46.69 sq. mi.

Markham Ravine 32.36 sq. mi.

Curry Creek 16.59 sq. mi.

Cross Canal Sum 288.22 sq. mi.

Developed by LLW and prepared by JLB

AMERICAN RIVER COMMON FEATURES GRR

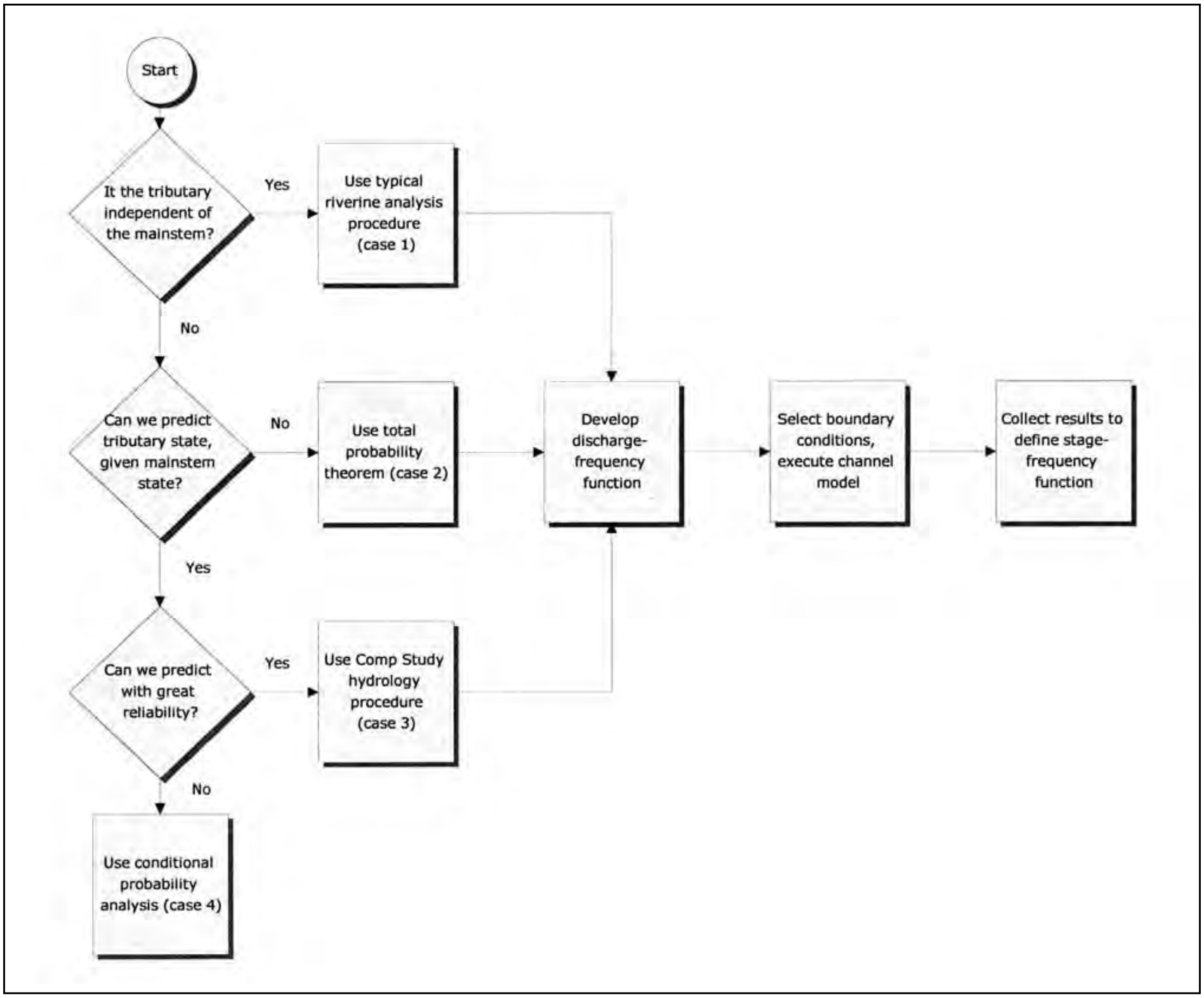
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

10-DAY VOLUME FREQUENCY CURVES CROSS CANAL TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS

SACRAMENTO DISTRICT

SEP 2008



Overview Flowchart for Tributary Analysis Procedure

American River Watershed
Common Features Project
Natomas Post-Authorization Change Report

American River Hydrology
&
Folsom Dam Reservoir Operations

APPENDIX B2

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FIGURES

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AMERICAN RIVER HYDROLOGY & FOLSOM DAM RESERVOIR OPERATIONS

A-1 Purpose

The scope of this General Reevaluation Report (GRR) covers the greater Sacramento area, which includes the Lower American River and the Natomas Basin. Hydraulic and geotechnical studies of the area have been on-going and have already identified many issues (e.g. seepage, erosion, vegetation, etc) which could lead to levee failure. The latest findings indicate that the Sacramento area is still highly susceptible to flooding due to levee failure even with all the authorized repairs and improvements. The economic analyses will evaluate the flood risk and cost benefit of fixing the identified problems. This write-up covers the development of the Folsom Dam discharge hydrographs provided to Hydraulic Design for the floodplain delineation efforts and the development of the hydrologic data inputs provided to Economics for the HEC-FDA model. The economic analysis will evaluate the extent of the damage caused by levee failures within the basin. Two scenarios were evaluated for the existing condition: the without-project (WO) condition and the future without-project condition, which is labeled as the no-action (NA) condition. These scenarios provide the information needed to perform an incremental analysis of the state of the levees at various levels of improvement (objective release 115,000 cfs, 145,000 cfs, or 160,000 cfs) and of the affect of the levee state when combined with the other authorized project components. Generally, these scenarios are hypothetical and would not be built or implemented as stand-alone projects. The reservoir routings covered herein were developed for planning purposes, only. All reservoir elevations provided herein use the NGVD29 vertical datum.

A-2 Background

As an interim means of reducing flood risk, Congress authorized the American River Common Features Project under Section 101(a) (1) of the Water Resources Development Act (WRDA) 1996. The features that were common to three candidate plans identified by the Corps, SAFCA, and the State of California Reclamation Board (State Reclamation Board) in the 1996 Supplemental Information Report (SIR) were covered in the authorization. The levee repairs and improvements included:

- 24 miles of slurry wall in the levees along the lower American River
- 12 miles of levee modifications along the east bank of the Sacramento River downstream from the Natomas Cross Canal
- Installation of three telemeter streamflow gages upstream from the Folsom Reservoir
- Modification to the flood warning system along the lower American River
- Raising the left bank of the non-Federal levee upstream of Mayhew Drain for a distance of 4,500 feet by an average of 2.5 feet
- Raising the right bank of the American River levee from 1,500 feet upstream to 4,000 feet downstream of the Howe Avenue Bridge by an average of 1 foot
- Modifying the south levee of the Natomas Cross Canal for a distance of 5 miles to ensure that the south levee is consistent in level with the level of protection provided by the authorized levee along the east bank of the Sacramento River
- Modifying the north levee of the Natomas Cross Canal for a distance of 5 miles to ensure the height of the levee is equivalent to the height of the south levee as authorized (above)
- Installing gates to the existing Mayhew Drain culvert and pumps to prevent backup of floodwater on the Folsom Boulevard side of the gates
- Installing a slurry wall in the north levee of the American River from the east levee of the Natomas east Main Drain upstream for a distance of approximately 1.2 miles
- Installing a slurry wall in the north levee of the American River from 300 feet west of Jacob Lane north for a distance of approximately 1 mile to the end of the existing levee

Section 366 of WRDA 1999 authorized more improvements which included the raising and strengthening of the levees along the American River and additional work in Natomas.

The Common Features GRR was initiated because the economic basis for the original authorization has changed. The Common Features Project has been subject to significant cost increases due to major design modifications and to additional work proposals. Further investigations into additional modes of levee failure (i.e. slope stability, seepage, underground utilities and vegetative growth and long term degradation effects that include erosion) have revealed that in order to ensure the integrity of the levee system, while sustaining 160,000 cfs, much more work is required than was originally identified under WRDA 96 and WRDA 99. According to *Appendix D – Hydraulic Technical Documentation of the F3 Document*, the hydraulic modeling and geotechnical studies have identified potential seepage issues on both the Sacramento and American Rivers and erosion issues on the American River. In order to better describe the potential impact of flooding within the entire Sacramento area, the scope of the Common Features project must be expanded to consider the risk of levee failure along the Sacramento River, American River and the Natomas Basin. This system-wide approach provides a more comprehensive view of the flood risk to the Sacramento metropolitan area.

Congress also authorized the “Folsom Modifications Project” under Section 101 of WRDA 1999 and the “Folsom Dam Raise Project” in 2003. Although these projects were authorized independently, the project performances are intertwined based on when the projects are assumed completed. Due to constructability issues with the “Folsom Modifications Project”, both the “Folsom Modifications Project” and the “Folsom Dam Raise Project” required reexamination. The Corps sought to combine the objectives of these two authorized projects with Reclamation’s dam safety project. This resulted in the Joint Federal Project (JFP), which met the flood damage reduction and dam safety objectives of the USACE, Reclamation, and the local sponsor. The ability of the downstream levees to handle 160,000 cfs is a key factor in achieving the following goals: 1) control the 1-in-200 year event by holding the release at 160,000 cfs (or less) and 2) control the PMF event while maintaining at least 3 ft of freeboard.

A-3 American River Hydrology

The Comprehensive Study data provides the majority of the input to the Hydraulic Design HEC-RAS model. The one exception is the data for the American River. Both the hydrology and routing tool for American River flows differ. Although the HEC-ResSim model built for the Comprehensive Study simulates system-wide operation for multiple reservoirs on the Sacramento River along with those on its major tributaries, the Folsom Dam Excel-based reservoir routing model provides the means necessary to examine Folsom Dam project features in more detail. For consistency, the same hydrology used in other American River studies was utilized for the Common Features GRR. See *Appendix A – Synthetic Hydrology Technical Documentation* for a discussion on the differences between the Comprehensive Study and the American River studies unregulated hydrographs for the American River.

A series of hypothetical inflow hydrographs (i.e. 50%-, 10%-, 4%-, 2%-, 1%-, 0.5%-, 0.2%-annual chance flood events) were developed for the flood risk management analyses. See **Figure A-1**. Design flood hydrographs can be patterned after historical or hypothetical events. In this instance, the flood hydrographs are patterned after the synthetic 2001 PMF event. Each hydrograph consists of multiple waves -- as would occur if a series of storms moved through the region. The sequencing of waves is an important aspect to consider when developing synthetic flood hydrographs. Antecedent waves could induce encroachment into the flood pool prior to the arrival of the main wave. This situation is most likely to occur when a project has limited release capability as under the existing project condition.

The selected hydrograph pattern is proportioned to match the annual maximum 3-day volume and peak for designated exceedance probabilities. The 3-day duration is considered the most critical within the American River basin. Past analyses has shown that the 3-day duration has the greatest impact on operation of the existing flood control system (Folsom Dam and the downstream levees), as well as plan formulation for the American River Basin and most other Sacramento Basin tributaries.

The flood volumes are obtained from a family of unregulated inflow frequency curves. The statistics used to generate these curves were last updated in 2004 using the statistical procedures and methodologies outlined in *Bulletin 17B, Guidelines for Determining Flood Flow Frequency* (United States Geologic Survey [USGS], 1982). *Rain Flood Flow Frequency Analysis, American River, California* (Corps, 2004) documents this process from start to finish beginning with preparation of the data and ending with development of the Log Pearson III statistics presented in **Table A-1.** The mean daily flow at the Fair Oaks gage downstream was used to develop the unregulated inflow for Folsom Dam. The drainage area between Fair Oaks and Folsom Dam does not generate a significant amount of local flow.

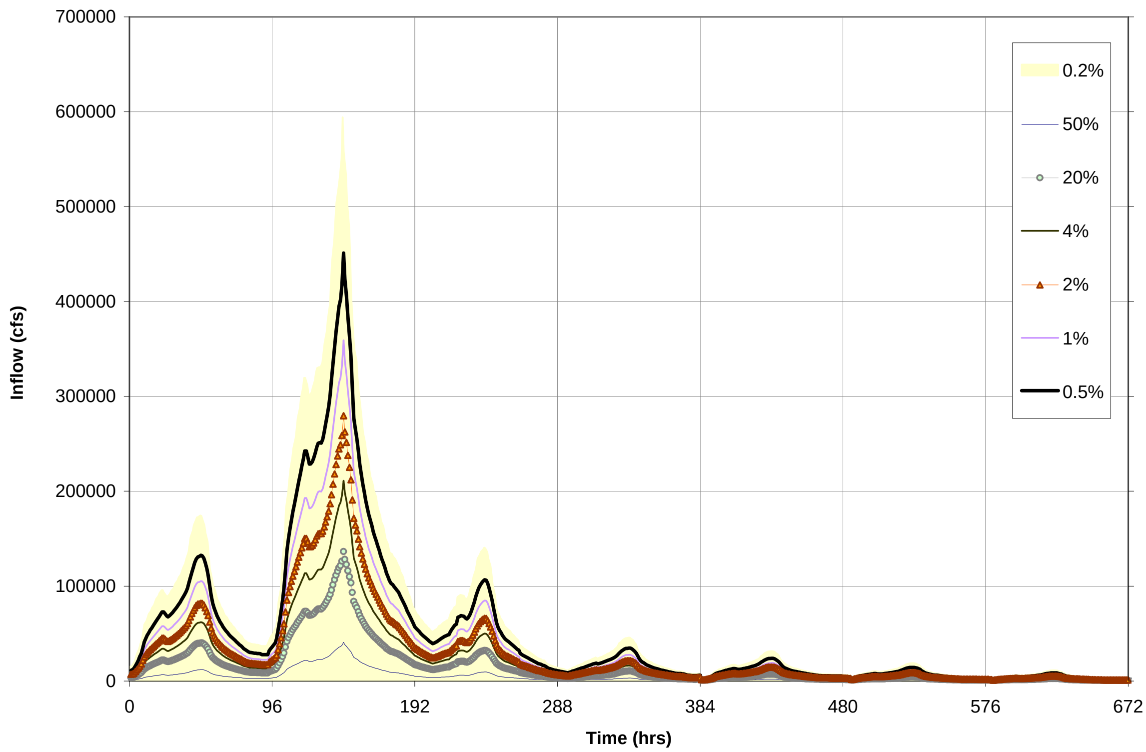

FIGURE A-1
FLOOD HYDROGRAPHS

The flood hydrographs above are based on a storm centered over the American River basin. Other storm centerings (i.e. Shanghai Bend, the mainstem of the Sacramento River) were considered to identify the conditions that would put the most stress on levee locations susceptible to failure. *Appendix A – Synthetic Hydrology Technical Documentation* contains a discussion regarding the development of the Comprehensive Study hydrographs based on the different storm centerings. The Comprehensive Study results were used to identify the coincident frequencies on the American River given a 50%-, 10%-, 4%-, 2%-, 1%-, 0.5%-, or 0.2%-annual chance flood event occurring elsewhere outside the American River basin. These coincident frequencies were used to develop two additional sets of flood hydrographs, one for the Shanghai Bend centering and another for the Sacramento River mainstem centering.

TABLE A-1: American River at Fair Oaks (1905-2004) – Unregulated Inflow Statistics			
Duration	**Log Mean (cfs)**	**Log Standard Deviation (cfs)**	**Skew**
Peak	4.581	0.430	-0.08
1 Day	4.453	0.425	-0.05
3 Day	4.326	0.414	-0.05
7 Day	4.162	0.398	-0.13
15 Day	4.015	0.373	-0.26
30 Day	3.897	0.360	-0.42

The family of unregulated rain flood frequency curves generated from these statistics is presented in **Figure A-2**. Exceedance frequencies can be read off of the mean 3-day rain flood frequency curve (**Figure A-3**). For the 0.01 probability event, the mean 3-day volume is 188,400 cfs.

A-4 Reservoir Model and Operating Assumptions

The Folsom Dam Operations and Planning Model was updated to include the latest storage capacity table developed in 2005, the auxiliary spillway rating curves derived from the Folsom Dam Auxiliary Spillway physical model study results from Nov 2007, and the dam safety assumptions coordinated with Reclamation.

a. Water Control Plan

The Water Control Diagram (WCD) provides the guidelines and limitations defining the release and storage of water within the flood control space. Around 1995, an interim WCD was implemented for Folsom Dam. This interim WCD is the product of an operational agreement between Reclamation and the Sacramento Area Flood Control Agency (SAFCA). The Folsom Dam WCD maintains a minimum allowable flood control reservation of 400,000 acre-feet. With an additional 270,000 acre-feet of variable flood space based on creditable storage available in upstream reservoirs, a maximum flood control reservation of 670,000 acre-feet is possible. This WCD will be referred to as the 400/670 WCD **(Figure A-4)**. The 400/670 diagram is more conservative than the WCD contained in the 1986 Folsom Dam Water Control Manual so there is no conflict in operation.

Under WRDA 1999, Congress directed the reduction of the variable flood control space from the current operating range of 400,000-670,000 acre-feet to 400,000-600,000 acre-feet upon the completion of improvements to Folsom Dam. The modifications to the project will include the construction of an auxiliary spillway under the JFP project, which will be followed by a 3.5 ft dam raise. The hypothetical future WCD for Folsom Dam is herein referred to as the 400/600 WCD **(Figure A-5)**.

Operation within the surcharge pool is prescribed by the applicable Emergency Spillway Release Diagram (ESRD). The diagram is constructed following procedures in EM 1110-2-3600, “Engineering and Design – Management of Water Control Systems”. The ESRD smoothes the transition from releases made under normal flood operation releases to those required for dam safety. The diagram indicates the minimum permissible release that can be made without endangering the structure and without releasing quantities in excess of natural runoff. The ESRD attenuates Folsom Dam flood outflows to a level less than the inflow to the dam. The release specified is made immediately in order to reduce the magnitude of later releases. The objective of the ESRD is to avoid creating a worse situation than already exists and to provide a set of rules to increase flows above the downstream channel capacity in order to protect the dam from overtopping. The ESRD instructs the operators on how and when to make this key operating decisions when the only information known is reservoir elevation and the current release.

b. Operational Limitations

1) Surcharge Storage (Flood Pool) Limitation

Per Code of Federal Regulations (CFR) 33.208.11, the project owner (Reclamation) has full responsibility for the safety of the dam/appurtenant facilities and for regulation of the project during surcharge utilization. In 2007, the Corps and Reclamation reached an agreement that Reclamation practices and standards should take precedence in defining dam safety operation and criteria. The maximum surcharge space requirement is greatly affected by the inflow design flood volume, the total discharge capacity of the project, and the plan of operation. Folsom Dam spillway was originally sized to handle a much smaller inflow design event (the probable maximum flood – aka PMF). The maximum surcharge pool level of 475.5 ft and the accompanying 5 feet of freeboard are no longer sufficient under current conditions. According to the report *American River Basin, California, Folsom Dam and Lake Revised PMF Study* (Corps, 2001), Folsom Dam can only pass 70 percent of the PMF -- assuming full operation of the outlets and spillway gates and no dam failure; The amount of overtopping is estimated to be 3.5 feet above all earthen structures.

Under the Joint Federal Project, the maximum surcharge storage space requirement would increase from elevation 475.5 to elevation 477.5. This increase is accompanied by a decrease in the freeboard requirement per Reclamation's freeboard analyses. Freeboard space above the maximum allowable surcharge storage is needed to prevent overtopping mainly by wind or wave action. The authorized storage space would remain constant and independent of any modifications to the project. The dam safety operation for the Folsom Dam project is constrained by downstream safety considerations which limit or delay increases above what the levees can handle until the reservoir water surface exceeds the designated Flood Pool. The release is held to the emergency objective release while the pool is less than or equal to the designated Flood Pool. Under the existing operation, the Flood Pool is set at elevation 470.0 ft. The 1986 ESRD allows usage of about 45,000 acre-feet of surcharge storage between elevation 466 ft (normal full pool) and elevation 470.0 ft. Once the Flood Pool is exceeded, any delays in meeting the dam safety release requirement may put the dam and downstream inhabitants at greater risk.

2) Discharge Rate of Increase Limitation

Corps guidance EM 1110-2-1420, "Engineering and Design - Hydrologic Engineering Requirements for Reservoirs" states that project operation plans should ensure that release rates-of-change be gradual and not exceed the historical maximum rates of increase. The current Folsom Dam rate-of-increase is 15,000 cfs per 2-hour period. This requirement was applied to all the Scenarios while the discharge remained at or below the emergency objective release. Thereafter, the rate of increase is unlimited for the WO conditions -- similar to the existing operation. For the NA conditions, the rate-of-increase changes to 100,000 cfs/hr while the discharge remains at or below 360,000 cfs. This criterion was coordinated with Reclamation as a requirement for their dam safety operation under the JFP project and the recommended plan (JFP project plus 3.5 ft Dam Raise) as described in the 2007 PAC document.

3) Downstream Channel Limitations

The objective release for normal flood control operation is specified by the WCD. Prior to the authorized Common Features levee improvements, the normal objective release was thought to be 115,000 cfs. Given the information available today, the actual "safe" target for an indefinitely sustained release is 90,000 cfs. The 90,000 cfs offers a zero percent chance of levee failure for the WO condition. The authorized levee improvements enable the levee system to handle 115,000 cfs under normal flood operations. The 115,000 cfs offers a zero percent chance of levee failure for the NA condition. The objective release changes once the emergency flood control operation begins. For the WO condition, the emergency objective release increases to 115,000 cfs. For the NA-145 Scenario, the emergency objective release is increased to 145,000 cfs. For the W-160 Scenario, the emergency objective release is increased to 160,000 cfs. The ability of the downstream channel to sustain 160,000 cfs is a critical assumption for the Joint Federal Project.

A-5 Scenario Description

The Common Features GRR study covers two different Folsom Dam flood routing scenarios for the existing condition: the without-project condition and the no-action future without-project) condition. The without-project (WO) represents the period prior to any work on the levees. The objective release is limited to 115,000 cfs. The no-action condition represents the current state of the levee system after all the authorized repairs and improvements are complete. Under the NA condition, the downstream levees can sustain 145,000 cfs Altogether, there are six routings under the existing condition: WO1, WO2, WO3, NA1-145, NA2-145, and NA3-145. There are three routings under the "with-project" condition: W1-160, W2-160, and W3-160. Refer to **Table A-2** for key information associated with the various scenarios. The following describes the assumptions for each alternative. Given study time constraints, a standard ESRD was assembled for each alternative. No effort was made to "optimize" or tailor the ESRDs beyond establishing the total spillway capacity available, the "Flood Pool" elevation, the emergency objective release limit, and placement of the minimum induced surcharge curve.

a. WO Scenarios

This represents the levee condition existing prior to WRDA 1996 & 1999. The emergency objective release is 115,000 cfs. Prior to the authorized repairs/improvements, the American River levees were thought capable of handling 115,000 cfs under normal flood operations and 160,000 cfs for a short duration to facilitate downstream evacuation. Current studies estimate that the capacity of the levee system under the "without-project condition" was actually closer to 90,000 cfs as a "safe" release for normal flood control operation and no more than 115,000 cfs for emergency releases.

1) WO1 – This represents the levee condition existing prior to WRDA 1996 & 1999. The emergency objective release is 115,000 cfs. The dam safety release is restricted to 115,000 cfs until the water surface reaches 470.0 ft to facilitate evacuation of the downstream. The water control plan consists of the 400/670 water control diagram used in conjunction with a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam cannot pass the PMF without maintaining adequate freeboard. For dam safety purposes, outflow is made to match inflow once the water surface reaches pool elevation 475.5 feet.

2) WO2 – This represents the levee condition existing prior to WRDA 1996 & 1999. The emergency objective release is 115,000 cfs. The dam safety release is restricted to 115,000 cfs until the water surface reaches 470.0 ft to facilitate evacuation of the downstream. This scenario reflects improvements to Folsom Dam -- the construction of the Joint Federal Project (auxiliary spillway). The water control plan consists of the 400/600 water control diagram along with a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam cannot pass the PMF without overtopping the dam. For dam safety purposes, outflow is made to match inflow once the water surface reaches pool elevation 475.5 feet.

3) WO3 – This reflects additional improvements to Folsom Dam, the construction of the Joint Federal Project (auxiliary spillway) followed by a 3.5 ft dam raise. The emergency objective downstream release is 115,000 cfs. The dam safety release is not allowed to exceed 115,000 cfs until the water surface reaches 470.0 ft in order to facilitate evacuation of the downstream. The water control plan consists of both a 400/600 water control diagram and a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam cannot pass the PMF without overtopping the dam. For dam safety purposes, outflow is made to match inflow once the water surface reaches pool elevation 475.5 feet.

b. NA Scenarios

The NA scenarios represent the levee condition following the completion of WRDA 1996 & 1999. The downstream levees are capable of sustaining 145,000 cfs. Only, NA2 and NA3 operations are designed to pass the PMF -- meaning these scenarios can contain the resultant maximum surcharge volume within the maximum surcharge pool as specified in **Table A-2**. The resultant freeboard meets the freeboard requirement set by Reclamation for dam safety purposes. This also satisfies the Corps minimum freeboard requirement per regulation *ER 1110-8-2 (FR), "Engineering and Design - Inflow Design Floods for Dams and Reservoirs"*. No other goals or performance criteria were targeted in the NA2-145 and NA3-145 routings. The operation for the NA scenarios is intended to show increased performance as modifications are made to the project. NA3-145 outperforms NA2-145 which in turn must be better than NA1. Except for the downstream emergency objective release constraint of 145,000 cfs, NA2-145 and NA3-145 have operational criteria similar to the future with-project described in the next section.

1) NA1 – This scenario reflects no improvements to Folsom Dam. The emergency objective release is 145,000 cfs. The dam safety release is restricted to 145,000 cfs until the water surface exceeds 470.0 ft to facilitate evacuation of the downstream. The water control plan is comprised of the 400/670 water control diagram and a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam cannot pass the PMF without maintaining adequate freeboard. For dam safety purposes, outflow is made to match inflow once the water surface reaches pool elevation 475.5 feet.

2) NA2 – This scenario reflects an improvement made to Folsom Dam -- the construction of the Joint Federal Project (auxiliary spillway). The dam safety release is restricted to 145,000 cfs until the water surface reaches 466.0 ft to facilitate evacuation of the downstream. Downstream considerations no longer trump the dam safety operation within the surcharge space above pool elevation 466.0 ft. The water control plan consists of the 400/600 water control diagram along with a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam can pass the PMF without overtopping the dam.

3) NA3 -- This reflects additional improvements to Folsom Dam, the construction of the Joint Federal Project (auxiliary spillway) followed by the 3.5 ft dam raise. The height of the emergency gates will be increased to enable the three emergency spillway gates to remain in the closed position for a longer period, if necessary. The emergency objective downstream release is 145,000 cfs. The dam safety release is not allowed to exceed 145,000 cfs until the water surface exceeds 471.5 ft. The water control plan consists of both a 400/600 water control diagram and a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam can pass the PMF without overtopping the dam.

c. W Scenarios

The W scenarios are the future with-project condition. The W2 and W3 scenarios can pass the PMF while still satisfying the minimum 3 ft freeboard requirement for the top of dam. These scenarios are intended to show the increased performance gained by fixing the problems identified post WRDA 1996/1999 authorization. W2-160 and W3-160 have strong similarities to the 2007 PAC Report alternatives. W2-160 and W3-160 have the goal of passing the single 1-in-200 yr design event while maintaining a release of 160,000 cfs. Per coordination with Reclamation on the JFP, their preference is that this design event be maintained within the authorized normal full pool (elevation 466 feet). For the raise project, Reclamation prefers that the maximum water surface for the design event be confined at or below Flood Pool .5 feet.

1) W1 – This scenario reflects no improvements to Folsom Dam. The emergency objective release is 160,000 cfs. The dam safety release is restricted to 160,000 cfs until the water surface exceeds 466.0 ft. The water control plan is comprised of the 400/670 water control diagram and a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam cannot pass the PMF without maintaining adequate freeboard. For dam safety purposes, outflow is made to match inflow once the water surface reaches pool elevation 475.5 feet.

3) W2 – This scenario reflects an improvement made to Folsom Dam -- the construction of the Joint Federal Project (auxiliary spillway). The dam safety release is restricted to 160,000 cfs until the water surface exceeds 466.0 ft. Downstream considerations no longer trump the dam safety operation within the surcharge space above pool elevation 466.0 ft. The water control plan consists of the 400/600 water control diagram along with a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam can pass the PMF without overtopping the dam.

3) W3 -- This reflects additional improvements to Folsom Dam, the construction of the Joint Federal Project (auxiliary spillway) followed by the 3.5 ft dam raise. The height of the emergency gates will be increased to enable the three emergency spillway gates to remain in the closed position for a longer period, if necessary. The emergency objective downstream release is 160,000 cfs. The dam safety release is not allowed to exceed 160,000 cfs until the water surface reaches 471.5 ft. The water control plan consists of both a 400/600 water control diagram and a hypothetical emergency spillway release diagram. Under this scenario, Folsom Dam can pass the PMF without overtopping the dam.

TABLE A-2: DESCRIPTION OF SCENARIOS

Alternative	Top of Dam	Maximum Surcharge Flood Pool[1]	Freeboard[3]	Flood Pool[4]	Emergency Objective Release	Normal Flood Control Reservation Range[5]
	El, ft	El, ft	El, ft	El, ft	Cfs	El, ft (acre-feet)
WO1 Pre-Common Features	480.5	475.5[2]	5	470.0	90,000 (< 35% encroachment) 115,000 (> 35% encroachment)	425.8 to 388.3 (400,000 – 670,000)
WO2 Pre-Common Features Auxiliary Spillway	480.5	475.5[2]	5	470.0	90,000 (< 35% encroachment) 115,000 (> 35% encroachment)	425.8 to 399.7 (400,000 – 600,000)
WO3 Pre-Common Features Auxiliary Spillway Folsom Dam Raise 3.5 ft	484.0	479.0	5	470.0	90,000 (< 35% encroachment) 115,000 (> 35% encroachment)	425.8 to 399.7 (400,000 – 600,000)
NA1-145 Common Features	480.5	475.5	5	470.0	145,000	(425.8 to 388.3 400,000 – 670,000)
NA2-145 Common Features Auxiliary Spillway	480.5	477.5	3	466.0	145,000	425.8 to 399.7 (400,000 – 600,000)
NA3-145 Common Features Auxiliary Spillway Folsom Dam Raise 3.5 ft	484.0	481.0	3	471.5	145,000	425.8 to 399.7 (400,000 – 600,000)
W1-160 Common Features	480.5	475.5	5	470.0	160,000	(425.8 to 388.3 400,000 – 670,000)
W2-160 Common Features Auxiliary Spillway	480.5	477.5	3	466.0	160,000	425.8 to 399.7 (400,000 – 600,000)
W3-160 Common Features Auxiliary Spillway Folsom Dam Raise 3.5 ft	484.0	481.0	3	471.5	160,000	425.8 to 399.7 (400,000 – 600,000)

KEY
El, ft – Elevation in feet

Notes:

1. *These values reflect the highest allowable pool elevation given both freeboard and top of dam height requirements. The maximum surcharge flood pool is established by routing a PMF through the reservoir. The PMF has been updated or revised periodically (e.g. 1946, 1980, 1991, and 2001).*
2. *The existing project requires more surcharge storage than is available under the original project design. Under existing conditions with no modifications to Folsom Dam, the 2001 PMF event would overtop Folsom Dam.*
3. *Reclamation has determined that 3 feet provides sufficient freeboard for the with-project scenarios (no action).*
4. *The FDR flood pool elevations are associated with the JFP and 3.5 Ft Dam Raise projects described in the PAC document. The release from Folsom Dam will not exceed 160,000 cfs as long as the water surface remains at or below the FDR flood pool.*
5. *The authorized storage space allocation for flood control differs with the scenarios. The flood space requirement itself varies seasonally. The maximum space would be needed only during the most critical flood period (December through February)*

A-6 Summary of Routing Output Analyses

a. WO Scenarios (pre-dates improvements authorized under WRDA 1996 & 1999)

With the addition of an auxiliary spillway in WO2, the main benefit gained is the ability to accelerate evacuation of the flood space. Although the downstream channel was originally designed to sustain an objective release of 115,000 cfs under normal flood operations, the current findings is that the potential for levee failure was greater than thought possible at that time. Under today's standards, the downstream channel was never maintained well enough to sustain safe releases of 115,000 cfs. To ensure zero percent chance of failing the downstream levees, the normal objective release requirement should have been reduced to 90,000 cfs. According to the attached **Figure A-8**, WO1 is able to limit the release to 90,000 cfs up to a 1-in-25 yr chance event. WO2 and WO3 must not utilize the extra capacity made available by the addition of the auxiliary spillway beyond this "safe" level except for events larger than a 1-in-25 yr chance event. Reservoir encroachment is the unit of measurement selected to identify event size. The encroachment volume for a 1-in-25 yr chance event never exceeded 35% in the WO1 routing. Therefore, larger events would be characterized by their larger encroachment percentages. Thus, the model was adjusted to limit the release to 90,000 cfs as long as the encroachment level remained at or below 35%. Thereafter, the release restriction would be lifted and the discharge would be allowed to ramp up to 115,000 cfs.

The operation for the WO scenarios is intended to show increased performance as modifications are made to the Common Features project and improvements are made to Folsom Dam. WO3 outperforms WO2 which in turn is better than WO1. The WO scenarios were not intended to pass the PMF. Operation for the WO scenarios was not constrained by any measurable criteria (i.e. passing a certain percentage of the PMF or limiting the magnitude of any dam overtopping to a certain amount). These scenarios cannot contain the resultant maximum surcharge volume within the confines of the maximum surcharge pool specified in **Table A-2**. The resultant freeboard is also less than the required freeboard amount. For these scenarios, the operation postpones making releases greater than 115,000 cfs due to downstream considerations by using up to 4 ft of surcharge storage space. The dam safety release is restricted to 115,000 cfs until the water surface reaches 470.0 ft to facilitate evacuation of the downstream.

b. NA Scenarios

The ESRDs created for the various scenarios may be considered much too efficient. The NA3-145 alternative is an example of this. According to the attached **Figure A-9**, the routing results indicate that Folsom Dam operations can hold the release at 145,000 cfs for a 1-in-200 yr event. Note, however, significant use of the surcharge space is required to achieve this result. The "Flood Pool" is being greatly exceeded. The release is appropriate given the circumstances in the routing with rapidly falling inflow and insignificant rate of rise in the reservoir pool elevation. The only way to make the consequences of exceeding the "Flood Pool" fully apparent in the routing is to use "simplified" ESRDs -- ones in which the pool elevation would be the only factor used to determine the discharge requirement. The "simplified" ESRD would remove any flexibility in surcharge space usage by automatically forcing the discharge to increase beyond the target flow anytime the pool elevation exceeded the designated "Flood Pool". Under this scenario, at 471.5 ft the discharge would be held to 145,000 cfs but at 471.51 the release would be greater than 145,000 cfs. The "soft" enforcement makes more sense than the "hard" enforcement approach when it comes to reservoir operations. **Table A-3** offers a comparison of maximum water surface versus "Flood Pool" specification for the various scenarios.

c. W Scenarios

TABLE A-3: FLOOD POOL ROUTING SUMMARY [Ŧ]

1-in-N chance per year event	WO1 (Flood Pool 470.0 ft)		WO2 (Flood Pool 470.0 ft)		WO3 (Flood Pool 470.0 ft)		NA1-145 (Flood Pool 470.0 ft)		NA2-145 (Flood Pool 466.0 ft)		NA3-145 (Flood Pool 471.5 ft)		W1-160 (Flood Pool 470.0 ft)		W2-160 (Flood Pool 466.0 ft)		W3-160 (Flood Pool 471.5 ft)	
	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)	Max WS (El, ft)	Peak Outflow (cfs)
2	403.93	30295	403.53	37708	403.53	37708	402.43	30183	403.18	25215	403.18	25215	403.08	25891	401.91	37708	403.18	25215
10	429.80	43692	408.97	90000	408.97	90000	429.13	43127	421.65	71655	421.65	71655	431.09	43519	421.65	71655	421.65	71655
25	442.53	98760	427.80	90000	427.80	90000	442.69	99738	431.43	115000	431.43	115000	444.54	104311	432.02	115000	432.02	115000
50	457.34	115000	443.02	115000	443.02	115000	457.01	115000	442.97	115000	442.97	115000	459.13	115000	444.04	115000	444.04	115000
100	476.35	123107	461.00	115000	461.00	115000	470.81	145000	460.46	115000	460.46	115000	472.32	145000	461.31	115000	461.31	115000
200	476.33	444310	476.65	169173	478.67	138359	476.40	320142	470.02	210332	474.92	145000	476.37	321017	470.02	196633	472.47	160000
250	476.65	476319	475.23	331691	477.27	232803	476.67	412114	470.65	309673	477.90	197562	476.64	408551	470.44	296022	477.15	193667
500	479.62	554268	480.97	627077	481.31	510279	479.01	512982	472.08	594159	478.32	558062	479.04	513195	471.57	594159	478.03	534386

Notes:

Ŧ *The gray shaded area depicts encroachment into the remaining surcharge storage space above the "Flood Pool" mark; Dam Safety operation takes the highest priority above the "Flood Pool" mark.*

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A-7 Risk Analysis (HEC- FDA Inputs)

Corps engineering guidance (EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies") and planning guidance (ER 1105-2-100, "Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures" and ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies") require that risk analyses be used to quantify the project performance of the various scenarios. The hydrologic data provided to Economics as input for the HEC-FDA program includes the unregulated inflow exceedance probability function and the curves defining the relationship between unregulated inflow and reservoir discharge. The uncertainty in the hydrology is defined by the confidence limits, derived via statistics. The uncertainty in reservoir discharge is derived by changing the parameters used in the reservoir routings. The risk analysis scenarios reflect the operating conditions ranging from the most likely to occur (BASE) to the most extreme operating conditions likely to produce the largest (MAXIMUM) or smallest (MINIMUM) expected release. The BASE condition assumptions and results are previously described for the W01, W02, W03, NA1, NA2, and NA3 scenarios. Generally, the operational criteria are developed based on actual flood operations, the analysis of historical data, and discussion between representatives of the Corps, SAFCA, and Reclamation. **Table A-4** presents selected assumptions used to create the different scenarios.

TABLE A-4: RISK ANALYSIS OPERATIONAL ASSUMPTIONS [1, 2]

Uncertainty Parameters	Alternative	Discharge Scenario: BASE (Normal)	MAXIMUM (Upper Limit)	MINIMUM (Lower Limit)
Initial Encroachment [3] (acre-feet)	WO & NA	0	50,000	0
Extra Space in Folsom Lake (acre-feet)	WO & NA	0	0	100,000
Available Upstream Reservoir Space (acre-feet)	WO & NA	0	0	150,000
Starting Storage (acre-feet)	WO & NA	367,000	417,000	429,000
Response Time Delay [4] (hours)	WO	8	8	8
	NA	4	8	0
Main Dam River Outlets Operation During Concurrent Spillway Operation (percent gate opening)	WO & NA	60	0	60

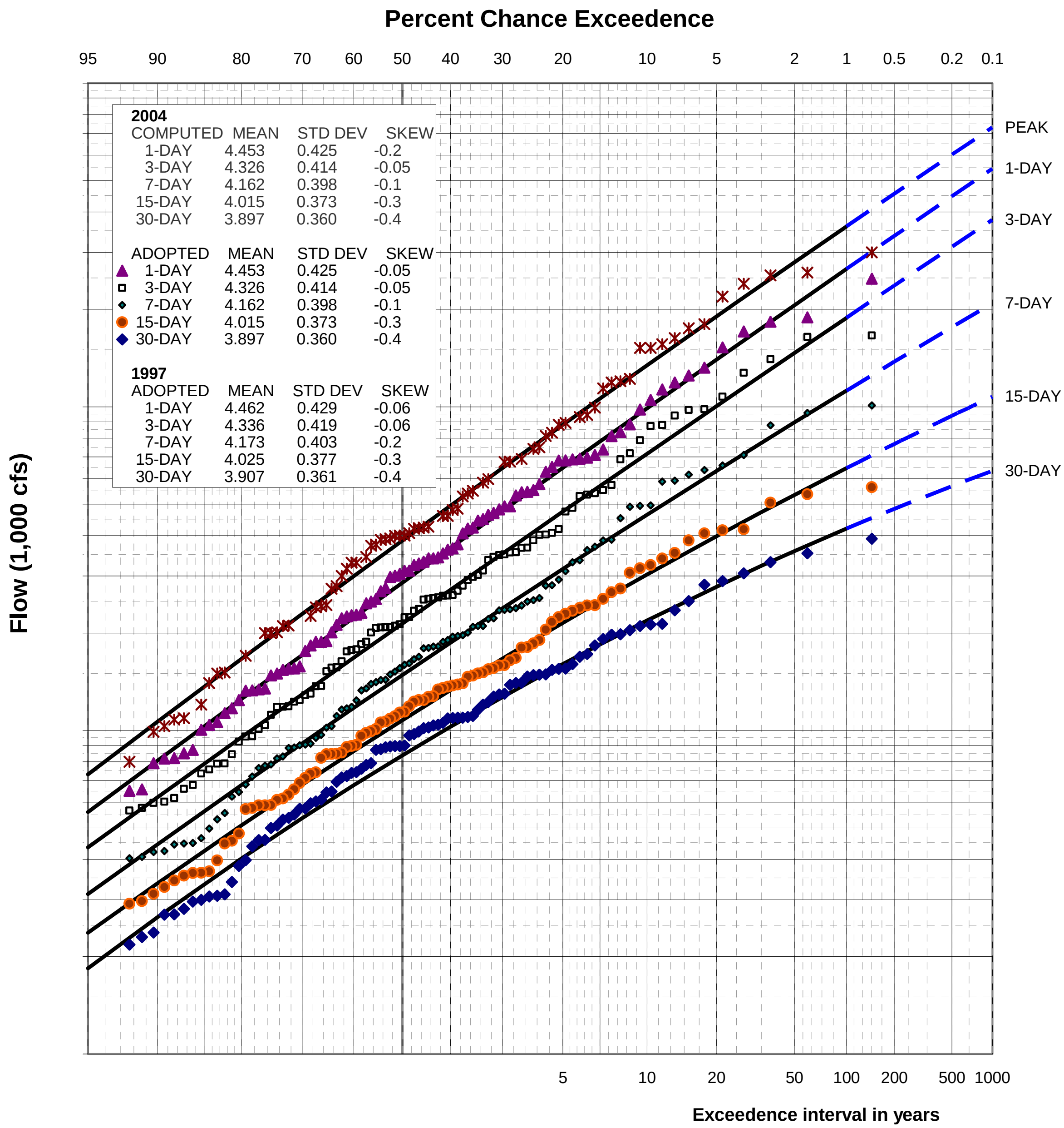
KEY
Cfs – cubic feet per second

Notes:
1. *Discharge is presumed through only one power penstock due to maintenance work during the flood season (per Reclamation).*
2. *Application of the uncertainty parameters may sometimes result in anomalies for the smaller or more frequent events. The settings meant to induce the largest or smallest discharge may actually result in the reverse. This issue appears intermittently.*
3. *Encroachment is relative to the allowable storage as determined from the water control diagram (dependent on upstream storage space).*
4. *Lag in matching Release to previous hour Inflow – while discharge is less than the normal objective release target.*

A-8 Conclusion

Water Management produced routings for two different scenarios. The without-project (WO) condition reflects the American River levee system prior to any improvements or repair work. The no-action (NA) condition reflects the existing state of the American River levees with the improvements made as authorized by WRDA 1996 and 1999. The NA condition will result in the ability of the downstream channel to sustain 145,000 cfs (or 160,000 cfs as reported in the 2007 PAC Report). The 50%-, 20%-, 4%-, 2%-, 1%-, 0.5%, 0.2%-annual chance flood events were routed through Folsom Dam for the various WO and NA scenarios. The routing results were given to Hydraulic Design for the floodplains development and to Economics for the economic benefit analyses. The hydrographs provided to Hydraulic Design are shown in **Figures A-4 through A-6**.

Figure A-10 through A-23 provides a snapshot of the data provided to Economics in a variety of ways. **Figure A-10 through A-13** presents the set of WO, NA, and W results (BASE condition only) as regulated frequency curves. This allows one to view the increase in project performance as improvements are made to Folsom Dam. **Figure A-14** consolidates the results of all the routings (BASE condition only) as “inflow versus outflow curves” to allow comparisons across the different set of routings. **Figure A-15 through A-23** presents the uncertainty band around the discharge for any given event. Note that the uncertainty range required some adjustment around the more frequent event where the points crossed. Generally, the anomalies (MAX < BASE < MIN) where the points cross occur for events with less than 1-in-5 yr chance exceedance. In these instances, the MAX discharge is lower than BASE due to the inability to match inflow quickly (8 hour lag). This handicap is a benefit or plus for the smaller flood events. The MIN discharge is large than BASE due to the ability to match inflow quickly (1 hour lag). This advantage (rapid response) is a detriment or negative for the smaller, more frequent events. The initial starting storage also is a factor in this aspect. A full summary of the routings can be found in **Tables A-5** through **A-31**. The reservoir routings covered herein were developed for planning purposes only. These scenarios are hypothetical and would not be built or implemented as stand-alone projects. All reservoir elevations provided herein use the NGVD29 vertical datum.



NOTES:

1. Adjusted USGS gage 11446500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions.
3. Computed Probability
4. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004.

AMERICAN RIVER WATERSHED PROJECT

COMMON FEATURES

GENERAL REEVALUATION REPORT

RAIN FLOOD FREQUENCY CURVES
AMERICAN RIVER AT FAIR OAKS
UNREGULATED CONDITIONS

FIGURE A-2

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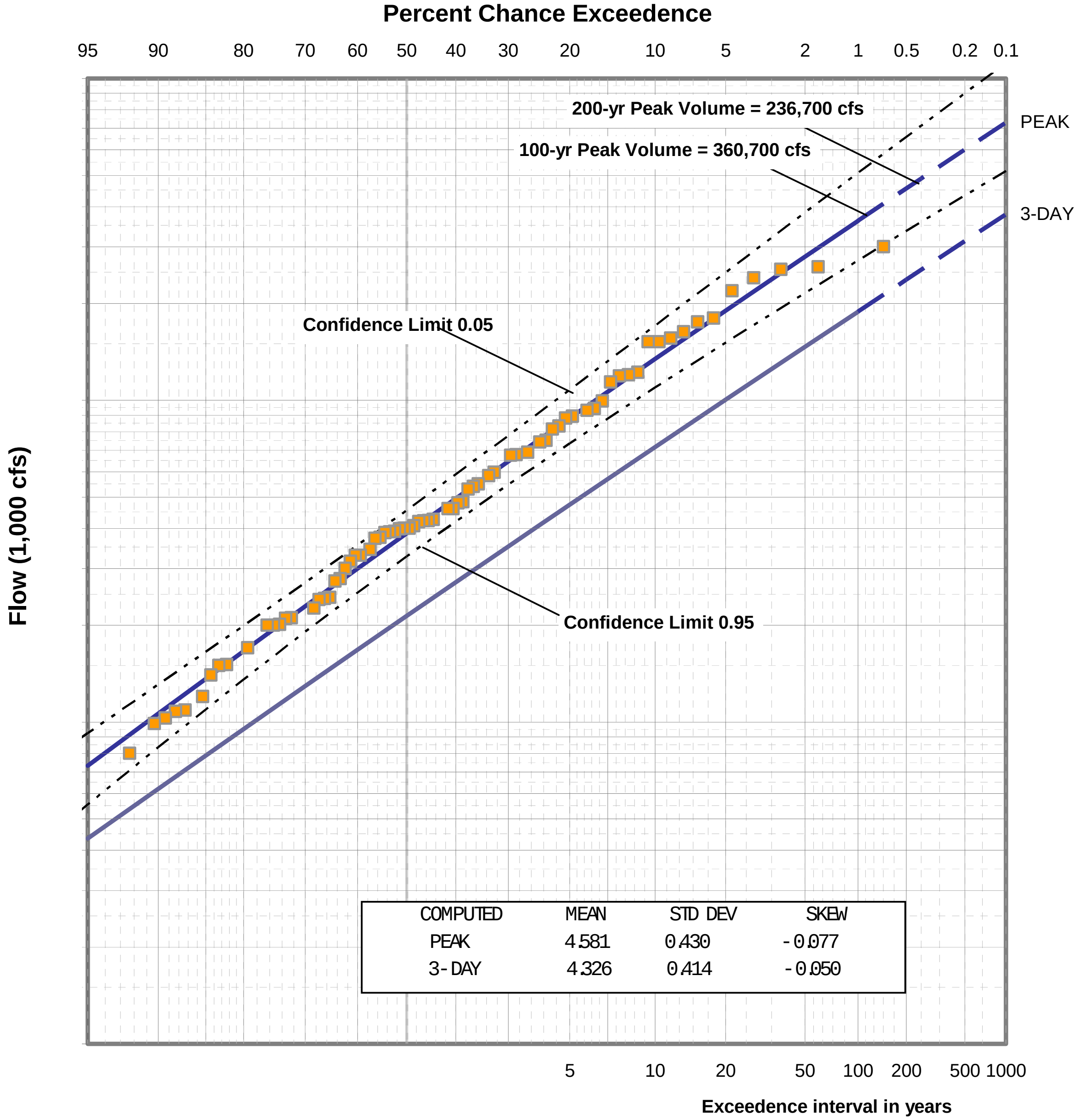

NOTES:

1. Adjusted USGS gage 11446500 to account for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions.
3. Computed Probability
4. No adjustments for outliers.
5. Confidence limits based on station statistics
6. Drainage area: 1,888 sq. mi.
7 Period of record: 1905-2004.

AMERICAN RIVER WATERSHED PROJECT

COMMON FEATURES

UNREGULATED PEAK AND MEAN 3-DAY RAIN FLOOD FREQUENCY CURVES AMERICAN RIVER AT FAIR OAKS

FIGURE A-3

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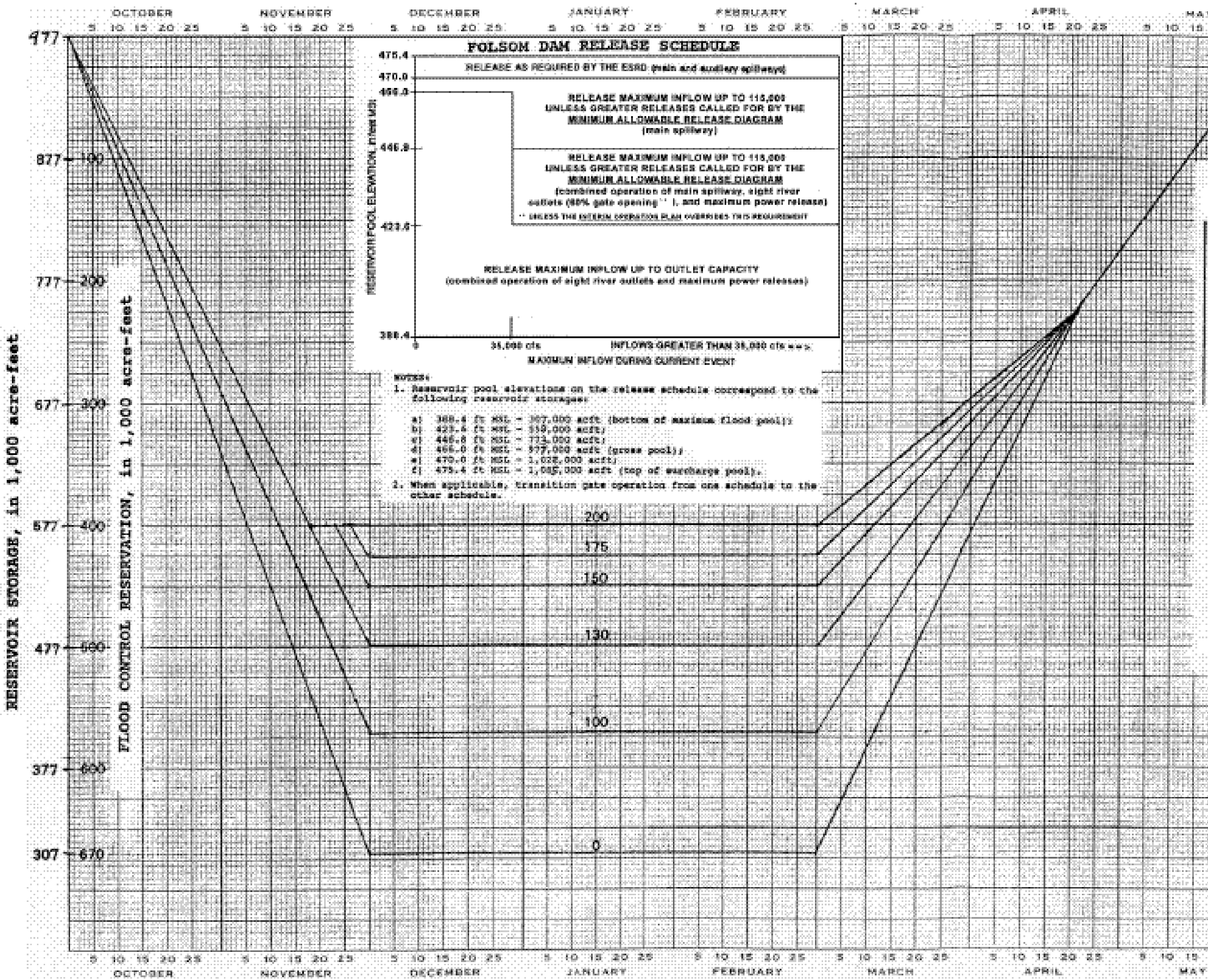


FLOOD CONTROL DIAGRAM FOR FOLSOM DAM AND LAKE

USE OF DIAGRAM

1. Folsom Dam and Lake shall be operated for flood control in accordance with the Flood Control Diagram. When water is stored within the Flood Control Reservation, reservoir releases must be in accordance with requirements of this diagram.
2. The parameters on the flood control diagram define the required Flood Control Reservation, on any given day, based on available space in the upstream reservoirs. Once the required Flood Control Reservation is computed, the Required Reservoir Storage for flood control can be determined. Water stored in excess of the Required Reservoir Storage must be evacuated. Computation of the parameter is discussed below:

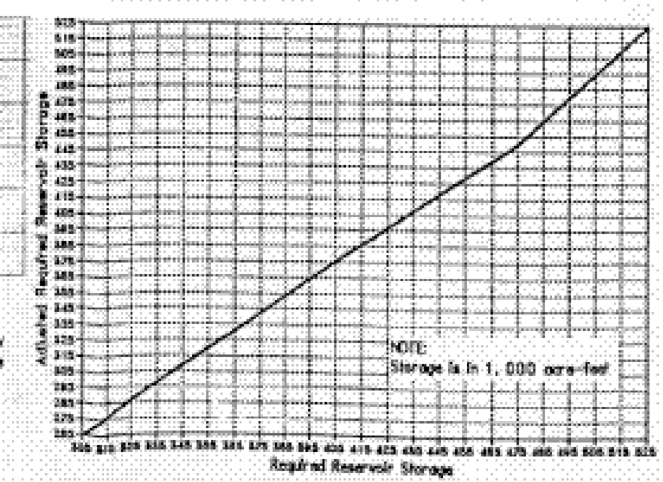
FOLSOM DAM AND LAKE
COMPUTATION OF REQUIRED RESERVOIR STORAGE

1. Compute space available below spillway crest, in acre-feet, for the following reservoirs: French Meadows, Hell Hole and Union Valley.
2. The amount of creditable flood control transfer space in each reservoir is then computed by taking the smaller of the space available or the maximum creditable space for that reservoir.
   a. The maximum creditable space by reservoir is as follows:
      French Meadows - 45,000 acre-feet
      Hell Hole - 80,000 acre-feet
      Union Valley - 75,000 acre-feet
   b. Combine the creditable flood control transfer space for each reservoir to compute the total creditable space.
3. Determine the Flood Control Reservation at Folsom Lake by applying the creditable flood control transfer space (parameter on the Flood Control Diagram in 1,000 acre-feet).

SAMPLE COMPUTATION OF REQUIRED RESERVOIR STORAGE

RESERVOIR	STORAGE ON JAN 1 (TAF)	STORAGE AT SPILLWAY CREST (TAF)	SPACE AVAILABLE (TAF)	MAXIMUM CREDITABLE SPACE (TAF)	CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)
French Meadows	75.7	110.7	35	45	35
Hell Hole	87.6	207.6	120	80	80
Union Valley	170.1	235.1	65	75	65
TOTAL CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)					180
FLOOD CONTROL RESERVATION AT FOLSOM LAKE (TAF)					420
REQUIRED RESERVOIR STORAGE AT FOLSOM LAKE (TAF)					557

3. During a potential flood situation, water stored within the Flood Control Reservation, defined hereon, shall be released as rapidly as possible subject to the following schedule:
   a. Required Flood Control Release - Promptly release inflow up to 115,000 cfs, while inflows are increasing, as discussed in the FOLSOM DAM RELEASE SCHEDULE. Control flows in the American River below the dam to not more than 115,000 cfs, except when larger releases are required by the accompanying INTERIM OPERATION PLAN.
   b. Releases will not be increased more than 15,000 cfs or decreased more than 10,000 cfs during any 2 hour period.



4. Maintenance or repair of any one power generating unit at Folsom Dam which results in loss of the power penstock for more than one day may require additional Flood Control Reservation. The amount of additional reservation is defined by the Adjusted Required Reservoir Storage, as identified on the graph at right, depending on the following conditions:
   a. The Required Reservoir Storage in Folsom Lake, as computed in paragraph 2 above;
   b. The existing and forecasted meteorological conditions in the basin; and,
   c. The duration the generating unit is expected to be off-line.

Required Reservoir Storage greater than or equal to 525,000 acre-feet requires no additional Flood Control Reservation.

FIGURE A-4
WATER CONTROL DIAGRAM -- HISTORICAL
EXISTING CONDITION 400/670

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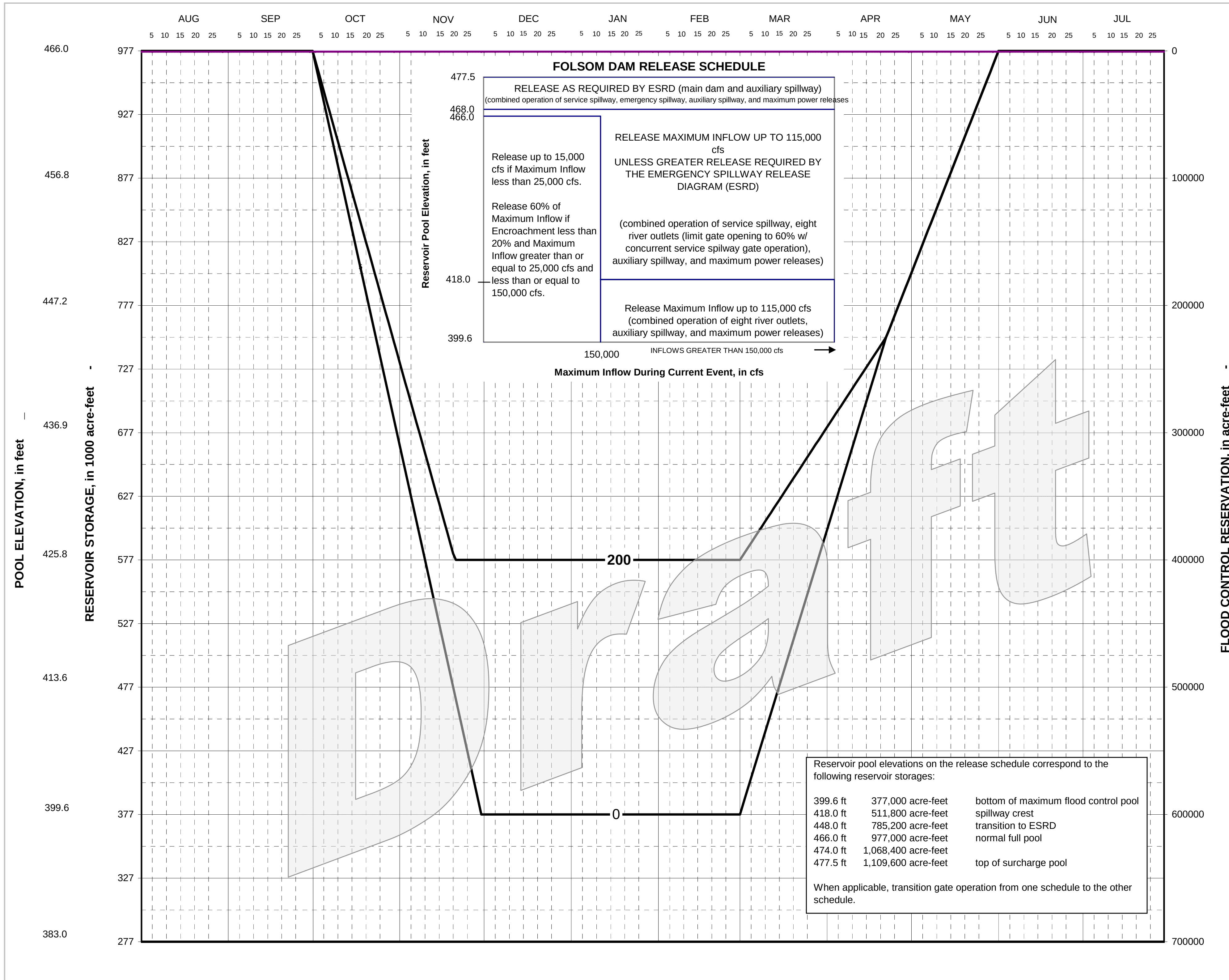

FLOOD CONTROL DIAGRAM

USE OF DIAGRAM

1. Folsom Dam and Lake shall be operated for flood control in accordance with the Flood Control Diagram. When water is stored within the Flood Control Reservation, reservoir releases must be in accordance with the requirements of this diagram.

2. The parameters on the flood control diagram define the required Flood Control Reservation, on any given day, based on available space in the upstream reservoirs. Once the required Flood Control Reservation is computed, the Required Reservoir Storage for flood control can be determined. Water stored in excess of the Required Reservoir Storage must be evacuated. Computation of the parameter is discussed below:

COMPUTATION OF REQUIRED FLOOD RESERVATION STORAGE

1. Compute space available below spillway crest, in acre-feet, for the following reservoirs: French Meadows, Hell Hole and Union Valley.

2. The amount of creditable flood control transfer space in each reservoir is then computed by taking the smaller of the space available or the maximum creditable space for that reservoir.

   a. The maximum creditable space by reservoir is as follows:
      French Meadows 45,000 acre-feet
      Hell Hole 80,000 acre-feet
      Union Valley 75,000 acre-feet

   b. Combine the creditable flood control transfer space for each reservoir to compute the total creditable space.

   c. Determine the Flood Control Reservation at Folsom Lake by applying the creditable flood control transfer space (parameter on the Flood Control Diagram in 1,000 acre-feet).

SAMPLE COMPUTATION OF REQUIRED RESERVOIR STORAGE

RESERVOIR	STORAGE ON JAN 1 (TAF)	STORAGE @ SPILLWAY CREST (TAF)	SPACE AVAILABLE (TAF)	MAXIMUM CREDITABLE SPACE (TAF)	CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)
FRENCH MEADOWS	65.7	110.7	45	45	45
HELL HOLE	87.6	207.6	120	80	80
UNION VALLEY	160.1	235.1	75	75	75
TOTAL CREDITABLE FLOOD CONTROL TRANSFER SPACE (TAF)					200
FLOOD CONTROL RESERVATION AT FOLSOM LAKE (TAF)					577
REQUIRED RESERVOIR STORAGE AT FOLSOM LAKE (TAF)					577

RELEASE SCHEDULE

3. During a potential flood situation, water stored within the Flood Control Reservation, defined herein, shall be released as rapidly as possible subject to the following schedule:

   a. Required flood Control Release - Promptly release inflow up to 115,000 cfs while inflows are increasing, as discussed in the FOLSOM DAM RELEASE SCHEDULE. Control flows in the American River below the dam to not more than 115,000 cfs, except when larger releases are required by the accompanying EMERGENCY SPILLWAY RELEASE DIAGRAM (ESRD). Once the reservoir pool begins falling, maintain releases in excess of inflow until water stored in the Flood Control Reservation is evacuated.

   b. Releases will not be increased more than 30,000 cfs or decreased more than 10,000 cfs during any 2-hour period.

FIGURE A-5
WATER CONTROL DIAGRAM -- HYPOTHETICAL
FUTURE CONDITION 400/600

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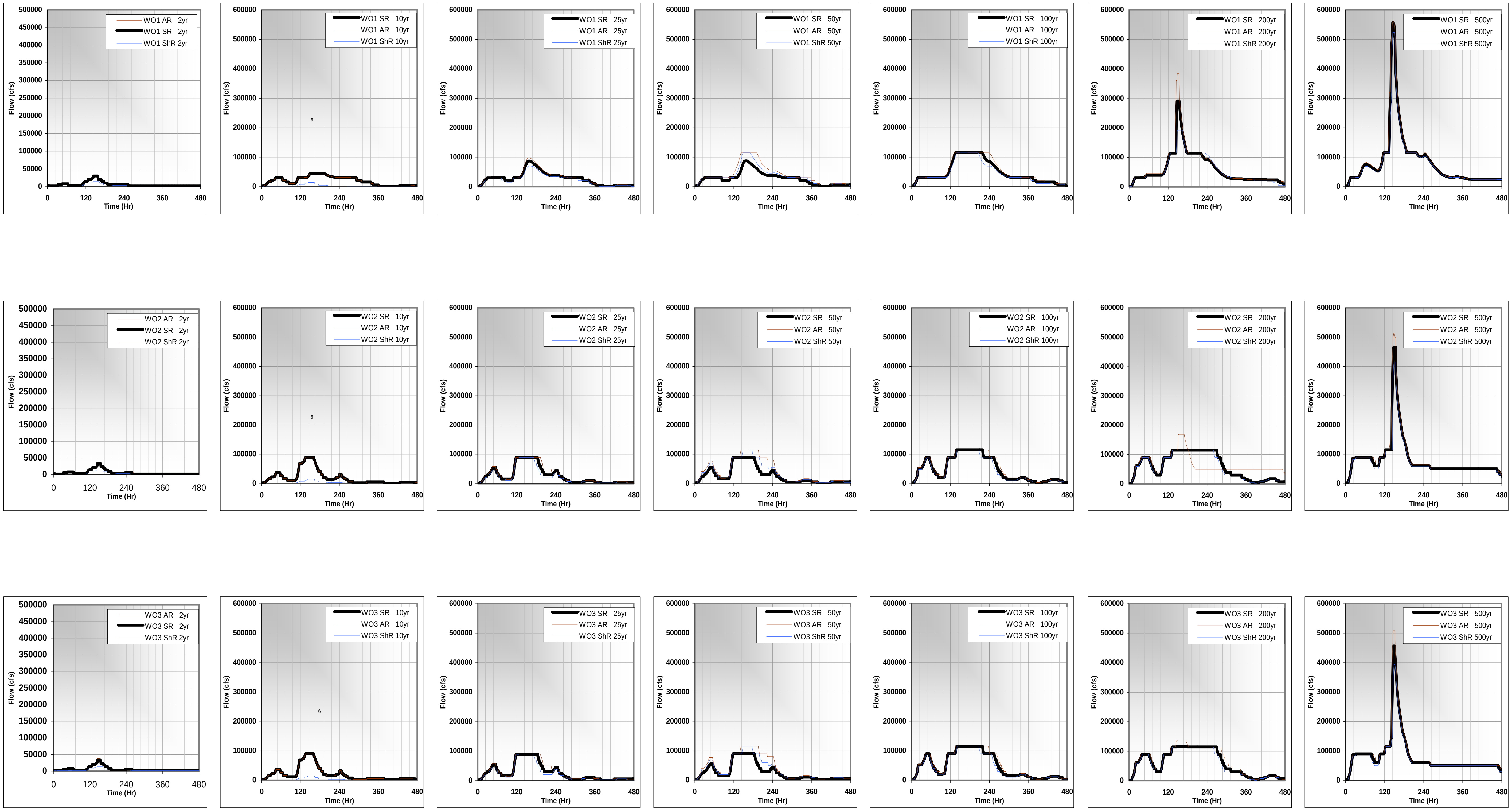

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-8: DISCHARGE HYDROGRAPHS – BASE – EXISTING CONDITION

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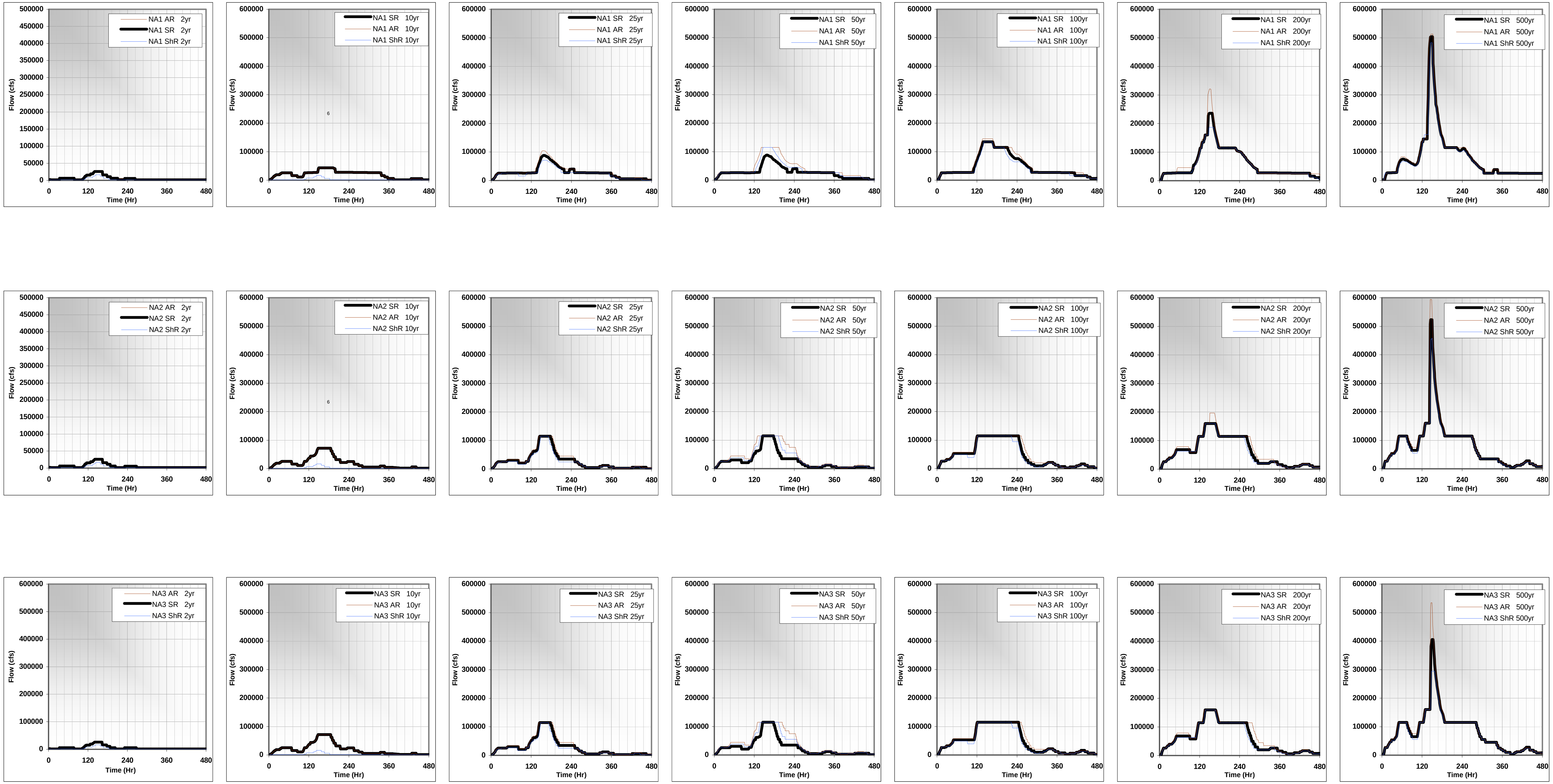

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-9: DISCHARGE HYDROGRAPHS – BASE – FUTURE WITHOUT-PROJECT (NO ACTION)

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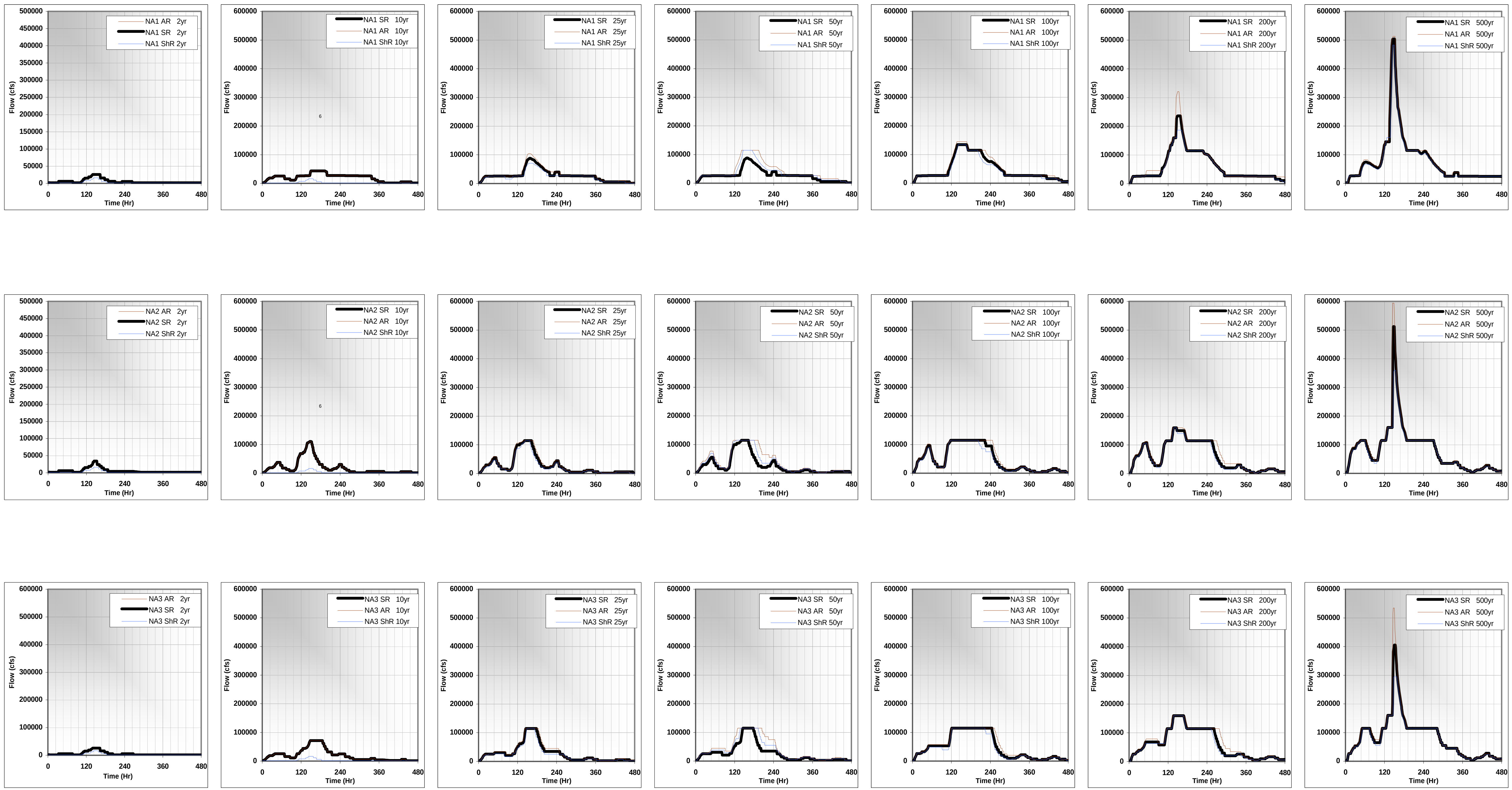

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-10: DISCHARGE HYDROGRAPHS – BASE – WITH-PROJECT

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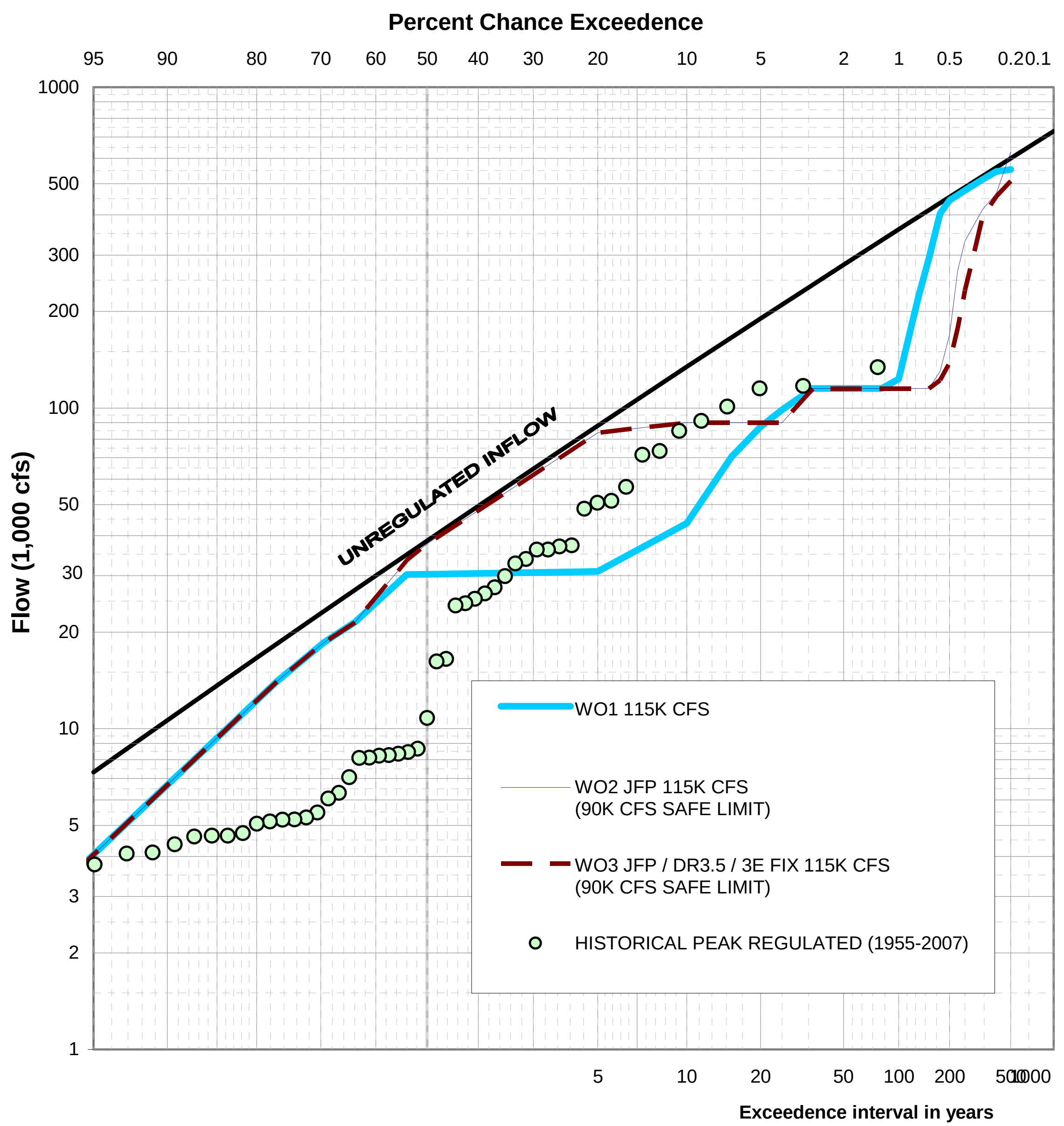

NOTES:

1. Adjusted USGS gage 11446500 to accoiunt for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions
3. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004 (Unregulated).

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES GRR

REGULATED FREQUENCY CURVES
FOLSOM DAM
EXISTING CONDITION
(WITHOUT-PROJECT)

FIGURE A-11

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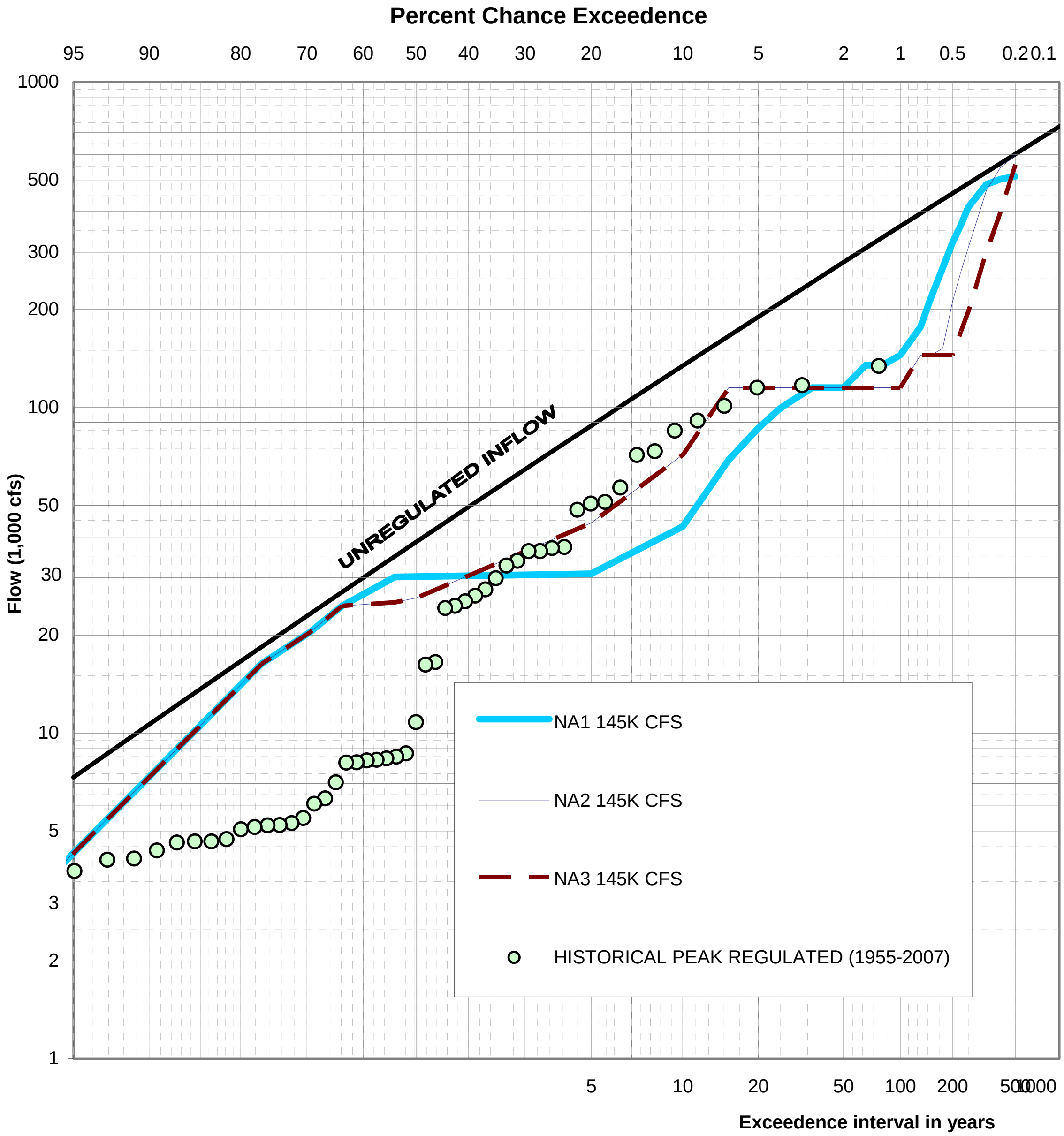

NOTES:

1. Adjusted USGS gage 11446500 to accoiunt for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions
3. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004 (Unregulated).

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES GRR

REGULATED FREQUENCY CURVES
FOLSOM DAM
FUTURE WITHOUT-PROJECT
(NO ACTION)

FIGURE A-12

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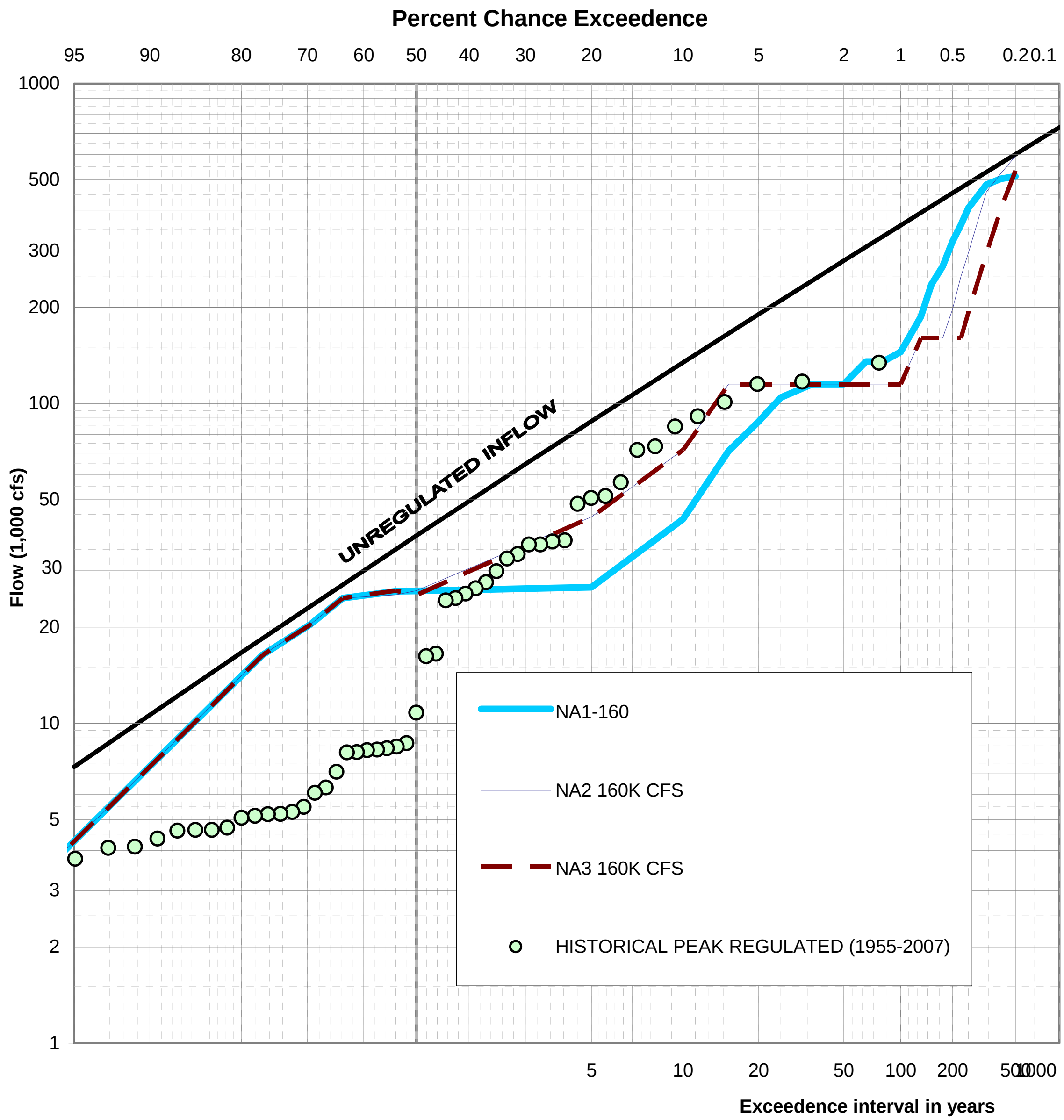

NOTES:

1. Adjusted USGS gage 11446500 to accoiunt for daily change in storage at upstream reservoirs (potential channel, out-of-channel, or storage losses neglected).
2. Median plotting positions
3. No adjustments for outliers.
4. Drainage area: 1,888 sq. mi.
5. Period of record: 1905-2004 (Unregulated).

AMERICAN RIVER WATERSHED PROJECT
COMMON FEATURES GRR

REGULATED FREQUENCY CURVES
FOLSOM DAM
FUTURE PROJECT

FIGURE A-13

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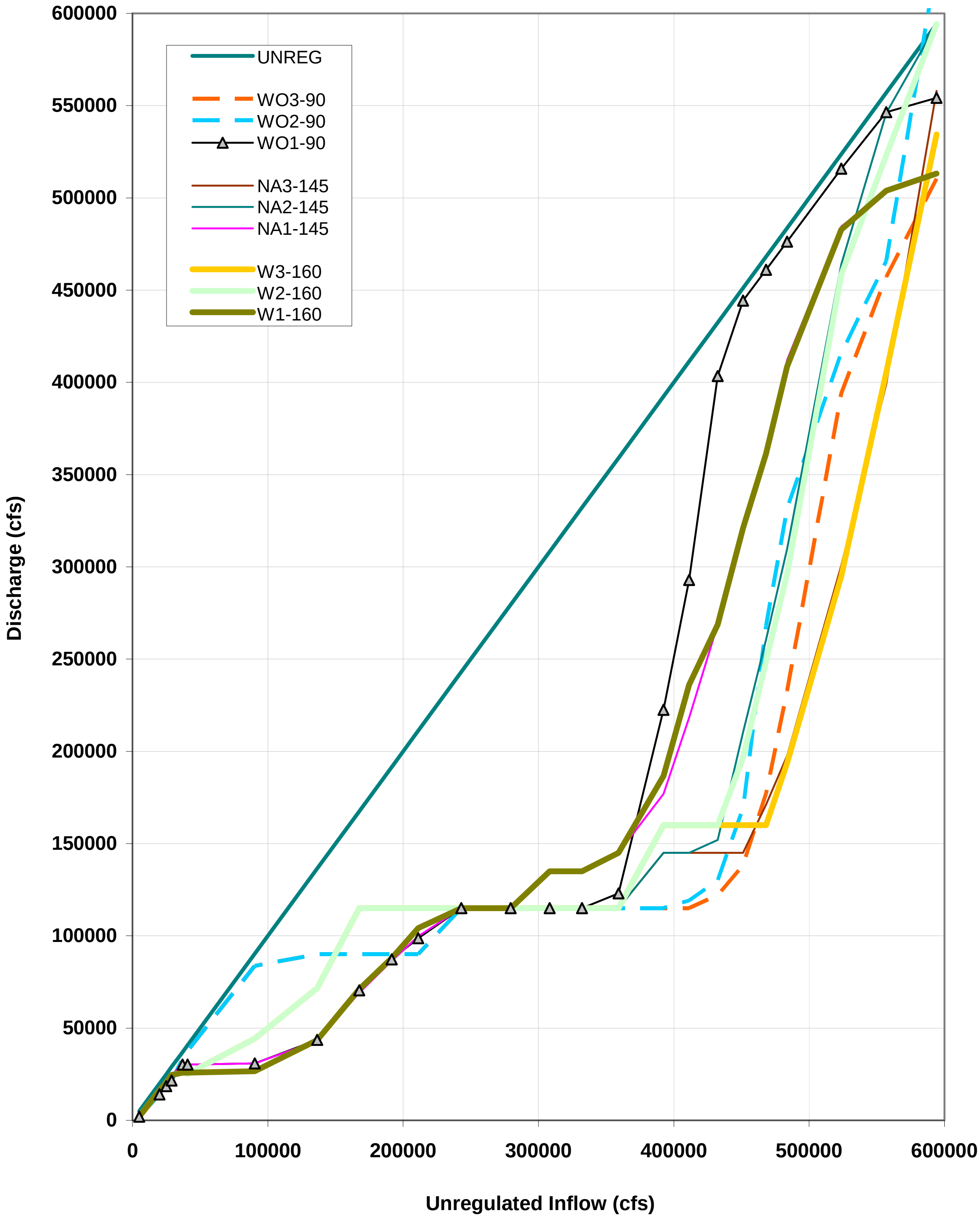

FIGURE A-14: INFLOW-OUTFLOW TRANSFORM – BASE – COMPARISON

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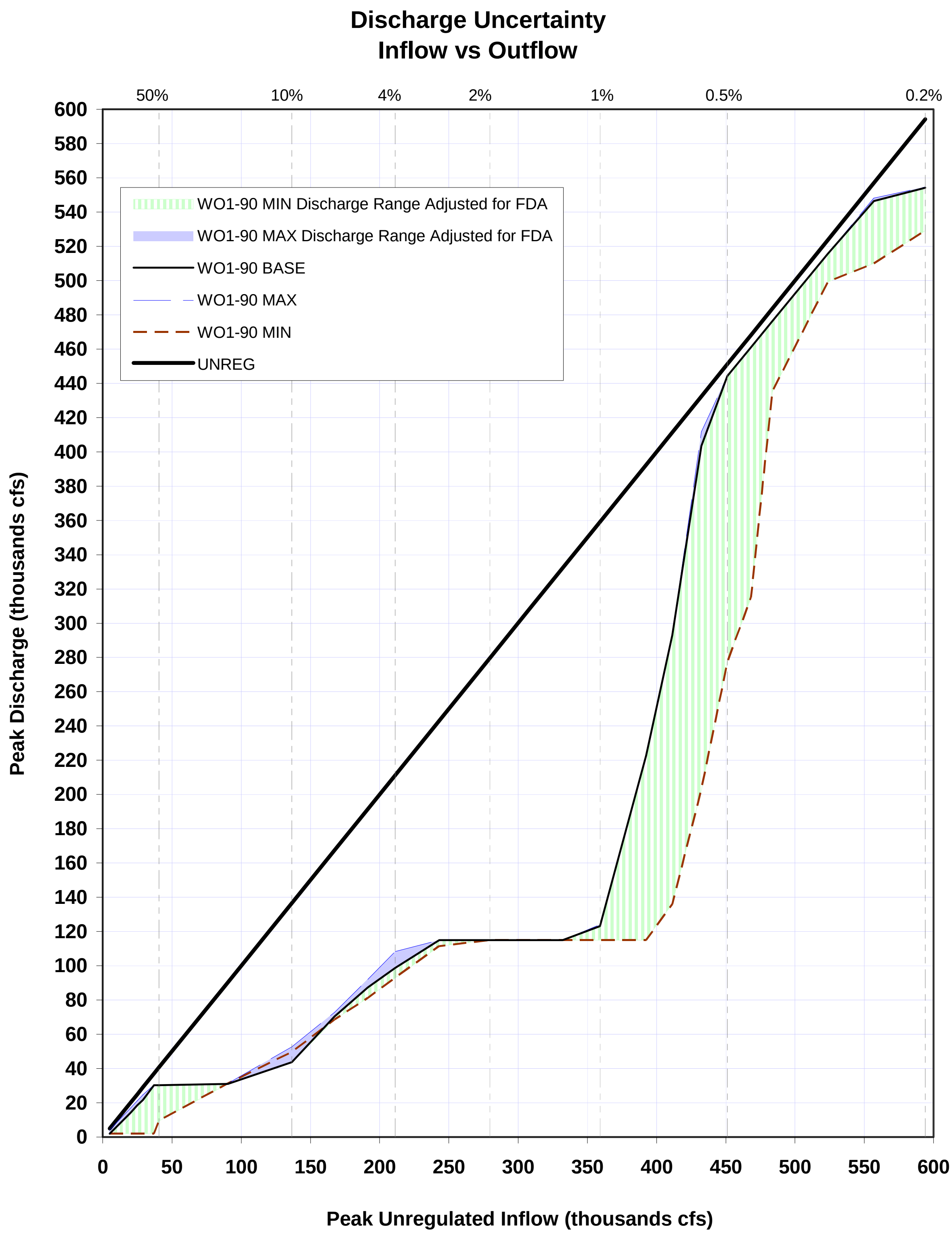

FIGURE A-15: DISCHARGE UNCERTAINTY – WO1 WITHOUT-PROJECT – 115,000 CFS

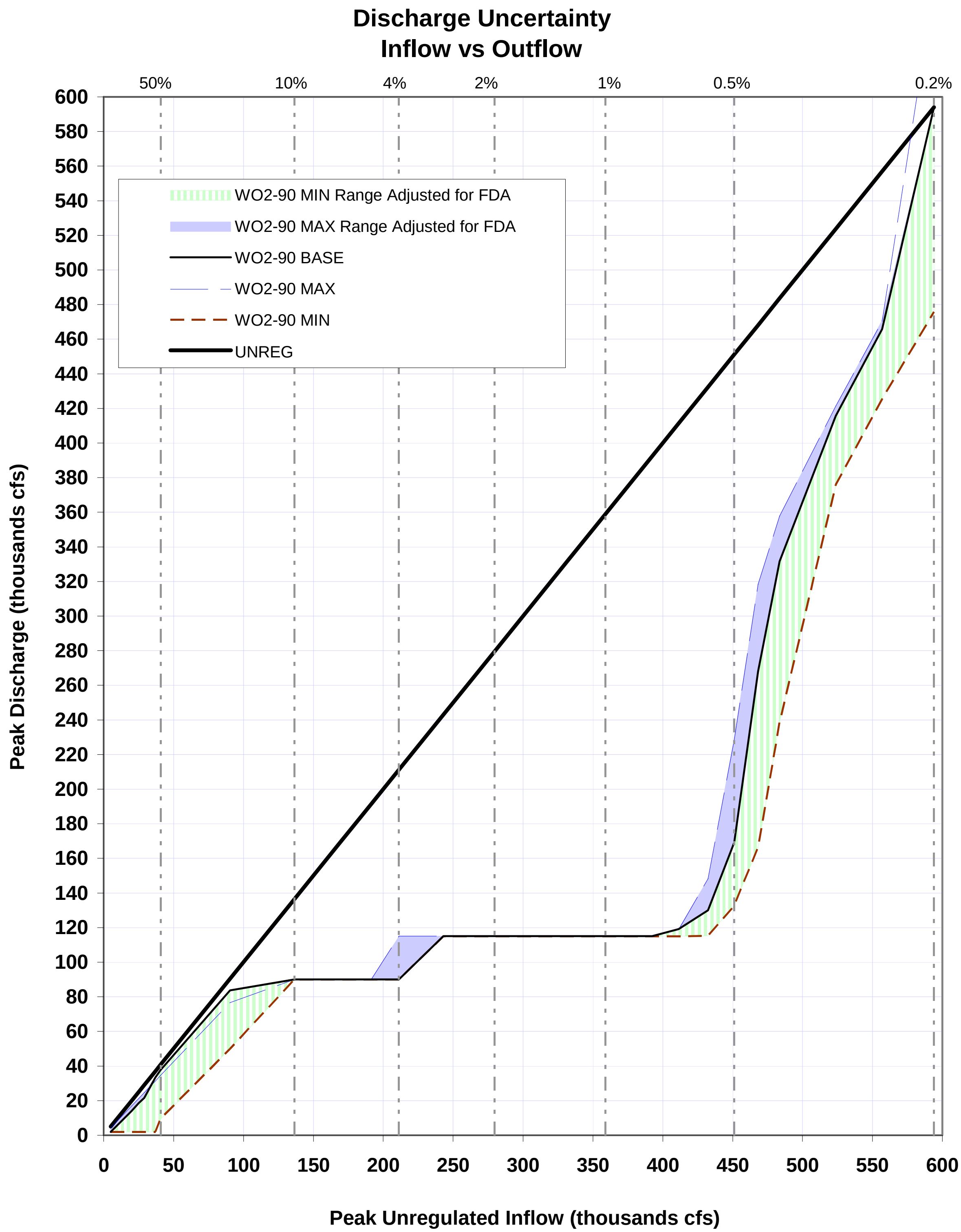

FIGURE A-16: DISCHARGE UNCERTAINTY – WO2 WITHOUT-PROJECT – 115,000 CFS

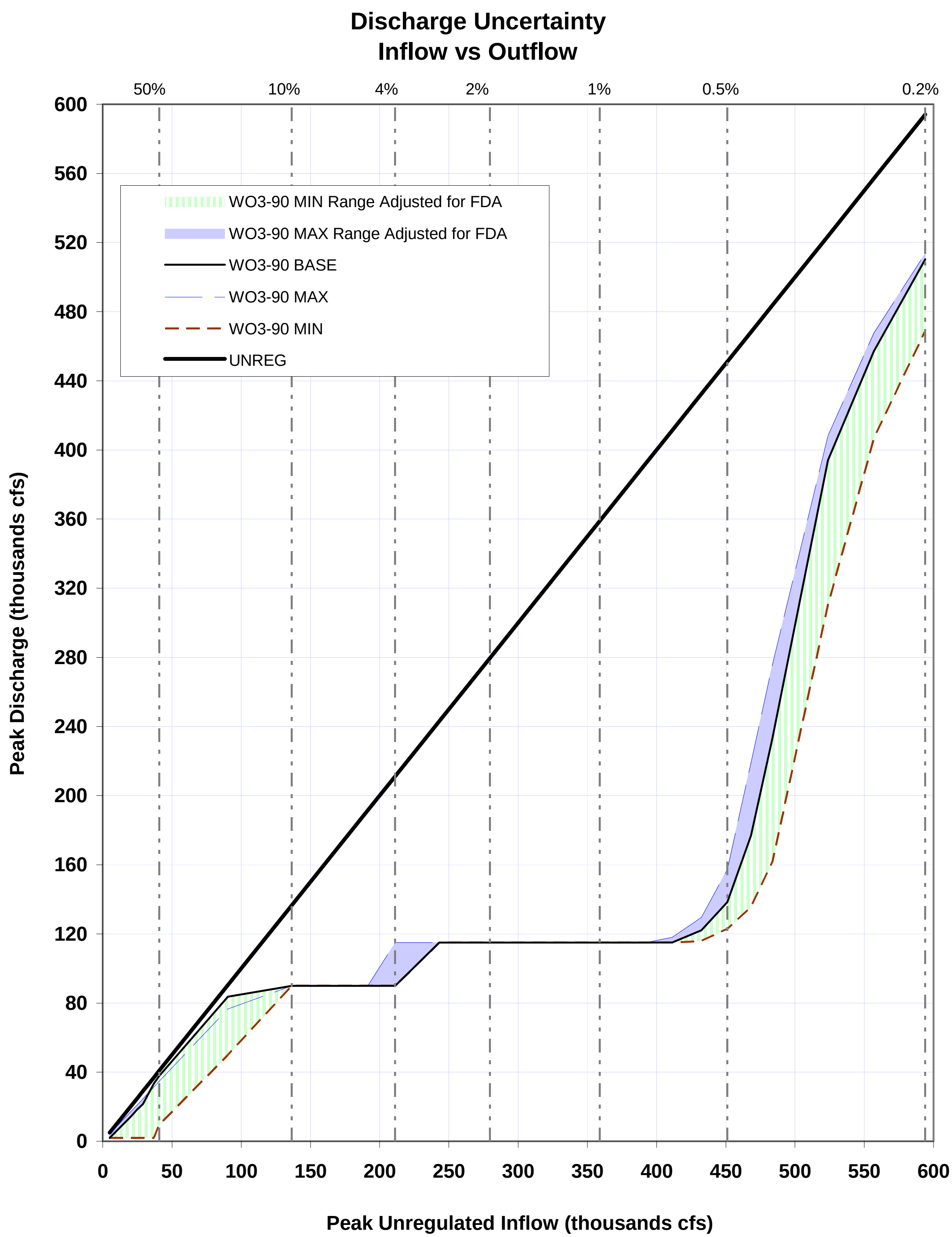

FIGURE A-17: DISCHARGE UNCERTAINTY – WO3 WITHOUT-PROJECT – 115,000 CFS

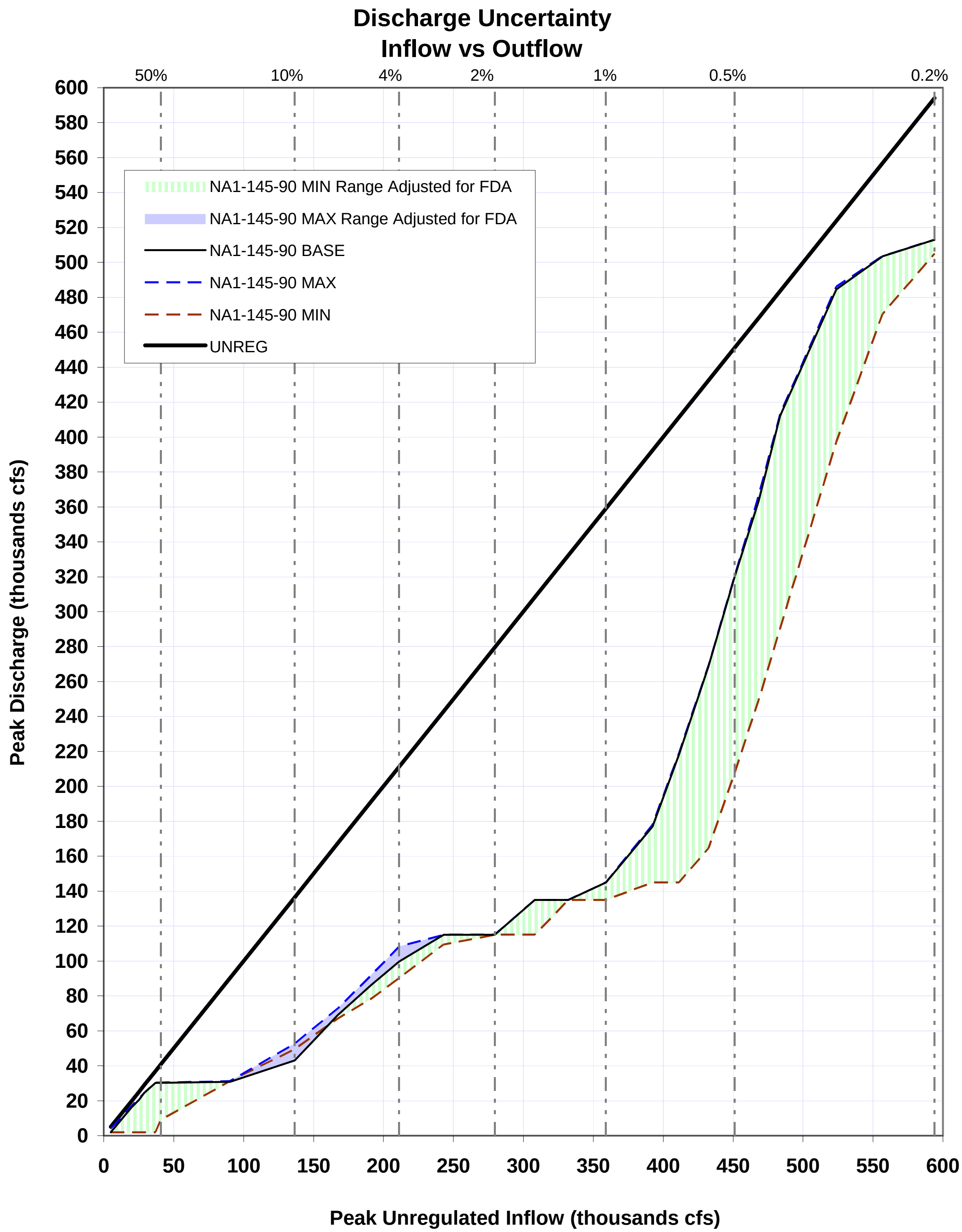

FIGURE A-18: DISCHARGE UNCERTAINTY – NA1 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

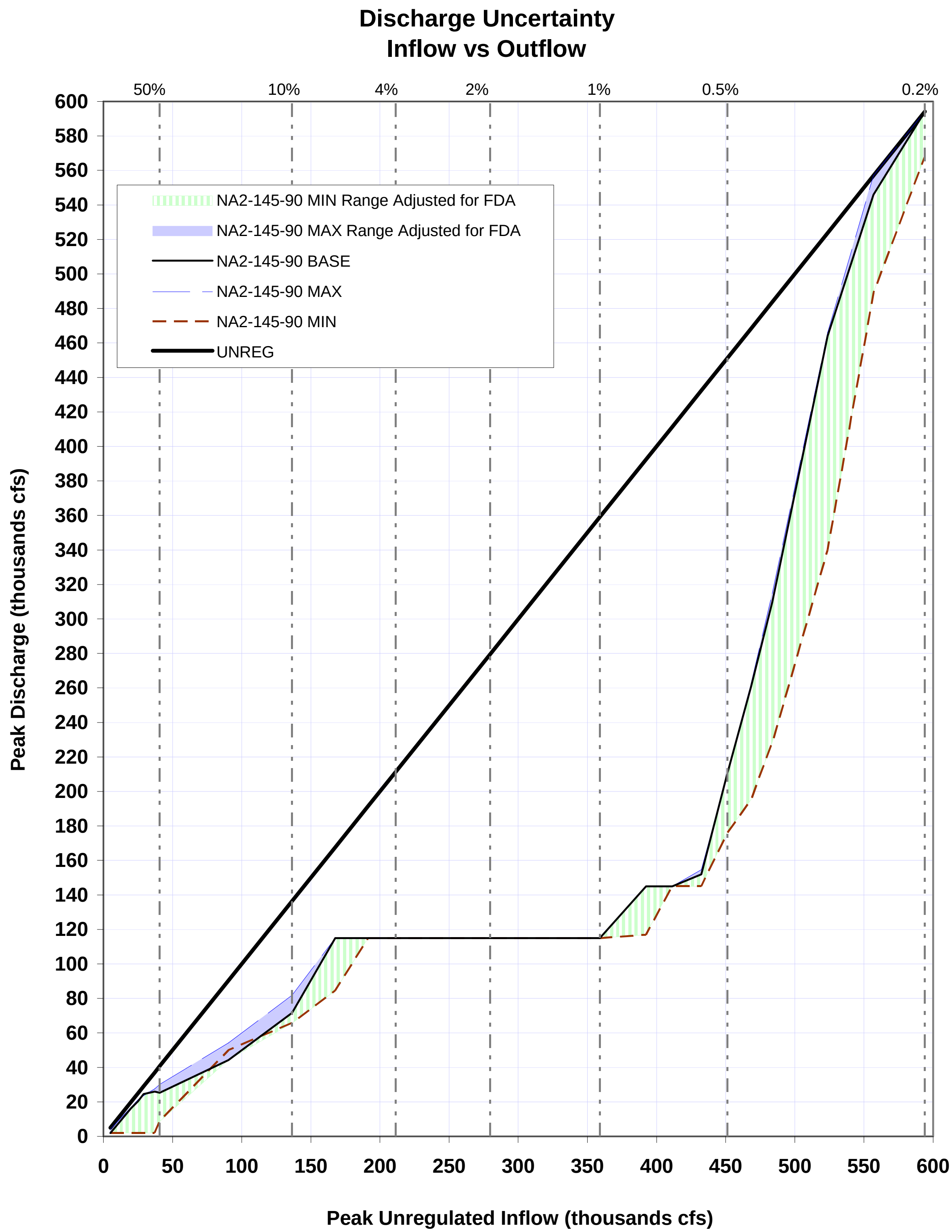

FIGURE A-19: DISCHARGE UNCERTAINTY – NA2 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

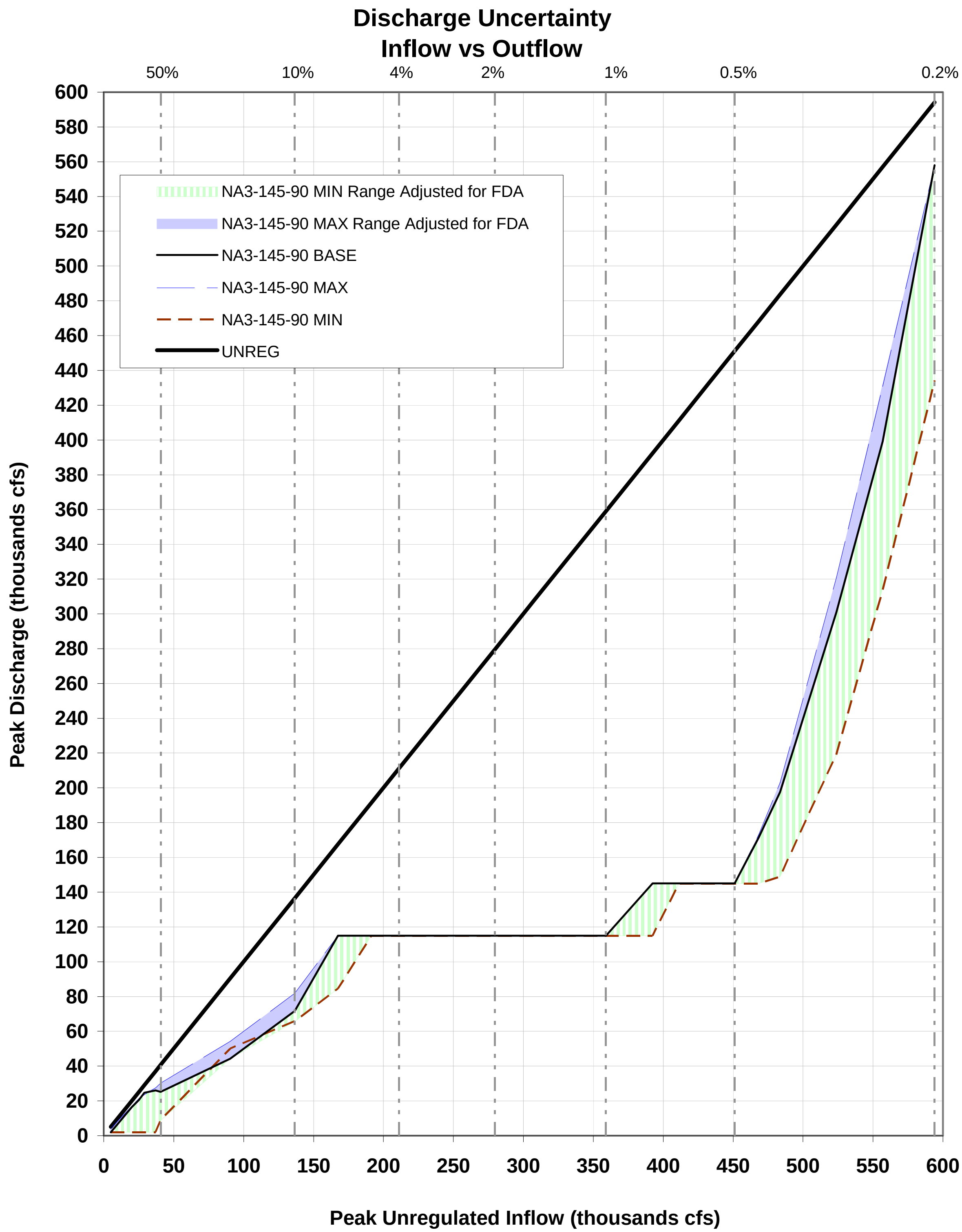

FIGURE A-20: DISCHARGE UNCERTAINTY – NA3 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

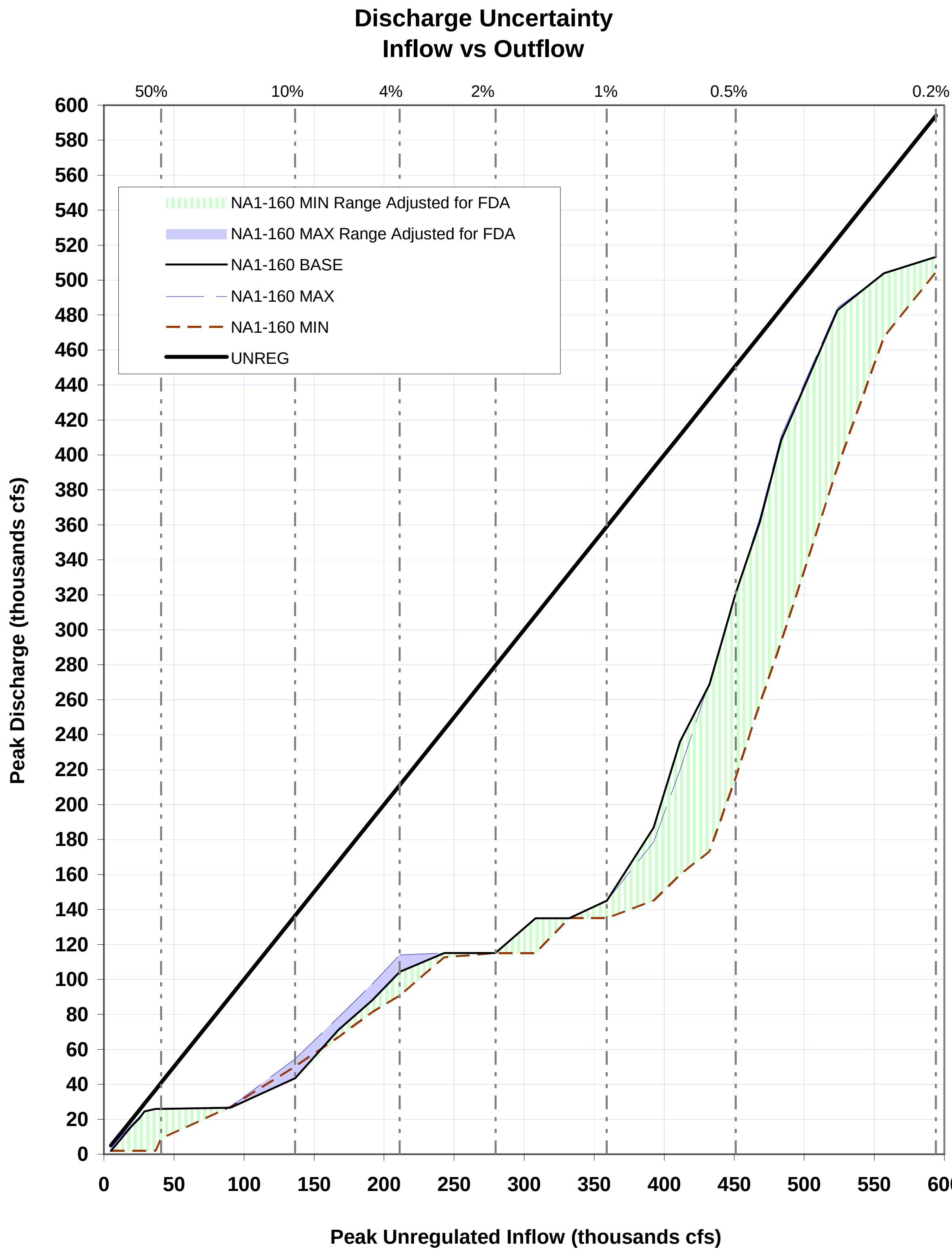

FIGURE A-21: DISCHARGE UNCERTAINTY – W1 WITH-PROJECT – 160,000 CFS

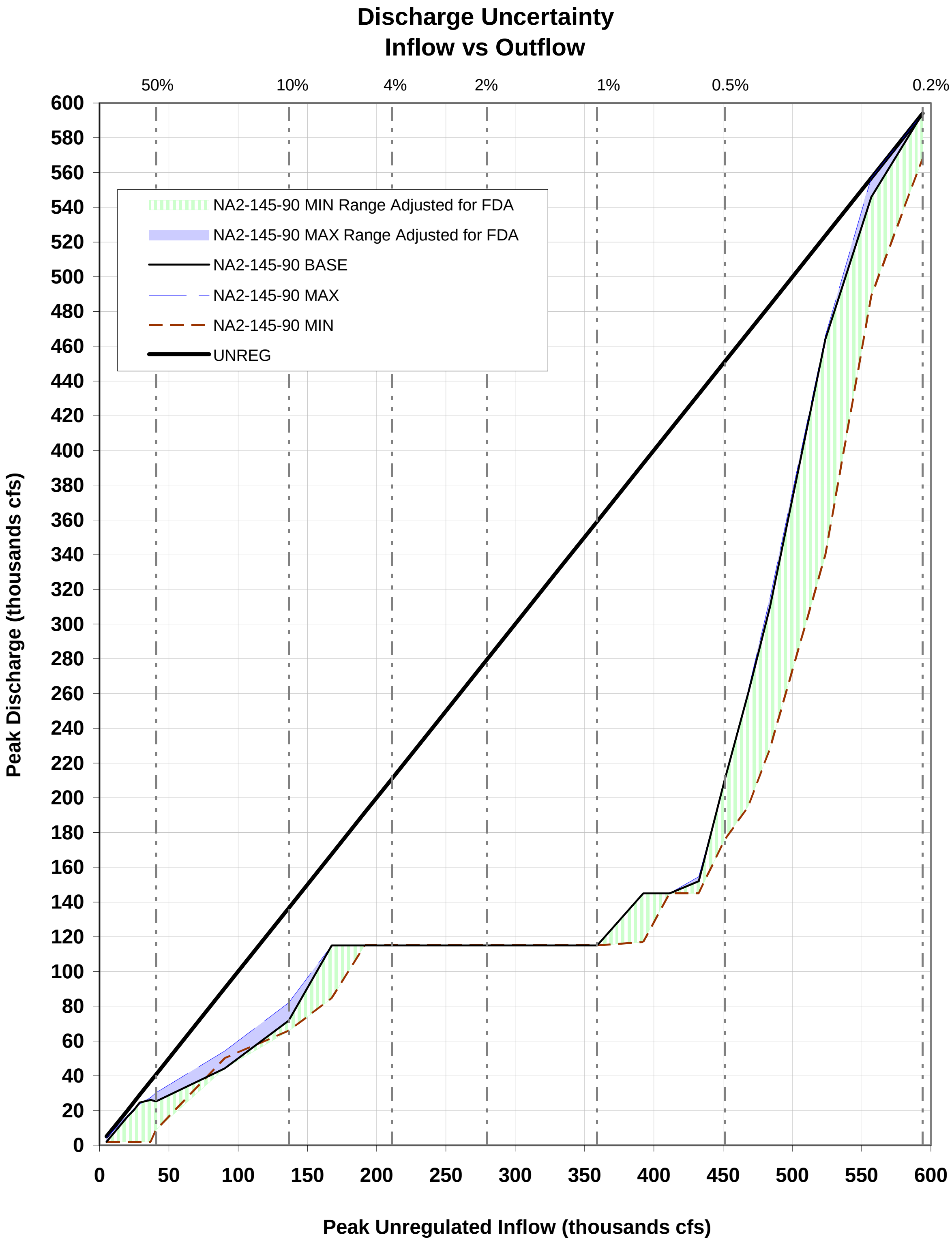

FIGURE A-22: DISCHARGE UNCERTAINTY – W2 WITH-PROJECT – 160,000 CFS

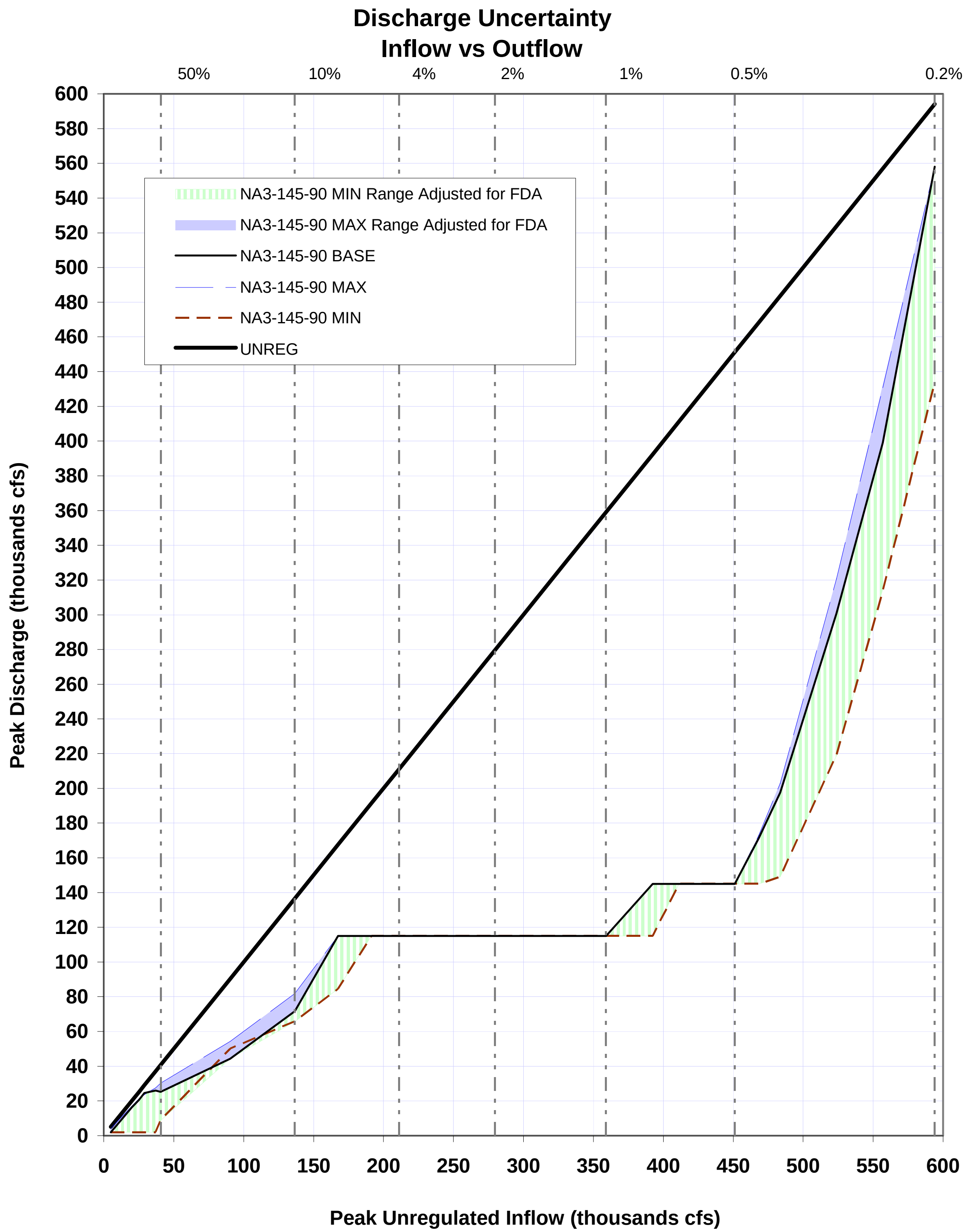

FIGURE A-23: DISCHARGE UNCERTAINTY – W3 WITH-PROJECT – 160,000 CFS

TABLE A-5: W01 BASE (R000_800CF_No Fix_115_FP470_P1_20080914)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.83	391.87	20002	20002	14057	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.49	389.60	25004	25004	18558	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	403.38	395.66	29000	29000	21525	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.75	398.21	37002	37002	30284	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.93	399.44	40722	40722	30295	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.82	494.78	90369	90369	30928	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.80	602.86	136522	136522	43692	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.17	651.53	167533	167533	70490	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	439.45	691.72	191482	191482	87307	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	442.53	721.38	211227	211227	98760	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	448.80	783.74	243016	243016	115000	0	0.00	0	0	0	23	23	0	0	0	0	0	0
50	457.34	872.50	279485	279485	115000	0	0.00	0	0	0	50	50	0	0	0	0	0	0
65	464.38	948.85	308218	308218	115000	0	0.00	0	0	0	68	68	0	0	0	0	0	0
80	470.37	1016.12	332148	332148	115000	0	0.00	0	0	33	84	84	0	0	0	0	0	0
100	**476.35**	**1085.39**	**359078**	**359078**	**123107**	**0**	**0.00**	**0**	**0**	**52**	**105**	**91**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.79	1078.77	392399	392399	222593	0	0.00	0	0	46	100	85	22	0	14	0	20	0
150	476.38	1085.73	411351	411351	292965	0	0.00	0	0	42	96	81	24	0	18	0	-6	28
175	474.78	1066.96	432395	432395	403445	0	0.00	0	0	27	90	74	27	0	21	10	56	146
200	**476.33**	**1085.18**	**451163**	**451163**	**444310**	**0**	**0.00**	**0**	**0**	**27**	**92**	**76**	**29**	**0**	**23**	**12**	**-6**	**88**
225	476.68	1089.26	468139	468139	461029	0	0.00	0	0	28	94	78	33	0	25	14	74	70
250	476.65	1088.92	483665	483665	476319	0	0.00	0	0	28	93	78	34	0	27	16	68	100
325	477.59	1099.94	523757	523757	515802	0	0.00	0	0	31	97	83	38	0	31	20	55	101
400	478.55	1111.42	556967	556967	546433	0	0.00	0	0	34	100	88	42	0	35	22	38	96
500	479.62	1124.16	594159	594159	554268	0	0.00	0	0	39	109	93	48	0	40	26	31	85

TABLE A-6: W01 MAX (R000_800CF_No Fix_115_FP470_P1_20080914)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.76	419.28	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.90	420.25	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	407.01	421.03	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.22	422.55	37002	37002	30425	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.31	423.19	40722	40722	30425	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.33	498.81	90369	90369	31248	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.70	601.95	136522	136522	52675	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.68	656.20	167533	167533	72904	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	440.67	703.42	191482	191482	92040	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	444.39	739.61	211227	211227	108290	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	450.77	803.74	243016	243016	115000	0	0.00	0	0	0	30	30	0	0	0	0	0	0
50	458.92	889.35	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	465.45	960.66	308218	308218	115000	0	0.00	0	0	0	71	71	0	0	0	0	0	0
80	470.97	1022.96	332148	332148	115000	0	0.00	0	0	36	86	86	0	0	0	0	0	0
100	**476.32**	**1085.03**	**359078**	**359078**	**124034**	**0**	**0.00**	**0**	**0**	**52**	**105**	**91**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.79	1078.80	392399	392399	222320	0	0.00	0	0	46	100	85	22	0	14	0	20	0
150	476.39	1085.81	411351	411351	293316	0	0.00	0	0	42	96	81	24	0	18	0	-6	28
175	474.87	1068.07	432395	432395	411752	0	0.00	0	0	26	90	74	27	0	21	10	57	150
200	**476.37**	**1085.67**	**451163**	**451163**	**444310**	**0**	**0.00**	**0**	**0**	**28**	**93**	**77**	**29**	**0**	**23**	**12**	**-6**	**89**
225	476.67	1089.18	468139	468139	461029	0	0.00	0	0	28	94	78	33	0	25	14	68	70
250	476.66	1089.00	483665	483665	476319	0	0.00	0	0	28	94	78	34	0	27	16	49	99
325	477.74	1101.76	523757	523757	515802	0	0.00	0	0	31	97	83	38	0	32	20	53	95
400	478.68	1112.95	556967	556967	548181	0	0.00	0	0	36	101	88	42	0	36	22	32	98
500	479.76	1125.81	594159	594159	554678	0	0.00	0	0	39	111	93	49	0	40	26	53	81

TABLE A-7: W01 MIN (R000_800CF_No Fix_115_FP470_P1_20080914)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.84	464.05	40722	38674	9546	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.31	498.68	90369	84059	31233	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	428.58	592.07	136522	126249	49521	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	434.39	644.26	167533	154598	68674	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	437.99	677.88	191482	176491	81089	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	440.84	705.03	211227	194541	92975	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	445.30	748.65	243016	223601	111456	0	0.00	0	0	0	0	0	0	0	0	0	0	0
50	451.35	809.74	279485	256938	115000	0	0.00	0	0	0	32	32	0	0	0	0	0	0
65	456.85	867.28	308218	283204	115000	0	0.00	0	0	0	50	50	0	0	0	0	0	0
80	461.62	918.59	332148	305080	115000	0	0.00	0	0	0	62	62	0	0	0	0	0	0
100	**466.62**	**973.78**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**14**	**75**	**75**	**0**	**0**	**0**	**0**	**0**	**0**
130	474.76	1066.72	392399	360850	115000	0	0.00	0	0	49	105	94	0	0	0	0	0	0
150	476.90	1091.89	411351	381289	135890	0	0.00	0	0	54	116	104	0	0	0	0	0	0
175	475.90	1080.08	432395	407507	203141	0	0.00	0	0	48	105	92	22	0	13	0	29	0
200	**475.92**	**1080.38**	**451163**	**429875**	**277213**	**0**	**0.00**	**0**	**0**	**41**	**97**	**84**	**25**	**0**	**18**	**0**	**73**	**27**
225	475.85	1079.48	468139	448786	314895	0	0.00	0	0	36	97	83	27	0	21	10	97	0
250	475.00	1069.51	483665	465352	435147	0	0.00	0	0	23	89	75	29	0	23	11	162	58
325	475.98	1080.98	523757	506439	499294	0	0.00	0	0	23	92	77	33	0	27	15	-6	147
400	476.25	1084.24	556967	540033	509928	0	0.00	0	0	27	96	81	39	0	31	19	106	156
500	477.41	1097.86	594159	577133	529188	0	0.00	0	0	31	104	88	45	0	36	22	70	132

TABLE A-8: W02 BASE (R060_800FM_No Fix_115_FP470_P1_20080908)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.83	391.87	20002	20002	14057	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.49	389.60	25004	25004	18558	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	403.38	395.66	29000	29000	21525	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.67	397.61	37002	37002	33505	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.53	396.67	40722	40722	37708	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	403.99	399.85	90369	90369	83680	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	408.97	435.18	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	415.21	482.19	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	421.58	532.97	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	427.80	585.26	211227	211227	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	433.71	638.02	243016	243016	115000	0	0.00	0	0	0	29	29	0	0	0	0	0	0
50	443.02	726.21	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	449.41	789.86	308218	308218	115000	0	0.00	0	0	0	68	68	0	0	0	0	0	0
80	454.76	845.21	332148	332148	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
100	**461.00**	**911.80**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**102**	**102**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.81	987.06	392399	392399	115000	0	0.00	0	0	23	127	127	0	0	0	0	0	0
150	472.83	1044.29	411351	411351	115000	0	0.00	0	0	43	138	126	0	0	0	0	0	0
175	476.38	1085.74	432395	432395	129972	0	0.00	0	0	54	147	133	0	0	0	0	0	0
200	**476.65**	**1088.93**	**451163**	**451163**	**169173**	**0**	**0.00**	**0**	**0**	**152**	**53**	**14**	**20**	**0**	**0**	**0**	**3**	**0**
225	474.79	1067.11	468139	468139	268061	0	0.00	0	0	80	56	15	24	0	17	0	55	0
250	475.23	1072.29	483665	483665	331691	0	0.00	0	0	62	58	14	25	0	19	8	-5	45
325	478.02	1105.13	523757	523757	415711	0	0.00	0	0	62	62	15	30	0	24	13	-6	80
400	479.76	1125.81	556967	556967	465830	0	0.00	0	0	63	65	15	34	0	28	16	-5	80
500	480.97	1140.34	594159	594159	627077	25	0.47	0	0	47	68	13	40	0	32	20	-2	77

TABLE A-9: W02 MAX (R060_800FM_No Fix_115_FP470_P1_20080908)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.76	419.28	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.90	420.25	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	407.01	421.03	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.22	422.55	37002	37002	31387	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.31	423.19	40722	40722	34542	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	408.59	432.46	90369	90369	76656	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	412.41	460.77	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	418.11	505.04	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	423.57	549.39	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	428.52	591.54	211227	211227	115000	0	0.00	0	0	0	10	10	0	0	0	0	0	0
35	434.66	646.79	243016	243016	115000	0	0.00	0	0	0	32	32	0	0	0	0	0	0
50	443.71	732.89	279485	279485	115000	0	0.00	0	0	0	55	55	0	0	0	0	0	0
65	450.81	804.21	308218	308218	115000	0	0.00	0	0	0	72	72	0	0	0	0	0	0
80	456.24	860.80	332148	332148	115000	0	0.00	0	0	0	86	86	0	0	0	0	0	0
100	**463.05**	**934.22**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**113**	**113**	**0**	**0**	**0**	**0**	**0**	**0**
130	470.95	1022.74	392399	392399	115000	0	0.00	0	0	37	135	135	0	0	0	0	0	0
150	475.46	1074.96	411351	411351	118897	0	0.00	0	0	51	146	130	0	0	0	0	0	0
175	476.56	1087.80	432395	432395	148180	0	0.00	0	0	53	149	132	0	0	0	0	0	0
200	**474.94**	**1068.80**	**451163**	**451163**	**228405**	**0**	**0.00**	**0**	**0**	**99**	**57**	**17**	**22**	**0**	**15**	**0**	**53**	**0**
225	474.96	1069.02	468139	468139	318472	0	0.00	0	0	63	59	17	26	0	18	6	64	38
250	476.00	1081.29	483665	483665	357755	0	0.00	0	0	59	60	16	26	0	20	9	-5	57
325	478.22	1107.42	523757	523757	421382	0	0.00	0	0	63	64	16	31	0	25	14	-6	80
400	479.93	1127.86	556967	556967	470310	0	0.00	0	0	62	66	15	35	0	29	17	-5	77
500	481.08	1141.63	594159	594159	663803	33	0.58	0	0	47	70	14	41	0	33	21	-2	78

TABLE A-10: W02 MIN (R060_800FM_No Fix_115_FP470_P1_20080908)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.84	464.05	40722	38674	9546	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.33	483.15	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	418.32	506.69	136522	126249	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	421.73	534.18	167533	154598	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	425.96	569.46	191482	176491	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	429.85	603.33	211227	194541	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	434.59	646.18	243016	223601	115000	0	0.00	0	0	0	22	22	0	0	0	0	0	0
50	441.93	715.57	279485	256938	115000	0	0.00	0	0	0	46	46	0	0	0	0	0	0
65	448.57	781.34	308218	283204	115000	0	0.00	0	0	0	63	63	0	0	0	0	0	0
80	453.72	834.34	332148	305080	115000	0	0.00	0	0	0	79	79	0	0	0	0	0	0
100	**460.26**	**903.83**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**100**	**100**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.01	978.09	392399	360850	115000	0	0.00	0	0	16	127	127	0	0	0	0	0	0
150	469.43	1005.36	411351	381289	115000	0	0.00	0	0	32	134	134	0	0	0	0	0	0
175	474.36	1062.07	432395	407507	115124	0	0.00	0	0	50	147	130	0	0	0	0	0	0
200	**476.58**	**1088.06**	**451163**	**429875**	**132562**	**0**	**0.00**	**0**	**0**	**55**	**152**	**136**	**0**	**0**	**0**	**0**	**0**	**0**
225	476.63	1088.71	468139	448786	166144	0	0.00	0	0	155	55	15	20	0	0	0	3	0
250	474.88	1068.11	483665	465352	238763	0	0.00	0	0	95	57	16	24	0	17	0	50	15
325	476.43	1086.35	523757	506439	375796	0	0.00	0	0	55	61	15	28	0	22	10	-6	68
400	478.35	1108.97	556967	540033	425258	0	0.00	0	0	57	64	15	33	0	26	14	-1	84
500	480.11	1129.97	594159	577133	475823	0	0.00	0	0	47	68	15	39	0	30	17	-2	83

TABLE A-11: W03 BASE (R060_800DR3.5e_115_FP470_P1_20080907)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.83	391.87	20002	20002	14057	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.49	389.60	25004	25004	18558	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	403.38	395.66	29000	29000	21525	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.67	397.61	37002	37002	33505	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.53	396.67	40722	40722	37708	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	403.99	399.85	90369	90369	83680	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	408.97	435.18	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	415.21	482.19	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	421.58	532.97	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	427.80	585.26	211227	211227	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	433.71	638.02	243016	243016	115000	0	0.00	0	0	0	29	29	0	0	0	0	0	0
50	443.02	726.21	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	449.41	789.86	308218	308218	115000	0	0.00	0	0	0	68	68	0	0	0	0	0	0
80	454.76	845.21	332148	332148	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
100	**461.00**	**911.80**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**102**	**102**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.81	987.06	392399	392399	115000	0	0.00	0	0	23	127	127	0	0	0	0	0	0
150	472.81	1044.11	411351	411351	115088	0	0.00	0	0	43	138	126	0	0	0	0	0	0
175	476.78	1090.42	432395	432395	122131	0	0.00	0	0	55	149	135	0	0	0	0	0	0
200	**478.67**	**1112.80**	**451163**	**451163**	**138359**	**0**	**0.00**	**0**	**0**	**60**	**154**	**140**	**0**	**0**	**0**	**0**	**0**	**0**
225	478.38	1109.31	468139	468139	176952	0	0.00	0	0	162	56	15	24	0	0	0	15	0
250	477.27	1096.17	483665	483665	232803	0	0.00	0	0	150	58	14	25	0	18	0	34	0
325	477.72	1101.50	523757	523757	394043	0	0.00	0	0	72	62	15	30	0	24	13	-6	75
400	479.49	1122.65	556967	556967	457102	0	0.00	0	0	76	65	15	34	0	28	16	-5	74
500	481.31	1144.50	594159	594159	510279	0	0.00	0	0	77	68	14	40	0	32	20	-2	75
PMF	486.00	1201.47	905770	905770	1105372	214	2.00	0	0	131	134	18	93	0	61	49	247	146

TABLE A-12: W03 MAX (R060_800DR3.5e_115_FP470_P1_20080907)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.76	419.28	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.90	420.25	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	407.01	421.03	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.22	422.55	37002	37002	31387	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.31	423.19	40722	40722	34542	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	408.59	432.46	90369	90369	76656	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	412.41	460.77	136522	136522	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	418.11	505.04	167533	167533	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	423.57	549.39	191482	191482	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	428.52	591.54	211227	211227	115000	0	0.00	0	0	0	10	10	0	0	0	0	0	0
35	434.66	646.79	243016	243016	115000	0	0.00	0	0	0	32	32	0	0	0	0	0	0
50	443.71	732.89	279485	279485	115000	0	0.00	0	0	0	55	55	0	0	0	0	0	0
65	450.81	804.21	308218	308218	115000	0	0.00	0	0	0	72	72	0	0	0	0	0	0
80	456.24	860.80	332148	332148	115000	0	0.00	0	0	0	86	86	0	0	0	0	0	0
100	**463.05**	**934.22**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**113**	**113**	**0**	**0**	**0**	**0**	**0**	**0**
130	470.95	1022.74	392399	392399	115000	0	0.00	0	0	37	135	135	0	0	0	0	0	0
150	475.37	1073.85	411351	411351	118010	0	0.00	0	0	51	146	130	0	0	0	0	0	0
175	477.72	1101.61	432395	432395	129653	0	0.00	0	0	57	152	135	0	0	0	0	0	0
200	**478.72**	**1113.42**	**451163**	**451163**	**157288**	**0**	**0.00**	**0**	**0**	**60**	**156**	**138**	**0**	**0**	**0**	**0**	**0**	**0**
225	477.50	1098.98	468139	468139	219082	0	0.00	0	0	151	59	18	25	0	17	0	24	0
250	476.79	1090.52	483665	483665	275466	0	0.00	0	0	105	60	16	26	0	20	0	53	7
325	478.10	1106.01	523757	523757	408380	0	0.00	0	0	73	64	16	31	0	25	13	74	61
400	479.87	1127.11	556967	556967	467639	0	0.00	0	0	77	66	15	35	0	29	16	71	59
500	481.43	1147.07	594159	594159	513811	0	0.00	0	0	78	70	15	41	0	33	21	-2	72

TABLE A-13: W03 MIN (R060_800DR3.5e_115_FP470_P1_20080907)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.84	464.05	40722	38674	9546	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.33	483.15	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	418.32	506.69	136522	126249	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	421.73	534.18	167533	154598	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	425.96	569.46	191482	176491	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	429.85	603.33	211227	194541	90000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	434.59	646.18	243016	223601	115000	0	0.00	0	0	0	22	22	0	0	0	0	0	0
50	441.93	715.57	279485	256938	115000	0	0.00	0	0	0	46	46	0	0	0	0	0	0
65	448.57	781.34	308218	283204	115000	0	0.00	0	0	0	63	63	0	0	0	0	0	0
80	453.72	834.34	332148	305080	115000	0	0.00	0	0	0	79	79	0	0	0	0	0	0
100	**460.26**	**903.83**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**100**	**100**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.01	978.09	392399	360850	115000	0	0.00	0	0	16	127	127	0	0	0	0	0	0
150	469.43	1005.36	411351	381289	115000	0	0.00	0	0	32	134	134	0	0	0	0	0	0
175	474.21	1060.36	432395	407507	115938	0	0.00	0	0	49	146	128	0	0	0	0	0	0
200	**477.18**	**1095.22**	**451163**	**429875**	**122877**	**0**	**0.00**	**0**	**0**	**57**	**154**	**138**	**0**	**0**	**0**	**0**	**0**	**0**
225	478.80	1114.32	468139	448786	135427	0	0.00	0	0	61	158	143	0	0	0	0	0	0
250	479.05	1117.37	483665	465352	161583	0	0.00	0	0	171	57	16	23	0	0	0	0	0
325	476.54	1087.58	523757	506439	310409	0	0.00	0	0	83	61	15	28	0	22	9	55	38
400	478.05	1105.51	556967	540033	406670	0	0.00	0	0	64	64	15	33	0	26	14	-1	78
500	479.89	1127.38	594159	577133	468932	0	0.00	0	0	68	68	16	39	0	30	16	77	70

TABLE A-14: NA1-145 BASE (R000_800CF_No Fix_145_FP470_P1_20080919)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.17	394.19	37002	37002	30237	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	402.43	389.16	40722	40722	30183	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.74	486.34	90369	90369	30848	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.13	596.95	136522	136522	43127	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	434.65	646.67	167533	167533	69092	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	439.01	687.48	191482	191482	86500	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	442.69	722.96	211227	211227	99738	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	448.44	780.03	243016	243016	115000	0	0.00	0	0	0	22	22	0	0	0	0	0	0
50	457.01	868.92	279485	279485	115000	0	0.00	0	0	0	49	49	0	0	0	0	0	0
65	461.09	912.80	308218	308218	135000	0	0.00	0	0	0	61	61	0	0	0	0	0	0
80	466.44	971.77	332148	332148	135000	0	0.00	0	0	9	74	74	0	0	0	0	0	0
100	**470.81**	**1021.10**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**39**	**92**	**92**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.31	1073.15	392399	392399	177012	0	0.00	0	0	49	105	105	20	1	0	0	14	0
150	475.74	1078.26	411351	411351	218286	0	0.00	0	0	49	106	106	23	0	16	0	18	0
175	476.07	1082.12	432395	432395	268700	0	0.00	0	0	47	104	103	25	0	19	0	-6	16
200	**476.40**	**1086.00**	**451163**	**451163**	**320142**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**28**	**0**	**21**	**11**	**65**	**42**
225	476.58	1088.08	468139	468139	363164	0	0.00	0	0	41	103	102	31	0	24	12	48	42
250	476.67	1089.18	483665	483665	412114	0	0.00	0	0	36	101	99	32	0	26	14	-5	47
325	477.17	1095.00	523757	523757	484550	0	0.00	0	0	35	102	101	37	0	30	18	56	49
400	477.83	1102.80	556967	556967	503557	0	0.00	0	0	38	107	107	41	0	35	21	37	46
500	479.01	1116.85	594159	594159	512982	0	0.00	0	0	42	129	115	47	0	39	25	30	52

TABLE A-15: NA1-145 MAX (R000_800CF_No Fix_145_FP470_P1_20080919)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	30423	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30424	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.33	498.81	90369	90369	31248	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	429.70	601.95	136522	136522	52675	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.68	656.20	167533	167533	72904	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	440.67	703.42	191482	191482	92040	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	444.39	739.61	211227	211227	108290	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	450.77	803.74	243016	243016	115000	0	0.00	0	0	0	30	30	0	0	0	0	0	0
50	458.92	889.35	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	462.29	925.84	308218	308218	135000	0	0.00	0	0	0	65	65	0	0	0	0	0	0
80	467.20	980.23	332148	332148	135000	0	0.00	0	0	16	78	78	0	0	0	0	0	0
100	**471.07**	**1024.11**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**40**	**92**	**92**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.32	1073.28	392399	392399	178071	0	0.00	0	0	48	105	105	20	0	0	0	13	0
150	475.75	1078.35	411351	411351	218943	0	0.00	0	0	49	106	106	23	0	17	0	14	0
175	476.08	1082.17	432395	432395	269028	0	0.00	0	0	47	104	103	25	0	19	0	-6	15
200	**476.41**	**1086.03**	**451163**	**451163**	**320618**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**28**	**0**	**22**	**11**	**56**	**42**
225	476.59	1088.23	468139	468139	366078	0	0.00	0	0	40	104	102	31	0	24	12	50	42
250	476.67	1089.19	483665	483665	413033	0	0.00	0	0	36	102	99	32	0	26	14	-5	46
325	477.19	1095.24	523757	523757	485904	0	0.00	0	0	35	102	101	37	0	31	18	45	47
400	477.84	1102.98	556967	556967	503676	0	0.00	0	0	39	108	108	41	0	35	21	36	47
500	479.02	1116.98	594159	594159	513077	0	0.00	0	0	42	126	115	48	0	39	25	44	52

TABLE A-16: NA1-145 MIN (R000_800CF_No Fix_145_FP470_P1_20080919)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	417.13	497.21	90369	84059	31233	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	428.58	592.07	136522	126249	49521	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	433.77	638.60	167533	154598	67040	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	437.47	672.98	191482	176491	78462	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	440.35	700.34	211227	194541	90191	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	444.94	745.01	243016	223601	109419	0	0.00	0	0	0	0	0	0	0	0	0	0	0
50	451.06	806.80	279485	256938	115000	0	0.00	0	0	0	31	31	0	0	0	0	0	0
65	456.61	864.68	308218	283204	115000	0	0.00	0	0	0	48	48	0	0	0	0	0	0
80	458.74	887.48	332148	305080	135000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
100	**463.26**	**936.53**	**359078**	**329825**	**135000**	**0**	**0.00**	**0**	**0**	**0**	**68**	**68**	**0**	**0**	**0**	**0**	**0**	**0**
130	468.87	998.98	392399	360850	145000	0	0.00	0	0	26	84	84	0	0	0	0	0	0
150	472.83	1044.26	411351	381289	145000	0	0.00	0	0	47	103	103	0	0	0	0	0	0
175	475.66	1077.28	432395	407507	164525	0	0.00	0	0	52	118	118	14	1	0	0	2	0
200	**475.58**	**1076.33**	**451163**	**429875**	**207706**	**0**	**0.00**	**0**	**0**	**50**	**117**	**117**	**23**	**0**	**17**	**0**	**4**	**0**
225	475.81	1079.03	468139	448786	249188	0	0.00	0	0	48	118	118	25	0	19	0	-5	5
250	476.10	1082.45	483665	465352	290568	0	0.00	0	0	45	106	106	27	0	21	0	-5	21
325	476.63	1088.66	523757	506439	397225	0	0.00	0	0	36	105	104	32	0	26	13	-6	92
400	476.97	1092.73	556967	540033	470504	0	0.00	0	0	32	104	103	37	0	30	18	-1	63
500	478.01	1105.02	594159	577133	505120	0	0.00	0	0	36	121	110	43	0	34	21	-2	50

TABLE A-17: NA2-145 BASE (R060_800FM_No Fix_145_FP466_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	424.92	560.66	167533	167533	115000	0	0.00	0	0	0	26	26	0	0	0	0	0	0
20	428.02	587.24	191482	191482	115000	0	0.00	0	0	0	36	36	0	0	0	0	0	0
25	431.43	617.37	211227	211227	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
35	437.15	669.98	243016	243016	115000	0	0.00	0	0	0	57	57	0	0	0	0	0	0
50	442.97	725.68	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.11	786.85	308218	308218	115000	0	0.00	0	0	0	103	103	0	0	0	0	0	0
80	453.74	834.47	332148	332148	115000	0	0.00	0	0	0	127	127	0	0	0	0	0	0
100	**460.46**	**906.02**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**137**	**137**	**0**	**0**	**0**	**0**	**0**	**0**
130	461.49	917.22	392399	392399	145000	0	0.00	0	0	0	144	125	0	0	0	0	0	0
150	466.34	970.57	411351	411351	145000	0	0.00	0	0	11	153	134	0	0	0	0	0	0
175	469.94	1011.13	432395	432395	151924	0	0.00	0	0	33	160	142	0	0	0	0	0	0
200	**470.02**	**1012.12**	**451163**	**451163**	**210332**	**0**	**0.00**	**0**	**0**	**25**	**160**	**142**	**21**	**0**	**15**	**0**	**0**	**0**
225	470.31	1015.33	468139	468139	260498	0	0.00	0	0	21	160	143	25	0	18	0	-5	19
250	470.65	1019.31	483665	483665	309673	0	0.00	0	0	18	160	144	26	0	20	9	-5	35
325	471.23	1025.87	523757	523757	464074	0	0.00	0	0	13	183	144	30	0	24	13	-6	111
400	471.61	1030.22	556967	556967	545951	0	0.00	0	0	12	189	146	34	0	28	16	-5	176
500	472.08	1035.62	594159	594159	594159	0	0.00	0	0	14	196	150	40	0	32	20	-2	153
PMF	477.51	1099.03	905770	905770	812199	0	0.00	0	0	57	255	129	85	0	55	43	0	146

TABLE A-18: NA2-145 MAX (R060_800FM_No Fix_145_FP466_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	23588	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	27464	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30225	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	414.02	473.00	90369	90369	54221	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	423.56	549.32	136522	136522	81913	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	427.18	579.96	167533	167533	115000	0	0.00	0	0	0	28	28	0	0	0	0	0	0
20	430.25	606.84	191482	191482	115000	0	0.00	0	0	0	38	38	0	0	0	0	0	0
25	433.17	633.13	211227	211227	115000	0	0.00	0	0	0	47	47	0	0	0	0	0	0
35	438.57	683.35	243016	243016	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
50	444.11	736.88	279485	279485	115000	0	0.00	0	0	0	77	77	0	0	0	0	0	0
65	450.07	796.61	308218	308218	115000	0	0.00	0	0	0	105	105	0	0	0	0	0	0
80	456.02	858.42	332148	332148	115000	0	0.00	0	0	0	128	128	0	0	0	0	0	0
100	**461.90**	**921.63**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**139**	**139**	**0**	**0**	**0**	**0**	**0**	**0**
130	460.99	911.73	392399	392399	145000	0	0.00	0	0	0	142	124	0	0	0	0	0	0
150	466.51	972.53	411351	411351	145000	0	0.00	0	0	14	153	135	0	0	0	0	0	0
175	469.98	1011.59	432395	432395	154629	0	0.00	0	0	32	178	142	0	0	0	0	0	0
200	**470.03**	**1012.15**	**451163**	**451163**	**209579**	**0**	**0.00**	**0**	**0**	**25**	**180**	**142**	**21**	**0**	**15**	**0**	**0**	**0**
225	470.31	1015.44	468139	468139	262069	0	0.00	0	0	21	182	143	25	0	18	0	-5	10
250	470.71	1019.97	483665	483665	314605	0	0.00	0	0	18	183	143	26	0	20	9	-5	25
325	471.20	1025.58	523757	523757	466105	0	0.00	0	0	13	187	144	31	0	25	14	-6	100
400	471.75	1031.94	556967	556967	556967	0	0.00	0	0	13	193	145	35	0	29	17	-5	143
500	471.90	1033.55	594159	594159	594159	0	0.00	0	0	13	201	150	40	0	32	21	-2	140

TABLE A-19: NA2-145 MIN (R060_800FM_No Fix_145_FP466_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.10	587.92	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	428.64	592.60	191482	176491	115000	0	0.00	0	0	0	25	25	0	0	0	0	0	0
25	431.48	617.85	211227	194541	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
35	436.67	665.48	243016	223601	115000	0	0.00	0	0	0	48	48	0	0	0	0	0	0
50	442.99	725.90	279485	256938	115000	0	0.00	0	0	0	62	62	0	0	0	0	0	0
65	448.29	778.56	308218	283204	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
80	451.74	813.77	332148	305080	115000	0	0.00	0	0	0	106	106	0	0	0	0	0	0
100	**458.45**	**884.30**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**131**	**131**	**0**	**0**	**0**	**0**	**0**	**0**
130	465.67	963.13	392399	360850	116941	0	0.00	0	0	0	146	118	0	0	0	0	0	0
150	463.97	944.31	411351	381289	145000	0	0.00	0	0	0	146	127	0	0	0	0	0	0
175	468.50	994.84	432395	407507	145000	0	0.00	0	0	31	156	138	0	0	0	0	0	0
200	**470.21**	**1014.21**	**451163**	**429875**	**175825**	**0**	**0.00**	**0**	**0**	**32**	**159**	**141**	**19**	**1**	**0**	**0**	**5**	**0**
225	470.28	1015.10	468139	448786	194960	0	0.00	0	0	29	160	144	21	0	0	0	0	0
250	470.16	1013.63	483665	465352	228088	0	0.00	0	0	23	161	146	23	0	17	0	-5	0
325	470.84	1021.39	523757	506439	339880	0	0.00	0	0	17	162	147	28	0	22	10	-6	67
400	471.55	1029.61	556967	540033	488931	0	0.00	0	0	13	162	148	33	0	26	14	-1	119
500	471.80	1032.40	594159	577133	568037	0	0.00	0	0	12	180	150	39	0	30	17	-2	229

TABLE A-20: NA3-145 BASE (R060_800DR3.5e_145_FP471.5_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	424.92	560.66	167533	167533	115000	0	0.00	0	0	0	26	26	0	0	0	0	0	0
20	428.02	587.24	191482	191482	115000	0	0.00	0	0	0	36	36	0	0	0	0	0	0
25	431.43	617.37	211227	211227	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
35	437.15	669.98	243016	243016	115000	0	0.00	0	0	0	57	57	0	0	0	0	0	0
50	442.97	725.68	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.11	786.85	308218	308218	115000	0	0.00	0	0	0	103	103	0	0	0	0	0	0
80	453.74	834.47	332148	332148	115000	0	0.00	0	0	0	127	127	0	0	0	0	0	0
100	**460.46**	**906.02**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**137**	**137**	**0**	**0**	**0**	**0**	**0**	**0**
130	461.49	917.22	392399	392399	145000	0	0.00	0	0	0	144	125	0	0	0	0	0	0
150	466.26	969.69	411351	411351	145000	0	0.00	0	0	7	152	133	0	0	0	0	0	0
175	469.90	1010.67	432395	432395	145000	0	0.00	0	0	34	160	142	0	0	0	0	0	0
200	**474.92**	**1068.57**	**451163**	**451163**	**145000**	**0**	**0.00**	**0**	**0**	**53**	**171**	**153**	**0**	**0**	**0**	**0**	**0**	**0**
225	477.03	1093.42	468139	468139	171154	0	0.00	0	0	56	173	156	19	1	0	0	4	0
250	477.36	1097.31	483665	483665	197562	0	0.00	0	0	56	174	158	23	0	0	0	7	0
325	477.22	1095.62	523757	523757	300796	0	0.00	0	0	48	196	157	28	0	22	10	-6	78
400	477.90	1103.69	556967	556967	399130	0	0.00	0	0	39	201	158	32	0	26	14	-5	100
500	478.32	1108.60	594159	594159	558062	0	0.00	0	0	28	205	159	38	0	30	18	-2	151

TABLE A-21: NA3-145 MAX (R060_800DR3.5e_145_FP471.5_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	23588	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	27464	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30225	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	414.02	473.00	90369	90369	54221	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	423.56	549.32	136522	136522	81913	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	427.18	579.96	167533	167533	115000	0	0.00	0	0	0	28	28	0	0	0	0	0	0
20	430.25	606.84	191482	191482	115000	0	0.00	0	0	0	38	38	0	0	0	0	0	0
25	433.17	633.13	211227	211227	115000	0	0.00	0	0	0	47	47	0	0	0	0	0	0
35	438.57	683.35	243016	243016	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
50	444.11	736.88	279485	279485	115000	0	0.00	0	0	0	77	77	0	0	0	0	0	0
65	450.07	796.61	308218	308218	115000	0	0.00	0	0	0	105	105	0	0	0	0	0	0
80	456.02	858.42	332148	332148	115000	0	0.00	0	0	0	128	128	0	0	0	0	0	0
100	**461.90**	**921.63**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**139**	**139**	**0**	**0**	**0**	**0**	**0**	**0**
130	460.99	911.73	392399	392399	145000	0	0.00	0	0	0	142	124	0	0	0	0	0	0
150	466.41	971.34	411351	411351	145000	0	0.00	0	0	9	151	133	0	0	0	0	0	0
175	470.14	1013.42	432395	432395	145000	0	0.00	0	0	34	179	143	0	0	0	0	0	0
200	**#N/A**	**#N/A**	**451163**	**451163**	**#N/A**	**#N/A**	**#N/A**	**0**	**0**	**15**	**74**	**#N/A**	**5**	**#N/A**	**0**	**0**	**#N/A**	**#N/A**
225	477.06	1093.72	468139	468139	172840	0	0.00	0	0	56	195	156	19	0	0	0	4	0
250	477.19	1095.30	483665	483665	202925	0	0.00	0	0	55	197	157	23	0	17	0	1	0
325	477.39	1097.70	523757	523757	320734	0	0.00	0	0	47	199	156	29	0	22	11	100	35
400	478.01	1104.97	556967	556967	430723	0	0.00	0	0	37	205	157	32	0	26	14	-5	100
500	478.08	1105.79	594159	594159	558062	0	0.00	0	0	27	210	159	38	0	30	18	-2	167

TABLE A-22: NA3-145 MIN (R060_800DR3.5e_145_FP471.5_P1_20080916)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.10	587.92	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	428.64	592.60	191482	176491	115000	0	0.00	0	0	0	25	25	0	0	0	0	0	0
25	431.48	617.85	211227	194541	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
35	436.67	665.48	243016	223601	115000	0	0.00	0	0	0	48	48	0	0	0	0	0	0
50	442.99	725.90	279485	256938	115000	0	0.00	0	0	0	62	62	0	0	0	0	0	0
65	448.29	778.56	308218	283204	115000	0	0.00	0	0	0	81	81	0	0	0	0	0	0
80	451.74	813.77	332148	305080	115000	0	0.00	0	0	0	106	106	0	0	0	0	0	0
100	**458.45**	**884.30**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**131**	**131**	**0**	**0**	**0**	**0**	**0**	**0**
130	465.98	966.59	392399	360850	115000	0	0.00	0	0	0	147	147	0	0	0	0	0	0
150	463.97	944.31	411351	381289	145000	0	0.00	0	0	0	146	127	0	0	0	0	0	0
175	468.21	991.54	432395	407507	145000	0	0.00	0	0	23	155	137	0	0	0	0	0	0
200	**471.93**	**1033.95**	**451163**	**429875**	**145000**	**0**	**0.00**	**0**	**0**	**44**	**164**	**146**	**0**	**0**	**0**	**0**	**0**	**0**
225	474.23	1060.55	468139	448786	145000	0	0.00	0	0	52	169	153	0	0	0	0	0	0
250	476.87	1091.48	483665	465352	145000	0	0.00	0	0	60	176	161	0	0	0	0	0	0
325	481.26	1143.79	523757	506439	182469	0	0.00	0	0	69	184	169	22	0	0	0	10	0
400	485.04	1189.63	556967	540033	406641	80	1.04	0	0	61	182	168	25	0	17	6	167	63
500	486.04	1201.93	594159	577133	670948	220	2.04	0	0	49	197	167	32	0	23	10	-2	440

TABLE A-23: NA1-160 BASE (R000_800CF_No Fix_160_FP470_P1_20081214)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.60	397.18	37002	37002	25945	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.08	393.58	40722	40722	25891	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	418.26	506.23	90369	90369	26643	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	431.09	614.37	136522	136522	43519	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	436.58	664.64	167533	167533	71079	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	440.71	703.82	191482	191482	87949	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	444.54	741.14	211227	211227	104311	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	450.77	803.76	243016	243016	115000	0	0.00	0	0	0	28	28	0	0	0	0	0	0
50	459.13	891.67	279485	279485	115000	0	0.00	0	0	0	54	54	0	0	0	0	0	0
65	462.93	932.91	308218	308218	135000	0	0.00	0	0	0	65	65	0	0	0	0	0	0
80	468.15	990.91	332148	332148	135000	0	0.00	0	0	23	78	78	0	0	0	0	0	0
100	**472.32**	**1038.47**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**43**	**96**	**96**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.29	1072.93	392399	392399	186741	0	0.00	0	0	48	104	102	30	10	0	0	22	0
150	475.86	1079.58	411351	411351	236150	0	0.00	0	0	48	105	102	32	8	17	0	36	5
175	476.03	1081.62	432395	432395	268705	0	0.00	0	0	48	105	103	34	9	19	0	82	17
200	**476.37**	**1085.66**	**451163**	**451163**	**321017**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**37**	**9**	**22**	**11**	**53**	**42**
225	476.56	1087.85	468139	468139	361431	0	0.00	0	0	41	104	102	40	9	24	12	64	42
250	476.64	1088.84	483665	483665	408551	0	0.00	0	0	38	103	100	41	9	26	14	71	46
325	477.14	1094.64	523757	523757	482854	0	0.00	0	0	35	102	101	48	12	30	18	86	49
400	477.86	1103.24	556967	556967	503865	0	0.00	0	0	38	107	107	41	0	35	21	36	48
500	479.04	1117.15	594159	594159	513195	0	0.00	0	0	43	129	115	48	0	39	25	32	51

TABLE A-24: NA1-160 MAX (R000_800CF_No Fix_160_FP470_P1_20081214)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	26113	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	26125	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	419.62	517.12	90369	90369	27084	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	431.28	616.04	136522	136522	54716	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	438.30	680.77	167533	167533	78433	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	443.02	726.15	191482	191482	97176	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	446.43	759.84	211227	211227	114092	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	452.77	824.45	243016	243016	115000	0	0.00	0	0	0	34	34	0	0	0	0	0	0
50	460.96	911.37	279485	279485	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
65	464.23	947.20	308218	308218	135000	0	0.00	0	0	0	69	68	0	0	0	0	0	0
80	468.90	999.41	332148	332148	135000	0	0.00	0	0	27	82	80	0	0	0	0	0	0
100	**472.51**	**1040.60**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**44**	**96**	**96**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.13	1071.01	392399	392399	178470	0	0.00	0	0	48	102	102	30	10	0	0	9	0
150	475.70	1077.77	411351	411351	219943	0	0.00	0	0	48	104	103	32	9	17	0	45	0
175	476.05	1081.83	432395	432395	270444	0	0.00	0	0	48	105	103	34	9	19	0	86	15
200	**476.38**	**1085.69**	**451163**	**451163**	**321521**	**0**	**0.00**	**0**	**0**	**45**	**104**	**102**	**37**	**9**	**22**	**11**	**51**	**42**
225	476.57	1087.95	468139	468139	363644	0	0.00	0	0	41	104	102	40	9	24	12	69	42
250	476.65	1088.93	483665	483665	410822	0	0.00	0	0	37	102	99	41	9	26	14	77	46
325	477.16	1094.95	523757	523757	484299	0	0.00	0	0	35	103	101	48	11	31	18	48	48
400	477.82	1102.73	556967	556967	503510	0	0.00	0	0	38	107	107	51	10	35	21	49	46
500	479.01	1116.84	594159	594159	512982	0	0.00	0	0	43	127	115	57	9	39	25	36	52

TABLE A-25: NA1-160 MIN (R000_800CF_No Fix_160_FP470_P1_20081214)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	418.60	508.91	90369	84059	27017	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	430.16	606.08	136522	126249	50159	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	435.32	652.92	167533	154598	66881	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	438.84	685.88	191482	176491	81222	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	441.67	713.08	211227	194541	90784	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	446.19	757.45	243016	223601	112689	0	0.00	0	0	0	0	0	0	0	0	0	0	0
50	452.28	819.34	279485	256938	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
65	457.86	877.97	308218	283204	115000	0	0.00	0	0	0	50	50	0	0	0	0	0	0
80	459.50	895.65	332148	305080	135000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
100	**464.68**	**952.16**	**359078**	**329825**	**135000**	**0**	**0.00**	**0**	**0**	**0**	**70**	**70**	**0**	**0**	**0**	**0**	**0**	**0**
130	470.22	1014.37	392399	360850	145000	0	0.00	0	0	34	87	87	0	0	0	0	0	0
150	471.89	1033.48	411351	381289	160000	0	0.00	0	0	45	99	98	22	24	0	0	0	0
175	475.26	1072.52	432395	407507	173176	0	0.00	0	0	50	111	111	31	10	0	0	8	0
200	**475.59**	**1076.50**	**451163**	**429875**	**215563**	**0**	**0.00**	**0**	**0**	**50**	**110**	**110**	**33**	**9**	**17**	**0**	**27**	**0**
225	475.83	1079.24	468139	448786	257292	0	0.00	0	0	48	107	106	34	8	20	0	65	28
250	476.10	1082.41	483665	465352	293291	0	0.00	0	0	46	107	106	36	8	22	0	65	49
325	476.60	1088.34	523757	506439	392913	0	0.00	0	0	36	106	105	40	8	26	14	90	61
400	476.93	1092.23	556967	540033	467440	0	0.00	0	0	32	105	104	49	12	30	17	74	65
500	477.96	1104.34	594159	577133	504670	0	0.00	0	0	36	124	111	55	12	34	20	87	52

TABLE A-26: NA2-160 BASE (R060_800FM_No Fix_160_FP466_P1_20090106)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	425.56	566.08	167533	167533	115000	0	0.00	0	0	0	24	24	0	0	0	0	0	0
20	428.70	593.15	191482	191482	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
25	432.02	622.68	211227	211227	115000	0	0.00	0	0	0	42	42	0	0	0	0	0	0
35	437.51	673.33	243016	243016	115000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
50	444.04	736.19	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.69	792.72	308218	308218	115000	0	0.00	0	0	0	101	101	0	0	0	0	0	0
80	454.35	840.92	332148	332148	115000	0	0.00	0	0	0	125	125	0	0	0	0	0	0
100	**461.31**	**915.15**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**134**	**134**	**0**	**0**	**0**	**0**	**0**	**0**
130	459.65	897.26	392399	392399	160000	0	0.00	0	0	0	137	121	30	31	0	0	0	0
150	464.33	948.31	411351	411351	160000	0	0.00	0	0	0	146	131	32	33	0	0	0	0
175	467.74	986.26	432395	432395	160000	0	0.00	0	0	26	156	141	30	31	0	0	0	0
200	**470.09**	**1012.88**	**451163**	**451163**	**196633**	**0**	**0.00**	**0**	**0**	**26**	**157**	**143**	**37**	**17**	**0**	**0**	**37**	**0**
225	470.16	1013.72	468139	468139	248894	0	0.00	0	0	21	156	143	40	16	17	0	85	3
250	470.44	1016.88	483665	483665	296022	0	0.00	0	0	18	157	144	41	16	19	0	128	7
325	471.17	1025.16	523757	523757	458379	0	0.00	0	0	13	176	144	44	14	24	13	127	110
400	471.32	1026.88	556967	556967	523129	0	0.00	0	0	13	183	146	47	13	28	16	120	127
500	471.57	1029.74	594159	594159	594159	0	0.00	0	0	12	191	149	53	14	31	20	175	146
PMF	477.46	1098.49	905770	905770	811646	0	0.00	0	0	58	246	124	109	18	56	44	100	139

TABLE A-27: NA2-160 MAX (R060_800FM_No Fix_160_FP466_P1_20090106)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	23588	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	27464	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	30225	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	415.59	485.14	90369	90369	54221	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	423.58	549.49	136522	136522	81913	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	427.91	586.22	167533	167533	115000	0	0.00	0	0	0	26	26	0	0	0	0	0	0
20	430.94	612.96	191482	191482	115000	0	0.00	0	0	0	36	36	0	0	0	0	0	0
25	434.32	643.67	211227	211227	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
35	439.26	689.88	243016	243016	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
50	446.18	757.39	279485	279485	115000	0	0.00	0	0	0	78	78	0	0	0	0	0	0
65	451.66	812.98	308218	308218	115000	0	0.00	0	0	0	104	104	0	0	0	0	0	0
80	457.54	874.57	332148	332148	115000	0	0.00	0	0	0	126	126	0	0	0	0	0	0
100	**462.60**	**929.22**	**359078**	**359078**	**115155**	**0**	**0.00**	**0**	**0**	**0**	**136**	**106**	**0**	**0**	**0**	**0**	**0**	**0**
130	461.22	914.25	392399	392399	160000	0	0.00	0	0	0	136	123	30	31	0	0	0	0
150	464.46	949.80	411351	411351	160000	0	0.00	0	0	0	145	131	32	33	0	0	0	0
175	467.90	988.09	432395	432395	160000	0	0.00	0	0	27	154	141	30	31	0	0	0	0
200	**470.10**	**1012.99**	**451163**	**451163**	**195966**	**0**	**0.00**	**0**	**0**	**26**	**176**	**143**	**37**	**17**	**0**	**0**	**33**	**0**
225	470.20	1014.16	468139	468139	254566	0	0.00	0	0	20	177	143	40	16	17	0	92	2
250	470.35	1015.82	483665	483665	288029	0	0.00	0	0	18	179	144	41	16	19	0	118	7
325	471.14	1024.90	523757	523757	452926	0	0.00	0	0	13	185	145	44	14	24	14	175	94
400	471.33	1027.02	556967	556967	540048	0	0.00	0	0	12	189	146	47	13	28	17	175	120
500	471.55	1029.62	594159	594159	594159	0	0.00	0	0	13	197	149	53	13	32	21	175	107

TABLE A-28: NA2-160 MIN (R060_800FM_No Fix_160_FP466_P1_20090106)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.30	589.62	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	429.46	599.84	191482	176491	115000	0	0.00	0	0	0	23	23	0	0	0	0	0	0
25	432.18	624.13	211227	194541	115000	0	0.00	0	0	0	31	31	0	0	0	0	0	0
35	437.35	671.86	243016	223601	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
50	443.50	730.90	279485	256938	115000	0	0.00	0	0	0	61	61	0	0	0	0	0	0
65	448.76	783.26	308218	283204	115000	0	0.00	0	0	0	80	80	0	0	0	0	0	0
80	452.90	825.76	332148	305080	115000	0	0.00	0	0	0	116	116	0	0	0	0	0	0
100	**459.22**	**892.62**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**129**	**129**	**0**	**0**	**0**	**0**	**0**	**0**
130	466.33	970.48	392399	360850	121233	0	0.00	0	0	9	143	119	0	0	0	0	0	0
150	463.02	933.87	411351	381289	160000	0	0.00	0	0	0	140	125	27	28	0	0	0	0
175	467.23	980.56	432395	407507	160000	0	0.00	0	0	23	150	137	25	26	0	0	0	0
200	**470.09**	**1012.92**	**451163**	**429875**	**176230**	**0**	**0.00**	**0**	**0**	**30**	**153**	**140**	**33**	**14**	**0**	**0**	**6**	**0**
225	470.13	1013.35	468139	448786	198409	0	0.00	0	0	26	154	143	36	15	0	0	35	0
250	470.11	1013.14	483665	465352	227979	0	0.00	0	0	23	156	146	38	15	17	0	68	0
325	470.67	1019.48	523757	506439	327556	0	0.00	0	0	17	158	147	42	14	22	10	125	38
400	471.18	1025.30	556967	540033	463776	0	0.00	0	0	13	159	149	47	14	26	14	125	114
500	471.42	1028.03	594159	577133	544670	0	0.00	0	0	12	175	151	52	14	29	17	175	177

TABLE A-29: NA3-160 BASE (R060_800DR3.5e_160_FP471.5_P1_20081215)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	399.42	369.20	5000	5000	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	402.39	388.94	20002	20002	16328	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.53	389.84	25004	25004	20411	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	402.78	391.51	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	403.59	397.11	37002	37002	26005	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	403.18	394.30	40722	40722	25215	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	413.74	470.92	90369	90369	44261	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	421.65	533.58	136522	136522	71655	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	425.56	566.08	167533	167533	115000	0	0.00	0	0	0	24	24	0	0	0	0	0	0
20	428.70	593.15	191482	191482	115000	0	0.00	0	0	0	33	33	0	0	0	0	0	0
25	432.02	622.68	211227	211227	115000	0	0.00	0	0	0	42	42	0	0	0	0	0	0
35	437.51	673.33	243016	243016	115000	0	0.00	0	0	0	56	56	0	0	0	0	0	0
50	444.04	736.19	279485	279485	115000	0	0.00	0	0	0	75	75	0	0	0	0	0	0
65	449.69	792.72	308218	308218	115000	0	0.00	0	0	0	101	101	0	0	0	0	0	0
80	454.35	840.92	332148	332148	115000	0	0.00	0	0	0	125	125	0	0	0	0	0	0
100	**461.31**	**915.15**	**359078**	**359078**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**134**	**134**	**0**	**0**	**0**	**0**	**0**	**0**
130	459.65	897.26	392399	392399	160000	0	0.00	0	0	0	137	121	30	31	0	0	0	0
150	464.33	948.31	411351	411351	160000	0	0.00	0	0	0	146	131	32	33	0	0	0	0
175	467.47	983.26	432395	432395	160000	0	0.00	0	0	17	153	138	35	36	0	0	0	0
200	**472.47**	**1040.14**	**451163**	**451163**	**160000**	**0**	**0.00**	**0**	**0**	**46**	**164**	**150**	**32**	**33**	**0**	**0**	**0**	**0**
225	476.20	1083.60	468139	468139	160000	0	0.00	0	0	57	170	157	34	35	0	0	0	0
250	477.15	1094.82	483665	483665	193667	0	0.00	0	0	54	170	157	41	19	0	0	18	0
325	477.08	1093.97	523757	523757	294943	0	0.00	0	0	48	189	157	44	16	22	0	78	4
400	477.78	1102.31	556967	556967	405477	0	0.00	0	0	38	195	158	47	15	26	14	100	81
500	478.03	1105.25	594159	594159	534386	0	0.00	0	0	28	202	160	53	16	29	17	107	150

TABLE A-30: NA3-160 MAX (R060_800DR3.5e_160_FP471.5_P1_20081215)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	406.42	416.85	5000	5000	4242	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	406.74	419.09	20002	20002	16967	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	406.86	419.97	25004	25004	21210	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	406.97	420.78	29000	29000	24600	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	407.19	422.35	37002	37002	26113	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	407.29	423.06	40722	40722	26125	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	419.62	517.12	90369	90369	27084	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	431.28	616.04	136522	136522	54716	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	438.30	680.77	167533	167533	78433	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	443.02	726.15	191482	191482	97176	0	0.00	0	0	0	0	0	0	0	0	0	0	0
25	446.43	759.84	211227	211227	114092	0	0.00	0	0	0	0	0	0	0	0	0	0	0
35	452.77	824.45	243016	243016	115000	0	0.00	0	0	0	34	34	0	0	0	0	0	0
50	460.96	911.37	279485	279485	115000	0	0.00	0	0	0	59	59	0	0	0	0	0	0
65	464.23	947.20	308218	308218	135000	0	0.00	0	0	0	69	68	0	0	0	0	0	0
80	468.90	999.41	332148	332148	135000	0	0.00	0	0	27	82	80	0	0	0	0	0	0
100	**472.51**	**1040.59**	**359078**	**359078**	**145000**	**0**	**0.00**	**0**	**0**	**44**	**96**	**96**	**0**	**0**	**0**	**0**	**0**	**0**
130	475.46	1074.96	392399	392399	187473	0	0.00	0	0	49	103	103	20	0	0	0	5	0
150	475.86	1079.56	411351	411351	229570	0	0.00	0	0	49	104	103	23	0	17	0	-6	6
175	476.20	1083.56	432395	432395	279376	0	0.00	0	0	47	104	102	26	0	20	0	47	8
200	**476.47**	**1086.84**	**451163**	**451163**	**329343**	**0**	**0.00**	**0**	**0**	**44**	**104**	**102**	**28**	**0**	**22**	**11**	**-6**	**41**
225	476.60	1088.35	468139	468139	376509	0	0.00	0	0	40	103	101	31	0	24	12	-5	42
250	476.70	1089.55	483665	483665	421762	0	0.00	0	0	37	102	99	33	0	26	14	56	48
325	477.24	1095.85	523757	523757	488365	0	0.00	0	0	35	103	101	37	0	31	19	-6	42
400	477.87	1103.32	556967	556967	503936	0	0.00	0	0	38	107	107	42	0	35	21	45	48
500	479.04	1117.22	594159	594159	513243	0	0.00	0	0	43	127	115	48	0	39	25	30	51

TABLE A-31: NA3-160 MIN (R060_800DR3.5e_160_FP471.5_P1_20081215)

1 in X chance per year	Peak Elev	Storage	Peak Unreg Inflow	Peak Regulated Inflow	Peak Discharge	Crest Overflow	Amount above top of dam	Duration Pool >= PE 480.5 ft	Duration Pool >= PE 471 ft	Duration Pool >= PE 466 ft	Event Total Duration Q >= 115 tcfs	Main Wave Duration Q >= 115 tcfs	Event Total Duration Q >= 160 tcfs	Main Wave Duration Q = 160 tcfs	Event Total Duration Q >= 200 tcfs	Event Total Duration Q >= 300 tcfs	Max ROI 160-220k cfs	Max ROI >220k cfs
	Ft	TAF	Ft	cfs	cfs	cfs	ft	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	Hrs	cfs	cfs
1.01569	386.34	290.07	5000	6419	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.2977	398.86	365.50	20002	20133	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.4393	402.75	391.34	25004	24305	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.5655	405.77	412.26	29000	27959	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
1.8517	411.50	453.90	37002	35274	2000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
2	412.98	465.10	40722	38674	8916	0	0.00	0	0	0	0	0	0	0	0	0	0	0
5	416.16	489.65	90369	84059	50000	0	0.00	0	0	0	0	0	0	0	0	0	0	0
10	424.05	553.36	136522	126249	65753	0	0.00	0	0	0	0	0	0	0	0	0	0	0
15	428.30	589.62	167533	154598	84559	0	0.00	0	0	0	0	0	0	0	0	0	0	0
20	429.46	599.84	191482	176491	115000	0	0.00	0	0	0	23	23	0	0	0	0	0	0
25	432.18	624.13	211227	194541	115000	0	0.00	0	0	0	31	31	0	0	0	0	0	0
35	437.35	671.86	243016	223601	115000	0	0.00	0	0	0	45	45	0	0	0	0	0	0
50	443.50	730.90	279485	256938	115000	0	0.00	0	0	0	61	61	0	0	0	0	0	0
65	448.76	783.26	308218	283204	115000	0	0.00	0	0	0	80	80	0	0	0	0	0	0
80	452.90	825.76	332148	305080	115000	0	0.00	0	0	0	116	116	0	0	0	0	0	0
100	**459.22**	**892.62**	**359078**	**329825**	**115000**	**0**	**0.00**	**0**	**0**	**0**	**129**	**129**	**0**	**0**	**0**	**0**	**0**	**0**
130	467.26	980.92	392399	360850	115000	0	0.00	0	0	19	144	144	0	0	0	0	0	0
150	463.02	933.87	411351	381289	160000	0	0.00	0	0	0	140	125	27	28	0	0	0	0
175	467.04	978.39	432395	407507	160000	0	0.00	0	0	14	147	134	31	32	0	0	0	0
200	**470.56**	**1018.21**	**451163**	**429875**	**160000**	**0**	**0.00**	**0**	**0**	**36**	**155**	**142**	**33**	**34**	**0**	**0**	**0**	**0**
225	472.71	1042.91	468139	448786	160000	0	0.00	0	0	49	162	151	31	32	0	0	0	0
250	474.90	1068.38	483665	465352	160000	0	0.00	0	0	55	168	158	33	35	0	0	0	0
325	477.32	1096.76	523757	506439	214967	0	0.00	0	0	57	173	162	42	17	18	0	40	0
400	477.15	1094.84	556967	540033	310772	0	0.00	0	0	47	172	162	47	16	24	11	89	15
500	477.79	1102.40	594159	577133	420080	0	0.00	0	0	34	187	163	52	16	27	14	125	96

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Subappendix 5. Hydraulic

Sacramento River Bank Protection Project
Final Hydraulic Appendix

Todd Rivas

August 01, 2011

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Revised December 19, 2013

Table of Contents

1. Introduction and Authorization

The Sacramento River Bank Protection Project (SRBPP) is an erosion control project for the protection of the existing levees (including bank protection) and flood control facilities of the Sacramento River Flood Control Project (SRFCP). This project was originally authorized in 1960 and has included subsequent authorizations and phases. The original Phase II authorization was in 1974. The original linear feet of bank protection authorized for Phase II is nearing completion. Congress has authorized an additional 80,000 linear feet of erosion control work for Phase II per the Water Resources Development Act (WRDA) 2007. To construct this additional 80,000 linear feet authorized by congress, the Sacramento District of the United States Army Corps of Engineers (USACE) is developing a programmatic Post Authorization Change Report (PACR) and EIS/R (Environmental Impact Statement/Report) addressing the additionally authorized 80,000 linear feet of erosion control work. The PACR is necessary prior to constructing the 80,000 linear feet. According to USACE guidance, a PACR requires a hydraulic appendix. This hydraulic appendix is written to meet this requirement and support team efforts in preparing the PACR for constructing the 80,000 linear feet authorized by congress. The proposed new approach applies adaptive management to address cumulative hydraulic impacts as the project is implemented.

The project authorization is to reduce the risk of levee failures within the SRFCP system from erosion. The SRFCP is a dynamic system and it is not possible to predict which sites will be repaired in the future. Therefore this hydraulic appendix is programmatic and not site-specific. Site specific analysis will be conducted as part of developing site-specific Engineering Document Reports (EDR's) and Design Document Reports (DDR's) during site specific design.

2. Background Information

In the late 1800s the flood capacity of the Sacramento River and its tributaries was greatly reduced due to tailings from hydraulic mining. Hydraulic mining was officially halted in 1884 with two court cases (Woodruff v. North Bloomfield Gravel Mining Co. and People v. Gold Run Ditch and Mining Company). Levees were improperly built and rivers in the Sacramento Basin were unable to contain average year floods. It was proposed in 1880 that the state engineer take control of maintaining the drainage of the river basins, however this was never acted on by Congress. In 1894, it was suggested again that improvements to the channel of the lower Sacramento River would lower flood stages, however the construction of engineered levees on the Feather River was very important. Again, the legislature did not act on these recommendations. In 1904, another futile attempt was proposed to modify the channels of the sediment filled streams to increase slope and encourage movement of sediment from the river channel. It also proposed levees on the Yuba and Feather Rivers; however, the state did not take action. In 1905 the Rivers and Harbors Act of 1905 appointed three engineers from the Army to cooperate with the state and determine the feasibility of navigational improvements (Kochis 1963).

The California Debris Commission (CDC) was created in 1893 as part of the Rivers and Harbors Act. It was created by the Federal government and was made up of three army engineers that were appointed by the president. Minor work on debris control and Navigation were performed by the federal government prior to the creation of the CDC. In February 1900, Daguerre Point Dam was proposed on the Lower Yuba as a means to contain mining debris. The first flood control measures were first carried out in the Rivers and Harbors Act of 1910. The report is contained in House Document 81 and is from a report by the CDC. The flood control measures proposed included dredging of the Sacramento River below Cache Slough to increase channel capacity. Dredging was not performed on the Feather River even though it was included in the report (Kochis 1963).

Shortly after the 1910 flood control project approved in House Document 81 the state of California created the Reclamation Board Act of 1911. This was made up of three members appointed by the governor. The board was to examine plans for flood control and reclamation of lands in accordance with the CDC. If the Reclamation Board did not approve the plans then they could not be pursued. In 1913, the Reclamation Board's duties were more clearly defined to not include channel expansion or construction of weirs on the Sacramento River. The number of board members was also increased to seven (Kochis 1963).

In House Document 81, it suggests that the capacity of the Sacramento River at Collinsville needed to be in excess of 600000 cfs, where prior to the floods of 1907 and 1909, the capacity was recommended to be 250000 cfs. In the document, the reasoning for not simply widening the channel is articulated to be due to the need for scour flows to wash continued sediment downstream from the hydraulic mining tailings. Also, a wider channel would lower the depth of low flow events causing navigation to be an issue. As a result, the Basins surrounding the Sacramento River were investigated for reclamation. The two largest were the Sutter Basin and the Yolo Basin with 1,038,000 AF and 1,126,000 AF, respectively. Evaluation of the capacity needed in the river at various points showed that it needed a much greater capacity than was there at the time (Stimson 1911).

Table 1: Channel Capacity at locations along the Sacramento River

Localities	Distance	Capacity, cfs (1911)	Capacity, cfs (required)
Chico Landing	202	235000	235000
Colusa	151	70000	250000
Knights Landing	94	25000	250000
Below Feather River	81	65000	450000
Below American River	62	80000	525000
Below Cache Slough	16	165000	600000

The bypass system was first proposed in 1894 by Marsden, Manson, and Grunsky who were consultants to the commissioner of public works. This bypass system using the reclaimed basins along with channel improvements to various reaches along the Sacramento River, Feather River, Yuba River and smaller tributaries became the foundation for the Sacramento River Flood Control Project (Stimson 1911). Overtime the bypass system developed into the SRFCP with recommended freeboard requirements described in what is now known as the 1957 Profiles. These profiles describe the minimum freeboard required for the design discharge for each segment of the SRFCP which include SRBPP project sites. Please see appendix B for more information on the development of the 1957 profiles.

3. Cumulative Hydraulic Impacts of the Project

Construction of a repair site is likely to alter the hydraulics at least locally to some degree. Whether the effect on the hydraulics is significant or not depends on the site specific conditions and the characteristics of the repair. Even if the changes to the hydraulics are local and not significant from construction of a particular repair site, a series of repairs in the same general vicinity over time could together alter the hydraulics significantly leading to a cumulative hydraulic impact. For this report a cumulative hydraulic impact will be defined as a significant hydraulic effect resulting from implementing a single project action or a collection of project actions measured from a common baseline hydraulic condition. These actions can include actions from multiple projects and entities that are spatially and temporally distinct. However, for this project the focus will be on the cumulative hydraulic impacts from implementing this project. It is important to consider the cumulative hydraulic impacts of the Phase II additional 80,000 LF to ensure the SRFCP continues to operate according to design without increasing flood damage risk.

3.2. Current Cumulative Hydraulic Impacts Approach.

Recently potential cumulative hydraulic impacts on water surface elevation for the design discharge have been addressed by ensuring the water surface elevation does not increase within the project site by more than 0.1 feet. The value of 0.1 feet was selected based on engineering judgment and is a conservative estimate of the limit of hydraulic model accuracy. Anything below 0.1 feet can be reasonably interpreted as model “noise.” By limiting the changes to within the project site and to a relatively small value, the cumulative hydraulic impacts on water surface elevation from multiple repair sites in the same vicinity over a period of time can be reduced.

The advantage of this approach is that it can be implemented relatively easily and quickly at a low cost. A disadvantage is that the approach does not robustly model multiple actions to accurately reflect the actual cumulative hydraulic impacts from previous actions. Another disadvantage is that this approach does not measure affects from a baseline condition, making it very difficult to ensure that there really is no significant cumulative hydraulic impacts.

3.3. Proposed Cumulative Hydraulic Impacts Approach

The proposed new approach applies adaptive management to address cumulative hydraulic impacts as the project is implemented. To measure cumulative hydraulic impacts, a baseline condition needs to be established from which hydraulic changes can be measured. To establish a baseline hydraulic condition it is proposed that a current hydraulic model of the SRFCP system be developed based on the best available information. This model will then become the baseline hydraulic condition from which to measure cumulative hydraulic impacts of the project.

Changes to the system from project implementation will be added to the baseline model incrementally as construction is completed. New project actions will incorporate the proposed action into this updated hydraulic model and analyze the results to estimate if there are any significant negative cumulative hydraulic impacts from implementing the proposed action. The model with the proposed actions included will serve to estimate the cumulative hydraulic impacts up to that point of project implementation. Any proposed actions that are estimated to trigger negative cumulative hydraulic impacts will be either modified to avoid negative cumulative hydraulic impacts or the negative cumulative hydraulic impacts will be mitigated. An updated cumulative hydraulic impacts analysis will be conducted and reported in each site-specific EDR that is developed during project implementation.

The actual data used to develop the model will be determined in the future. However, a good initial candidate for the source of some of this data is from either the Comp Study or from new efforts by the State of California to collect recent topography data (including bathymetry) and develop new hydrology. It may be necessary to collect new topography data and/or develop new hydrology for some reaches.

It is proposed that the 1-dimensional (1D) HEC-RAS hydraulic model environment be used for estimating cumulative hydraulic impacts. There are 2-dimensional (2D) hydraulic models available. However, they can be computationally intensive and may not provide a lot of additional benefit compared to the effort for a system-wide cumulative hydraulic impacts analysis. It should be noted that the 2D hydraulic models may be used for site-specific design and analysis for smaller scale hydraulic impacts. The cumulative hydraulic impacts analysis is more concerned with larger scale changes to the system, not reach and local scale effects.

The advantage of the proposed approach is that it estimates the cumulative hydraulic impacts from a baseline condition in a manner that incorporates past project actions. In addition, it uses the best available information and hydraulic modeling to accurately measure the cumulative hydraulic impacts of the project on the SRFCP as it is implemented. This allows the project to adjust as needed to eliminate or reduce negative cumulative hydraulic impacts. The disadvantage is that this approach does not necessarily include effects from actions outside of the SRBPP project. Another disadvantage is that a 1D model may not accurately portray 2D and 3D processes. A third disadvantage is that it is more resource intensive than the current approach to cumulative hydraulic impacts. It should be noted that this approach can only be implemented if resources are available.

3.4. Significant Cumulative Hydraulic Impact Threshold

As noted earlier, construction of repair sites is likely to alter the hydraulics to some degree at some scale. A threshold could be reached where the magnitude of the cumulative changes from project implementation endangers the original design of the SRFCP. In general terms, this threshold is when the cumulative hydraulic impacts from project implementation significantly increases the flood damage risk at some point within the system. In all cases, the term “significant” is subjective. Based on engineering judgment and consistent with how cumulative hydraulic impacts are currently addressed, it is proposed that a significant cumulative hydraulic impact be defined as a greater than 0.1 foot change in the water surface elevation for the design discharge at any given point in the system. However, if the project can demonstrate that a greater than 0.1 foot change in the water surface elevation for the design discharge at any point does not alter the flood damage risk at any point of the SRFCP, than that particular cumulative hydraulic impact will not be considered significant. One possible example is to demonstrate that the 90% confidence interval high and low estimate of the water surface is still below the freeboard requirement for the design discharge and the probability of failure at the location is unchanged.

Therefore, even though the best estimate of the cumulative hydraulic impacts exceeds the 0.1 foot threshold, it may be concluded that the level of flood damage risk is unchanged and it is not a significant cumulative hydraulic impact.

4. Sea Level Change

The USACE EC-1165-2-211 requires all USACE coastal activity within the extent of the estimated tidal influence be considered for relative sea-level change effects. The southern portion of the project is within the estimated extent of the tidal influence and therefore sea level change needs to be considered for these areas. For this programmatic analysis, the extent of the project within the estimated tidal influence subject to potential sea level rise needs to be determined. Sites within this extent will need further site-specific sea-level change analysis. Sites outside the extent of the estimated tidal influence from sea level rise will not need a site-specific sea level change analysis. Changes in relative sea level could impact hydraulic, geotechnical, economic, real estate, and environmental analysis and considerations of the project. An analysis was conducted to determine this extent and a report written and included in Appendix A. The report focuses on the hydraulic considerations and provides information for other disciplines to include in their analysis and documentation.

The southern portion of the SRBPP project is subject to tidal affects and the range of potential sea level rise at the downstream (southern) boundary is estimated to be between 0.42 feet (low estimate) and 2.79 feet (high estimate) between 2013 (estimated construction start) and 2075 (50 years from estimated construction end in 2025).

The high and low value estimate of potential future sea level change determined in accordance with EC-1165-2-211 was used to modify the Common Features HEC-RAS model to estimate the extent of potential sea level change within the life of the project at a programmatic scale. This analysis was conducted for the 1% (100-year) flood and 50% (2-year) flood in order to approximate a reasonable range of conditions. The 1% flood is representative of design conditions and the 50% flood is included to consider potential environmental impacts.

The analysis indicates that the high estimate of potential sea level change (2.79 feet) increases the water surface elevation by greater than 0.1-foot for the areas shown in table 2 and figure 3. The 0.1 foot value was used as the smallest reasonable value for detecting meaningful changes in water surface elevation similar to what is described in the section on Cumulative Hydraulic Effects (section 4).

Table 2. Summary Table of Reaches Affected by Sea Level Change High Estimate

50% flood (2-year)

Reach	Area Affected
Sacramento River	USGS River Mile 48.85 (Downstream of River Landing Drive in the Pocket Area of Sacramento) to the downstream end
Yolo Bypass	2.4 miles south of Delhi Road on Solano County Road 5190C to the downstream end
DWSC	Entire Reach
Lindsey Slough	Entire Reach
Cache Slough	Entire Reach
Haas Slough	Entire Reach
Horseshoe Bend	Entire Reach
3 Mile Slough	Entire Reach
Georgiana Slough	Entire Reach
Miner Slough	Entire Reach
Steamboat Slough	Entire Reach
Sutter Slough	Entire Reach

1% flood (100-year)

Reach	Area Affected
Sacramento River	USGS River Mile 50.85 (Downstream of Dumfries Court in the Pocket Area of Sacramento) to the downstream end
Yolo Bypass	0.1 miles South of Yolo County Road 155 and 104 intersection to the downstream end
DWSC	Entire Reach
Lindsey Slough	Entire Reach
Cache Slough	Entire Reach
Haas Slough	Entire Reach
Horseshoe Bend	Entire Reach
3 Mile Slough	Entire Reach
Georgiana Slough	Entire Reach
Miner Slough	Entire Reach
Steamboat Slough	Entire Reach
Sutter Slough	Entire Reach

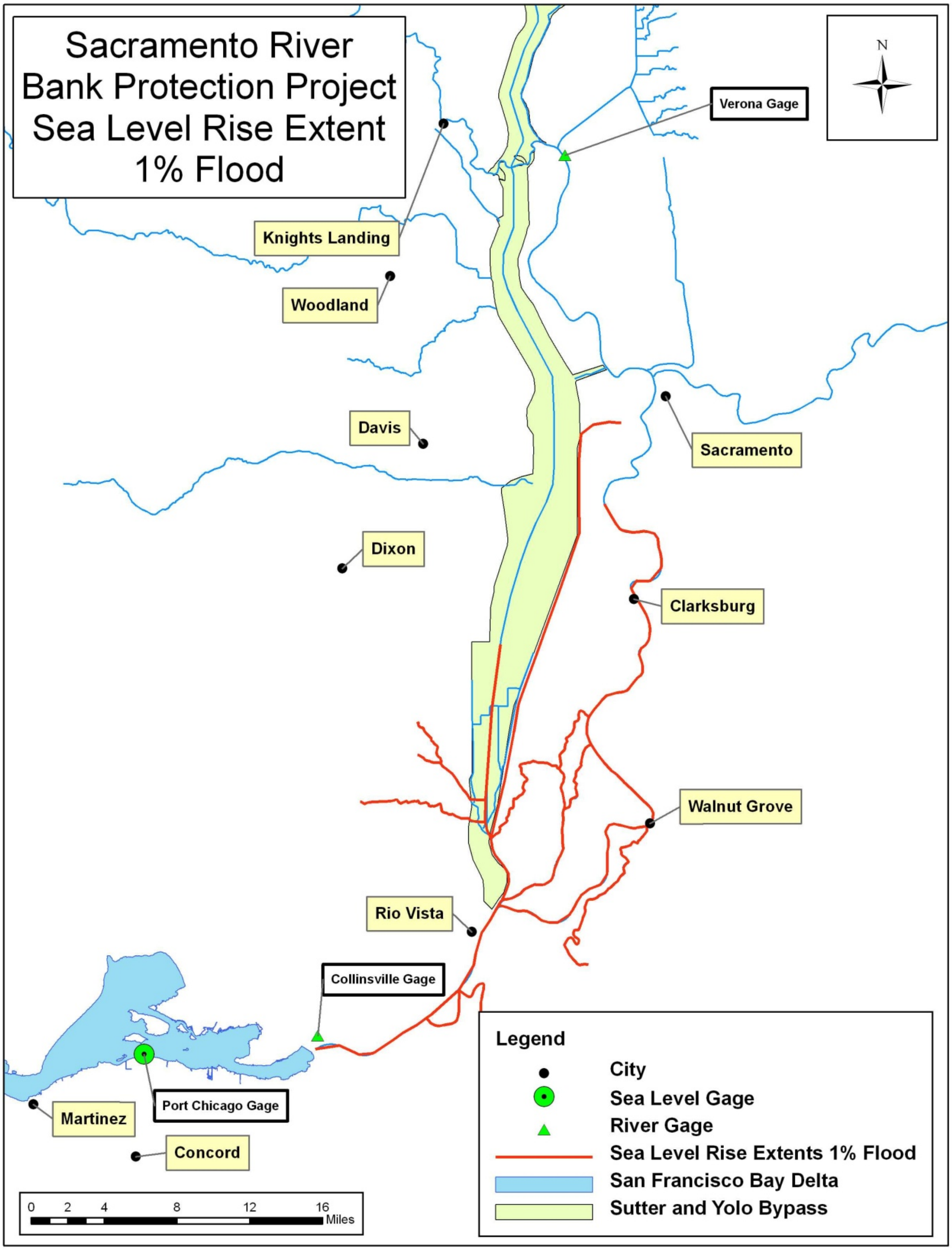

Figure 1. Maximum Estimated Extent of Sea Level Rise – 1% flood

The Yolo bypass and Sacramento River upstream limit of affects was increased by approximately 2 miles from the analysis results to provide a conservative estimate of the upstream limit of future sea level change impacts. Future erosion repair sites outside this adjusted area of potential sea level rise impacts shown below in table 3 will not need to incorporate sea level change into site specific analysis and design. Future erosion repairs within this adjusted area shown in table 3 will need to address sea level change in their site specific analysis and design.

Table 3.Adjusted Areas Potentially Affected by Sea Level Change

Reach	Area Affected
Sacramento River	Downstream of USGS River Mile 57.5 (Deep Water Ship Channel and Sacramento River intersection in the city of West Sacramento) to the downstream end of the channel at the Collinsville Gage in the Delta
Yolo Bypass	Downstream of Yolo County Road 152 to the downstream end of the channel
DWSC	Entire Reach
Lindsey Slough	Entire Reach
Cache Slough	Entire Reach
Haas Slough	Entire Reach
Horseshoe Bend	Entire Reach
3 Mile Slough	Entire Reach
Georgiana Slough	Entire Reach
Miner Slough	Entire Reach
Steamboat Slough	Entire Reach
Sutter Slough	Entire Reach

The requirements of EC-1165-2-211 apply to this federal project but are different than the state of California requirements and procedures for addressing sea level change. Both procedures yield similar numbers for the high sea level rise estimate. Since the high estimate provides the maximum estimated extent of sea level rise, the differences in the procedures are not significant. In fact, the USACE procedure provides a slightly more conservative estimate of the geographic extent of sea level rise than the state guidance.

A preliminary programmatic stone protection analysis indicates that sea level change is not likely to impact the size and gradation of stone protection. This is discussed in more detail in Appendix A. However, the site specific hydraulic analysis should consider addressing future local changes to stage, velocity, wave characteristics, and other site-specific hydraulic considerations for these reaches affected by sea level change.

5. Hydraulic Analysis and Design Considerations

The repair sites for the SRBPP will be analyzed and designed at a site specific level. The hydraulic analysis and design considerations included in this report are programmatic in nature and do not necessarily apply to every site. Similarly, there may be other hydraulic analysis and design considerations that need to be considered for a particular site that are not mentioned in this report. The information in this report does not prescribe or limit the hydraulic analysis and design considerations for site specific design. This will be determined on a case by case basis. This report simply outlines the hydraulic considerations that may be included in site specific design and analysis and how they could be included in general terms.

The without project condition will be analyzed using the baseline hydraulic model used for estimating the cumulative hydraulic impacts as described in section 3. The with-project conditions will use the hydraulic model used for estimating the cumulative hydraulic impacts as described in section 3. The cumulative hydraulic impacts model is the without project conditions model (the baseline model) with the addition of all implemented project features as of the date of the analysis. This approach provides a way to adaptively compare the with-project and the without project conditions as the project is implemented.

The scale of the hydraulic analysis will consider the level of risk and cost of the analysis and the anticipated repair construction cost. For example, an expensive, thorough, and detailed data collection and analysis effort may not be warranted for lower risk repairs that are relatively inexpensive. Further, it is imprudent to spend more money collecting data than the entire cost of the repair. In these situations, a less robust hydraulic analysis will likely occur. In general it is anticipated that a 2D hydraulic model based analysis is needed for most repair sites to assess changes in flow patterns and hydraulics due to the repair. However, for smaller channels and some other conditions a 1D hydraulic model based analysis may be appropriate. The level of analysis conducted for each repair site will be determined on a case-by-case basis using engineering judgment considering risk, funding, repair costs, and other considerations.

Some of the hydraulic considerations occur at the reach scale while others are more appropriately considered at the smaller local scale. Generally the reach scale considerations will be addressed in the site-specific EDR's (Engineering Document Reports) while the local scale considerations will be addressed in the site-specific analysis and design leading to plans and specifications, such as in the DDR's (Design Document Report's). Currently repair sites only have a DDR for the repair sites and generally only consider local scale hydraulic analysis. Future repairs conducted for the SRBPP Phase II additional 80,000 linear feet will consider both the reach and local scale factors in their hydraulic analysis as determined appropriate using engineering judgment.

5.2 Reach Scale Hydraulic Analysis and Design Considerations

Currently repair measure selection and design generally only consider local scale hydraulic factors. However, there are times where reach scale issues are a significant issue contributing to erosion at an erosion repair site. Therefore, reach scale issues will be addressed to best select and design erosion repairs as part of the SRBPP Phase II additional 80,000 LF implementation. It is generally anticipated that larger scale issues will be addressed in the site specific EDR. Some of these reach scale issues include operation of weirs, channel stability and sediment trends, river meander migration and cut-offs, and reservoir operations. However, there could be other issues that are identified and addressed during site specific analysis and design.

5.2.1. Weir and Flow Splits

The SRFCP operates as a system with a series of connected channels and bypasses. The bypasses are designed to divert flood flows from the main channel of the Sacramento River into either the Sutter or

Yolo Bypass. The intent is that the water diverted from the main channel of the Sacramento River reduces flood damage risk along the Sacramento River. Changes such as topography and vegetation in the vicinity of the weirs that control the flow into the bypasses could alter the flow splits between the main channel and the bypasses. This could increase flood damage risk for the portions of the SRFCP that experience greater flows as a result of the changes. Such a change could be a setback levee in the vicinity of a weir that reduces the water surface elevation for flood flows. This increases the proportion of the flow that continues in the main channel of the Sacramento River. Options for repair measures of erosion sites could be limited for this reason in the vicinity of the weirs. This will be addressed as needed during site development and selection of repair measures such as in the site specific EDR

5.2.2. Channel Stability and Sediment Trends

Reach scale channel instability and sediment trends could be a significant factor affecting erosion at a repair site. Repair sites could be located in a reach of a channel that is unstable. Repairs in unstable reaches need to be analyzed at a reach scale to ensure the repair does not contribute to further instability in the reach. This includes a repair contributing to creation of new or further degradation of existing erosion sites. A good indication of channel instability could be the presence of a lot of historical repair sites clustered in the same vicinity. This would indicate that larger scale reach hydraulic analysis is needed.

Similarly, large scale sediment trends could be contributing to erosion at a repair site. For example, a repair site could be located in a predominantly aggregating reach located downstream of a reach that is predominantly degrading. This point could potentially experience large amounts of deposition that could force the main channel against the bank, contributing significantly to erosion at the site. Similarly, a site in a predominantly degrading reach could be subject to erosion caused as the channel incises and erodes outward toward the channel banks. The selection and design of repair measures needs to adequately address reach scale channel stability and sediment trends to maximize the effectiveness of the repair.

5.2.3 River Meander Migration and Cut-offs

River channels tend to develop looping “S” patterns called meander bends when looking from above. These meanders bends tend to move downstream over time. If a meander bend makes too “sharp” of a turn, it becomes more efficient for the water to move in a generally straight line across one of the “C” shaped meander bends. Eventually the straight line portion of the flow becomes the predominant channel and the “C” portion becomes abandoned and gradually fills in. The formation of the straight line portion of the flow is generally called a “cut-off. “ The migration of the meander bends downstream and the formation of “cut-offs” can significantly alter the hydraulic conditions at repair sites over the life of the project. Repair sites located in channels with active meander bend and cut-off processes need to account for changing hydraulic conditions during the life of the project when selecting and designing the repair measure. This may include need to expand the study area to include more of the channel to adequately address possible changing hydraulic conditions. The potential for river meander migration and cut-offs will generally be addressed during site selection and development of the site specific-EDR.

5.2.4. Reservoir Operations

Reservoir Operations need to be considered when selecting and designing repair alternatives. Over time, consistent reservoir operations are included in the hydrologic record and the channel reaches a state of dynamic equilibrium. These conditions may be fairly accurately represented in hydraulic models. If the operation of a reservoir is altered significantly, however, the channel may undergo significant and rapid changes before reaching a new state of dynamic equilibrium. If it can be reasonably anticipated that a reservoir that controls flows in the channel of a repair site may be altered in the future, a conservative selection and design of a repair measure is needed that addresses the changed reservoir operation. Often times changes to reservoir operations may induce channel instability which was discussed previously. Therefore, hydraulic analysis for repair measure selection and design needs to include possible future changes to reservoir operations and the resulting channel behavior.

5.2.5. Other Reach Scale Hydraulic Analysis and Design Considerations

There could be other reach scale hydraulic analysis and design considerations. One example is the narrowing of a channel from one reach to another. The narrowing of the reach would tend to cause erosion as the water moves through the narrower reach at a higher velocity, contributing to additional erosion. Such sites may benefit from a setback levee that allows the channel to flow unrestricted at a lower velocity. This and other reach scale considerations will be addressed during selection and design of repair measures.

5.3. Local Scale Hydraulic Analysis and Design Considerations

5.3.1. Levee Height and Design Discharge

The SRBPP does not modify the height of levees but seeks to reduce flood damage risk from erosion for existing levees in the SRFCP. Furthermore, the SRBPP assumes any reduction in levee crown elevation will be regularly repaired as part of maintenance. This assumption is consistent with USACE policy and project documents. According to 33 CFR 208.10, cited in every project Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRRR) Manual:

> "(b) Levees (1) Maintenance: Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that: (i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place."

Also, the current SRBPP OMRRR manual states that "immediate steps will be taken to correct dangerous conditions disclosed by such inspections" (USACE). For that reason, assuming the levee height is maintained to its original design elevation is a valid assumption for hydraulic analysis and design of SRBPP repairs. If this assumption is not correct, the levee height needs to be addressed in accordance with the OMRRR manual and not the SRBPP project.

The SRBPP is part of the SRFCP and the design discharges are described in the 1957 profiles. Similar to levee height, the SRBPP is not involved in changing the design discharge. The 1957 profile describes a design discharge and a minimum freeboard for that discharge. Assuming the SRFCP is designed and constructed originally to convey the design discharges and maintain the minimum freeboard of the 1957 profile and is maintained to these conditions, the SRBPP does not need to check the absolute values of the 1957 profiles. The project can focus on the relative hydraulic changes. Therefore, the SRBPP will check for changes in the estimated water surface elevation for the design discharge. In addition, the project will check on a site specific basis changes to other hydraulic characteristics that need to be considered. These may include changes in flow patterns, velocity distribution, sedimentation, and other hydraulic characteristics. Some of these considerations are discussed in the reach scale hydraulic analysis and design considerations below.

5.3.1.2 Discharge for Other Considerations.

During site specific design of SRBPP, it may be advantageous to use the best available data and tools to conduct hydraulic analysis for other than design discharges. This may include more frequent events that may be important for environmental analysis and design or less frequent events considered for other purposes. In addition, this may be necessary to check for hydraulic changes at other than design flows. This may be needed because even if there are no significant changes for the design flow, there could be unintended impacts for lower flows as the flow patterns can change significantly as the stage changes. The need to analyze other flows will be determined on a case by case basis. The analysis of other than design flows will also use the best available data and tools to conduct an appropriate level of hydraulic analysis.

5.3.2. Stage, Discharge, and Velocity Considerations

Changes to water surface elevations (stage), discharge, and velocities from project implementation need to be considered during repair measure selection and design. This is typically analyzed with 1D or 2D hydraulic models during hydraulic analysis. For most sites, it is anticipated that a 2D analysis is needed to better account for changes in velocity patterns and magnitude. A 1D model tends to “average” out the changes over a larger area and does not allow for analyzing changes in flow patterns. These flow patterns can be a very important consideration during measure selection and design.

For example, a repair could encroach too far into the channel, resulting in locally increased velocities and water surface elevations leading to increased erosion. Similarly, a repair could move the point of the higher velocity closer to the opposite bank, increasing erosion pressures on the opposite bank that may or may not be adequately protected. The repairs could also redirect higher velocities against a nearby bank that may not be adequately protected. This is often seen when a new erosion site appears downstream of a recently repaired site. Even repairs that may not seem to have negative hydraulic impacts could have issues. For example, a relatively short set-back levee could induce a large eddy that reduces the effective conveyance area with similar results to a repair that encroaches too much on the channel. Another item that could affect the stage, discharge, and velocities in the vicinity of a repair site includes the hydraulic roughness. This could be due to planting new or a different type of vegetation on a repair site or removing vegetation from the repair site. This could affect the water surface elevations, discharge of the channel, and the velocities in the vicinity of the project. Hydraulic analysis will be conducted on a site-specific level during repair measure selection and design as determined by engineering judgment.

5.3.3. Rock Protection Design

While not all repairs include rock protection, those that require rock protection will need site specific hydraulic analysis to support site-specific measure selection and design of the rock protection. This includes the size and gradations for the rock used in SRBPP repairs. This may include analysis of rock to protect against erosion from channel flow, boat waves, and/or wind waves. Much of the information in this section originate from a draft, non-certified, unpublished report (USACE 2006) but is considered the best available information at this time and is appropriate for this programmatic level report since no designs decisions are being made in this report.

5.3.3.1. History of Rock Gradation for SRBPP Repairs.

Historically rock used on SRFCP has followed standardized gradations that were designed to protect against erosion from channel velocity. These were generally based on USACE studies in 1948, 1956, 1973, and 1992. The standardized gradations used in the SRFCP varied over the years starting in 1936 to present. A significant revision of the rock size and gradation occurred in 1974. This resulted in two standard rock gradations that were used on SRBPP projects until about 2006. These gradations are shown below in table 4 and table 5 and both used a filter for the design.

Table 4. 1974 Standard 160 lb Rock Gradation

Stone Weight (lbs.)	% Smaller by Weight
160	100
100	80-95
50	45-80
20	15-45
5	0-15

Table 5. 1974 Standard 200 lb Rock Gradation

Stone Weight (lbs.)	% Smaller by Weight
220	100
176	85-100
110	60-85
55	35-65
22	15-35
11	0-15

In 2006 USACE developed a new gradation launchable rock gradation for Sacramento River USGS mile 40 to 60 left bank based on EM 1110-2-1601 shown in table X below. The motivation for the design appears to be to account for recreational boat and wind caused wave erosion. This is a significant addition to previous designs that were only designed to protect against erosion from channel velocity. It appears that wind waves controlled the design for this section of the river.

The 2006 recommended gradation uses extra thickness that does not require a filter if designed and constructed properly. This typically means it needs to have a thicker section of rock than with an equivalent design that uses a filter (typically 2.5 – 4 times thicker). A thickness of 5 feet was selected for a design thickness of 1.5 feet. Also, for underwater placement, it is recommended to increase the volume by 50%.

Table 6. 2006 Recommended Rock Gradation.

Stone Weight (lbs.)	% Smaller by Weight
400	100
250	70-100
100	50-80
30	32-58
5	16-34
1	2-20
Less than ½" max. dimension	0-10

There is another gradation that was developed specifically for the Deep Water Ship Channel shown below in table 7. It is not clear how or when this gradation was developed but USACE 2006 states it is to be used for all slopes facing the Deep Water Ship Channel.

Table 7. Deep Water Ship Channel Gradation

Stone Weight (lbs.)	% Smaller by Weight
1,300	100
1,000	80-90
500	50-70
100	10-30
50	0-10

5.3.3.2. Current and Future Rock Protection Gradations for SRBPP Repairs.

Subsequently to the 2006 recommended gradation, plans and specifications for construction have included and/or adapted this gradation for use in soil filled quarry stone. Soil filled quarry stone is a mixture of the rock gradation and soil such that the rocks maintain three-points of contact with other rock and the entire mass is 70% rock and 30% soil by volume. This implies that the void ratio (volume of the voids divided by the volume of the rock) for the rock is over 40%. This seems unreasonably high and other USACE engineers agree this is an unreasonably high void ratio that is not possible to construct. The result is that it is unlikely that sites constructed to these specifications do not have a majority of the rock in three-point contact as intended. This could lead to faster erosion of the repair and reduce the effectiveness of the repair. The addition of the soil to the quarry stone does not appear to be documented in any design document report (DDR) or similar document. However, it does appear future repairs should reconsider the proportion of the rock to the soil and the intent of the design. It is likely that the proportion of the mixture that is soil will be reduced on future repairs significantly in the future compared to repairs constructed from 2006 to present.

In addition to the rock and soil proportion concern, some designs have altered the proportion of the smaller particles in the gradation and soil properties in an effort to reduce erosion from high water. These changes are documented in individual site-specific DDR's. Any modification to the gradation in future repairs will similarly be documented in a site-specific EDR or DDR.

Another concern with the use of the 2006 recommended gradation is that it was developed for the Sacramento River for USGS river miles 40 – 60 but is applied outside of this reach. While it may be applicable in other situations, this has not been checked. In particular, since wind caused waves controlled the size of the rock for the gradation, it is expected that channels further downstream would require even larger rock size as the wind waves are significantly larger. In addition, they could be subject to large ship traffic similar to the Deep Water Ship Channel. Also, repair sites at other locations could be subject to higher velocities than included in the 2006 recommended gradation. Since channel velocity did not control for Sacramento Rive USGS river mile 40 – 60, this may not be an issue, but it should be checked. In any case, the sizing and gradation of rock for rock protection will be a site-specific design that considers protection from channel velocity as well as wind and recreational boat waves for inclusion in future SRBPP repairs based on an appropriate level of analysis.

5.3.4. Other Hydraulic Considerations

There are other local scale hydraulic considerations that may be included in hydraulic analysis based on engineering judgment. For example, the transitions of repairs should be designed to provide a smooth hydraulic transition and avoid abrupt changes that can contribute to local erosion and sedimentation issues and possibly endanger the functionality of the repair. In addition, the elevation of the top of the rock protection and the upstream and downstream extents of the rock protection needs to be informed by the hydraulic analysis. Another consideration is sedimentation and/or erosion and/or scour near structures within the repair site. For example, repairs could contribute to sedimentation of pumps or contribute to erosion that could threaten the integrity of the SRFCP or nearby structures. These could include water intake and discharge facilities, bridges, docks, pipelines, and similar structures. These details and other items will be included and addressed as needed in hydraulic analysis in support of site-specific measure selection and design as needed based on engineering judgment.

6. Inundation Area Estimate for Project Benefit and Cost Analysis

The Sacramento Bank Protection Project is dynamic and it is not possible to determine exact location of repairs, repair alternative, or timing of repair construction. However, the type of project authorization (Flood Damage Risk Reduction) requires that an economic analysis be conducted that includes a benefit to cost ratio. Therefore, a coarse scale economic analysis was conducted using a representative selection of 101 sites with representative repair alternatives assumed to be implemented over the life of the Phase II 80,000 LF portion of the project. It should be noted that the project is only authorized to protect banks from erosion only and not other mechanisms such as seepage. One challenge in developing the economic analysis is that there is not enough reliable scientific information available to determine inundation areas from erosion only caused levee failure. The team decided to use a coarse scale economic analysis using the representative sites to develop a project wide benefit to cost ratio. The team decided to use the inundation areas developed as part of the 2002 Comprehensive Study (Comp Study) and that the economic analysis would not be used to screen sites for construction. This approach has a number of advantages described below:

I. The inundation areas have been developed and are readily available
II. The inundation area development uses a consistent approach applicable for large scale rough analysis like this large scale economic analysis.
III. The hydrology for the inundation area development has been mostly certified for the Comp Study
IV. The hydraulic models used for estimating the inundation areas are calibrated to known events.

However, using the Comprehensive Study data also has some disadvantages. These include:

I. Inundation areas may not be based on the most recent and/or accurate hydraulic model available.
II. The inundation areas do not assume failure of levees by erosion only. This introduces inconsistency to the economic analysis and likely overestimates damages.

Inundation areas from the USACE included multiple storm centerings and requires that the data be processes so it can be used readily for economic analysis. A contractor for DWR combined storm centerings and processed the Comp Study floodplains for economic analysis for another project. The team decided that the DWR contractor data modified for economic analysis was the most suitable inundation areas for use in a rough large scale economic analysis for the project and provides acceptable results for this coarse level of analysis. This is because the inundation areas are:

I. Based on relatively recent and consistent hydraulic modeling
II. Calibrated to known events
III. Based largely on certified hydrology
IV. Based on multiple storm centerings where deemed reasonable, providing a better overall picture of the damages.
    a. The DWR contractor modified the inundation areas by using only the greatest depth for any location from the multiple storm centering.
V. Based on a dataset that is in a format readily available for economic analysis.

The results are only appropriate for a rough scale project-wide economic analysis for estimating the project's overall benefit to cost ratio. The results should not be used to screen damage areas from future project actions or individual sites from future construction.

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Appendix A, Final Sea Level Change Analysis Report

1. Introduction and Authorization

The Sacramento River Bank Protection Project (SRBPP) is an erosion control project for the protection of the existing levees (including bank protection) and flood control facilities of the Sacramento River Flood Control Project (SRFCP). This project was originally authorized in 1960 and has included subsequent authorizations and phases. The original Phase II authorization was in 1974. The Sacramento District of the United States Army Corps of engineers (USACE) is developing a programmatic Post Authorization Change (PAC) document and EIS/R (Environmental Impact Statement/Report) addressing the additionally authorized 80,000 linear feet of erosion control work to Phase II of erosion as per the Water Resources Development Act (WRDA) 2007. The project authorization is to reduce the risk of levee failures within the SRFCP system from erosion.

2. Objectives and Scope

Recent research indicates continued or accelerated rise in global mean sea level height based on decades (and in some cases centuries) of measurements. Climate change has been identified as a likely cause of the increase in global sea level height by many researchers but is still subject to spirited debate. However, the reality of the observed rise in global sea level height at project specific locations and local vertical land movement needs to be adequately addressed by projects in and near coastal areas regardless of the causes.

EC-1165-2-211 “Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs” was enacted July 1, 2009 to provide guidance for “incorporating the direct and indirect physical effects of projected future sea-level change in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects.” EC-1165-2-211 requires all USACE coastal activity within the extent of the estimated tidal influence be considered for relative sea-level change effects.

The state of California requirements and procedures for considering sea level rise are not the same as the requirements and procedures outlined in EC-1165-2-211. The reader is referred to the state of California for the most recent requirements and procedures for projects subject only to the requirements of the state of California. However, this is a federal project subject to the requirements of EC-1165-2-211.

The downstream (southern) boundary of the SRBPP project ends in the San Francisco Bay Delta (Delta) as shown in figure 1. The Delta is subject to ocean tidal fluctuations, influence, and any potential sea level change. This impacts the hydraulics of project channels upstream of the Delta for some distance. Therefore, a sea level change analysis is needed to determine the impacts of sea level change on the SRBPP Phase II additional 80,000 linear feet PAC and EIS/R documentation. The Sacramento River at the

Collinsville gage is selected for the downstream boundary of the analysis because it matches existing hydraulic models and has available data necessary for the analysis. See Figure 1 for a map for the area considered in this analysis.

The purpose of this report is to analyze the upstream effects from estimated future changes (increases or decreases) in the downstream sea level elevation on the SRBPP in accordance with EC 1165-2-211. This will be included in the Phase II 80,000 linear feet authorization PAC and EIS/R documents. The PAC and EIS/R documents are programmatic and will be followed by appropriate site-specific engineering document reports (EDR's), designs, and accompanying environmental documentation. Therefore, this analysis is programmatic in nature and subsequent site-specific sea level change analysis and documentation may be needed.

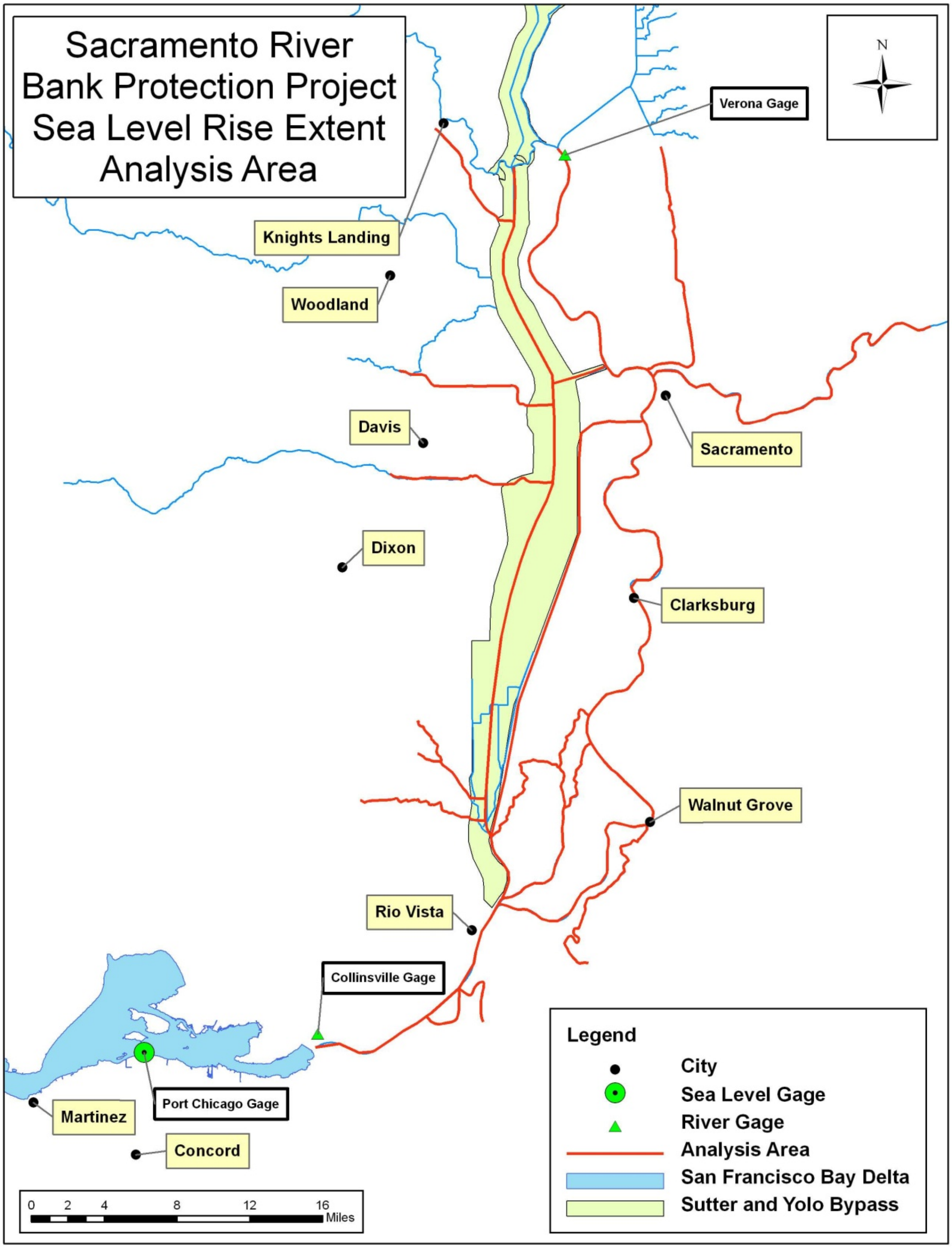

Figure 1: Map Showing Analysis Area

3. Potential Effects of Sea Level Change on the Project

EC 1165-2-211 requires that relative sea level change be considered. This includes both changes in sea level and the adjoining land elevations. Changes in relative sea level could impact hydraulic, geotechnical, economic, real estate, and environmental analysis and considerations of the project.

3.1 Hydraulic Considerations

Sea level changes could affect stages (water surface elevation), velocity magnitude and directions, and wave characteristics. In general, it would be expected to slow down velocities in the vicinity of the sea level rise due to backwater effects. The elevation of the top of the bank protection depends on the water surface elevation and the anticipated wave heights. Wave heights are a function of the fetch (the length of water over which a given wind has blown) and sometimes depth of the water over which the wind blows. Therefore, an increase in sea level could also lead to higher wave heights (from longer fetches or greater depths) in addition to needing the bank protection to be raised based on sea level rise alone. However, the increase in wave height from increased fetch and depth may be insignificant.

3.2 Geotechnical Considerations

3.2.1 Subsidence

Subsidence is a concern in the Sacramento-San Joaquin Delta. Subsidence of land is caused by decomposition of organic carbon in peat soils. The decomposition is occurring due to tilling/burning of soils, erosion by wind or water, lowering of water surface elevation and compaction/desiccation of organic soils with high saturated water contents (USGS/SF Estuary and Watershed Science). These factors contributing to subsidence occur as a result of agricultural practices. Therefore, agricultural areas are subject to subsidence. These agriculture practices do not occur on the levee so the levee is not generally subject to subsidence. However, the levee foundation (or possibly the levee itself) may consolidate from the weight of the levee and other items on the levee (e.g. trees, vehicles) which leads to lowering of the levee crown elevation.

Lowering of the levee crown due to consolidation is dependent upon localized conditions and is difficult to estimate over a broad geographic area as needed for this analysis. For this programmatic analysis, it is assumed that there is no reduction in levee crown elevation due to consolidation. This assumption is not conservative from an engineering perspective but it aligns with the project's authorization and Corp's policy. It is assumed any reduction in levee crown elevation will be regularly repaired as part of maintenance. This assumption is consistent with USACE policy and project documents. According to 33 CFR 208.10, cited in every project O&M Manual:

> "(b) Levees (1) Maintenance: Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that: (i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place."

Also, the current O&M manual states that "immediate steps will be taken to correct dangerous conditions disclosed by such inspections" (USACE). For that reason, assuming the levee height is maintained to its original design elevation is a valid assumption for this analysis. It is also assumed that the channel is not subsiding (i.e. there is no large scale subsidence that would include the channel). If the above assumptions are correct, subsidence should not be a significant issue for hydraulic modeling. These assumptions are consistent with USACE policy and the project. As a result of these assumptions, for this large scale hydraulic analysis, relative sea level change is the same as sea level change. That is, the levees and channels have no vertical movement.

3.2.2 Probability of Levee Breach

An increase in water surface elevation increases the probability of levee breach due to internal erosion and slope instability. This is due to an increase in seepage forces (pore pressure) and due to an increase in the water level (phreatic surface) within the levee, which affects the seepage exit area on the landside slope of the levee. This could lead to increased probability of levee breach.

3.3 Economic Considerations

Another consideration for this study is the project's economic analysis. If consolidation does not occur but the land protected by the levee subsides, this could cause the land-side levee height to increase. If the water surface elevation also increases, there would be a greater difference between the landside levee elevation and the water surface elevation, which could increase the probability of the levee breaching in the future. Furthermore, the larger height differential could lead to greater discharges through larger levee breaches and cause increased flood depths and damages. If relative sea level change is not considered, then the damages and benefits could potentially be underestimated. Seepage and slope stability are outside the scope of the SRBPP project.

3.4 Real Estate Considerations

Sea level changes can also have an impact on Real Estate since the designs needed to address future sea level rise and subsidence may require additional real estate needs. Future repairs and/or construction may require additional real estate to address higher landside slopes and/or increased seepage. Potential items that could be incorporated into the designs include seepage berms or stability berms on the landside of the levee to stabilize its slope. In addition, future maintenance, repair, rehabilitation, and replacement activities may require additional real estate due to relative sea level change.

3.5. Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRRR) manuals

According to EC-1165-2-211, relative sea level change also needs to be considered for Operation, Maintenance, Repair, Rehabilitation, and Replacement (OMRRR). It may be necessary or most cost effective to address sea level change in the OMRR manuals rather than during initial design and construction. For example, the actual sea level change is not specifically known and it may be more cost effective to address sea level change through the life of the project as it occurs, than to overdesign the project for a level of relative sea level change that may not occur. This needs to be considered in the development of OMRR manuals for project repair sites.

3.6 Environmental Considerations

Ecosystems in the vicinity of the existing and future water surfaces could also be impacted from relative sea level changes. This could destroy, damage, or change ecosystems that are:

1) Currently infrequently inundated but would become more frequently inundated due to sea level rise,
2) Currently regularly inundated but would become permanently inundated due to sea level rise,
3) Currently regularly inundated but would become less frequently inundated due to a drop in sea level,
4) Currently shallow water habitats but would become deeper due to sea level rise,
5) Or currently deep water habitats but would become shallow water habitats due to a drop in sea level.
6) Currently exhibiting consistent salinity characteristics that would change due to a rise or drop in sea level

Sea level change therefore could potentially alter the ecosystem of the Sacramento River system, including the delta region, but these environmental impacts will be addressed in other reports.

4. Sea Level Change Analysis

4.1 Analysis Introduction

The impact of sea level change depends on the magnitude of the elevation change for a given location. The focus of this report is to develop potential hydraulic analysis considerations for the SRBPP from a large-scale programmatic level and not a detailed site specific design. The purpose of the report is to determine the potential geographic extent of the impacts of sea level change over the next 50-year life of the project, and to determine what hydraulic analysis considerations are important to address in site specific analysis and design. The use of this analysis, hydraulic model, and results are only appropriate for the large scale programmatic analysis in this report and are not appropriate for site specific analysis or decision making.

4.2 Potential Geographic Extents of Sea Level Change Estimate Procedure

4.2.1 Background of Geographic Extent Estimation

Tidal effects are generally accepted to be negligible above the Verona gage on the Sacramento River. The results from the Common Features model sensitivity analysis confirm that there are no significant tidal impacts at or above the Verona gage on the Sacramento River. A rough sea level change estimate was modeled using an existing HEC-RAS model (a 1D hydraulic model developed by USACE) developed by the Common Features Project for estimating the sensitivity of the model from changes in the downstream water surface elevations and datum uncertainties. This model (called "the Common Features HEC-RAS model" in this report) was modified and analyzed to estimate the potential geographic extent of sea level rise and hydraulic considerations for future site-specific analysis following guidance in EC-1165-2-211. It was assumed that SRBPP construction would start in the year 2013 and end in 2025. The project's design life was taken as 50 years, so the change in elevation was analyzed from the year 2013 to 2075 (62 years). This assumes construction starts in 2013 and ends in 2025 with a 50-year project life (12 years of construction and 50-years after construction ends is the 62 years).

EC-1165-2-211 requires a low, medium, and high estimate for relative sea level change and provides estimating procedures. For this analysis only the high and low estimate are used to give the maximum estimated extents of sea level rise that needed to be considered for the project.

4.2.2 Low Sea Level Change Estimate

The low rate of sea level change was determined based on the historic rate of sea level change and from the mean sea level trends for the US Tide Stations in accordance with EC-1165-2-211. The downstream end of the hydraulic model used for this analysis is approximately the Collinsville river gage. Since sea level change trend information for the Collinsville gage is not readily available, the Port Chicago, Ca. tidal gage information was used to estimate the expected trend for the downstream stage boundary conditions for the hydraulic model. This gage was selected since it is in the vicinity of the Collinsville gage. It is assumed that the Collinsville gage would experience similar changes in sea level elevation to the Port Chicago gage. See figure 1 for the location of the Port Chicago and Collinsville gages.

Information on the Port Chicago, California gage was found at: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9415144 (2/22/2011). A screen shot of the website is shown in Appendix 1. The expected mean sea level trend at the Port Chicago tidal gage is 2.08 mm/year with a 95% confidence interval of + / -2.74 mm/yr (NOAA). This trend is based on monthly mean sea level data from 1976-2006. Since data has been recorded at that gage for less than 40 years, the range of uncertainty is large as expected based on EC-1165-2-211. EC 1165-2-211 suggests that tide stations should have a minimum of 40 years of data in order to use the trend to estimate future sea level elevations. When the Port Chicago tidal gage trend is compared to the San Francisco tidal gage trend (2.01 mm/yr with a 95% confidence interval of +/-.21 mm/yr, NOAA), the trends are similar. However, the San Francisco gage's range of uncertainty is much smaller since the trend is based on data from 1897-2006 (106 years). Since this study will be used as a large scale programmatic analysis and the Port Chicago gage trend agreed well with the long established San Francisco tidal gage trend, it is concluded that no additional gage analysis is needed.

4.2.3 High Sea Level Change Estimate

The high estimate was determined using equation (3) in appendix B of EC 1165-2-211. The information provided in this section is either required or provided by EC-1165-2-211. T_1 was taken as the difference between the year 2013 and 1986, while T_2 was taken as the difference between 2075 and 1986. The constant b was taken to be 1.005E-4 for the modified NRC Curve III (provided by EC-1165-2-211). The change in eustatic (global) sea level was estimated to be 2.71 ft over the 62 years. The change in relative (local) sea level is estimated to be 2.79 ft over the 62 years. The computations are shown in Appendix 2. The local sea level rise estimate is what is important for this analysis.

4.2.4 Hydraulic Model Development

For this analysis, an existing HEC-RAS model (a 1D hydraulic model developed by USACE) was used, which was developed by the Common Features Project for estimating the sensitivity of the model from changes in the downstream water surface elevations and datum uncertainties. This model (called "the Common Features HEC-RAS model" in this report) was modified and analyzed to estimate the potential geographic extent of sea level rise and hydraulic considerations for future site-specific analysis. This common features model has been previously reviewed and is appropriate to use for this broad-scale programmatic analysis.

As mentioned in section 3.2.1, for this analysis it is assumed that any reduction in levee crown elevation is repaired as part of on-going maintenance activities so that there is no change in levee crown elevation. Furthermore, it is assumed that the channel is not subsiding or otherwise changing geometry. It is expected that sediment movement in the channel will change the channel geometry to some degree. However, for this broad scale programmatic analysis, sediment effects are not considered and should not have a significant impact on the analysis.

In Hec-DSSVue (a program developed by USACE for managing and modifying hydraulic and hydrologic data), the downstream stage hydrograph boundary condition was modified by duplicating the existing conditions hydrographs for the Georgiana Slough, Sacramento River, and Three Mile Slough, and adding the high and low estimates for sea level rise. This was done for the 1% chance exceedance flood (1% flood, 100-year flood) and 50% (2-year) flood. (The one percent flood has 1 chance in 100 of being exceeded in any given year, while the fifty percent flood has a 1 chance in 2 of being exceeded in any given year). The 1% flood is representative of engineering analysis considerations and the 50% flood representative of environmental analysis considerations. In HEC-RAS, the unsteady flow data was edited so that the stage hydrographs corresponded to the modified hydrographs with the added estimates. The unsteady flow analysis was run for the 4 conditions (1% flood high estimate, 1% flood low estimate, 50% flood high estimate, and 50% flood low estimate) and the results were analyzed.

4.3. Potential Geographic Extent of Sea Level Change Results

After the models were run, the output files were opened up in HEC-DSSVue and the High/Low estimates for the 1% flood and 50% flood, were compared against the existing conditions model. Changes of less than 0.1 feet (ft) were considered insignificant and well within the range of model error. Reaches with a change in water surface elevation of greater than 0.1 ft were determined, and a summary of the results is shown in Table 1. The maps which show the extents of the affected reaches for the 1% and 50% floods are shown in Figure 2 and Figure 3, respectively.

Table 1: Summary Table of Reaches Affected by a 2.71 Ft Increase in Sea Level

50% flood (2-year)

Reach	Area Affected
Sacramento River	USGS River Mile 48.85 (Downstream of River Landing Drive in the Pocket Area of Sacramento) to the downstream end
Yolo Bypass	2.4 miles south of Delhi Road on Solano County Road 5190C to the downstream end
DWSC	Entire Reach
Lindsey Slough	Entire Reach
Cache Slough	Entire Reach
Haas Slough	Entire Reach
Horseshoe Bend	Entire Reach
3 Mile Slough	Entire Reach
Georgiana Slough	Entire Reach
Miner Slough	Entire Reach
Steamboat Slough	Entire Reach
Sutter Slough	Entire Reach

1% flood (100-year)

Reach	Area Affected
Sacramento River	USGS River Mile 50.85 (Downstream of Dumfries Court in the Pocket Area of Sacramento) to the downstream end
Yolo Bypass	0.1 miles South of Yolo County Road 155 and 104 intersection to the downstream end
DWSC	Entire Reach
Lindsey Slough	Entire Reach
Cache Slough	Entire Reach
Haas Slough	Entire Reach
Horseshoe Bend	Entire Reach
3 Mile Slough	Entire Reach
Georgiana Slough	Entire Reach
Miner Slough	Entire Reach
Steamboat Slough	Entire Reach
Sutter Slough	Entire Reach

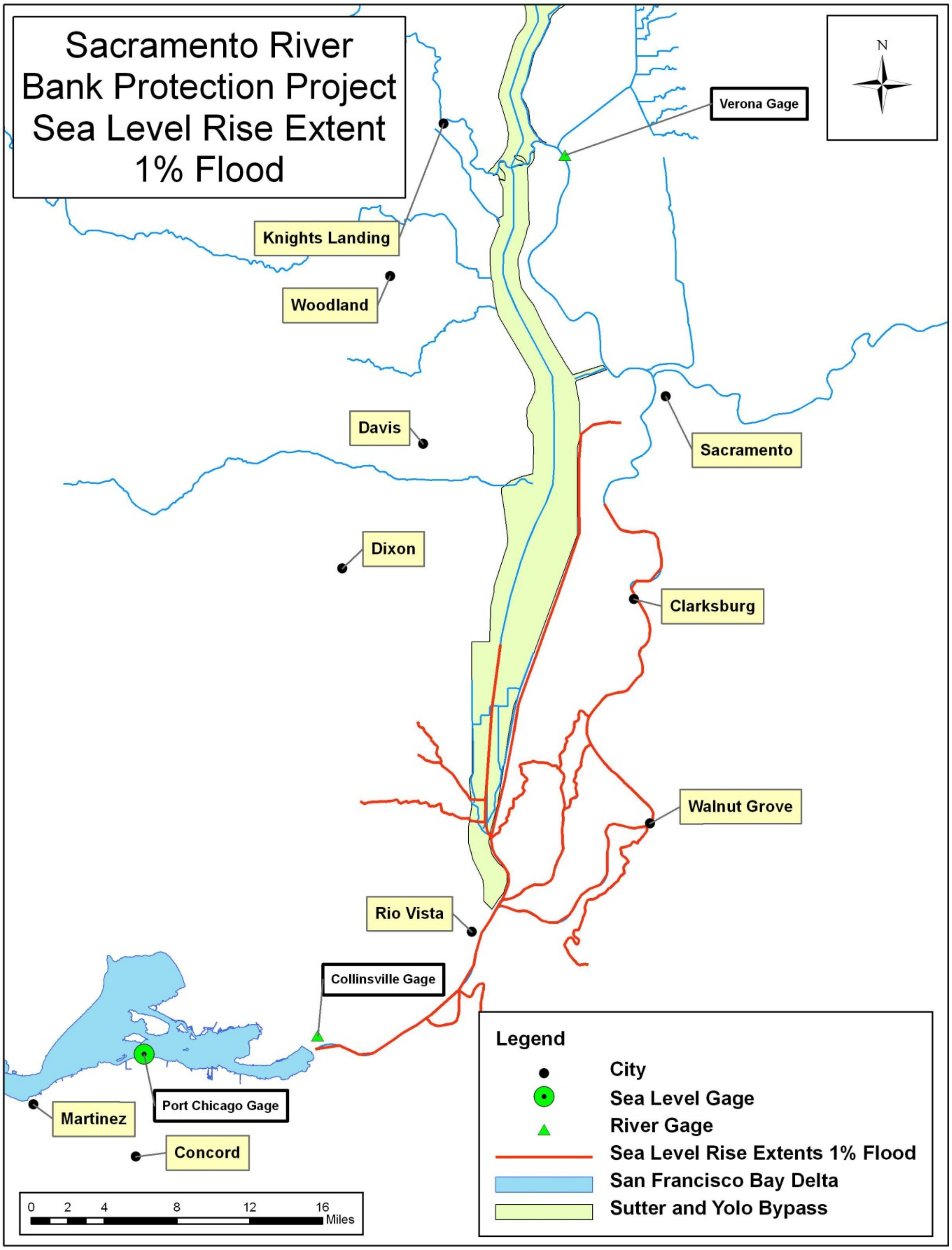

Figure 2: Maximum Estimated Extent of Sea Level Rise – 1% flood assuming 2.71 ft rise at Collinsville

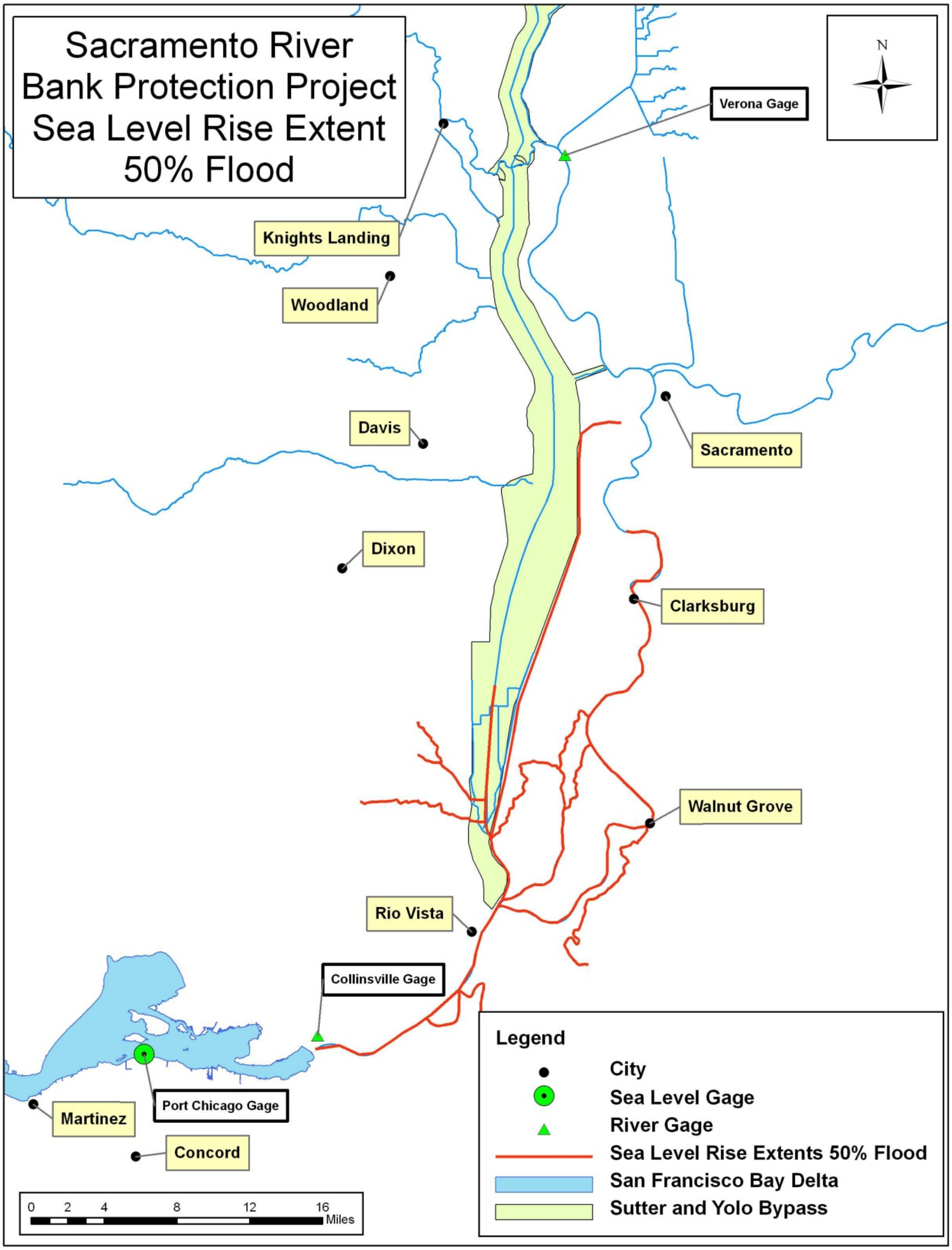

Figure 3: Maximum Estimated Extent of Sea Level Rise – 50% flood assuming 2.71 ft rise at Collinsville

A hydraulic model station is the number of miles from the downstream end of the channel in the Common Features HEC-RAS model. This is different than USGS miles but is generally close in value. It is appropriate here for relative comparison as the Yolo Bypass does not have USGS miles associated with it for its entire length. This way all reaches can be referenced using a common measuring system. This can be determined in GIS by overlaying the HEC-RAS cross-sections over aerial photos or other GIS data. Roads intersecting the river perpendicular to the channel that approximate these locations (located slightly upstream) are provided to provide an easier method to find the locations in the field.

The results from the analysis show that the 1% flood had a greater impact on the upstream water elevation than the 50% flood. The Sacramento River experienced changes greater than 0.1 ft up to USGS River Mile 50.85 (hydraulic model station 51.247), while the Yolo Bypass was affected up to the Yolo County Road 155 and 104 intersection (hydraulic model station 29.267). The entire Deep Water Ship Channel (DWSC) experienced changes greater than 0.1 ft. All other reaches downstream of the areas listed above were affected by the estimated maximum sea level rise. This includes Lindsey Slough, Cache Slough, Haas Slough, Horseshoe Bend, Three Mile Slough, Georgiana Slough, Miner Slough, Steamboat Slough, and Sutter Slough.

The initial analysis is based on the eustatic sea level rise equation for the high estimate (2.71 ft). If the changes were based on the relative sea level rise equation, the estimated maximum change in sea level is 2.79 ft (high estimate). The difference between the two values is 0.077-feet which is within the hydraulic model's range of error and is insignificant for the purpose of this analysis. The computations for the eustatic and local sea level rise are shown in Appendix 2. This was checked in the hydraulic models and the change does not significantly impact the analysis results.

To provide a conservative estimate, the estimated maximum limit of sea level change affects was increased from the model results by about 2 miles. Therefore the adjusted maximum upstream limits of sea level rise are lines of latitude drawn through Yolo County Road 152 for the Yolo Bypass and USGS River Mile 57.5 (approximately the intersection of the Deep Water Ship Channel and the Sacramento River near the city of West Sacramento). Erosion sites downstream of these locations and in the channels entirely affected by sea level rise (shown in table 1) will need to account for sea level change in site specific analysis. If the erosion site is outside this area it will not need to account for sea level change as it is not expected to be affected by sea level change over the estimated 50 year life of the project.

5. Estimating Seal Level Change Hydraulic Analysis Considerations

Site specific analysis will address potential sea level rise during implementation. This includes considering future changes to stage, velocity magnitude, velocity direction, velocity distribution, and wave characteristics. However, this will only need to be considered for the areas affected by sea level change. A reconnaissance level stone protection analysis was conducted to determine potential impacts of sea level change on velocities and wave heights affecting riprap design using HEC-RAS results, GIS, CHANLPRO Version 2.0 software, and engineering judgment.

5.1 Stone Protection Design Considerations

5.1.1 Velocity Considerations

The velocities from the high/low estimates for the 1% flood were compared against the existing conditions model to see if changes in sea level elevation would increase velocities along the reaches and impact stone protection design. Changes of less than 0.1 feet/second were considered insignificant and well within the range of model error.

After initial review of the velocity comparisons, there were significantly higher velocities on the Yolo Bypass- Egbert Tract reach when compared to other reaches. An investigation of the cross sections along the reach in HEC-RAS showed water being unrealistically confined to the main channel rather than allowed to flow in the main channel and the overbank as it really would. To align the model velocities with what would really occur, several levee heights within the reach were reduced to allow water to flow in the overbank. This resulted in more realistic velocities in the Yolo Bypass- Egbert Tract. The models were then run with the new geometry and the velocities compared.

After comparing the modified high/low sea level rise estimates to the existing conditions, a majority of the reaches either experienced a negligible change in velocity (<0.1 feet/second) or a decrease in velocity for the future sea level rise conditions. HEC-RAS model station 2.944 on the Three Mile Slough experienced the greatest increase in velocity (0.63 feet/second) for the 1% flood high estimate.

To determine if the expected maximum sea level rise (2.79 ft) could increase the size and gradation of stone protection, this site on Three-Mile Slough was analyzed assuming there is an erosion site at this location. There is not an erosion site at this location at this time. It should be noted that the purpose of this analysis is to determine if there is a relative change in the final recommended stone protection size and gradation from the CHANLPRO program. It is not intended to provide an actual design stone protection size and gradation for this or any other project site. The hydraulic variables from this point on Three-Mile Slough with the maximum change in velocity due to sea level rise were inputted into CHANLPRO (a USACE program for determining stone protection size and gradation). This is to determine if this change in velocity would impact stone protection design. The output tables from CHANLPRO for the existing project conditions and with- project conditions are shown in Appendix 3 and Appendix 4, respectively. The only difference between the two tables was the computed D_{30} (30% of the stone protection particles diameter are smaller than this value) for a stable gradation. However, this did not impact the design stone protection gradation. It is concluded from this relative comparison that velocity changes from future sea level rise should not affect stone protection design. However, there may be local 2D/3D effects that need to be considered during site specific analysis and design.

5.1.2 Wind Wave Considerations

The analysis in 5.1.1 only considers changes in stone protection design from changes in velocity due to sea level rise during the life of the project. However, waves from the wind could also impact stone protection design. Wind waves are generally a function of the fetch (the length of water over which a given wind has blown) and sometimes the depth. Changes in fetch lengths due to sea level change should be minimal in the project area, so the design of stone protection is not likely to be impacted by changes in fetch. A draft report (not certified) for designing the stone protection for repair sites along Sacramento River river miles 40 – 60 indicates depth may not be a significant factor in determining the design of stone protection (USACE 2006). This report concludes that depth is not a factor affecting wind caused wave height for the design of stone protection for this reach. It is likely that this is also applies for most or all of the area impacted by sea level change. However, wind waves need to be considered during site specific analysis and design, including potential changes in fetch and depth.

6. Conclusions

The Sacramento District of the United States Army Corps of engineers (USACE) is developing a programmatic Post Authorization Change (PAC) document and EIS/R (Environmental Impact Statement/Report) addressing the additionally authorized 80,000 linear feet of erosion control work to Phase II of erosion as per the Water Resources Development Act (WRDA) 2007. The project authorization is to reduce the risk of levee failures within the SRFCP system from erosion. EC-1165-2-211 requires all USACE coastal activity within the extent of the estimated tidal influence be considered for relative sea-level change effects. Changes in relative sea level could impact hydraulic, geotechnical, economic, real estate, and environmental analysis and considerations of the project. The report focuses on the hydraulic considerations and provides information for other disciplines to include in their analysis and documentation.

The southern portion of the SRBPP project is subject to tidal affects and the range of potential sea level rise at the downstream (southern) boundary is estimated to be between 0.42 feet (low estimate) and 2.79 feet (high estimate) between 2013 (estimated construction start) and 2075 (50 years from estimated construction end in 2025).

The high and low value estimate of potential future sea level change determined in accordance with EC-1165-2-211 was used to modify the Common Features HEC-RAS model to estimate the extent of potential sea level change within the life of the project at a programmatic scale. This analysis was conducted for the 1% (100-year) flood and 50% (2-year) flood in order to approximate a reasonable range of conditions. The 1% flood is representative of design conditions and the 50% flood is included to consider potential environmental impacts.

The analysis indicates that the high estimate of potential sea level change (2.79 feet) increases the water surface elevation by greater than 0.1-foot for the areas shown in table 1. The Yolo bypass and Sacramento River upstream limit of affects was increased by approximately 2 miles from the analysis results to provide a conservative estimate of the upstream limit of future sea level change impacts. Future erosion repair sites outside this adjusted area of potential sea level rise impacts shown below in table 2 will not need to incorporate sea level change into site specific analysis and design. Future erosion repairs within this adjusted area shown in table 2 will need to address sea level change in their site specific analysis and design.

As noted previously, the requirements of EC-1165-2-211 apply to this federal project but are different than the state of California requirements and procedures. Both procedures yield similar numbers for the high sea level rise estimate. Since the high estimate provides the maximum estimated extent of sea level rise, the differences in the procedures are not significant. In fact, the USACE procedure provides a slightly more conservative estimate of the geographic extent of sea level rise than the state guidance.

A preliminary programmatic stone protection analysis indicates that sea level change is not likely to impact the size and gradation of stone protection. However, the site specific hydraulic analysis should consider addressing future local changes to stage, velocity, and wave characteristics for these reaches affected by sea level change.

Table 2. Adjusted Areas Potentially Affected by Sea Level Change

Reach	Area Affected
Sacramento River	Downstream of USGS River Mile 57.5 (Deep Water Ship Channel and Sacramento River intersection in the city of West Sacramento) to the downstream end of the channel at the Collinsville Gage in the Delta
Yolo Bypass	Downstream of Yolo County Road 152 to the downstream end of the channel
DWSC	Entire Reach
Lindsey Slough	Entire Reach
Cache Slough	Entire Reach
Haas Slough	Entire Reach
Horseshoe Bend	Entire Reach
3 Mile Slough	Entire Reach
Georgiana Slough	Entire Reach
Miner Slough	Entire Reach
Steamboat Slough	Entire Reach
Sutter Slough	Entire Reach

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"Standard Operation and Maintenance Manual for the Sacramento River Flood Control Project." USACE. May 1995.

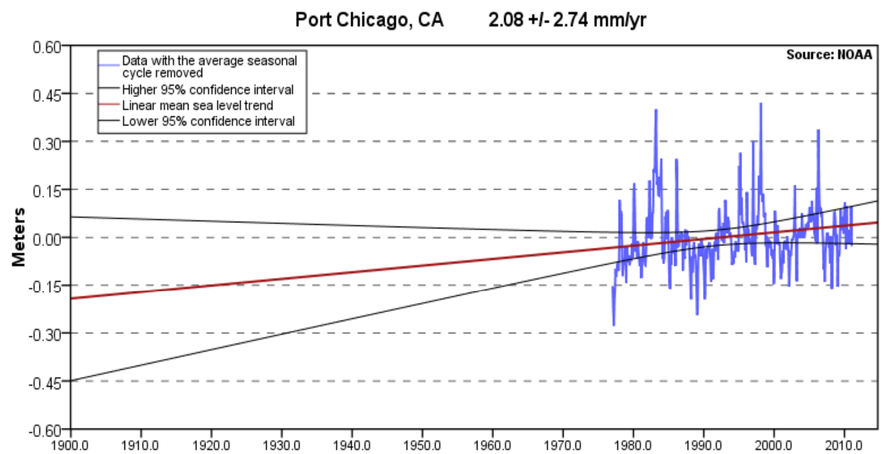
"Water Resource Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs." EC 1165-2-211. 24 Feb. 2011 < http://140.194.76.129/publications/eng circulars/ec1165-2-211/entire.pdf>

"§ 208.10 Local flood protection works; maintenance and operation of structures and facilities." GPO Access. 28 Feb. 2011. 1 March 2011 <http://ecfr.gpoaccess.gov/cgi/t/text/text idx?c=ecfr;rgn=div5;view=text;node=33%3A3.0.1.1.4;idno=33;cc=ecfr#33:3.0.1.1.4.0.1.1>

"Sacramento River Mile 40 to 60 Rock Riprap Gradation Design for River Currents, Wind and Boat Waves." Final Draft Report for Review. USACE 2006.

Appendix 1

Mean Sea Level Trend
9415144 Port Chicago, California



The mean sea level trend is 2.08 millimeters/year with a 95% confidence interval of +/- 2.74 mm/yr based on monthly mean sea level data from 1976 to 2006 which is equivalent to a change of 0.68 feet in 100 years.

The plot shows the monthly mean sea level without the regular seasonal fluctuations due to coastal ocean temperatures, salinities, winds, atmospheric pressures, and ocean currents. The long-term linear trend is also shown, including its 95% confidence interval. The plotted values are relative to the most recent Mean Sea Level datum established by CO-OPS. The calculated trends for all stations are available as a table in millimeters/year or a table in feet/century (0.3 meters = 1 foot).

If present, solid vertical lines indicate times of any major earthquakes in the vicinity of the station and dashed vertical lines bracket any periods of questionable data.

Source: http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=9415144

Appendix 2

Low Estimate Calculation:

$$\frac{2.08\ mm}{yr} \times 62\ yrs = 128.96mm = .128m$$

$$.128m \times \frac{3.28\ ft}{1\ m} = .42\ ft$$

High Estimate Calculation (Eustatic):

$$EQ3 = E(t2) - E(t1) = .0017(t2 - t1) +\ b(t2^2 - t1^2)$$

$$t2 = 2075 - 1986 = 89yrs$$

$$t1 = 2013 - 1986 = 27yrs$$

$$b = .0001005$$

$$EQ3 = .0017(89 - 27) +\ .0001005(89^2\ -\ 27^2) = .827m$$

$$.827m\ \times \frac{3.28ft}{1\ m} = 2.71\ ft$$

High Estimate Calculation (Relative):

$$EQ3 = E(t2) - E(t1) = .00208(t2 - t1) +\ b(t2^2 - t1^2)$$

$$t2 = 2075 - 1986 = 89yrs$$

$$t1 = 2013 - 1986 = 27yrs$$

$$b = .0001005$$

$$EQ3 = .00208(89 - 27) +\ .0001005(89^2\ -\ 27^2) = .8517m$$

$$.8517m\ \times \frac{3.28ft}{1\ m} = 2.794\ ft$$

Appendix 3

3 Mile Slough W/O Project (Station 2.944)

```
    PROGRAM OUTPUT FOR A NATURAL CHANNEL SIDE SLOPE RIPRAP, STRAIGHT REACH
                   INPUT PARAMETERS
    SPECIFIC WEIGHT OF STONE,PCF              135.0
    LOCAL FLOW DEPTH,FT                         5.9
    CHANNEL SIDE SLOPE,1 VER: 1.79 HORZ
    AVERAGE CHANNEL VELOCITY,FPS               4.35
    COMPUTED LOCAL DEPTH AVG VEL,FPS           4.35
    (LOCAL VELOCITY)/(AVG CHANNEL VEL)         1.00
    SIDE SLOPE CORRECTION FACTOR K1             .82
    CORRECTION FOR VELOCITY PROFILE IN BEND    1.00
    RIPRAP DESIGN SAFETY FACTOR                1.30


                           SELECTED STABLE GRADATIONS
                                  ETL GRADATION

    NAME    COMPUTED D30(MIN)  D100(MAX)  D85/D15  N=THICKNESS/   CT
THICKNESS
             D30 FT     FT         IN                 D100(MAX)          IN
     1         .14      .37       9.00       1.70       1.00      1.00
9.0

  D100(MAX)        LIMITS OF STONE WEIGHT,LB         D30(MIN)  D90(MIN)
     IN          FOR PERCENT LIGHTER BY WEIGHT          FT        FT
                  100           50            15
    9.00       30      12       9       6       4       2     .37       .53

           EQUIVALENT SPHERICAL DIAMETERS IN INCHES
  D100(MAX)  D100(MIN)  D50(MAX)  D50(MIN)  D15(MAX)  D15(MIN)
    9.0        6.6        6.0       5.3       4.8       3.6
```

Appendix 4

3 Mile Slough with Project -1% Flood High Est (Station 2.944)

```
    PROGRAM OUTPUT FOR A NATURAL CHANNEL SIDE SLOPE RIPRAP, STRAIGHT REACH
                   INPUT PARAMETERS
    SPECIFIC WEIGHT OF STONE,PCF              135.0
    LOCAL FLOW DEPTH,FT                         8.6
    CHANNEL SIDE SLOPE,1 VER: 1.79 HORZ
    AVERAGE CHANNEL VELOCITY,FPS               4.98
    COMPUTED LOCAL DEPTH AVG VEL,FPS           4.98
    (LOCAL VELOCITY)/(AVG CHANNEL VEL)         1.00
    SIDE SLOPE CORRECTION FACTOR K1             .82
    CORRECTION FOR VELOCITY PROFILE IN BEND    1.00
    RIPRAP DESIGN SAFETY FACTOR                1.30


                           SELECTED STABLE GRADATIONS
                                  ETL GRADATION

    NAME    COMPUTED D30(MIN)  D100(MAX)  D85/D15  N=THICKNESS/   CT
THICKNESS
             D30 FT     FT         IN                 D100(MAX)           IN
     1         .17      .37       9.00       1.70       1.00      1.00
9.0

  D100(MAX)        LIMITS OF STONE WEIGHT,LB          D30(MIN)  D90(MIN)
     IN          FOR PERCENT LIGHTER BY WEIGHT           FT        FT
                  100           50            15
    9.00       30     12       9      6      4      2     .37       .53

           EQUIVALENT SPHERICAL DIAMETERS IN INCHES
  D100(MAX)  D100(MIN)  D50(MAX)  D50(MIN)  D15(MAX)  D15(MIN)
    9.0        6.6        6.0       5.3       4.8       3.6
```

Appendix B, History of the 1957 Profiles

History of the 1957 Profiles on the Sacramento River

Background

In the late 1800s the flood capacity of the Sacramento River and its tributaries was greatly reduced due to tailings from hydraulic mining. Hydraulic mining was officially halted in 1884 with two court cases (Woodruff v. North Bloomfield Gravel Mining Co. and People v. Gold Run Ditch and Mining Company). Levees were improperly built and rivers in the Sacramento Basin were unable to contain average year floods. It was proposed in 1880 that the state engineer take control of maintaining the drainage of the river basins, however this was never acted on by Congress. In 1894, it was suggested again that improvements to the channel of the lower Sacramento River would lower flood stages, however the construction of engineered levees on the Feather River was very important. Again, the legislature did not act on these recommendations. In 1904, another futile attempt was proposed to modify the channels of the sediment filled streams to increase slope and encourage movement of sediment from the river channel. It also proposed levees on the Yuba and Feather Rivers; however, the state did not take action. In 1905 the Rivers and Harbors Act of 1905 appointed three engineers from the Army to cooperate with the state and determine the feasibility of navigational improvements (Kochis 1963).

The California Debris Commission (CDC) was created in 1893 as part of the Rivers and Harbors Act. It was created by the Federal government and was made up of three army engineers that were appointed by the president. Minor work on debris control and Navigation were performed by the federal government prior to the creation of the CDC. In February 1900, Daguerre Point Dam was proposed on the Lower Yuba as a means to contain mining debris. The first flood control measures were first carried out in the Rivers and Harbors Act of 1910. The report is contained in House Document 81 and is from a report by the CDC. The flood control measures proposed included dredging of the Sacramento River below Cache Slough to increase channel capacity. Dredging was not performed on the Feather River even though it was included in the report (Kochis 1963).

Shortly after the 1910 flood control project approved in House Document 81 the state of California created the Reclamation Board Act of 1911. This was made up of three members appointed by the governor. The board was to examine plans for flood control and reclamation of lands in accordance with the CDC. If the Reclamation Board did not approve the plans then they could not be pursued. In 1913, the Reclamation Board's duties were more clearly defined to not include channel expansion or construction of weirs on the Sacramento River. The number of board members was also increased to seven (Kochis 1963).

In House Document 81, it suggests that the capacity of the Sacramento River at Collinsville needed to be in excess of 600000 cfs, where prior to the floods of 1907 and 1909, the capacity was recommended to be 250000 cfs. In the document, the reasoning for not simply widening the channel is articulated to be due to the need for scour flows to wash continued sediment downstream from the hydraulic mining tailings. Also, a wider channel would lower the depth of low flow events causing navigation to be an issue. As a result, the Basins surrounding the Sacramento River were investigated for reclamation. The two largest were the Sutter Basin and the Yolo Basin with 1,038,000 AF and 1,126,000 AF, respectively. Evaluation of the capacity needed in the river at various points showed that it needed a much greater capacity than was there at the time (Stimson 1911).

Table 8. Channel Capacity at locations along Sacramento River

Localities	Distance	Capacity, cfs (1911)	Capacity, cfs (required)
Chico Landing	202	235000	235000
Colusa	151	70000	250000
Knights Landing	94	25000	250000
Below Feather River	81	65000	450000
Below American River	62	80000	525000
Below Cache Slough	16	165000	600000

The bypass system was first proposed in 1894 by Marsden, Manson, and Grunsky who were consultants to the commissioner of public works. This bypass system using the reclaimed basins along with channel improvements to various reaches along the Sacramento River, Feather River, Yuba River and smaller tributaries became the foundation for the Sacramento River Flood Control Project (Stimson 1911).

1957 Profiles

The 1957 Profiles for the Sacramento River were developed in a joint effort by the United States Army Engineer Division, the State Department of Water Resources and the State Reclamation Board. The levee and channel profiles were created based on a compilation of all data available from the Sacramento District at the time (McCollam 1957). The basis for most of this data was the investigation for Senate Document No. 23 entitled "Flood Control in the Sacramento and San Joaquin Basins" printed in 1926. For reaches not included in Senate Document No. 23, the data was obtained through hydrologic analysis in order to fill the data gaps necessary to establish channel capacities for the main tributaries of the Sacramento River.

Senate Document No. 23 was the document authorizing the revisions to the Old Sacramento River Flood Control Project in 1928. Further modifications to the flood control system were made after the 1937 flood. The 1938 modifications were mainly along the Feather River because "numerous levee failures occurred along the Feather River levees between 1920 and 1934, these levees were set back and enlarged to accommodate greater flows. These changes were summarized in memorandums issued by the USACE which define the minimum freeboard requirements for each segment of the Sacramento River Flood Control Project (SRFCP), collectively referred to as the 'USACE 1957 Profile'" (Archer 2009). Further modifications were made to the system in 1951 upstream of the Tisdale Bypass and in the Sutter Basin. The 1951 modifications were done in response to a project authorized to look into reclaiming the Butte Basin. However, the Butte Basin was never reclaimed. The Design flows were updated after the flood in 1955 to include the most current record of flows.

Data Collection

Bank and channel elevations were determined from river surveys from 1951 and levee elevations were determined from a combination of the survey, contract drawings, and from detailed final design surveys for the levees. The surveys were largely performed as part of the investigation for the memorandum of understanding (McCollam 1957).

Floodplains were constructed based on the flows and levees found in Senate Document No. 23. These were subsequently updated after each significant flooding event: 1935, 1936, 1937-38, 1940, 1942, 1950, and 1955. Field surveys and high water marks were obtained for these events and discharge was studied at key river stations.

Profiles

Drawings of the 1957 profiles were created with this information. The drawings are divided up into key stream systems. Each stream system is composed of several reaches, if present. Above the reach, the channel design flow is shown and the extent of the stream where it applies. The vertical datum for the profiles is the United States Engineers Datum (USED). This is different from NAVD88 and NGVD29. Conversions from the USED are an ongoing issue but some values have been suggested for USED to NGVD29 (~+3ft).

Limitations

There have been a number of changes to the Sacramento River since the 1957 Profiles were created. The major one is that the channel has migrated and the river miles described in the 1957 profiles are not the same as those from the Comprehensive Study. There is also a question of whether subsidence has played a role in the elevations of the current stream and the bypasses as the Sutter and Yolo County areas have significant subsidence in certain areas. In the 1957 profile, there is mention of the Butte Basin and its design capacity. However, the Butte Basin was never reclaimed for use as a bypass. Also, the 1957 Profiles predate Oroville. The profiles are not based on frequency as Senate document No. 23 did not account for frequency and only mentioned the design capacity based on a revised high flow event at the Collinsville Gage. Also, the 1957 profiles did not use Manning's equation that is the basis for much of today's hydraulic analysis. In addition, hydraulic modeling has improved dramatically since the 1957 profiles were developed. However, it should be noted that the 1957 profiles are based on observed high water marks for actual large flood events.

Current Efforts

There is an ongoing effort to find more complete documentation of the 1957/1955 profiles but since it is not officially tied to any projects, the funding to do such searches through the archives has not been warranted. The information here should not be considered complete, however is useful as a general background to the 1957 profiles and what lead up to them.

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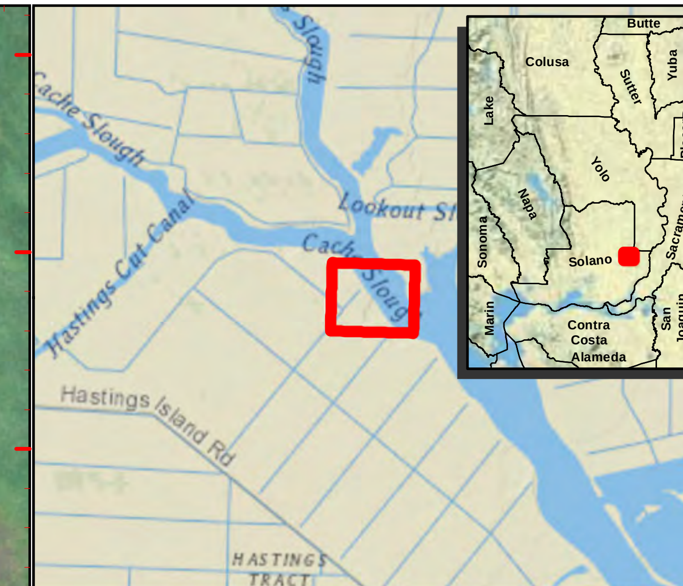
Subappendix 6. Real Estate Maps



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

DRAFT

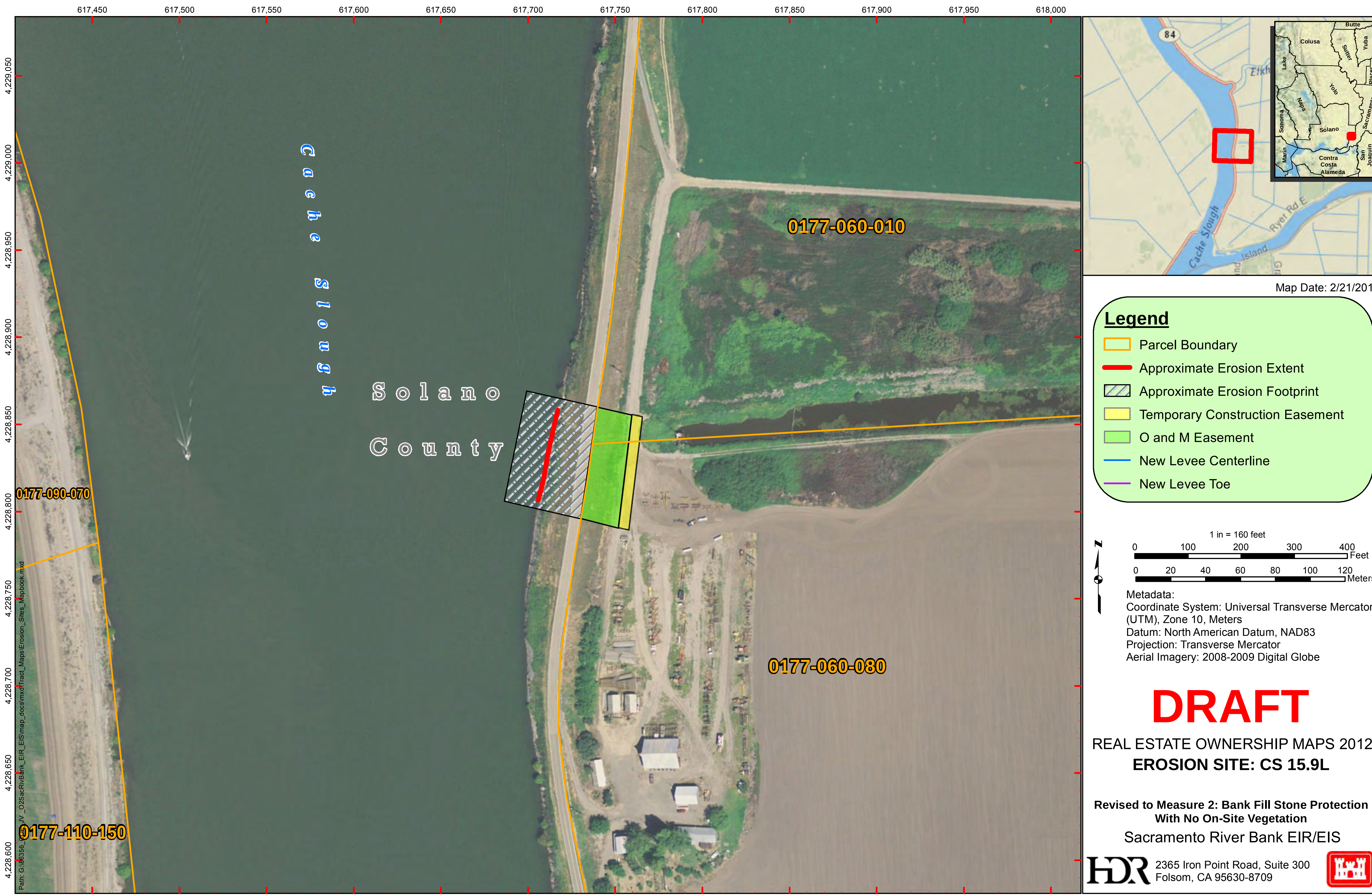
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: CHS 23.6R

Revised to Measure 2 Bank Fill Stone Protection With No On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

DRAFT

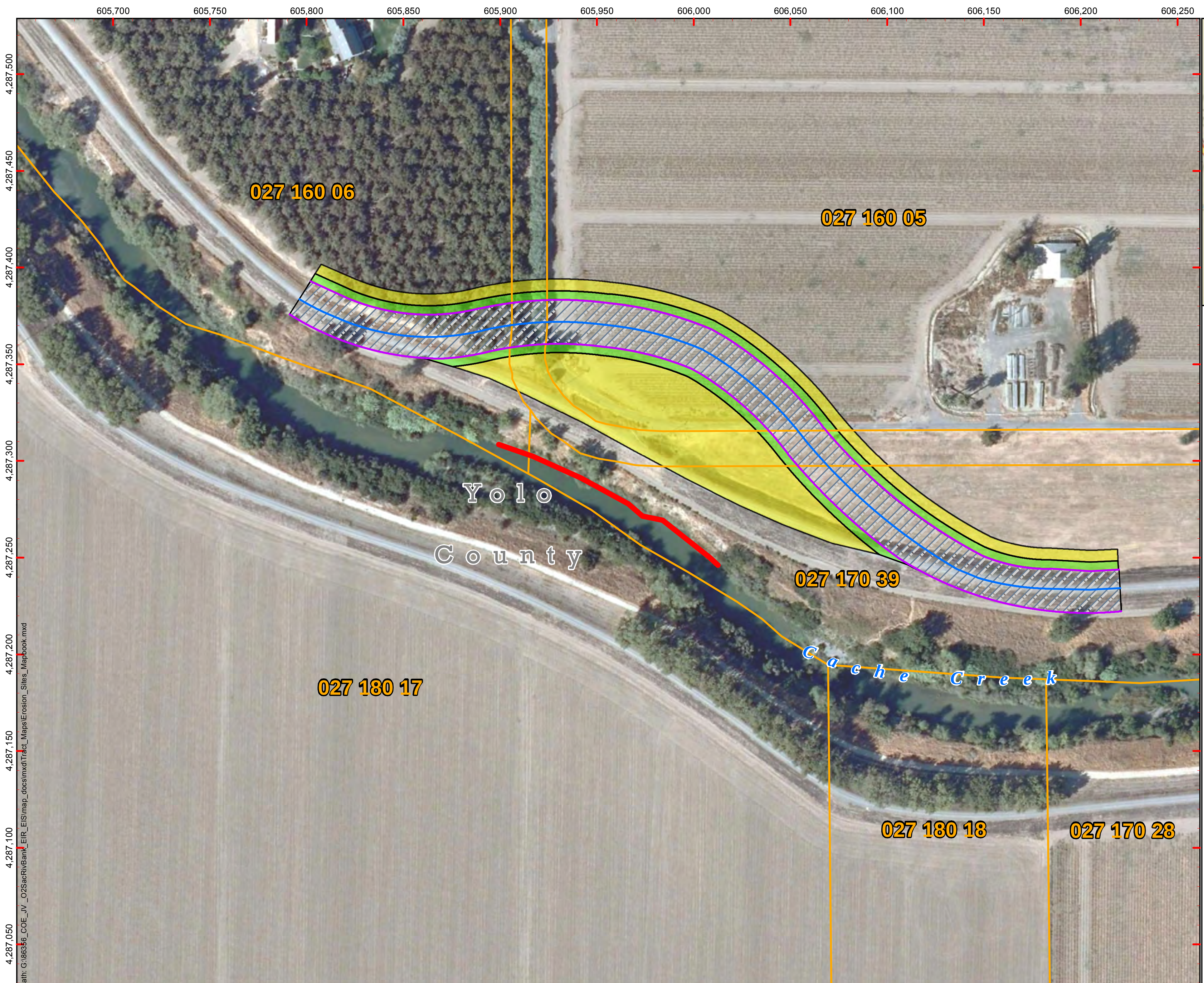
REAL ESTATE OWNERSHIP MAPS 2012

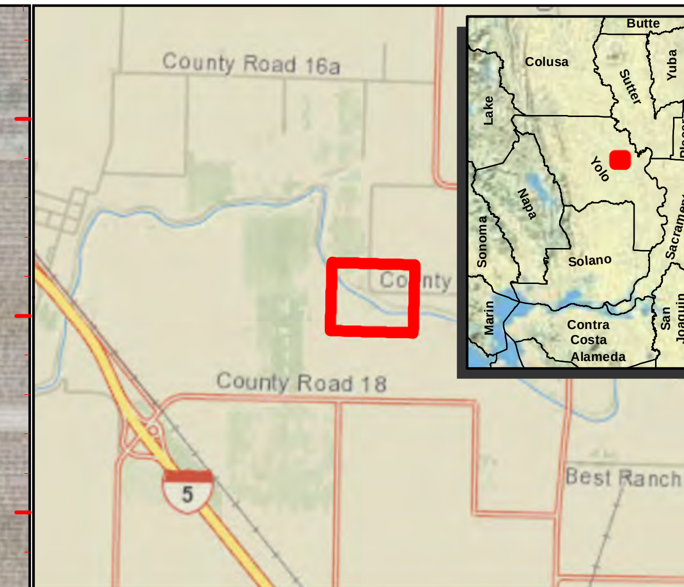
EROSION SITE: CS 15.9L

Revised to Measure 2: Bank Fill Stone Protection With No On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

DRAFT

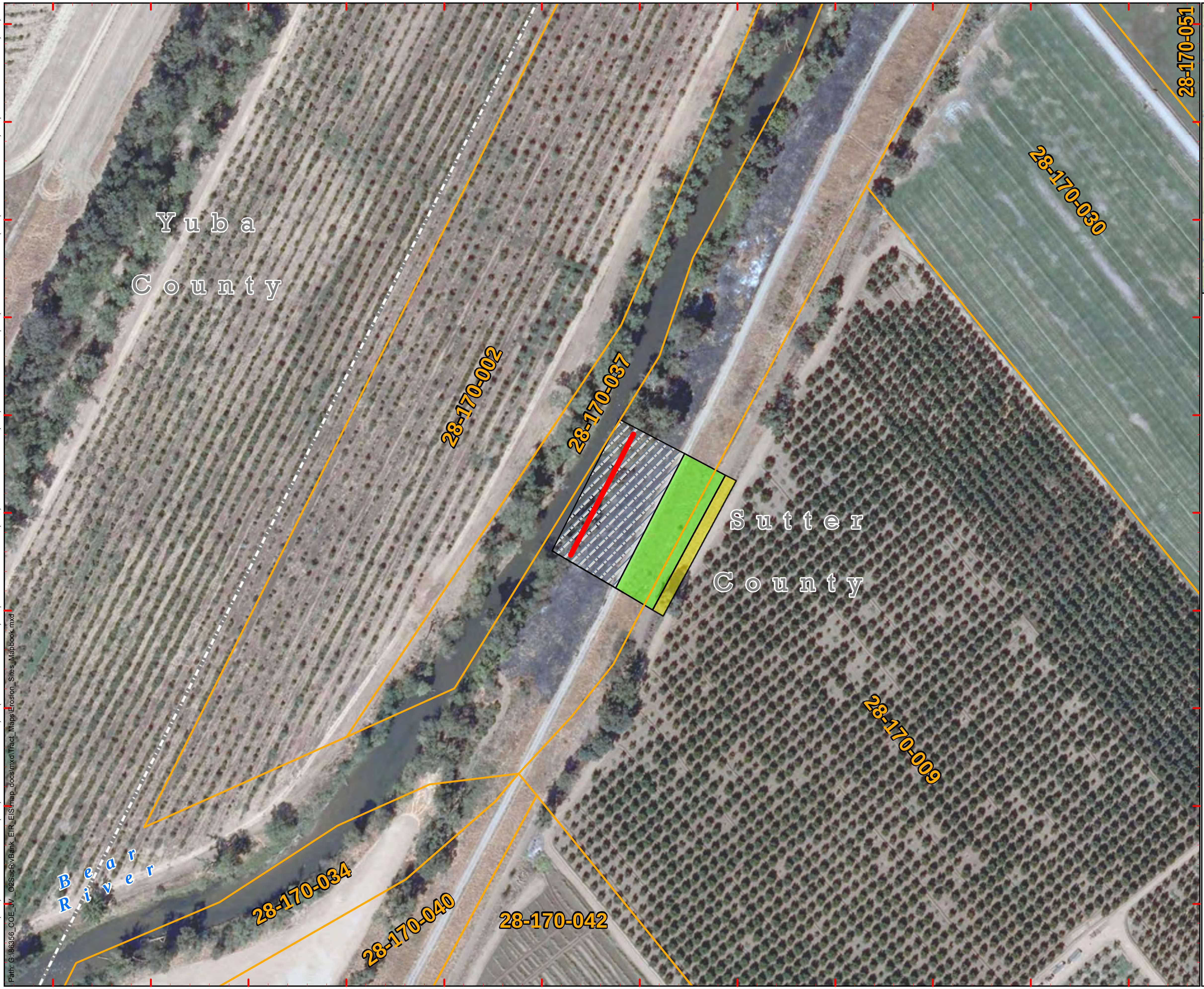
REAL ESTATE OWNERSHIP MAPS 2012

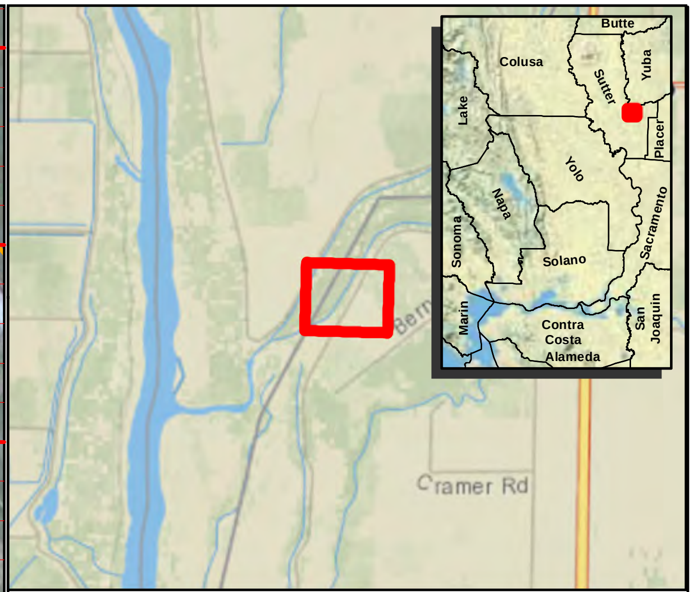
EROSION SITE: CHC 3.9L

AR Measure 10: Setback Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: BER 0.8L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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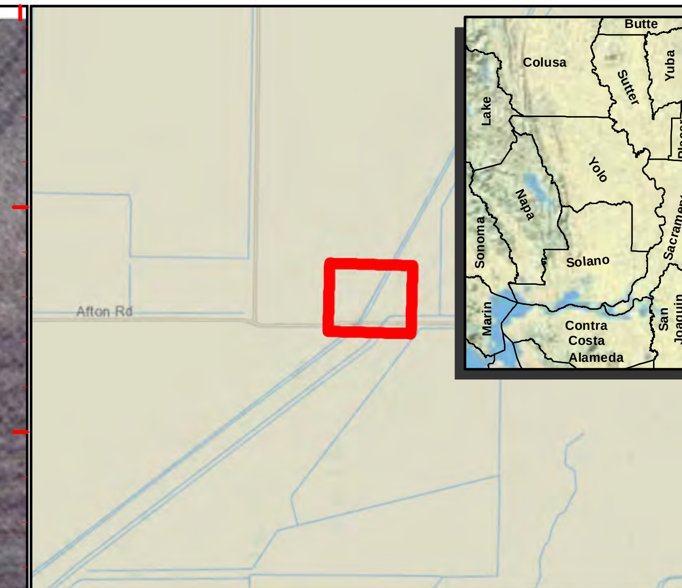
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: CS 22.8R

AR Design 4, Measure 9

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 140 feet

0 100 200 300 Feet

0 20 40 60 80 100 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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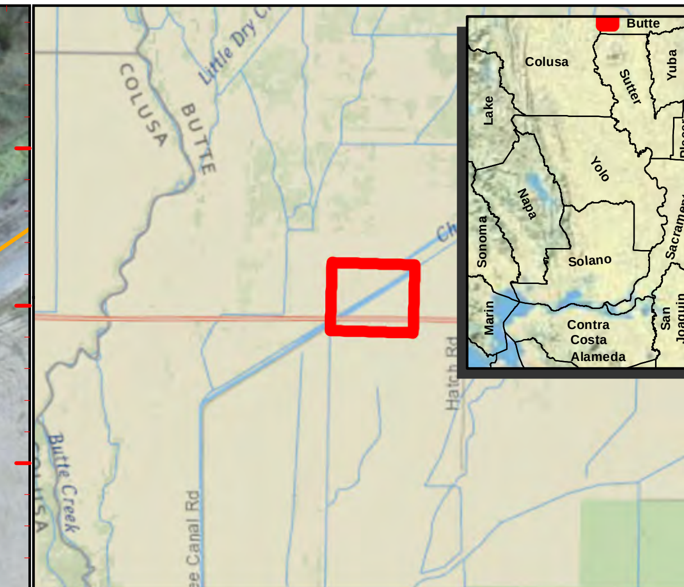
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: CHK 14.0L

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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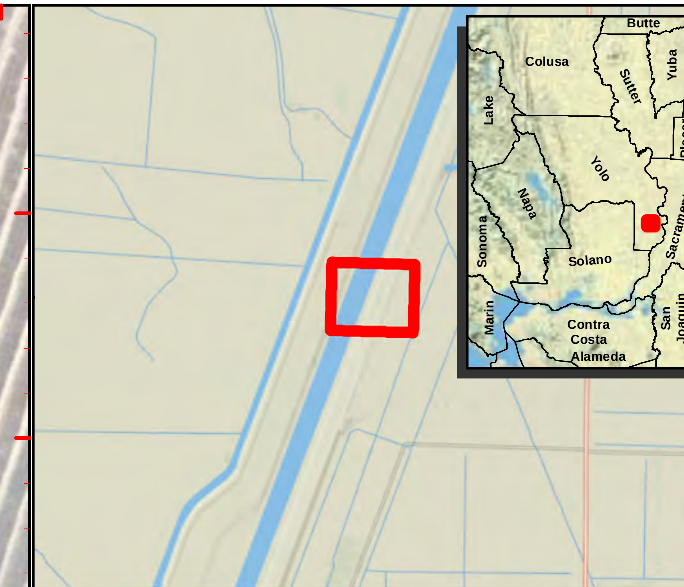
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: CHK 21.9L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 140 feet

0 100 200 300 Feet

0 20 40 60 80 100 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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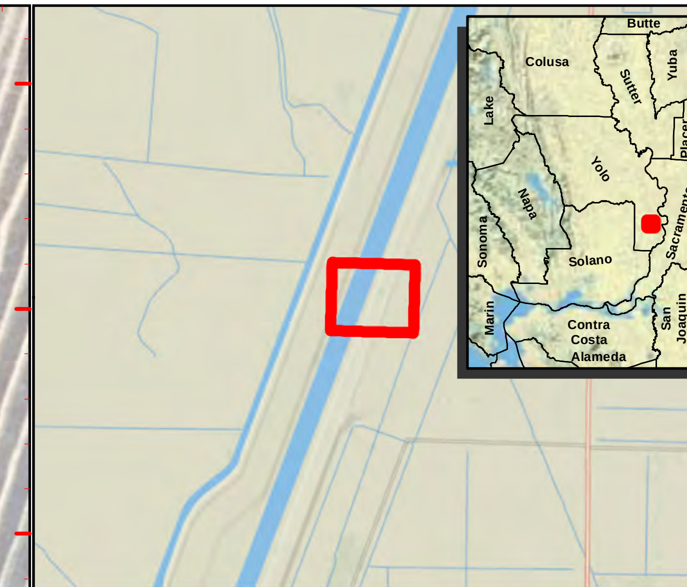
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: DWS 5.0L

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 140 feet

0 100 200 300 Feet

0 20 40 60 80 100 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: DWS 5.01L

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

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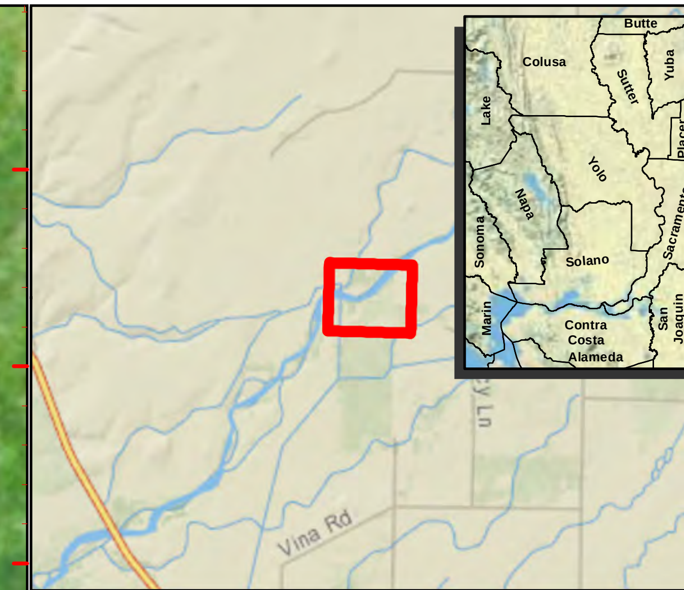

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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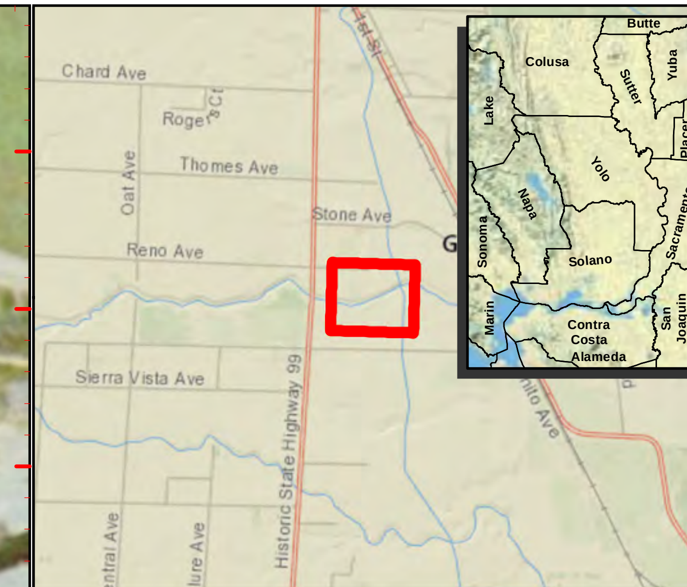
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: DC 2.4L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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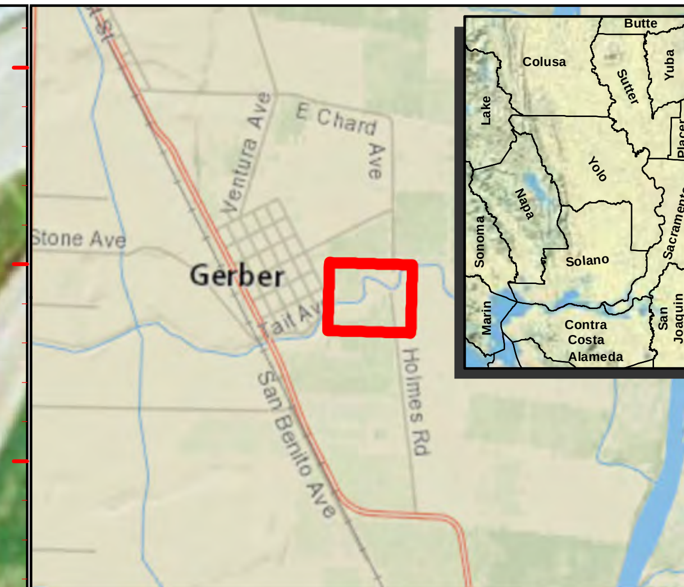
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: EIC 1.4L

AR Design 2, Method 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

N

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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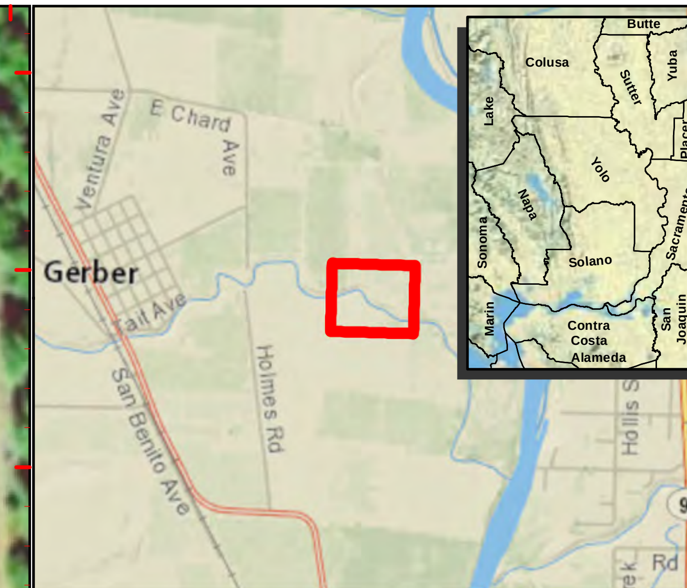
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: EIC 3.0R

AR Design 2, Method 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: EIC 4.1L

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 140 feet

0 100 200 300 Feet

0 20 40 60 80 100 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: FR 0.6L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 7/19/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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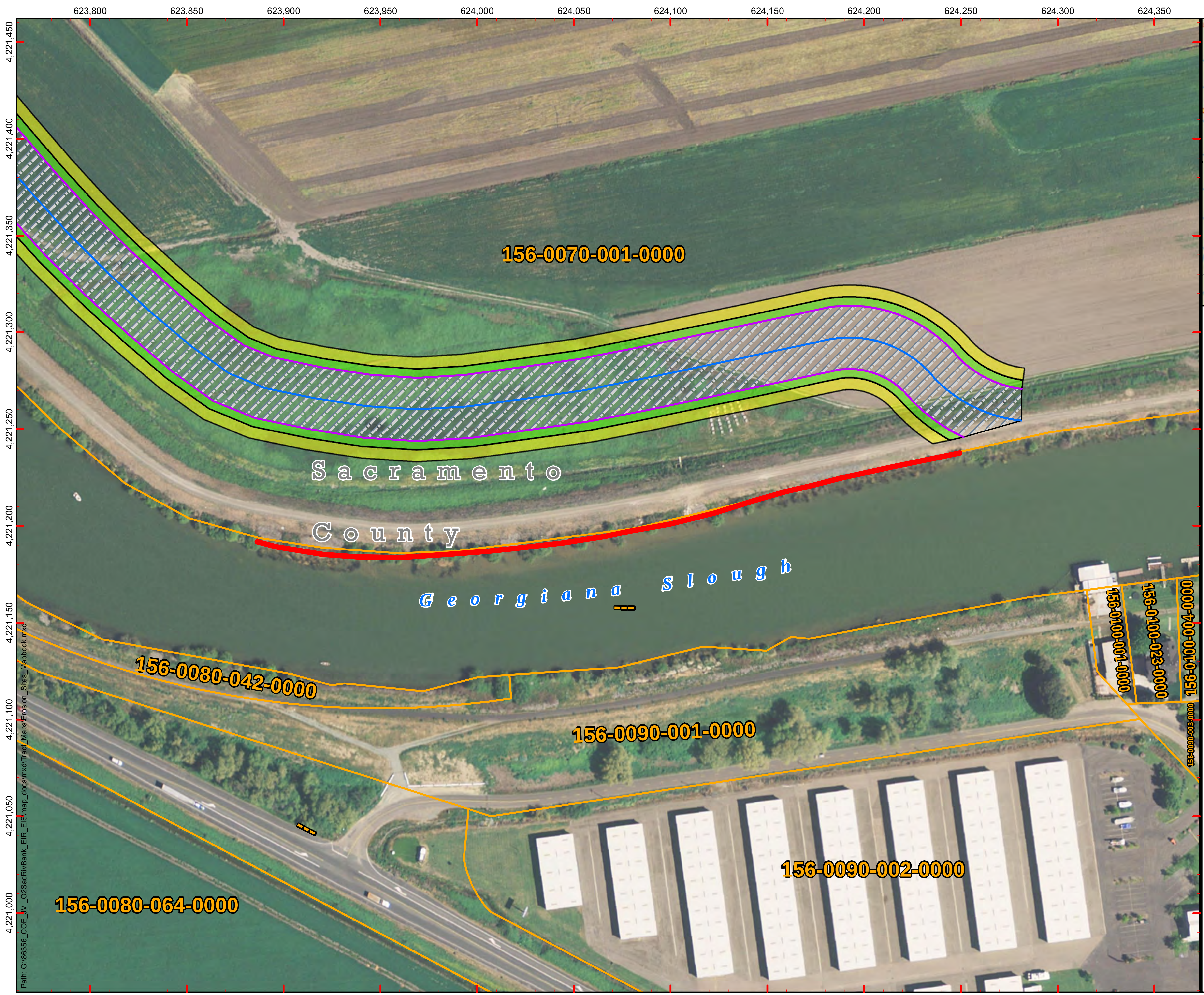
REAL ESTATE OWNERSHIP MAPS 2012

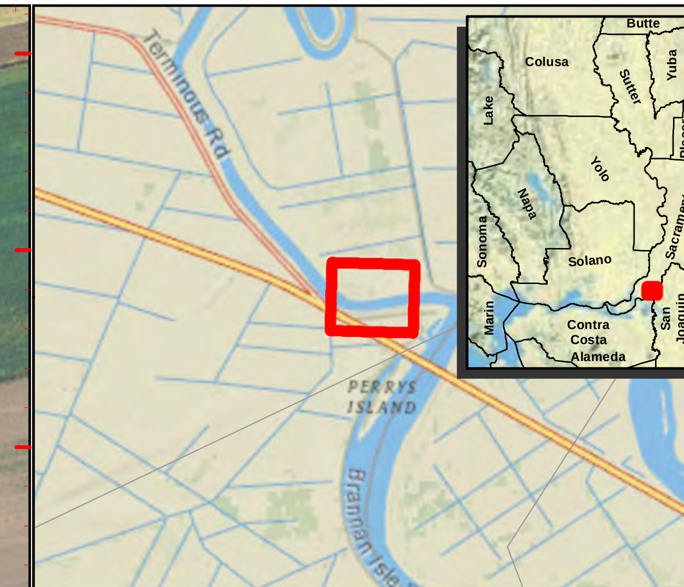
EROSION SITE: FR 5.0L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 0.3L

Revised to Measure 1: Combined Setback Levee (GEO 0.3L, GEO 1.7L and GEO 2.5L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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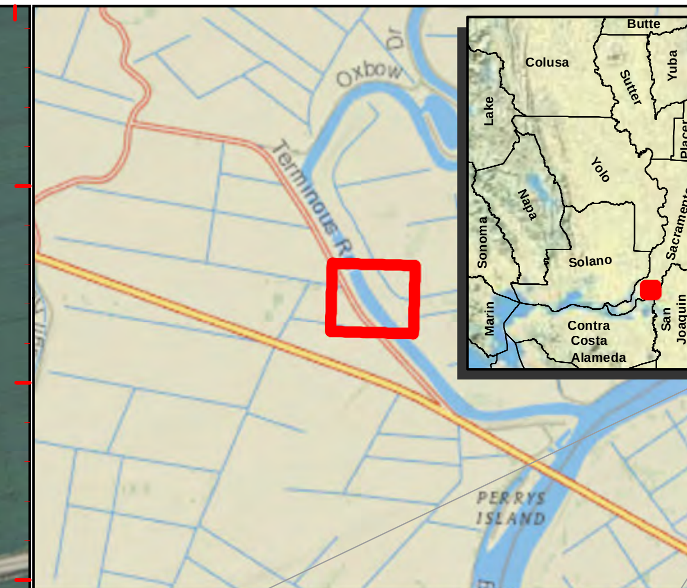
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Between GEO 0.3L and GEO 1.7L North of GEO 0.3L

Revised to Measure 1: Combined Setback Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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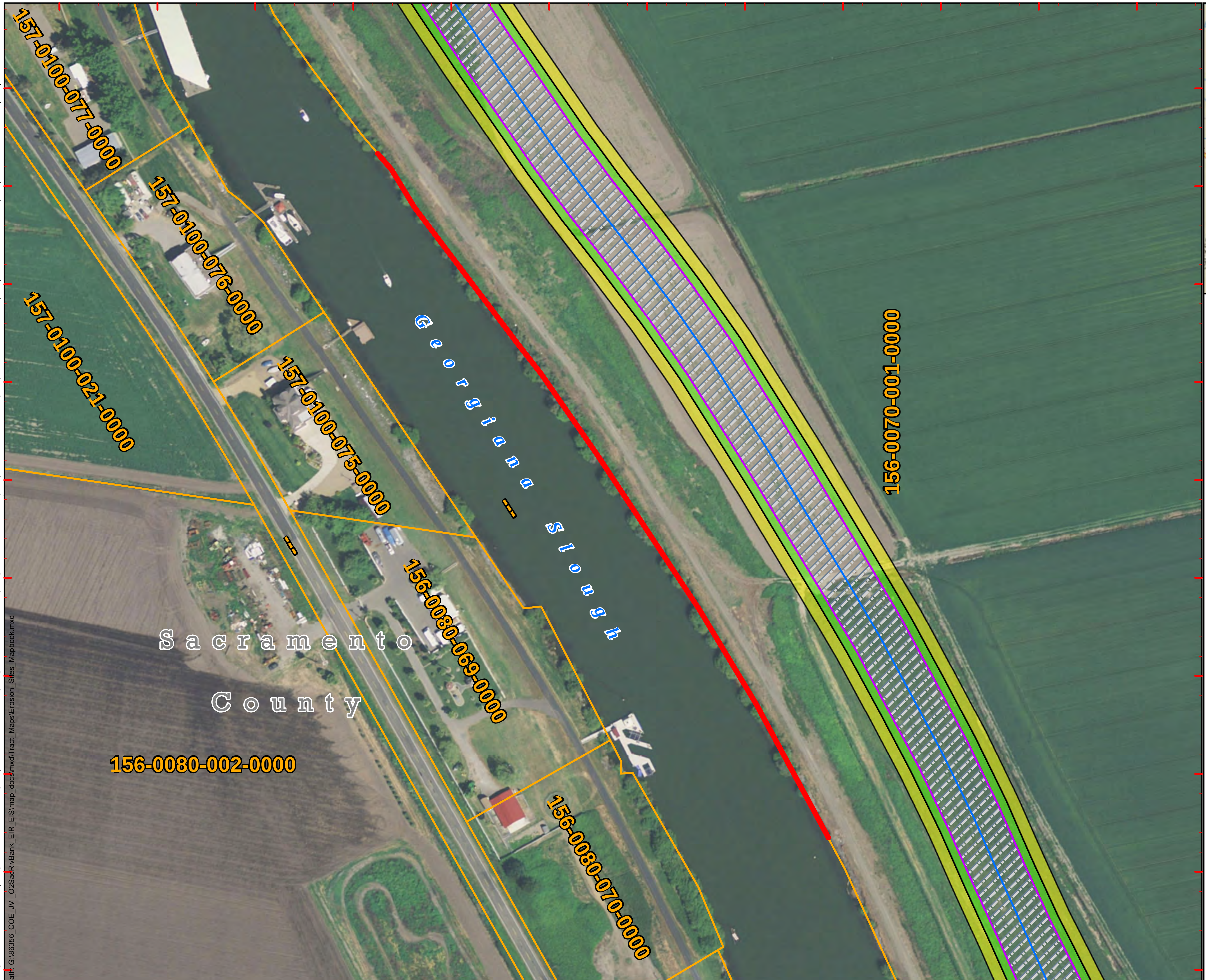
REAL ESTATE OWNERSHIP MAPS 2012

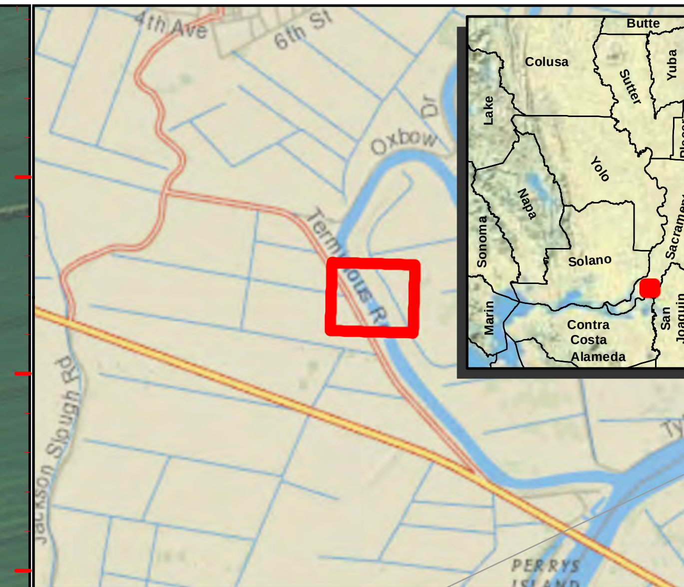
EROSION SITE: Between GEO 0.3L and GEO 1.7L South of GEO 1.7L

Revised to Measure 1: Combined Setback Levee

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 1.7L

Revised to Measure 1: Combined Setback Levee (GEO 0.3L, GEO 1.7L and GEO 2.5L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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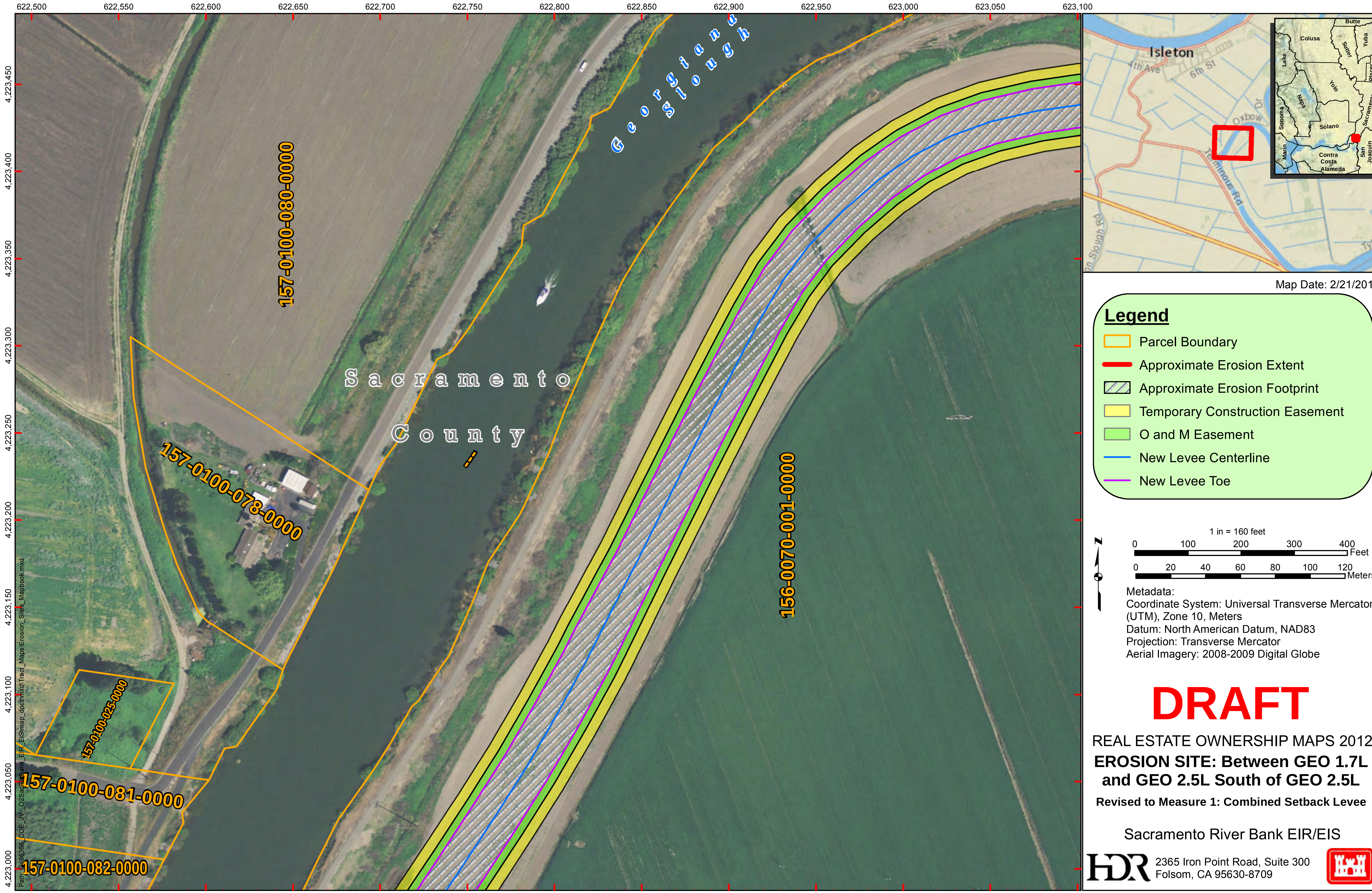
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Between GEO 1.7L and GEO 2.5L North of GEO 1.7L

Revised to Measure 1: Combined Setback Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Between GEO 1.7L and GEO 2.5L South of GEO 2.5L

Revised to Measure 1: Combined Setback Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 140 feet

0 100 200 300 Feet

0 20 40 60 80 100 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 2.5L

Revised to Measure 1: Combined Setback Levee (GEO 0.3L, GEO 1.7L and GEO 2.5L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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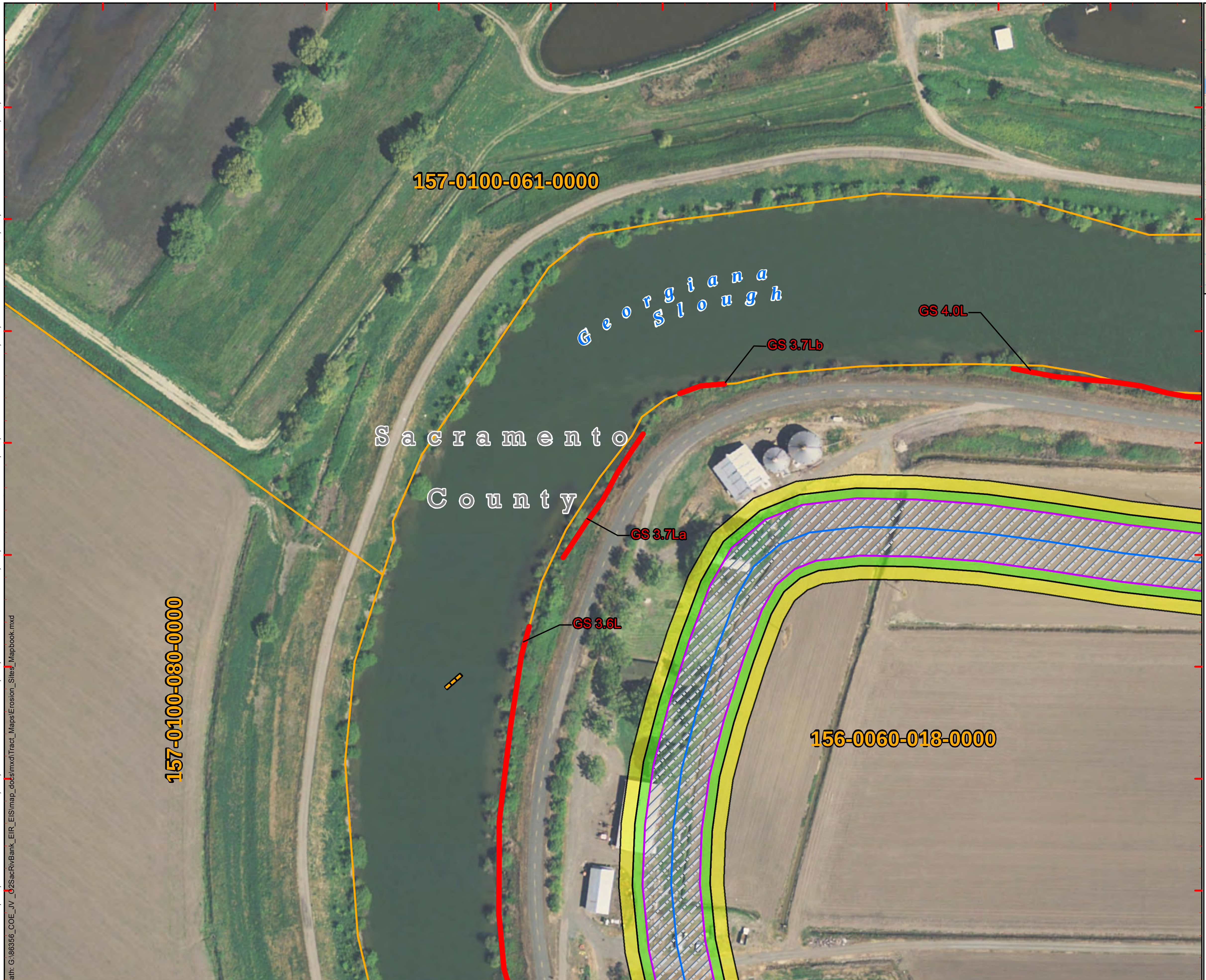
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 3.6L

Revised to Measure 1: Combined Setback Levee (GEO 3.6L, GEO 3.7La, GEO 3.7Lb and GEO 4.0L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 140 feet

0 100 200 300 Feet

0 20 40 60 80 100 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 3.7La

Revised to Measure 1: Combined Setback Levee (GEO 3.6L, GEO 3.7La, GEO 3.7Lb and GEO 4.0L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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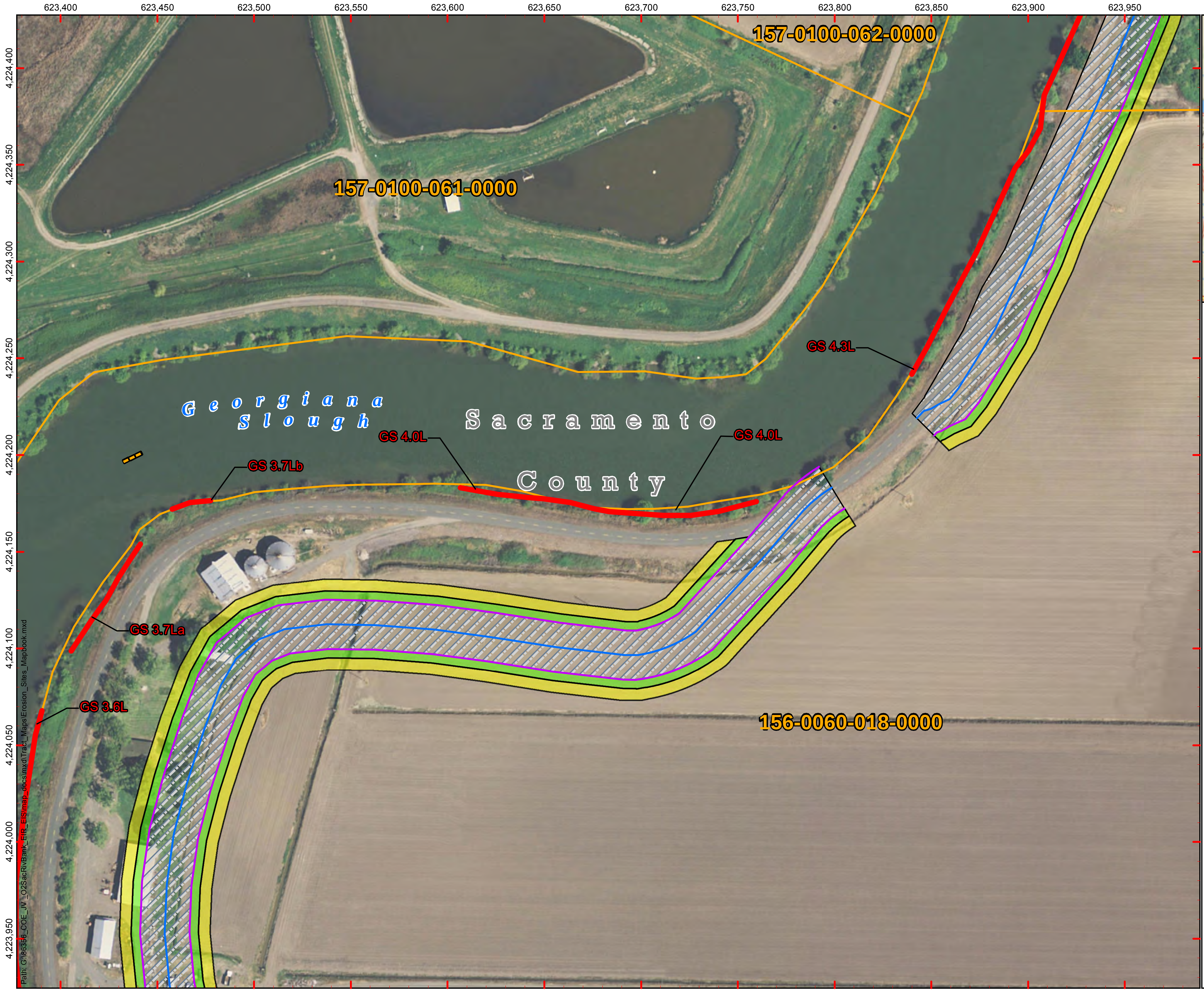
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 3.7Lb

Revised to Measure 1: Combined Setback Levee (GEO 3.6L, GEO 3.7La, GEO 3.7Lb and GEO 4.0L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

N

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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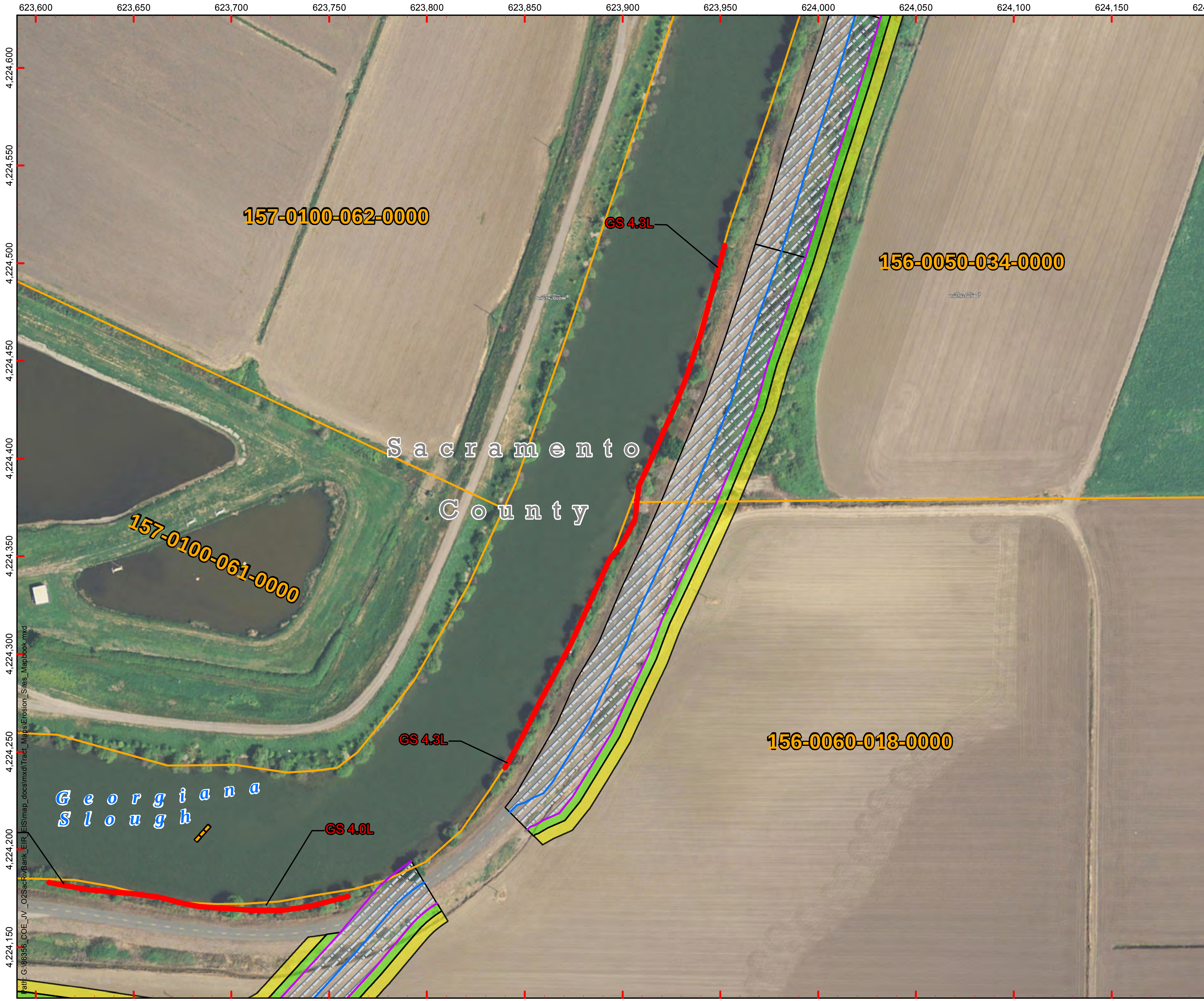
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 4.0L

Revised to Measure 1: Combined Setback Levee (GEO 3.6L, GEO 3.7La, GEO 3.7Lb and GEO 4.0L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 4.3L

Revised to Measure 3: Combined Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 4.5L

Revised to Measure 3: Combined Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 4.6L

Revised to Measure 3: Combined Adjacent Levee

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Between GEO 4.6L and GEO 5.3L

Revised to Measure 3: Combined Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 5.3L South

Revised to Measure 3: Combined Adjacent Levee

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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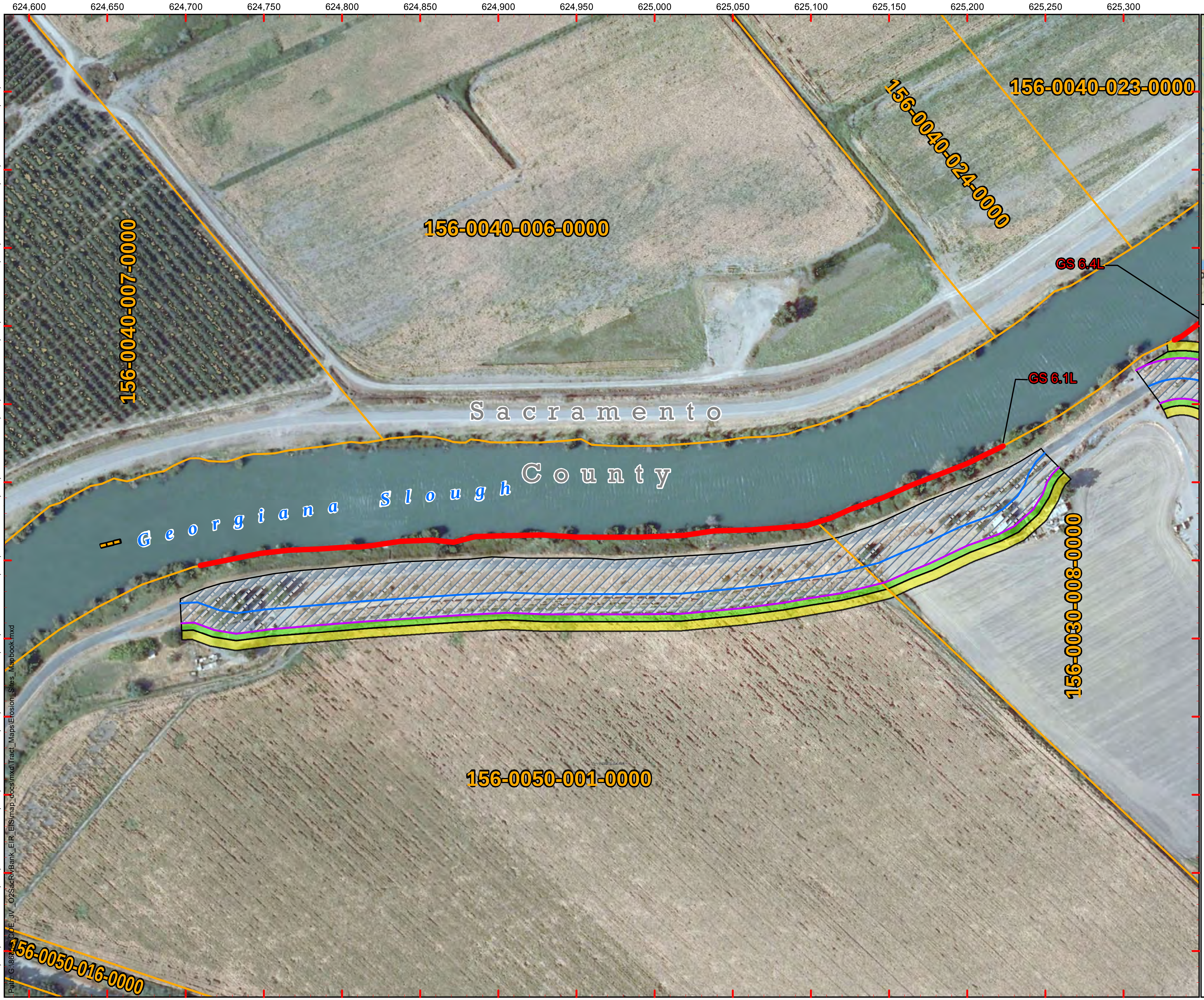
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 5.3L North

Revised to Measure 3: Combined Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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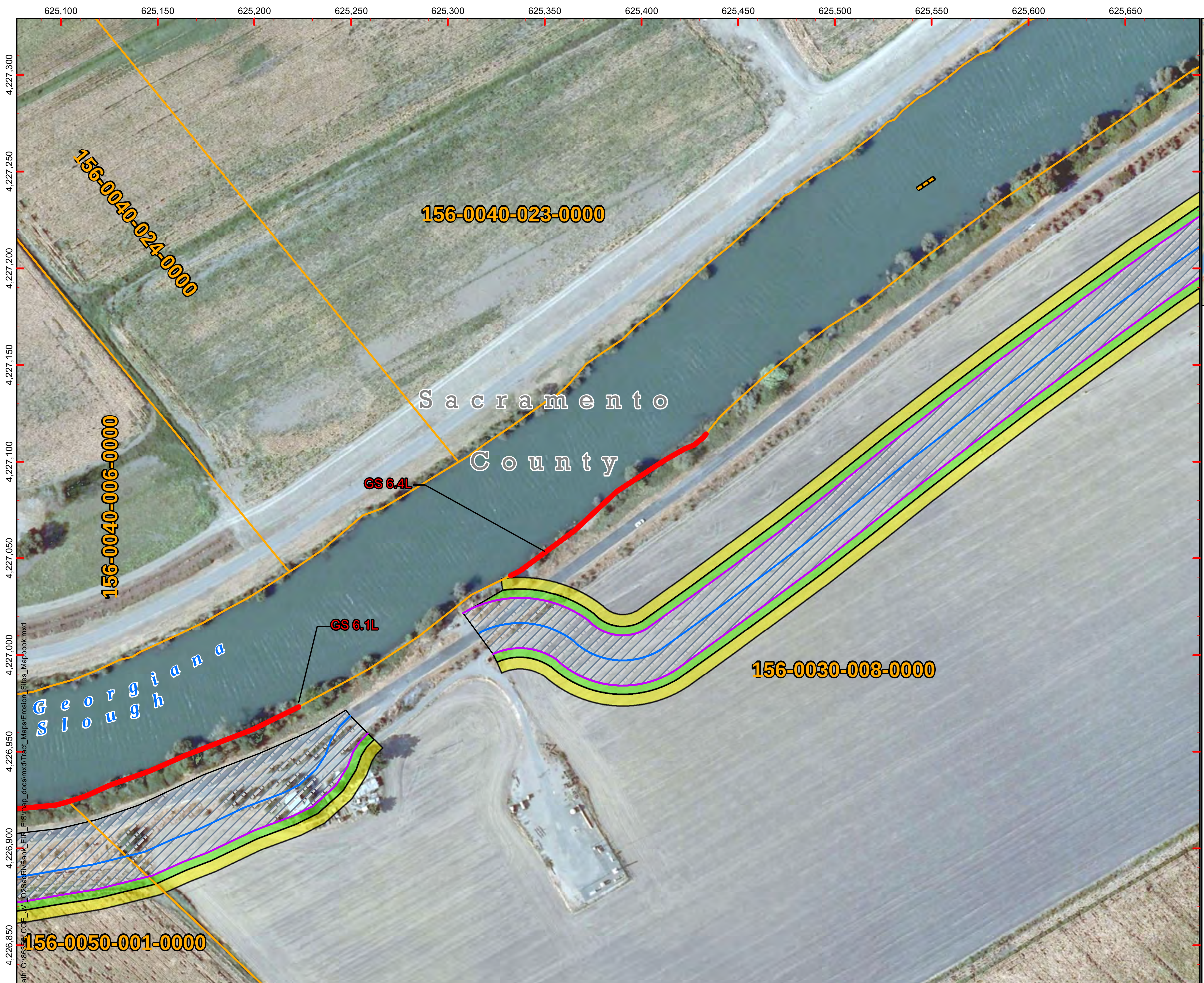
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 6.1L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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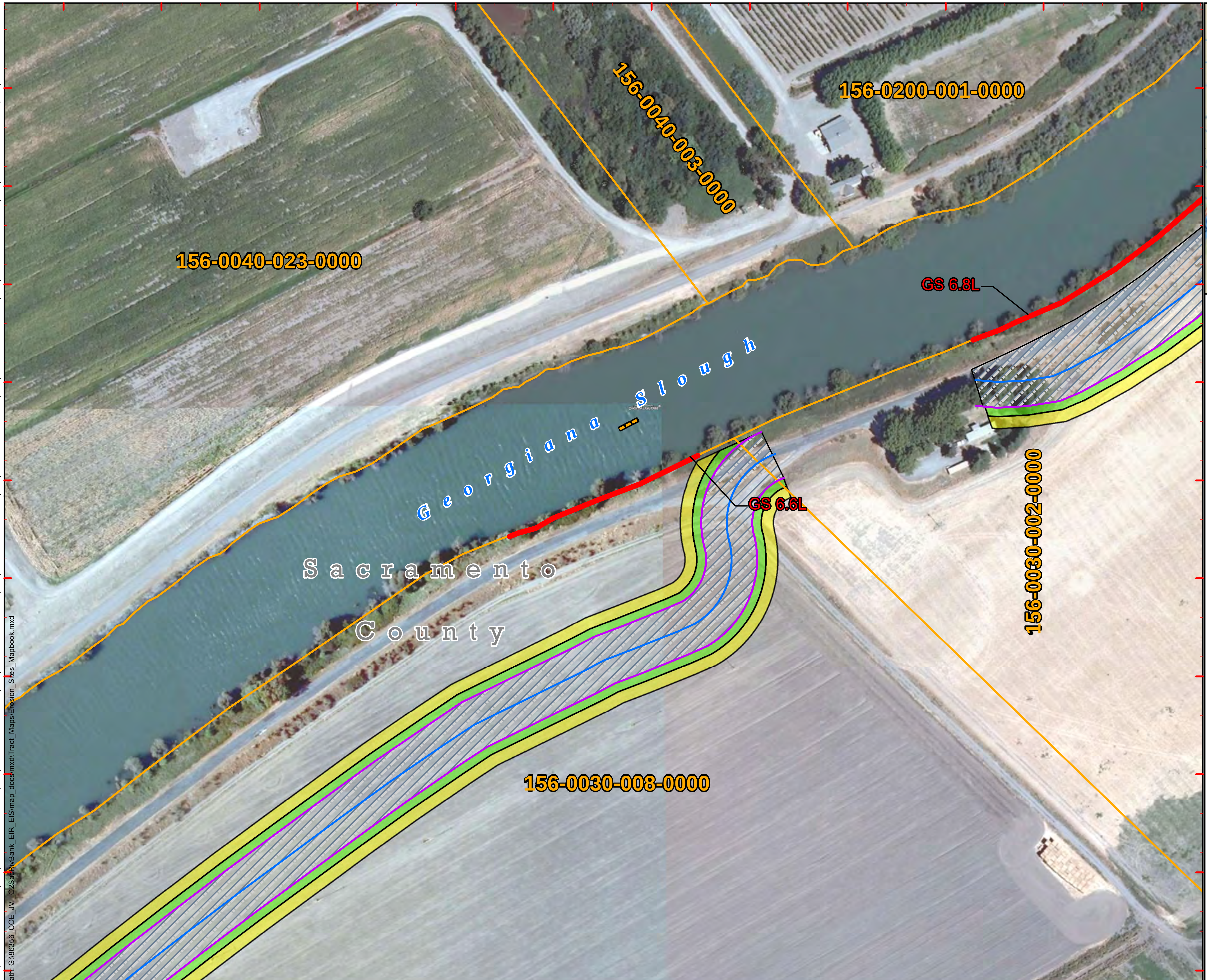
REAL ESTATE OWNERSHIP MAPS 2012

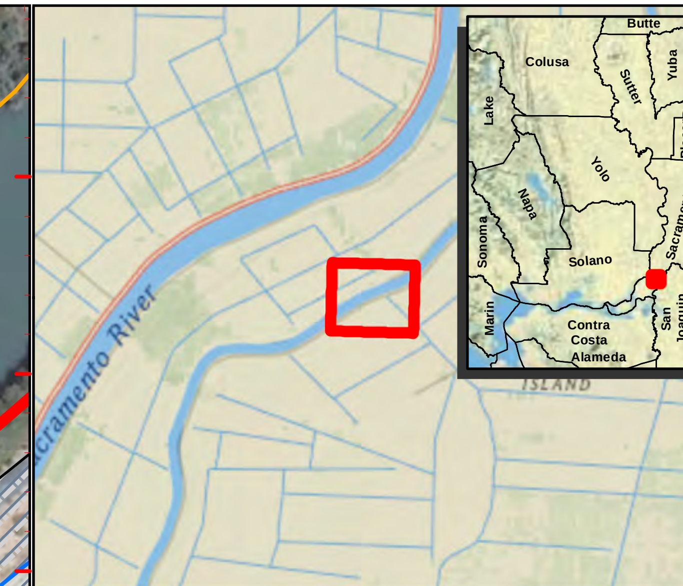
EROSION SITE: GEO 6.4L

Revised to Measure 1: Combined Setback Levee (GEO 6.4L and GEO 6.6L)

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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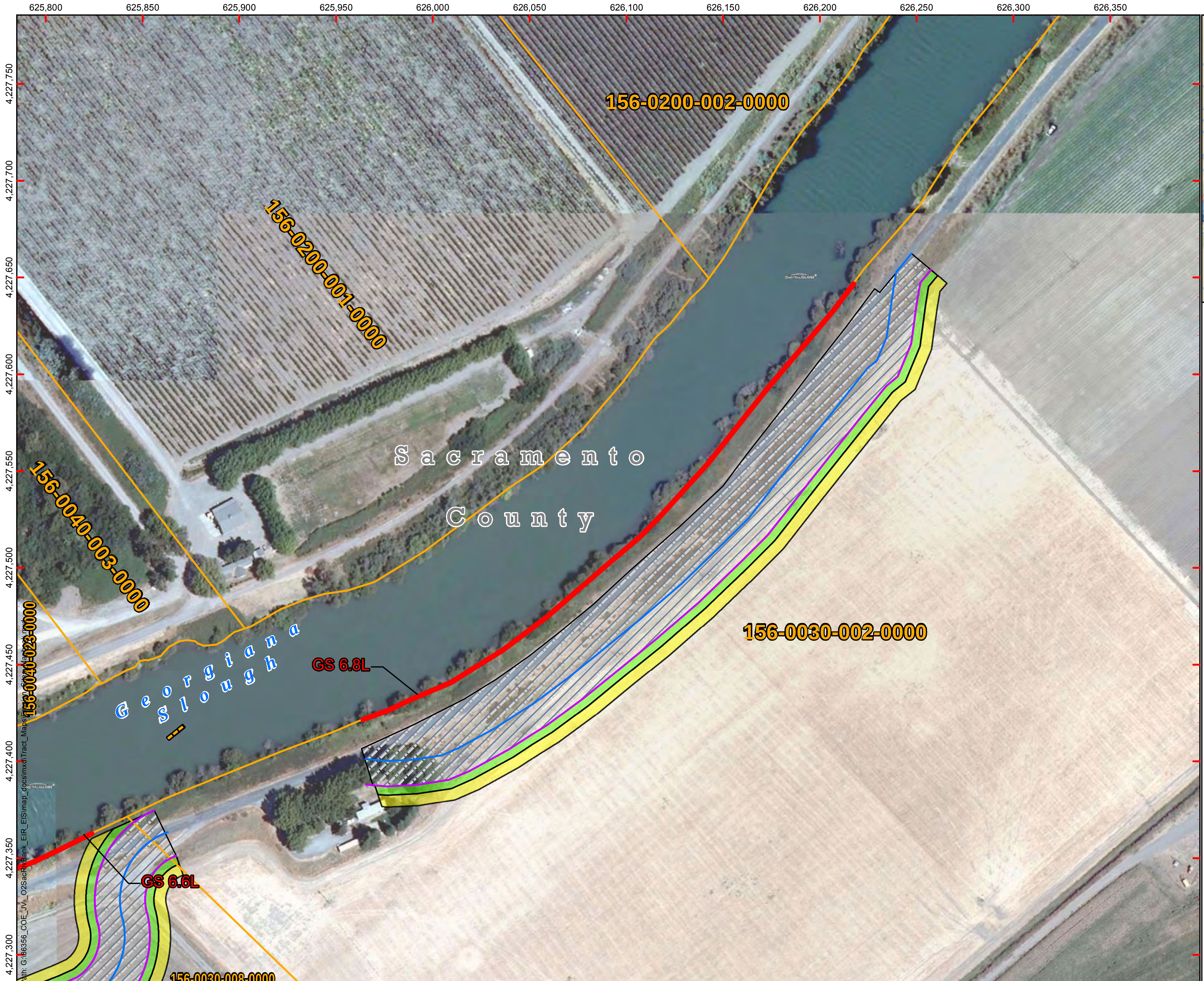
REAL ESTATE OWNERSHIP MAPS 2012

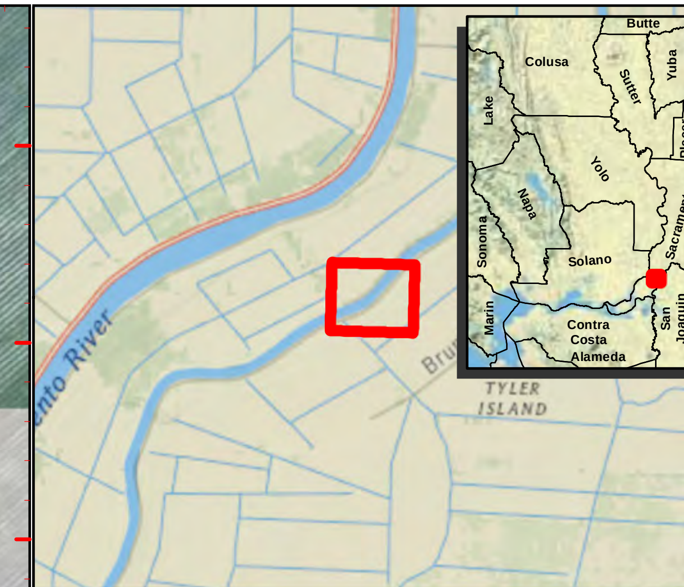
EROSION SITE: GEO 6.6L

Revised to Measure 1: Combined Setback Levee (GEO 6.4L and GEO 6.6L)

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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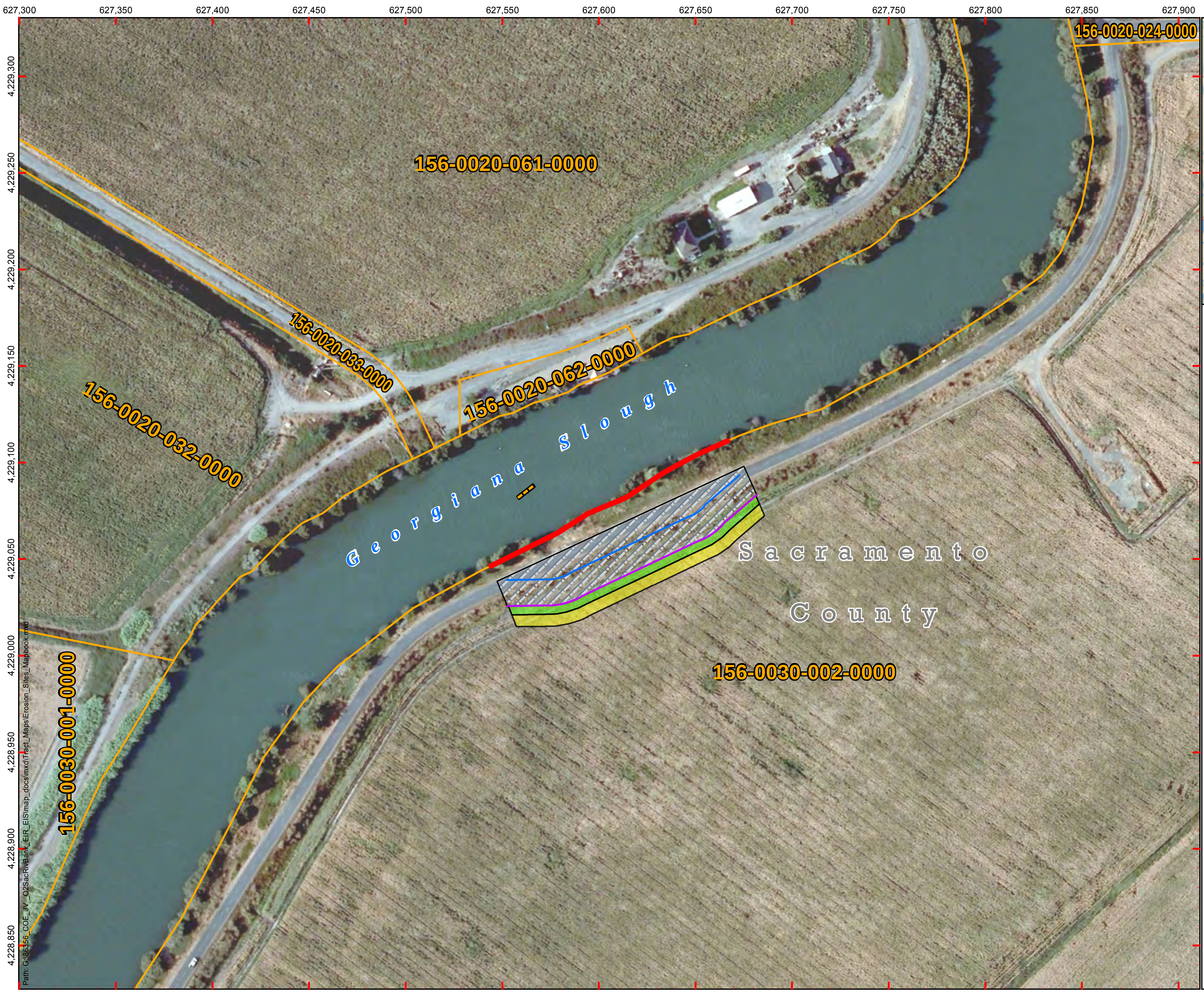
REAL ESTATE OWNERSHIP MAPS 2012

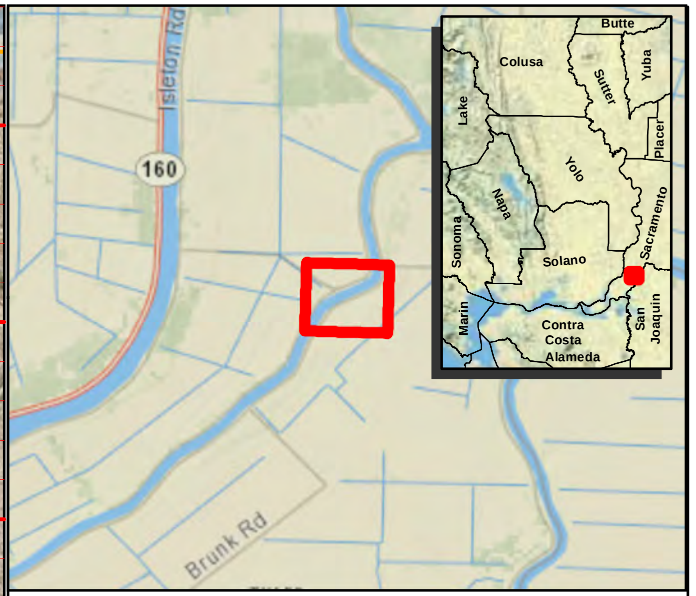
EROSION SITE: GEO 6.8L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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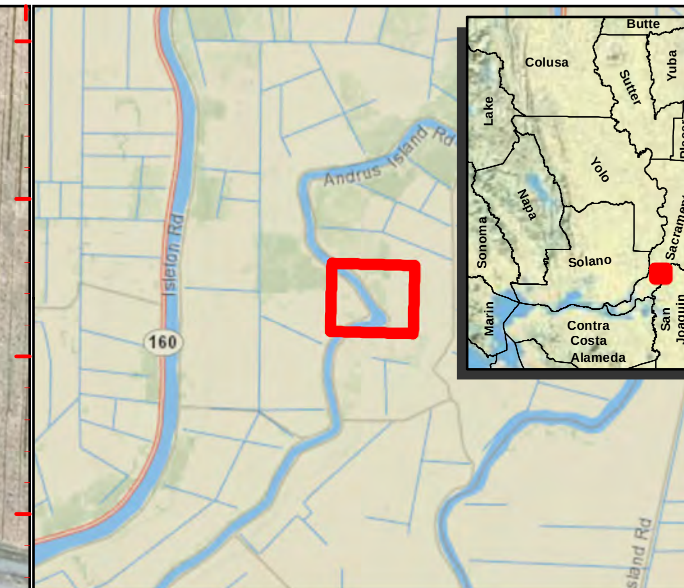
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 8.3L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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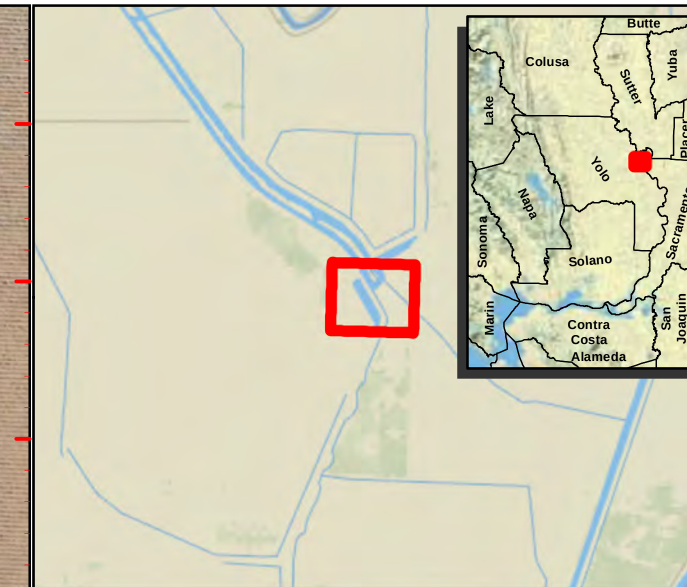
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: GEO 9.3L

AR Design 4, Measure 9

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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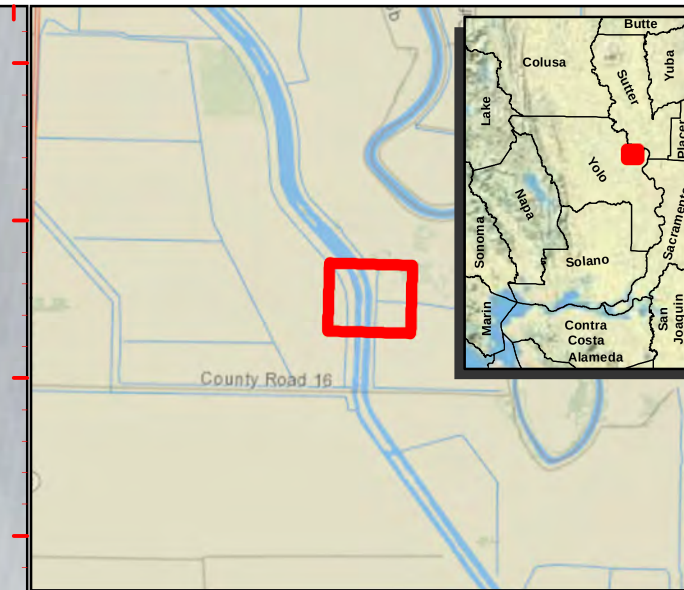
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: KLR 0.2R

Revised to Measure 2: Bank Fill Stone Protection With No On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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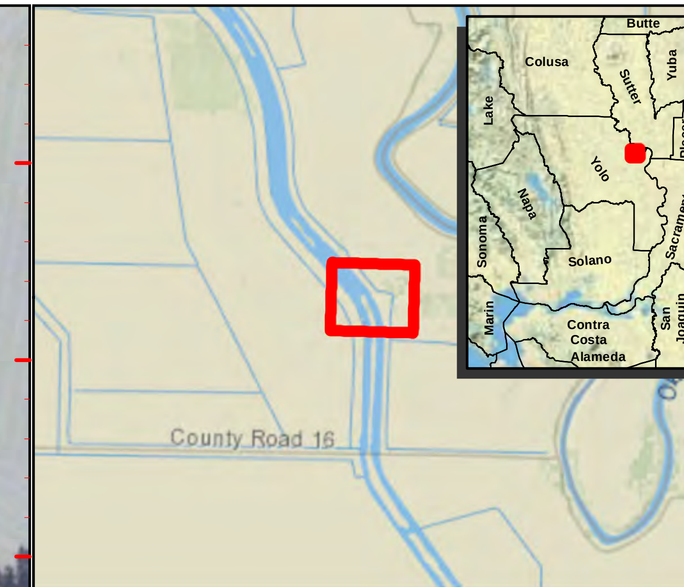
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: KLR 3.0L

Revised to Measure 2: Bank Fill Stone Protection With No On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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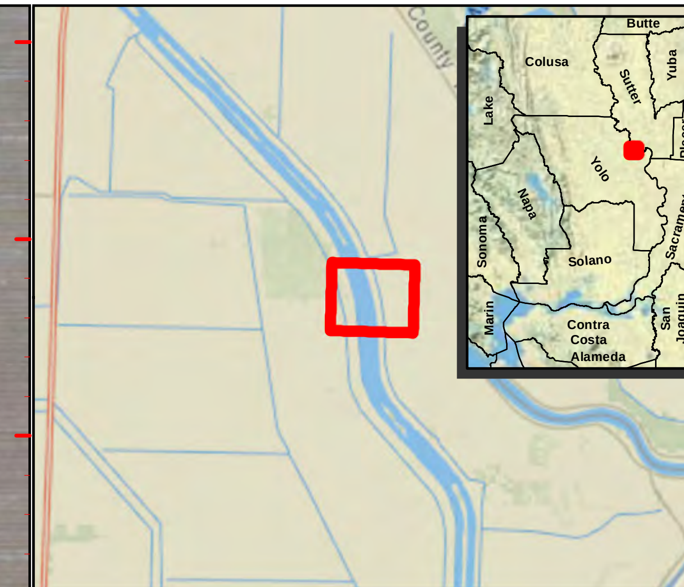
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: KLR 3.1L

Revised to Measure 2: Bank Fill Stone Protection

Sacramento River Bank EIR/EIS

2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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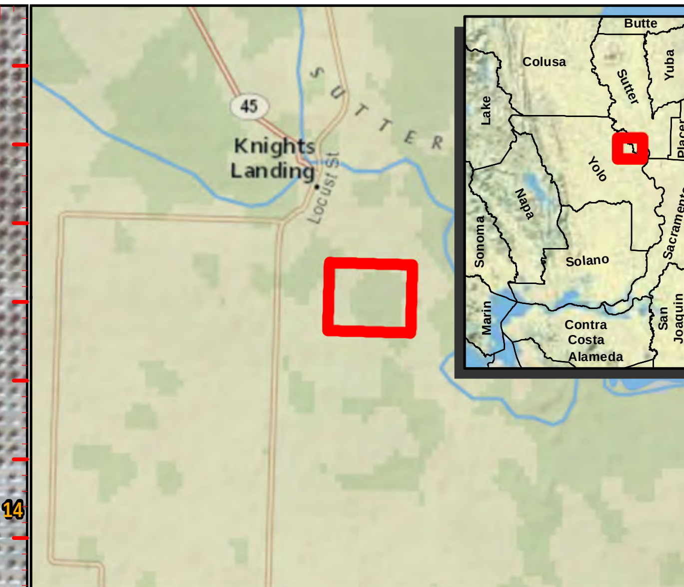
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: KLR 4.3L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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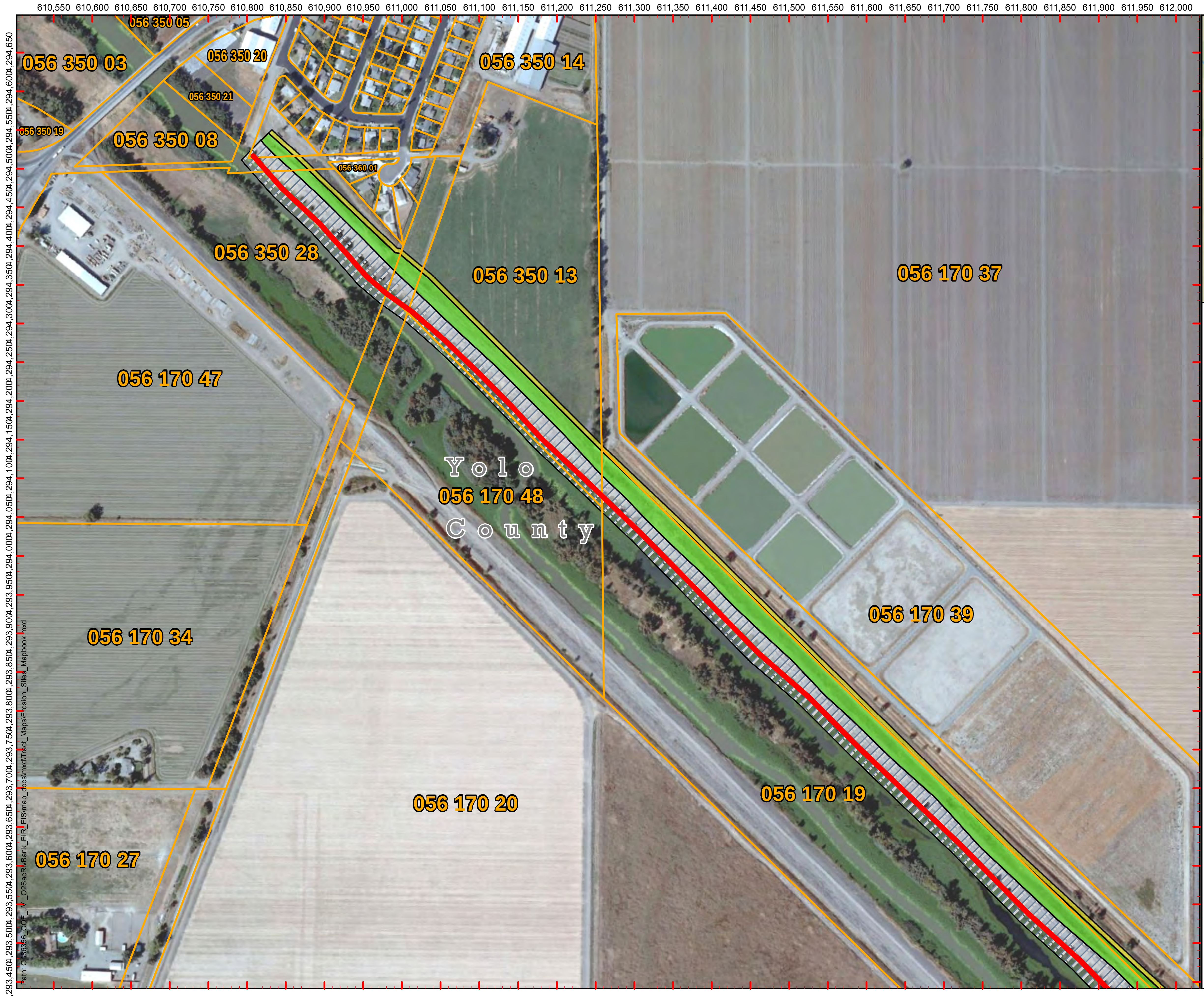
REAL ESTATE OWNERSHIP MAPS 2012

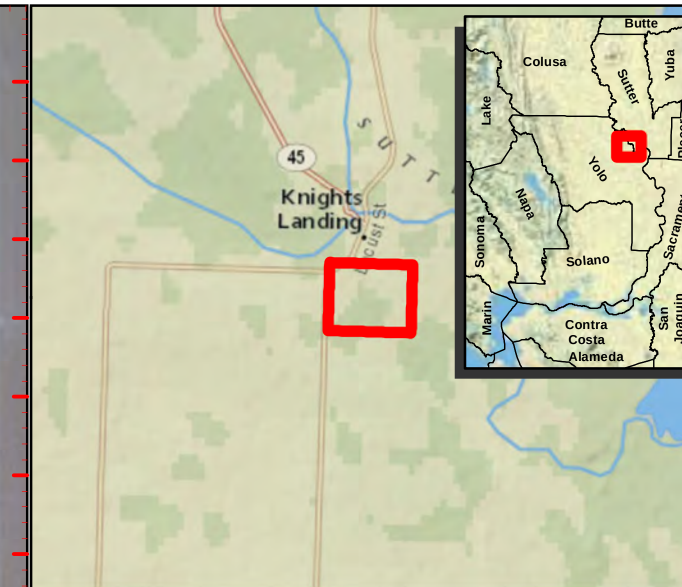
EROSION SITE: KLR 5.3L South

Revised to Measure 2: Bank Fill Rock Slope With No On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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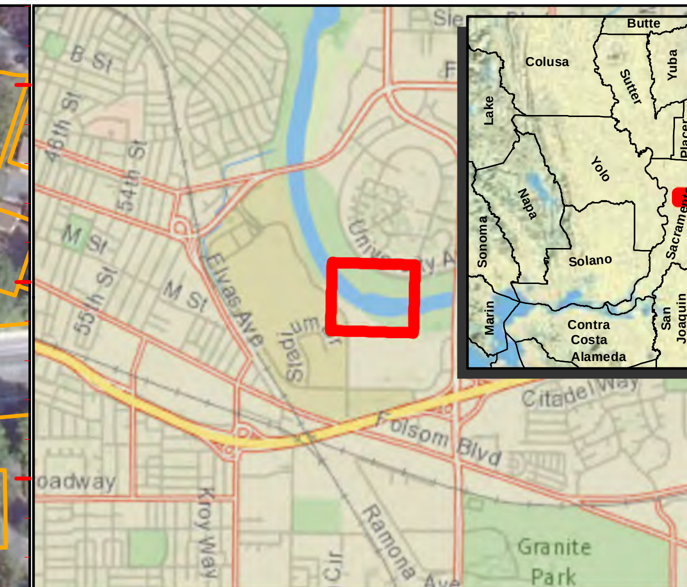
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: KLR 5.3L North

Revised to Measure 2: Bank Fill Rock Slope With No On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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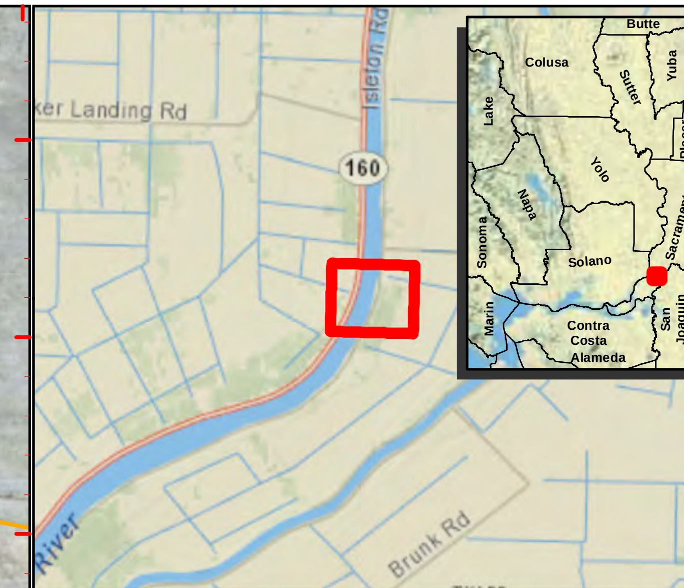
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: LAR 7.3R

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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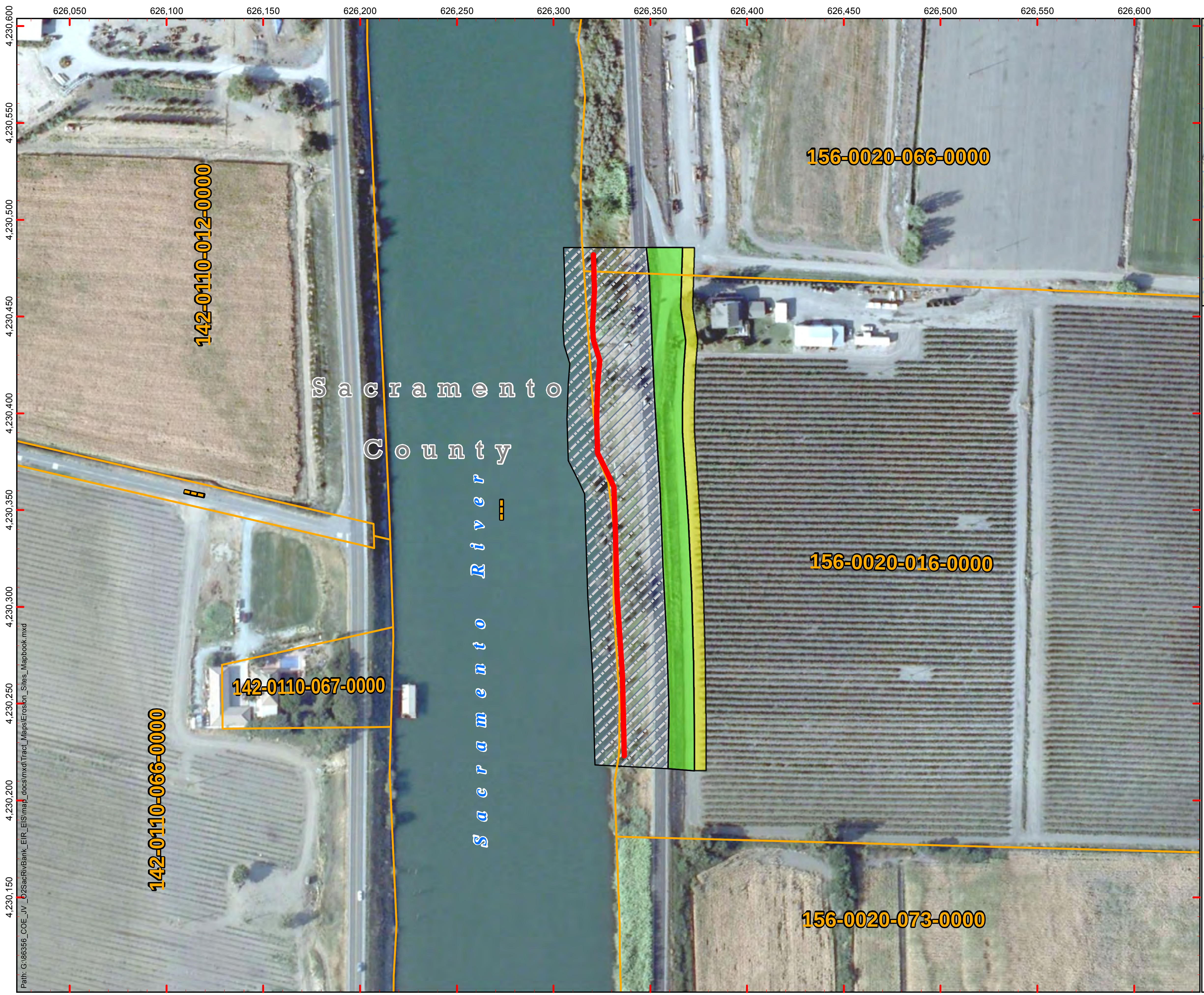
REAL ESTATE OWNERSHIP MAPS 2012

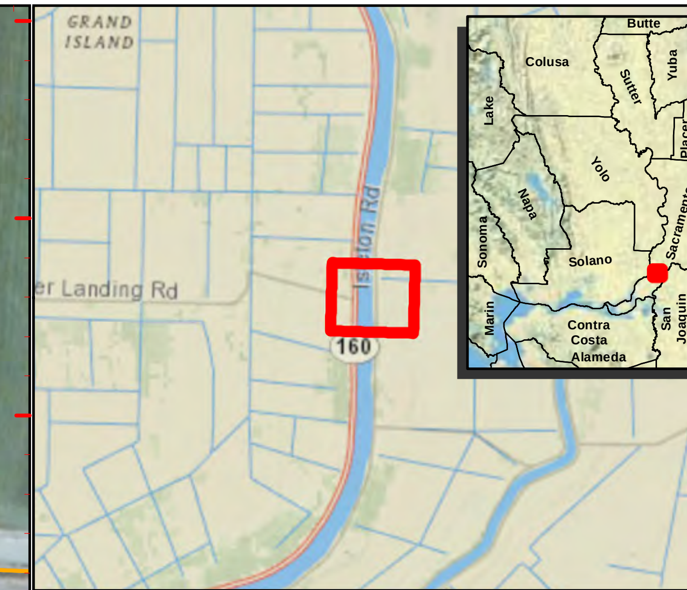
EROSION SITE: Sac 21.5L

Revised to Measure 4c: Riparian and Wetland Bench with Re-Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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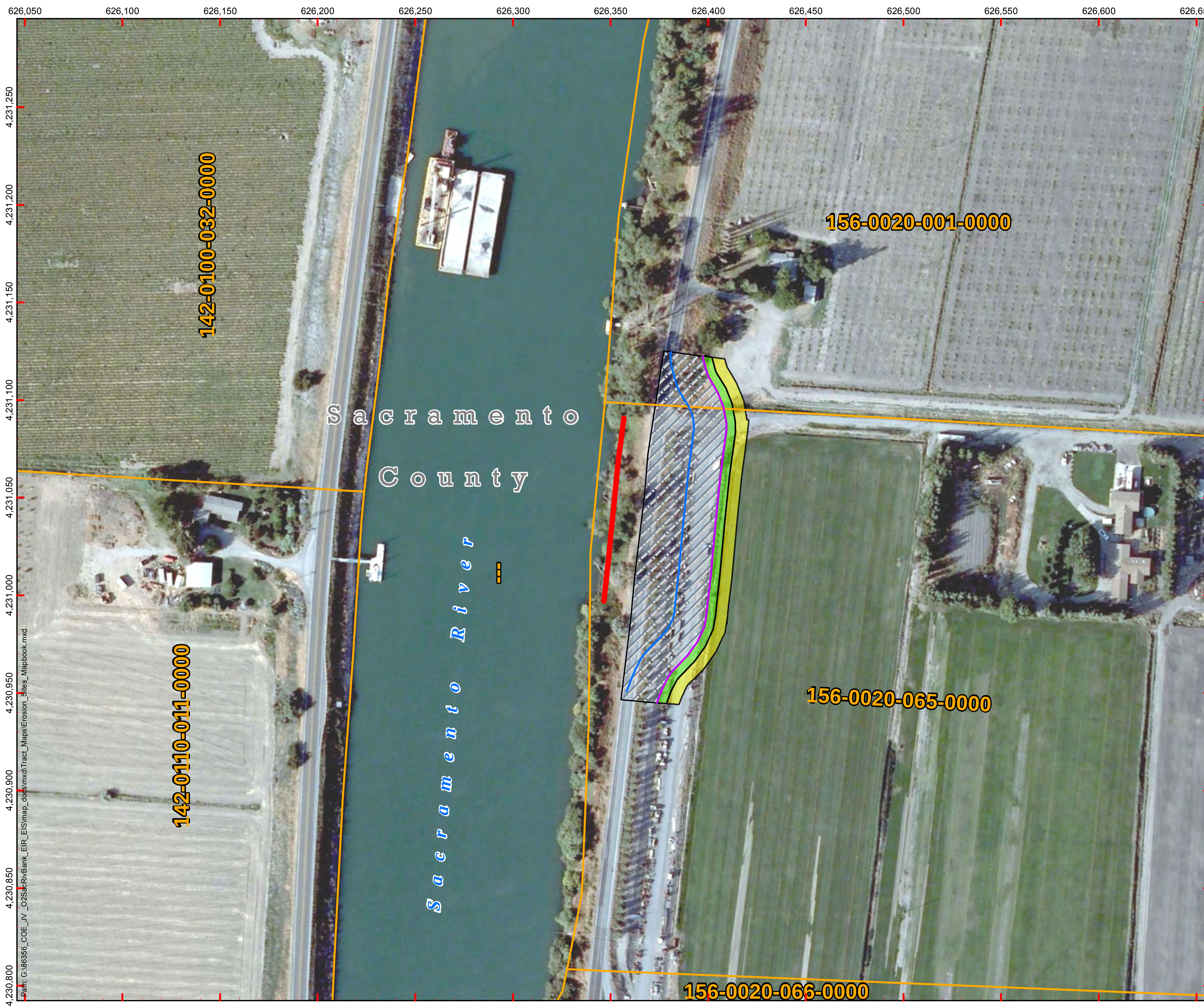
REAL ESTATE OWNERSHIP MAPS 2012

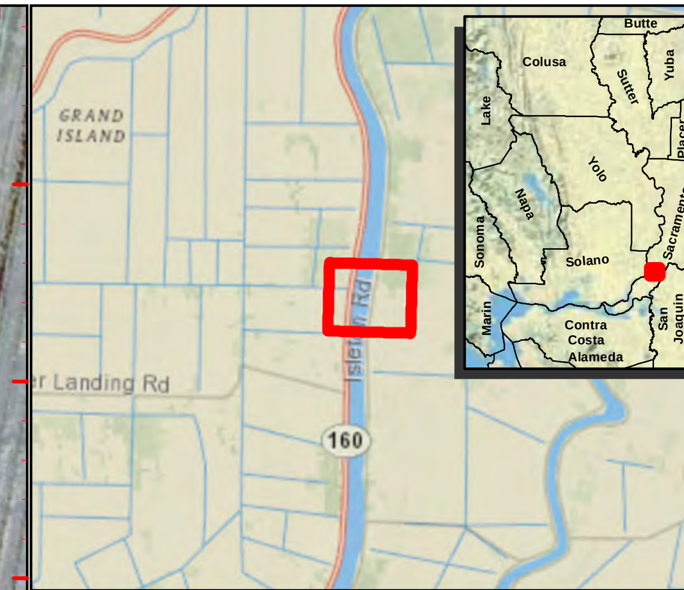
EROSION SITE: Sac 22.5L

Revised to Measure 4c:Riparian and Wetland Bench with Re-Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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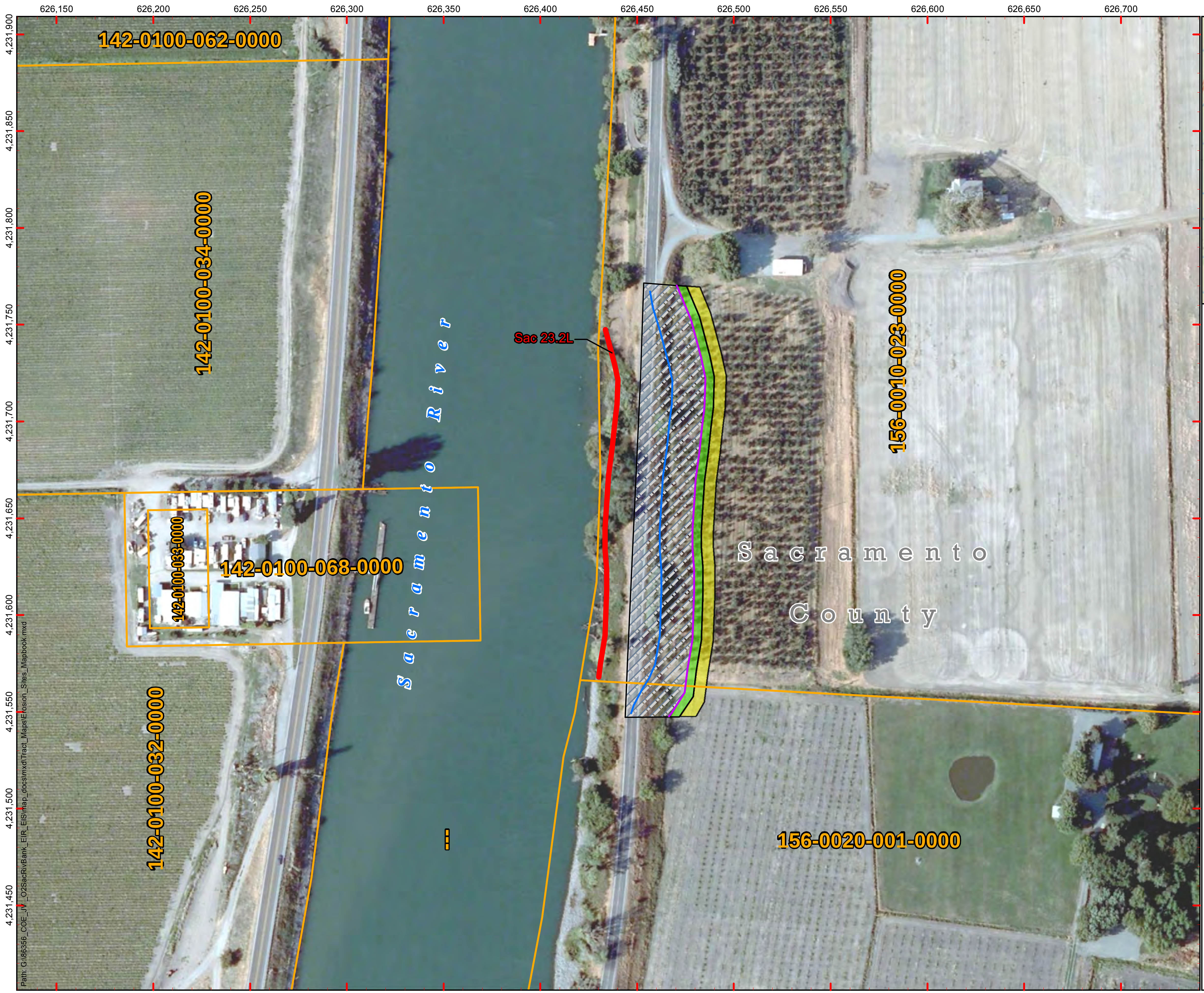
REAL ESTATE OWNERSHIP MAPS 2012

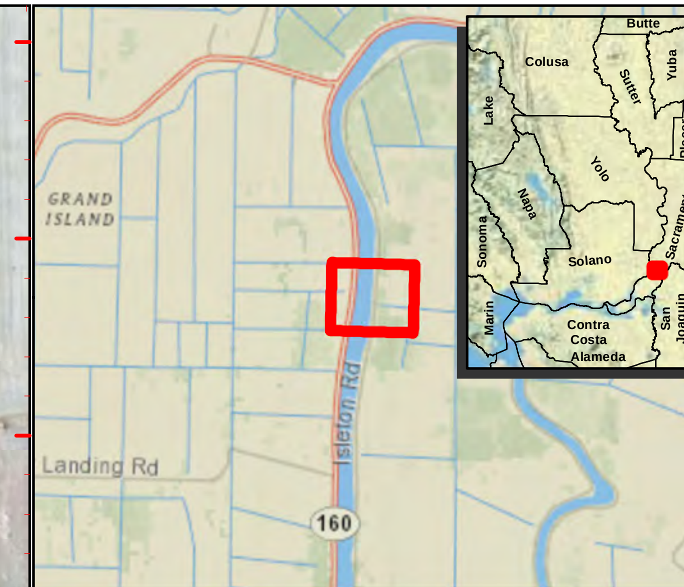
EROSION SITE: Sac 22.7L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 23.2L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

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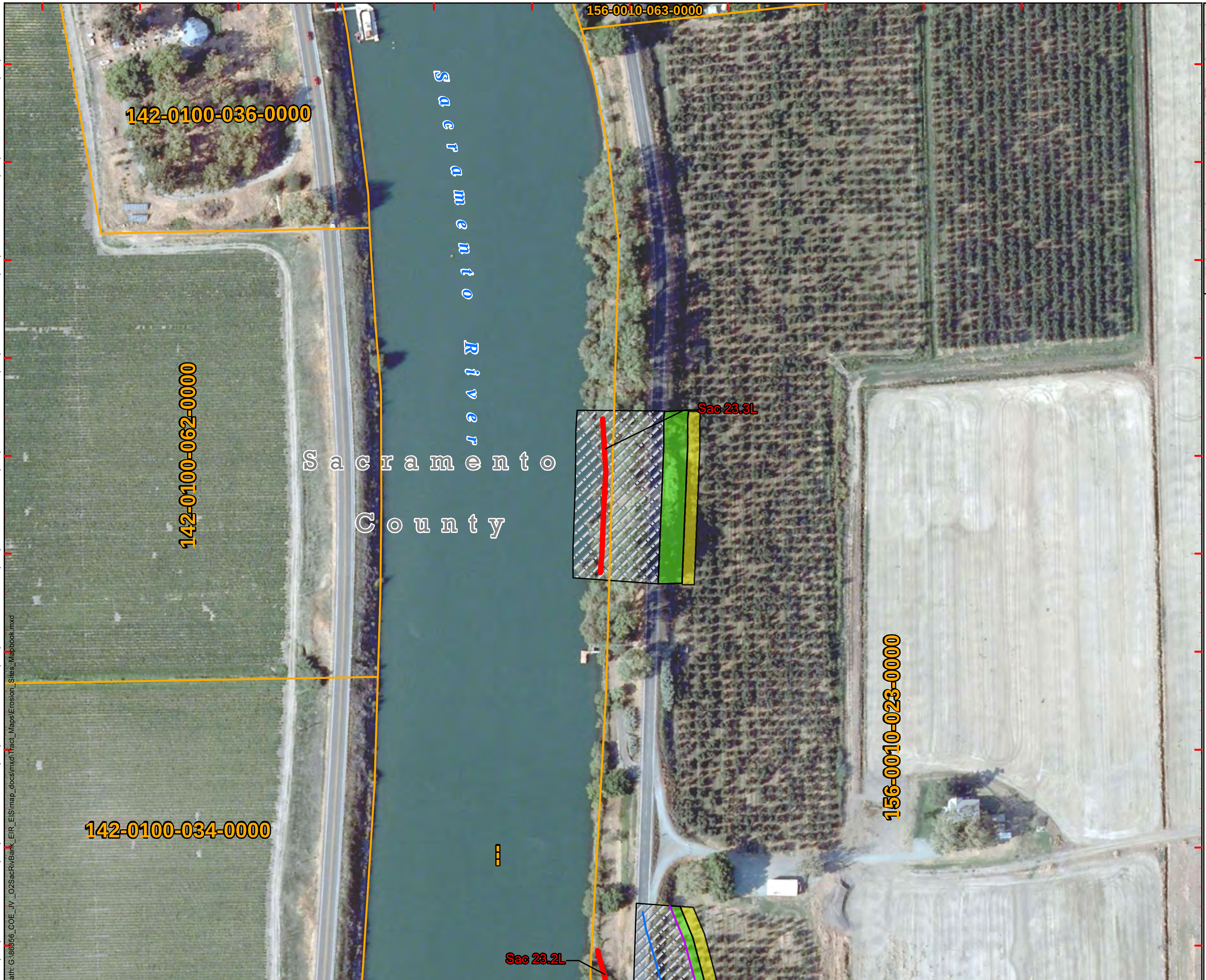

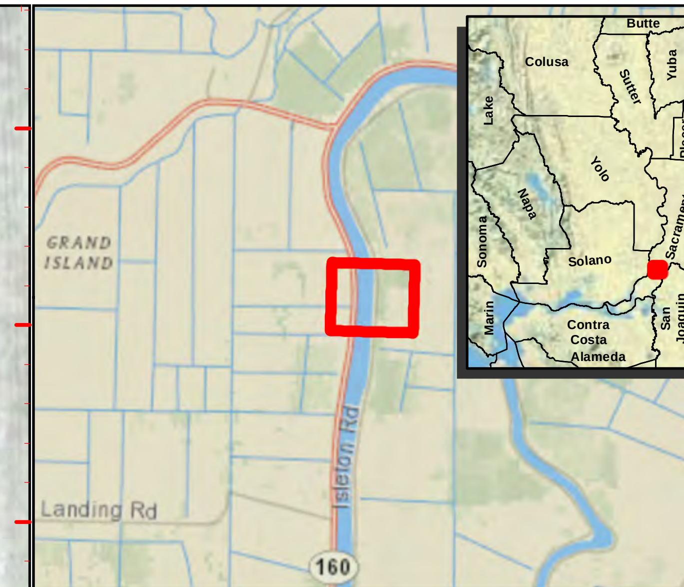

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 23.3L

AR Design 4, Measure 9

Sacramento River Bank EIR/EIS

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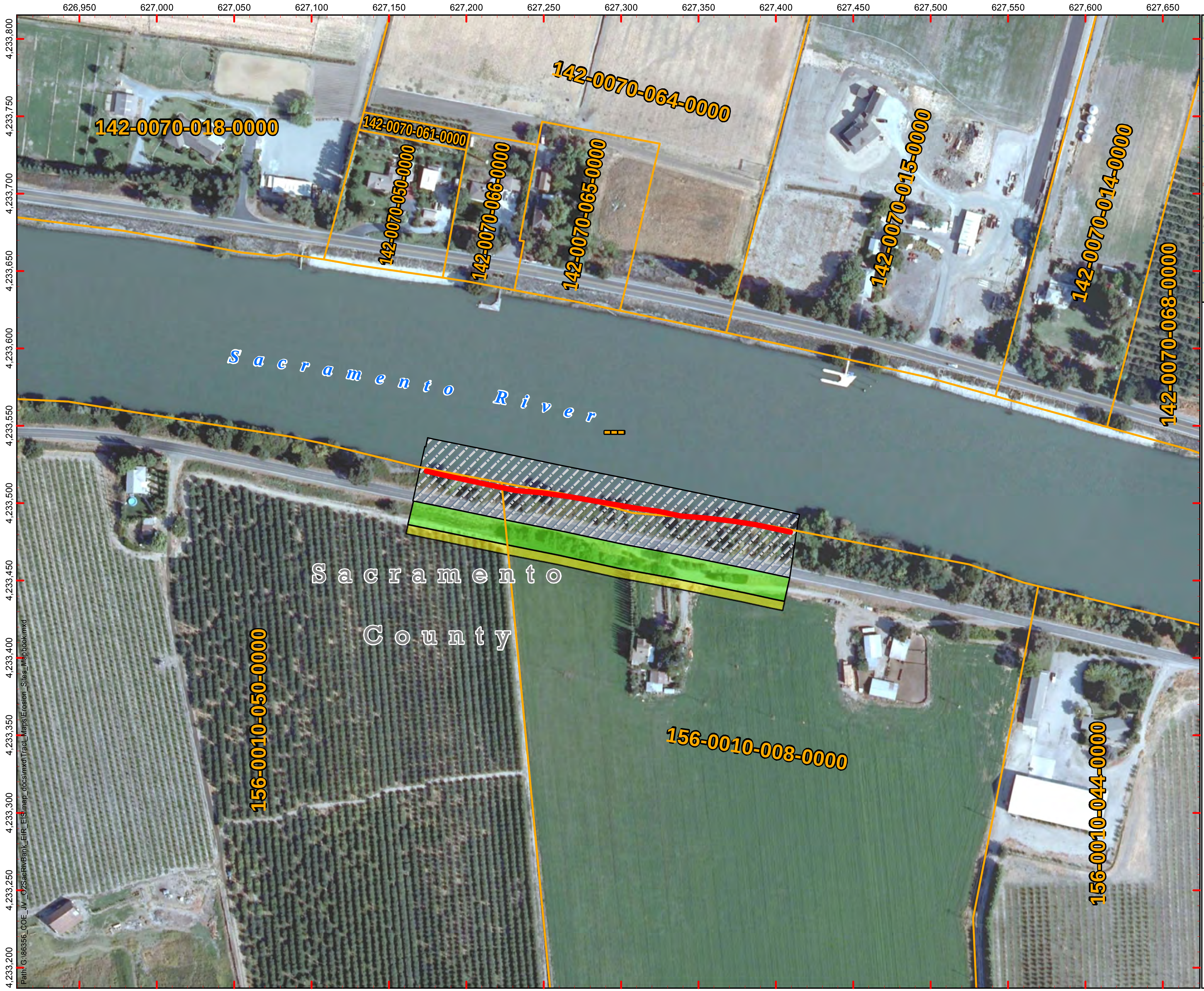

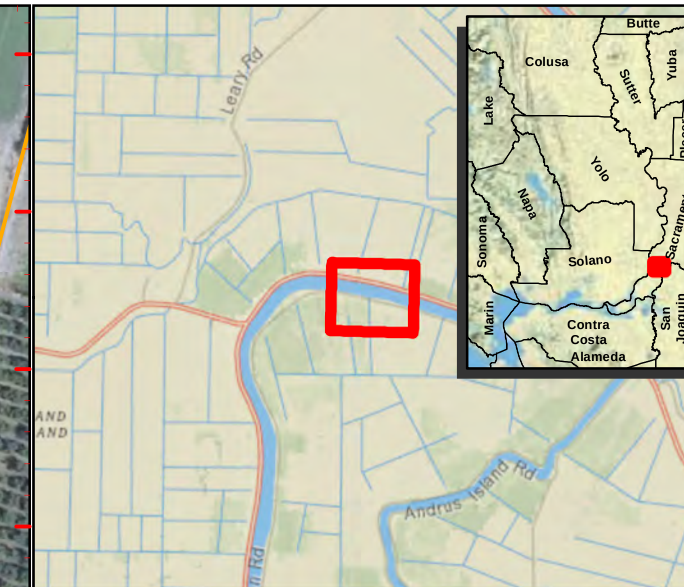

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 24.8L

Revised to Measure 2: Bank Fill Store Protection With No On-Site Vegetation

Sacramento River Bank EIR/EIS

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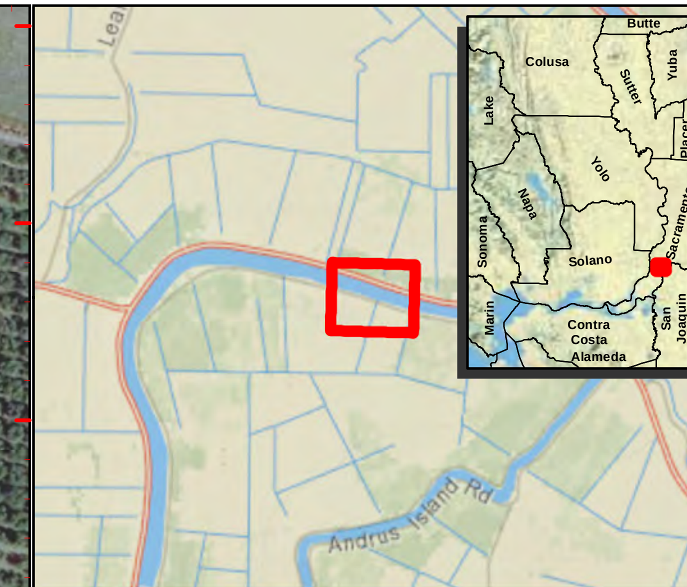

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 25.2L

AR Design 4, Alternative 8

Sacramento River Bank EIR/EIS

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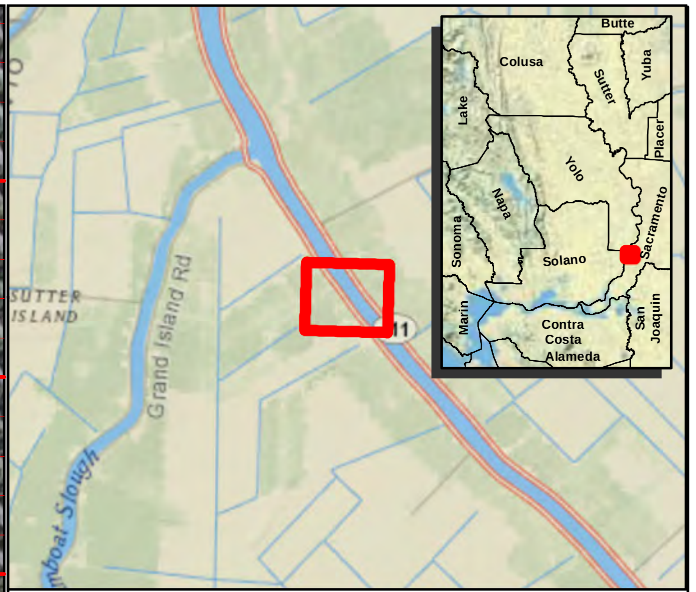

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

N

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 31.6R

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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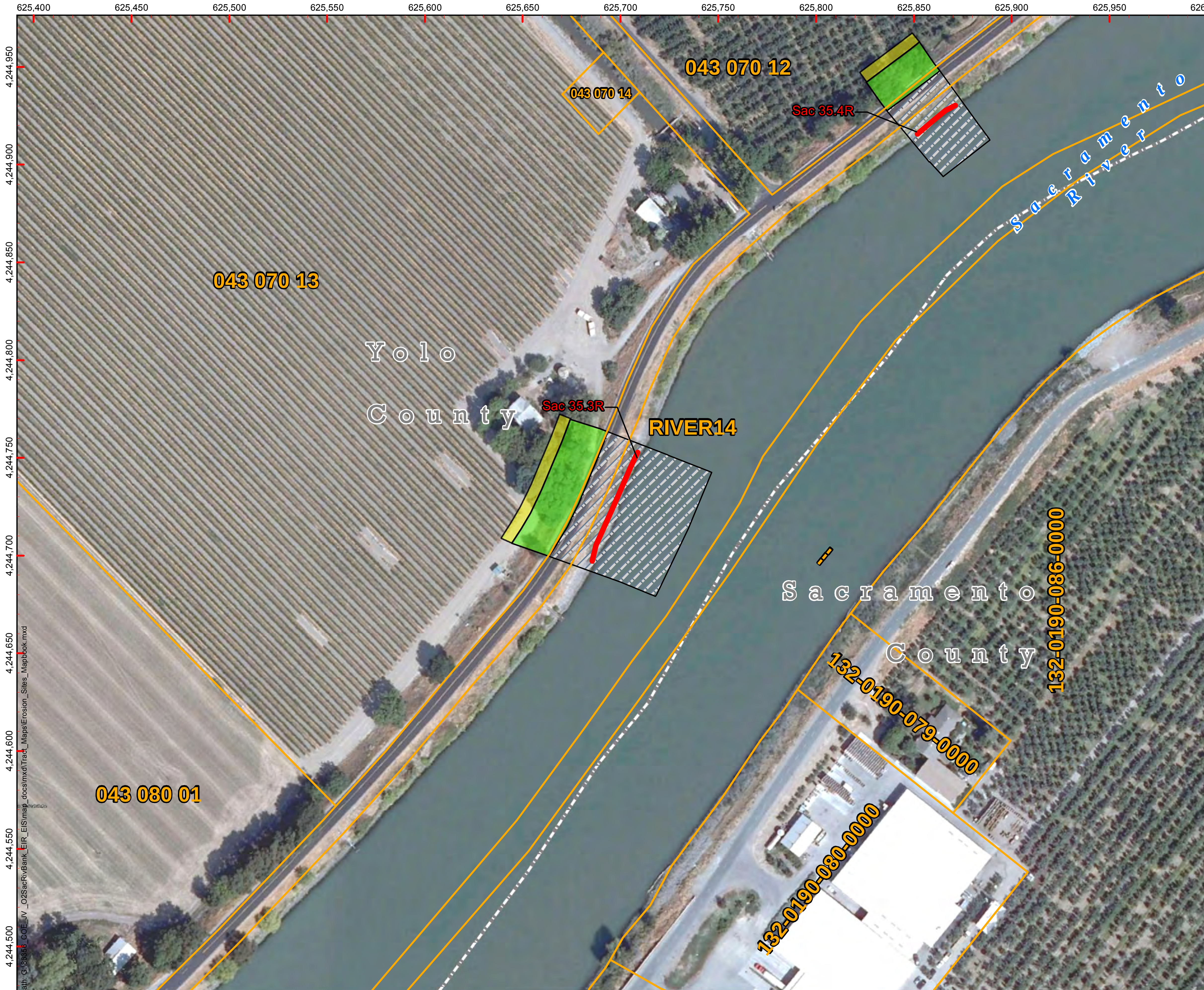

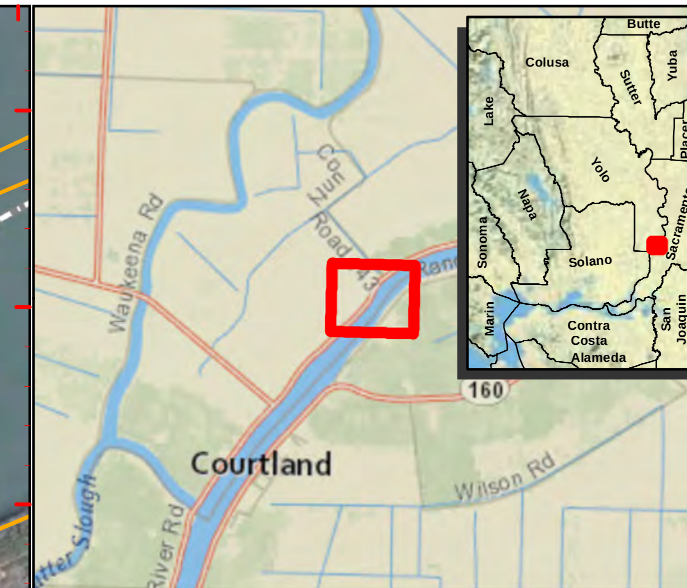

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 35.3R

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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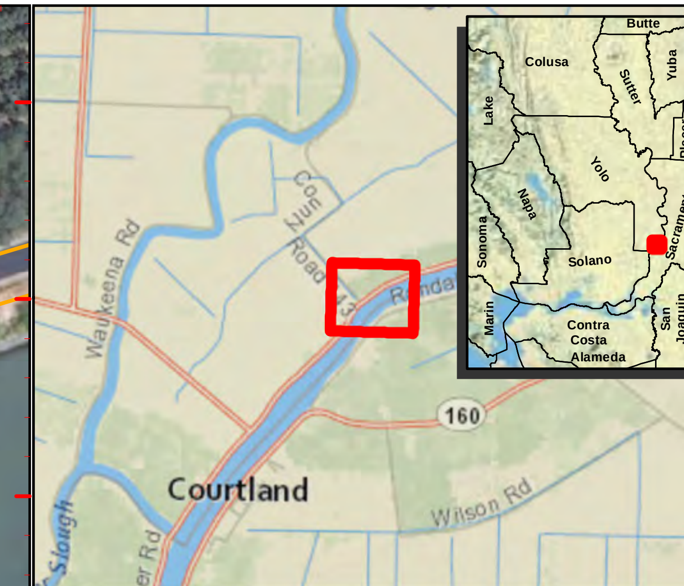

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 35.4R

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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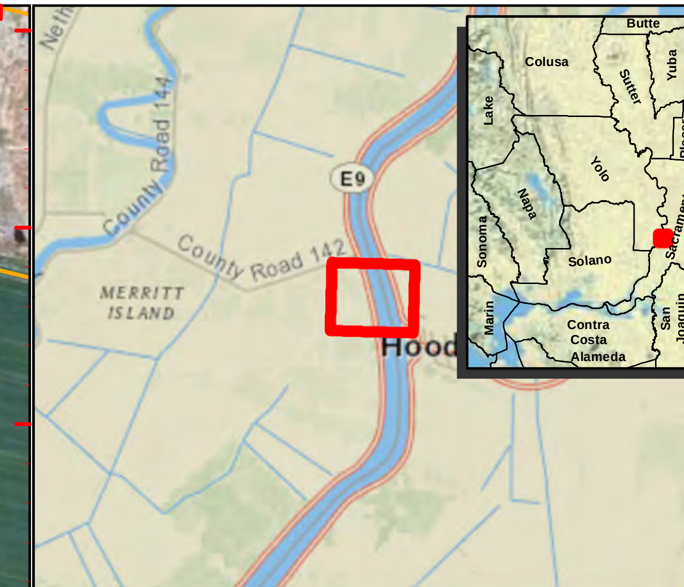

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 38.5R

AR Design 1, Measure 2

Sacramento River Bank EIR/EIS

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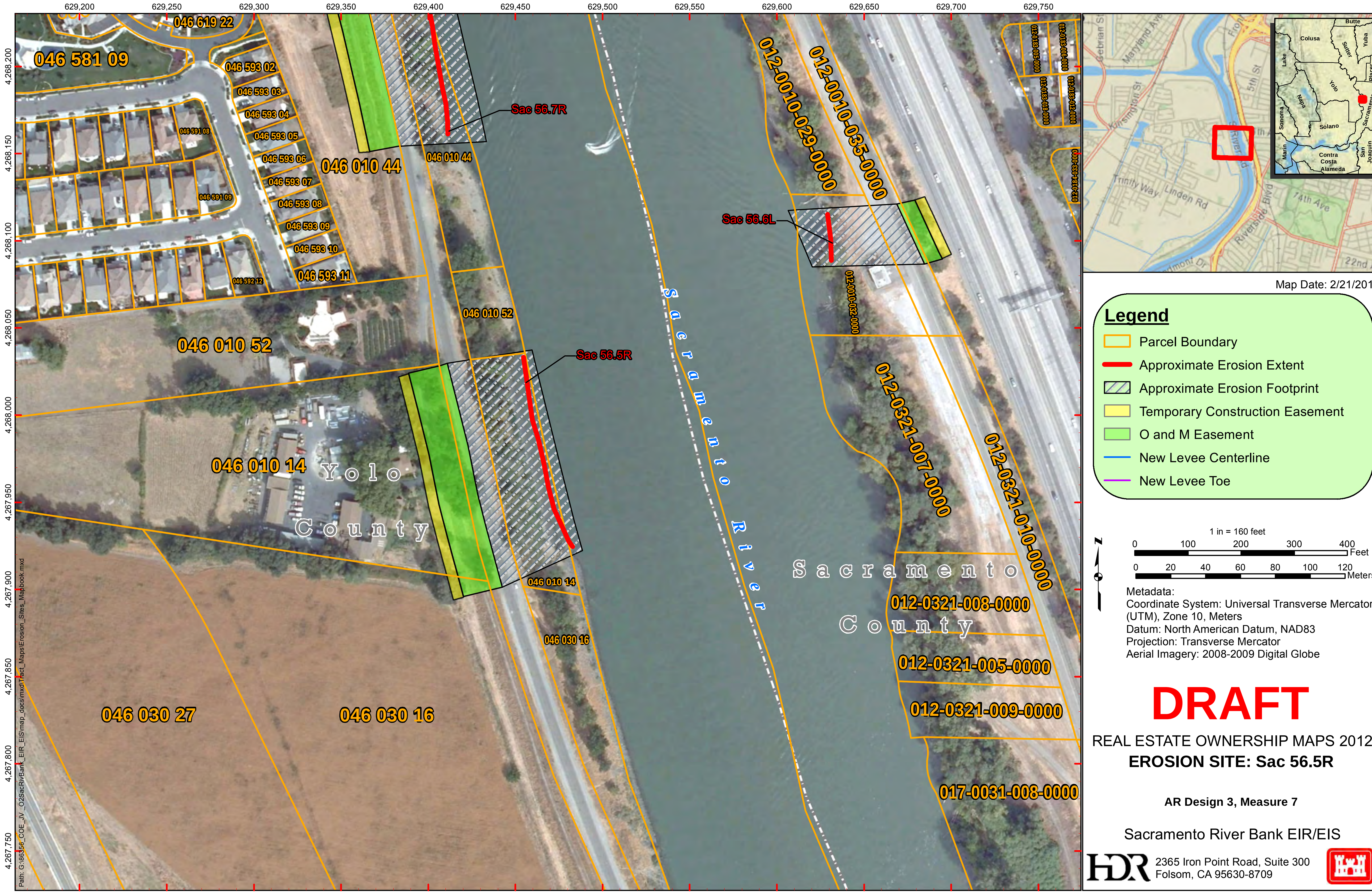

Map Date: 2/21/2012

Metadata:
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Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 56.5R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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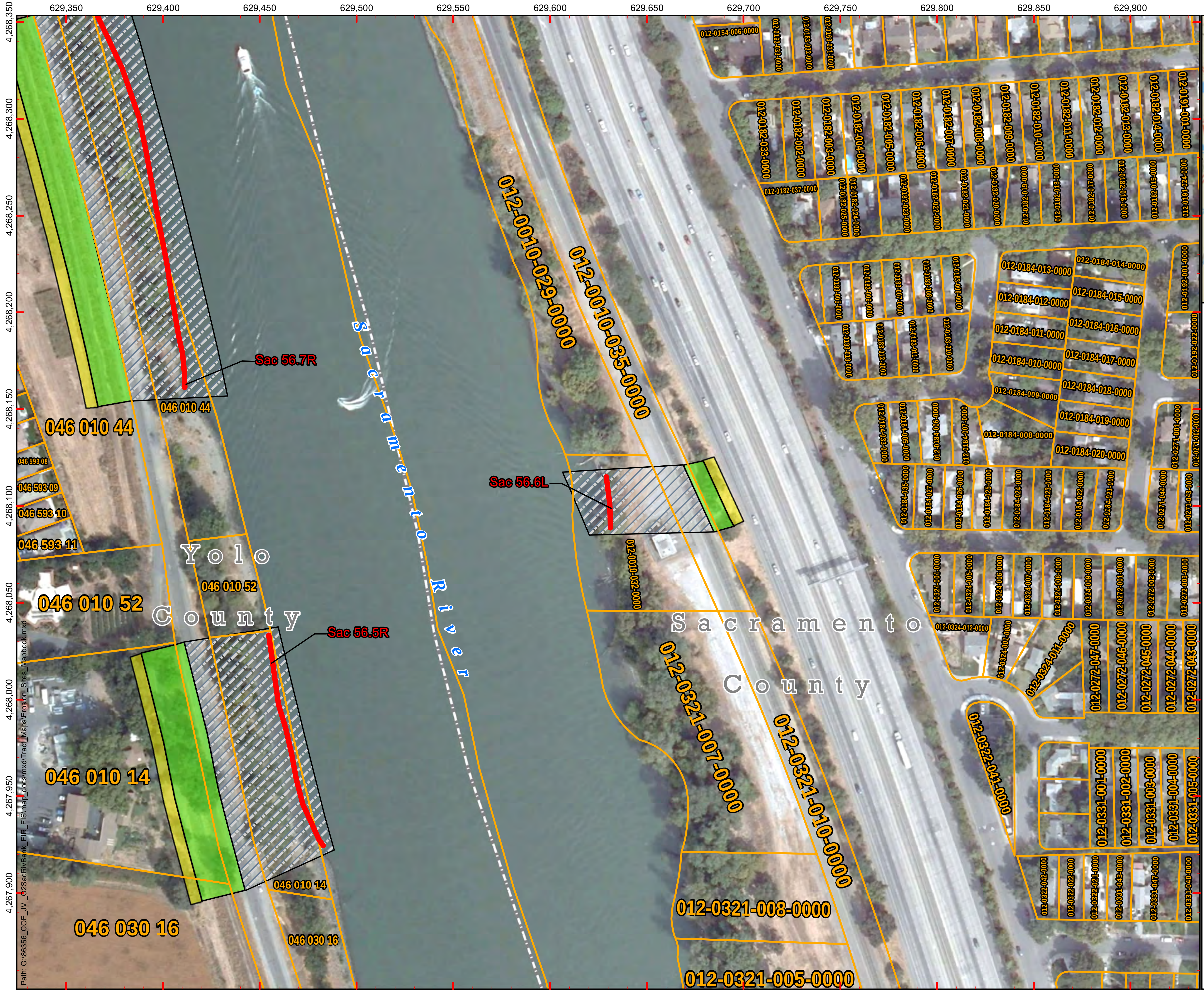

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 56.6L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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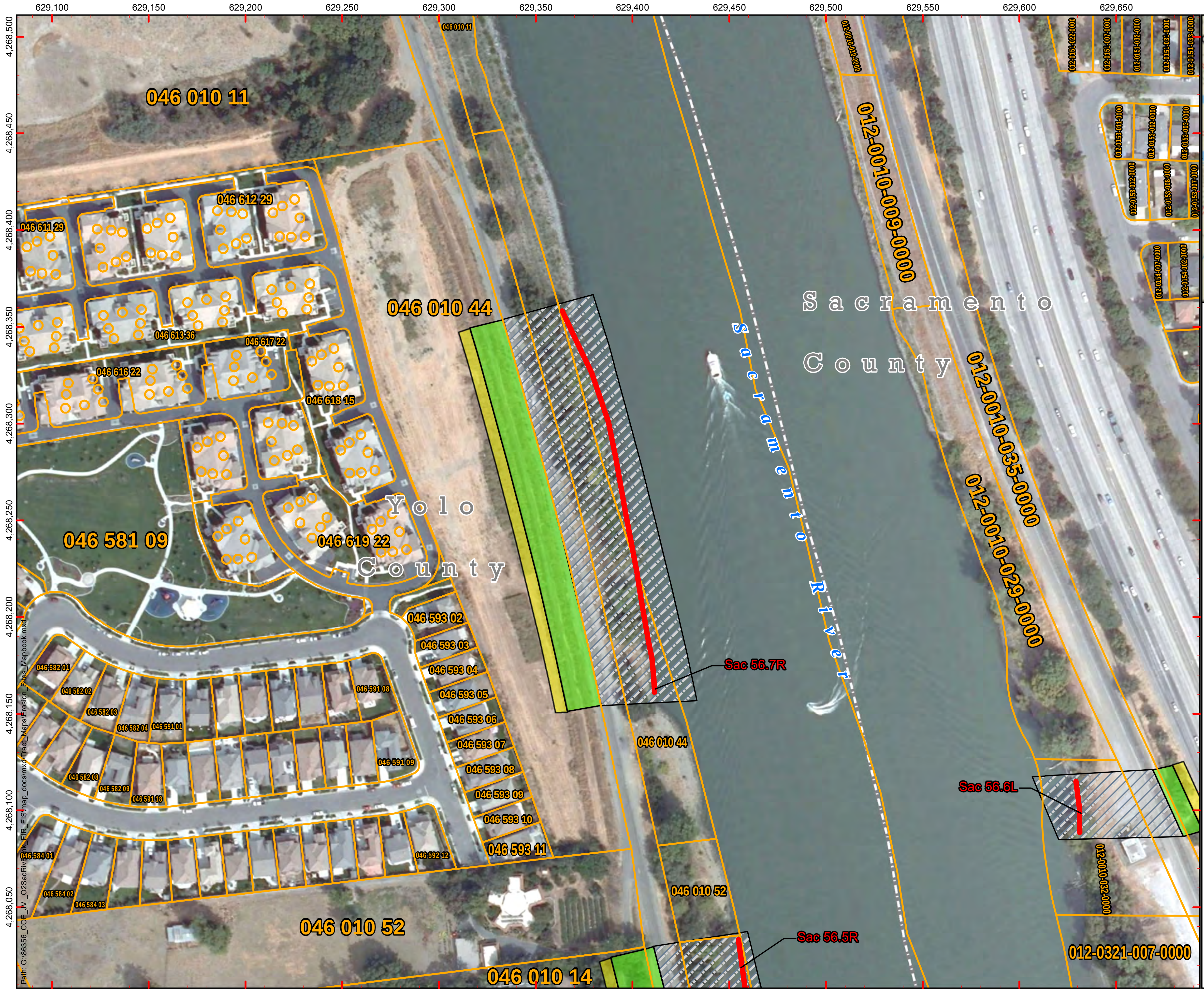

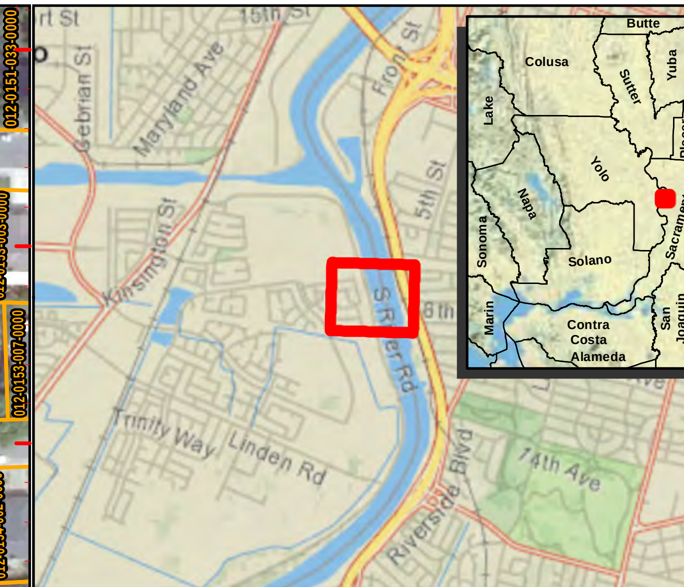

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 56.7R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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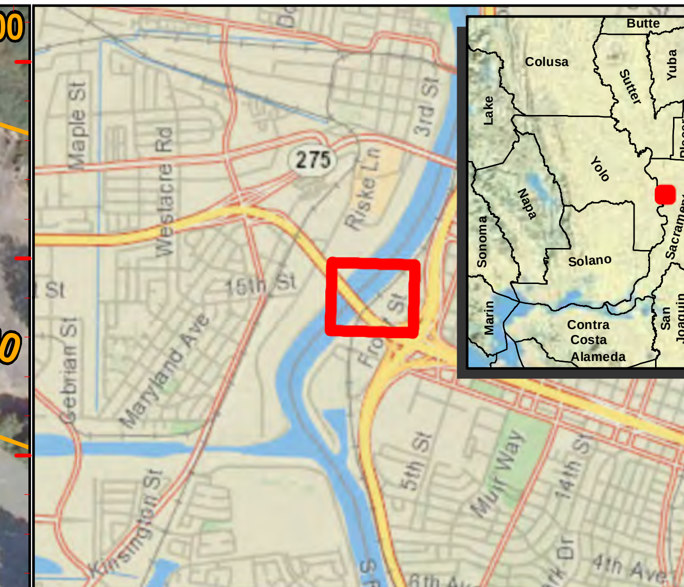

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 58.4L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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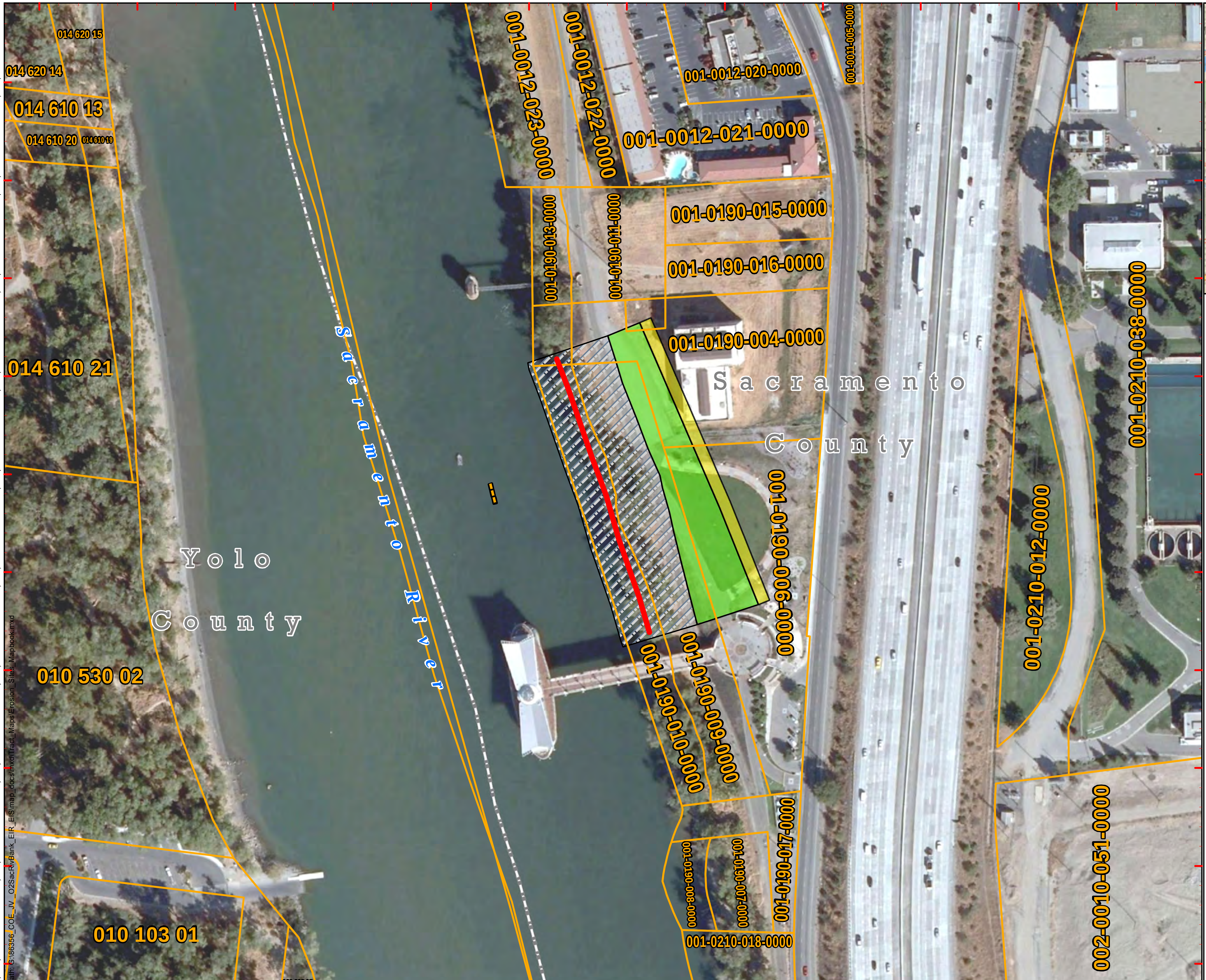

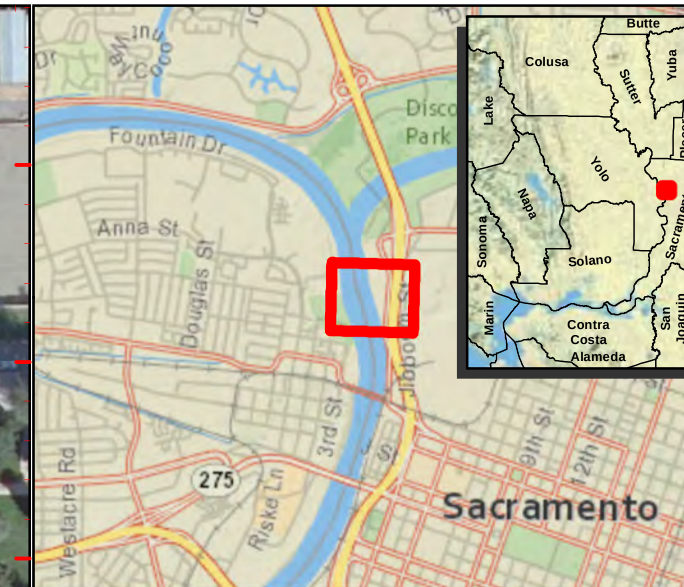

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 60.1L

AR Design 2, Measure 3

Sacramento River Bank EIR/EIS

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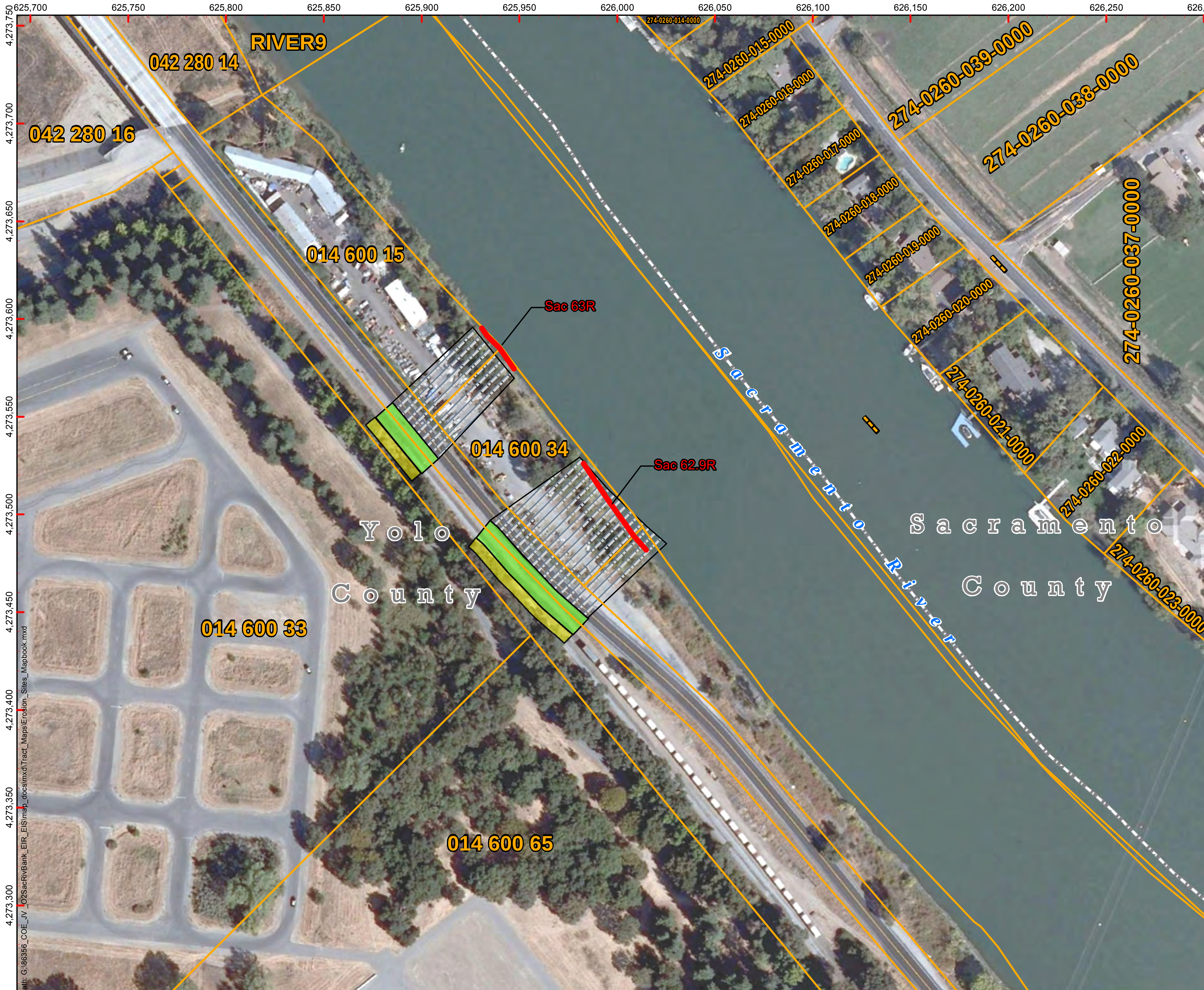

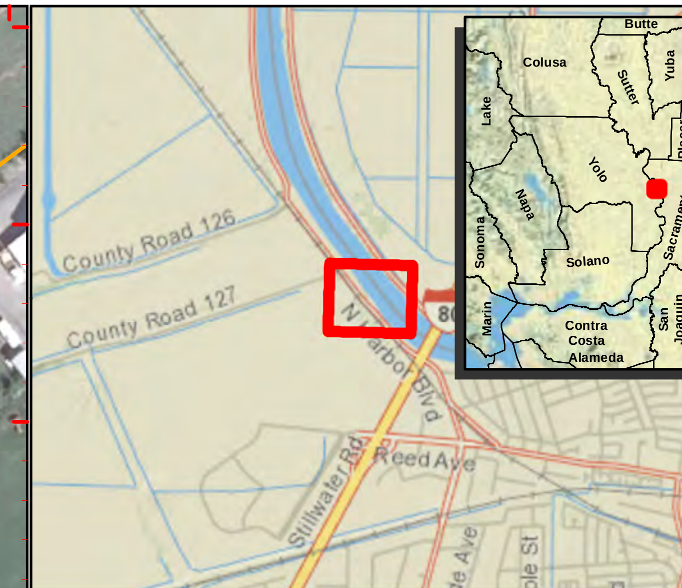

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 62.9R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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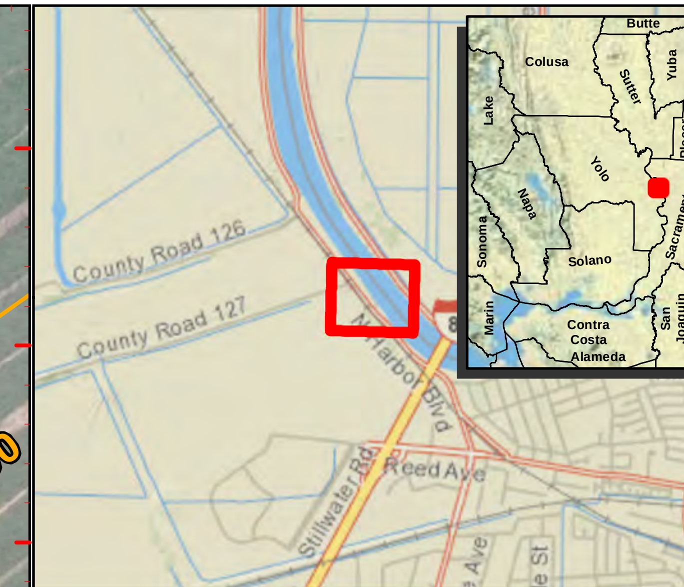

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 63R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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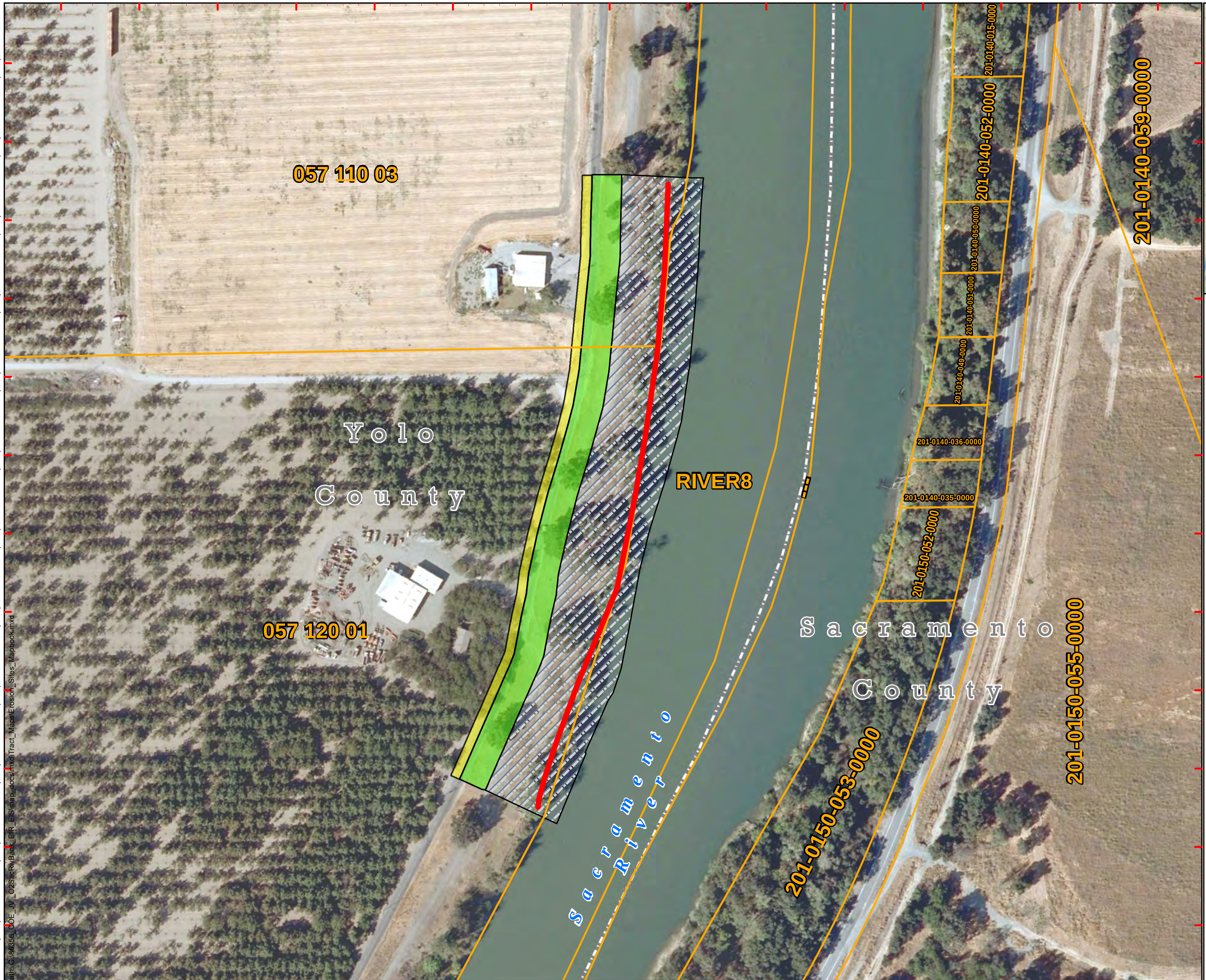

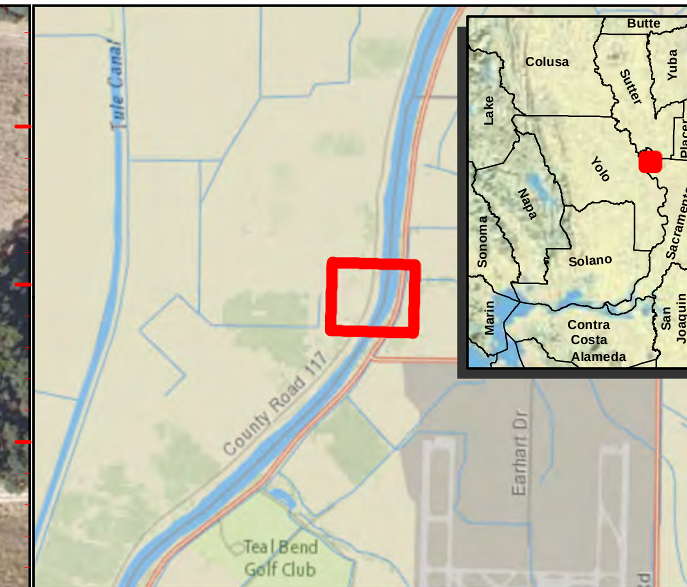

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 74.4R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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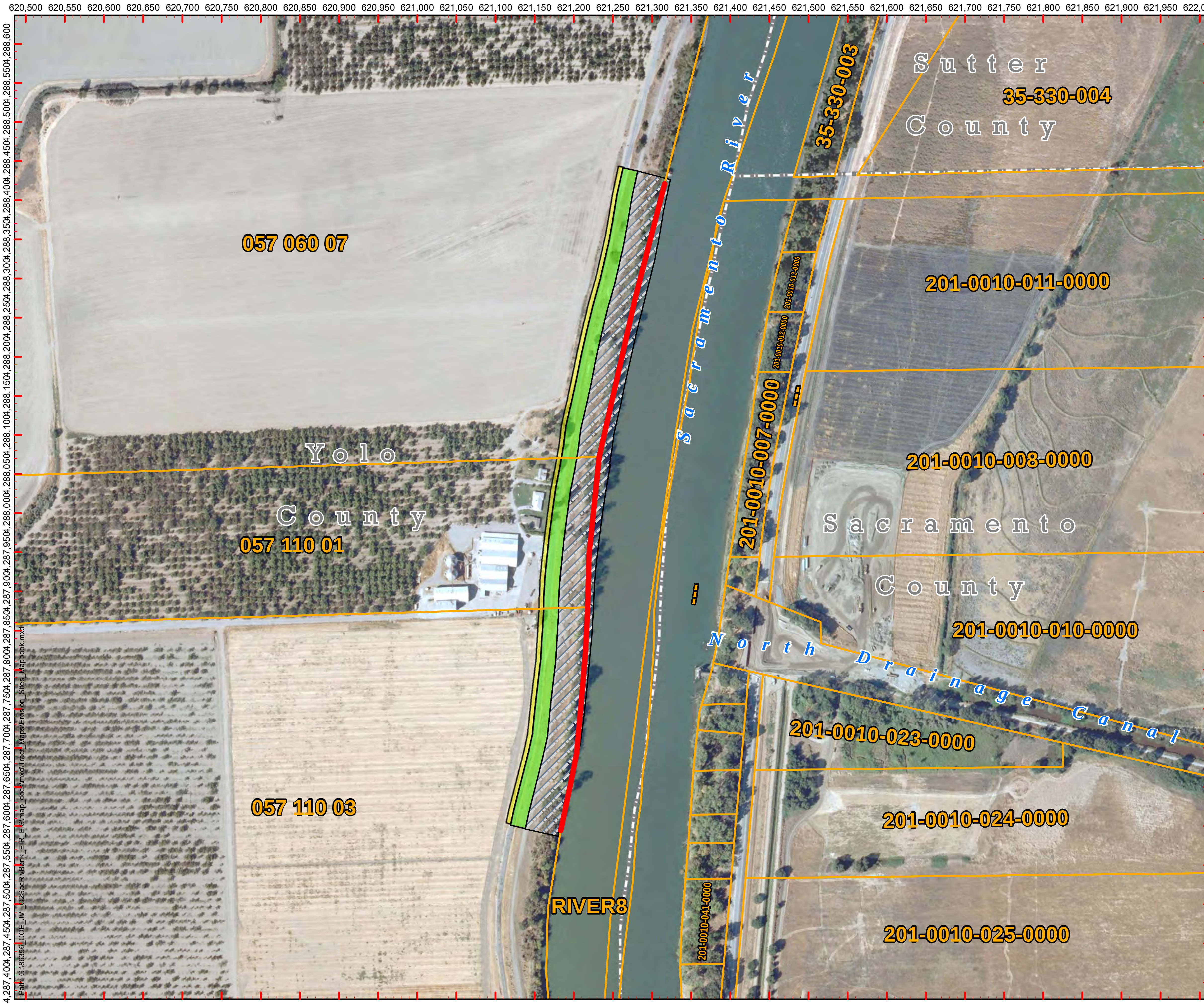

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 75.3R

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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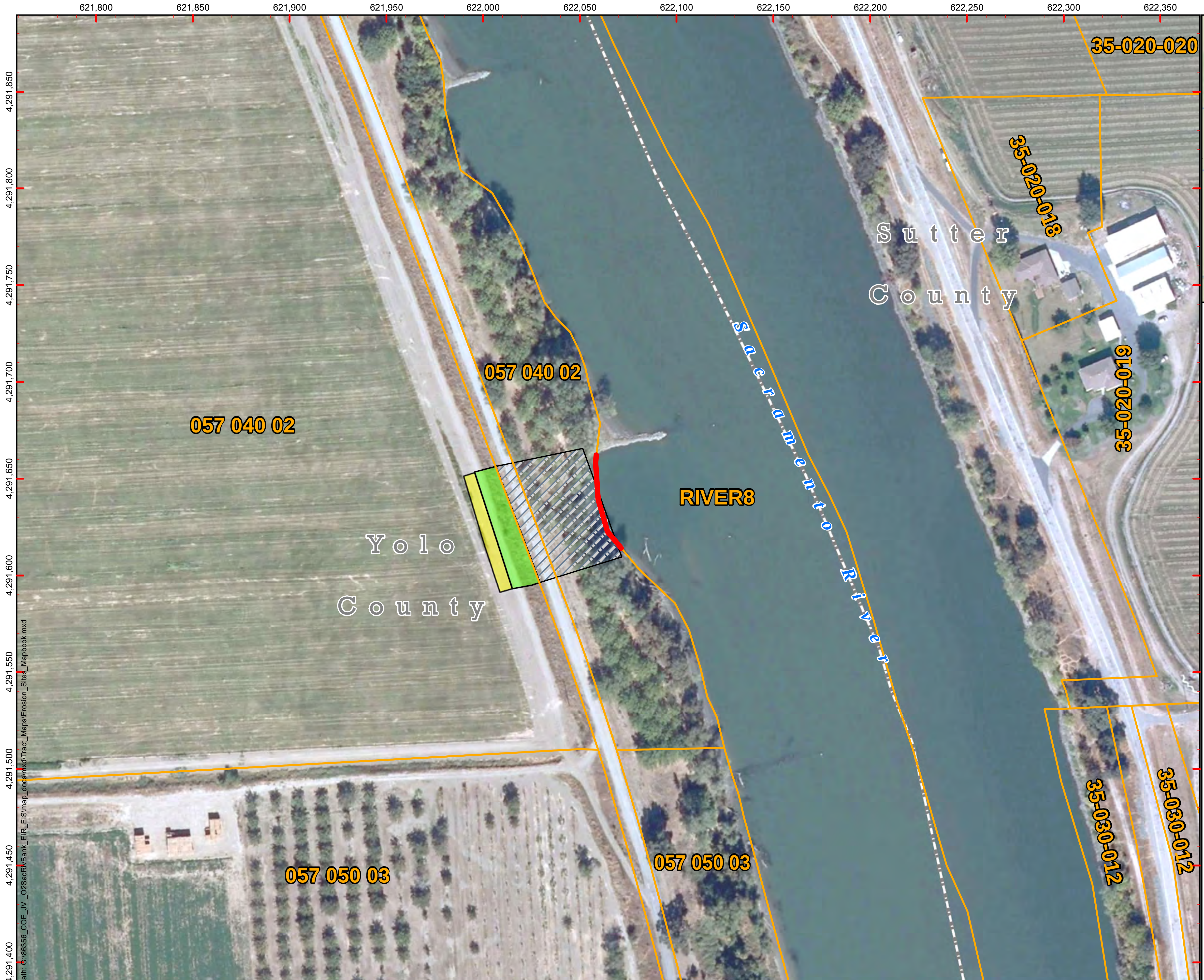

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 77.7R

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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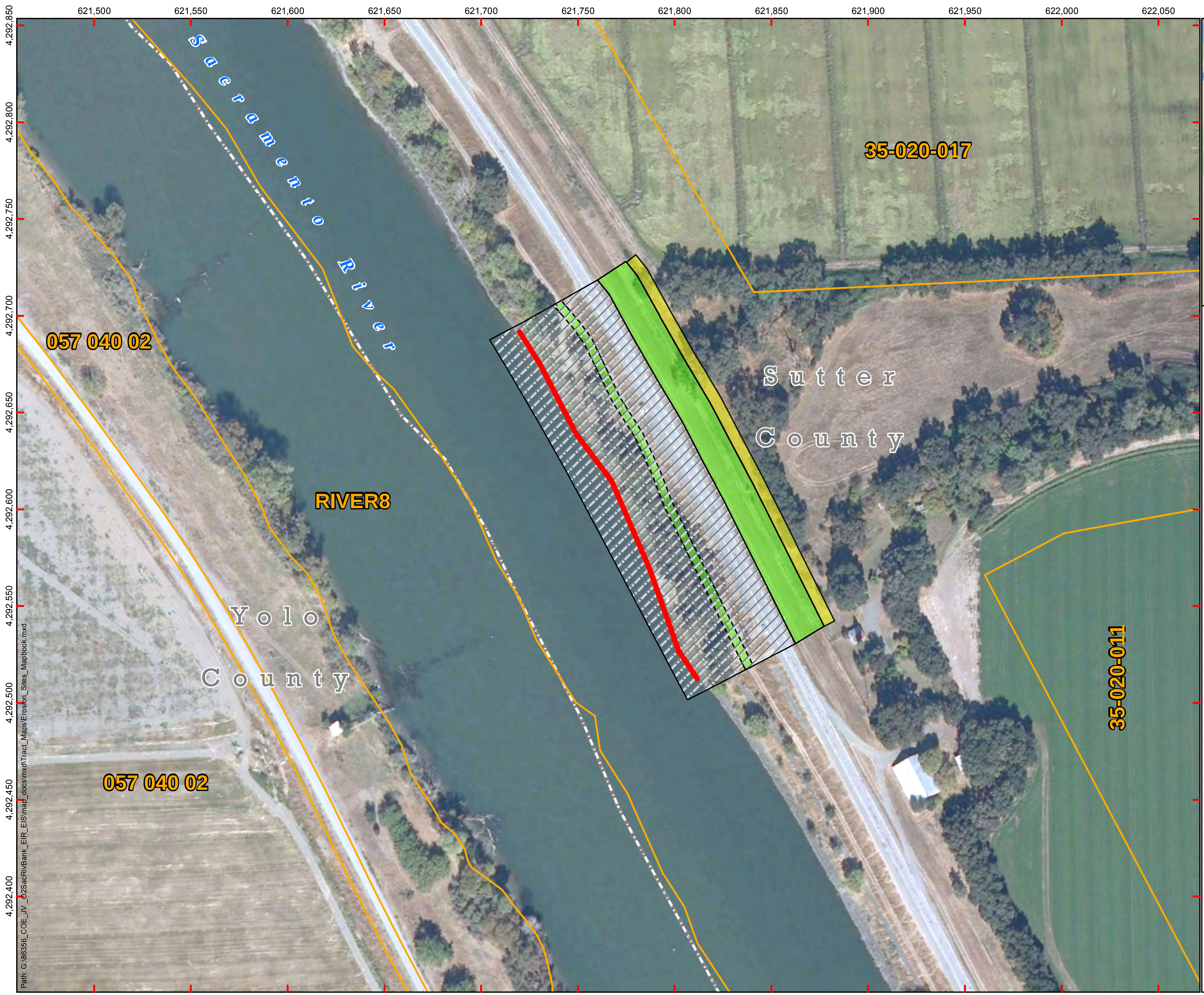

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 78.3L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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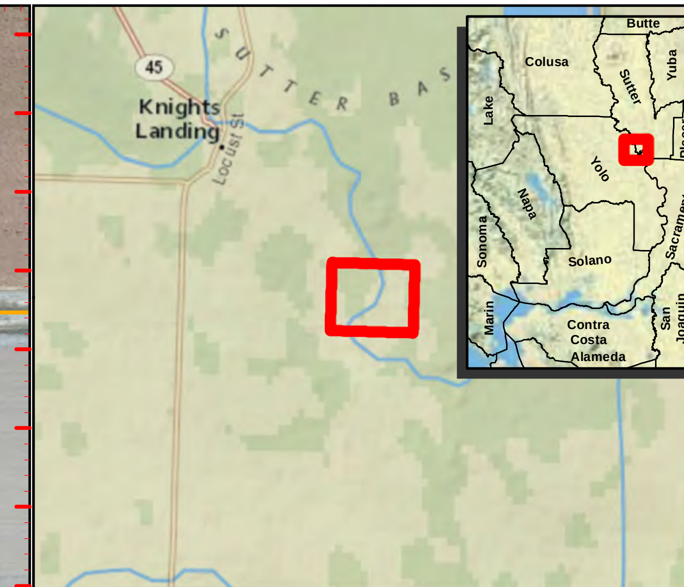

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 86.3L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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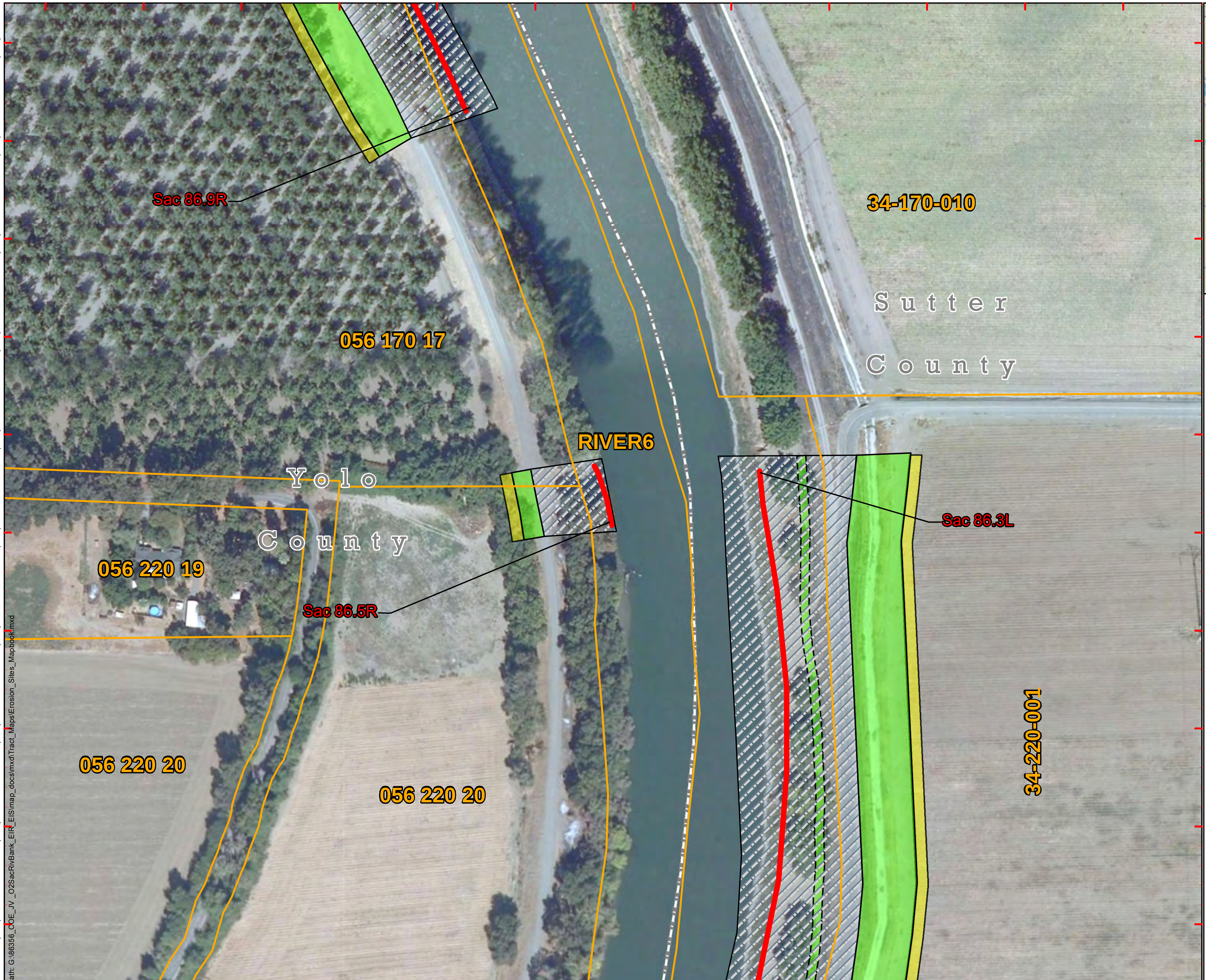

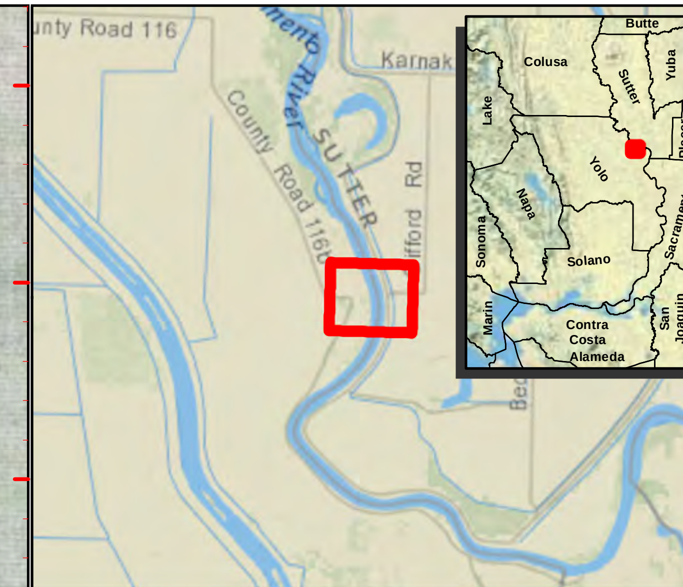

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 86.5R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

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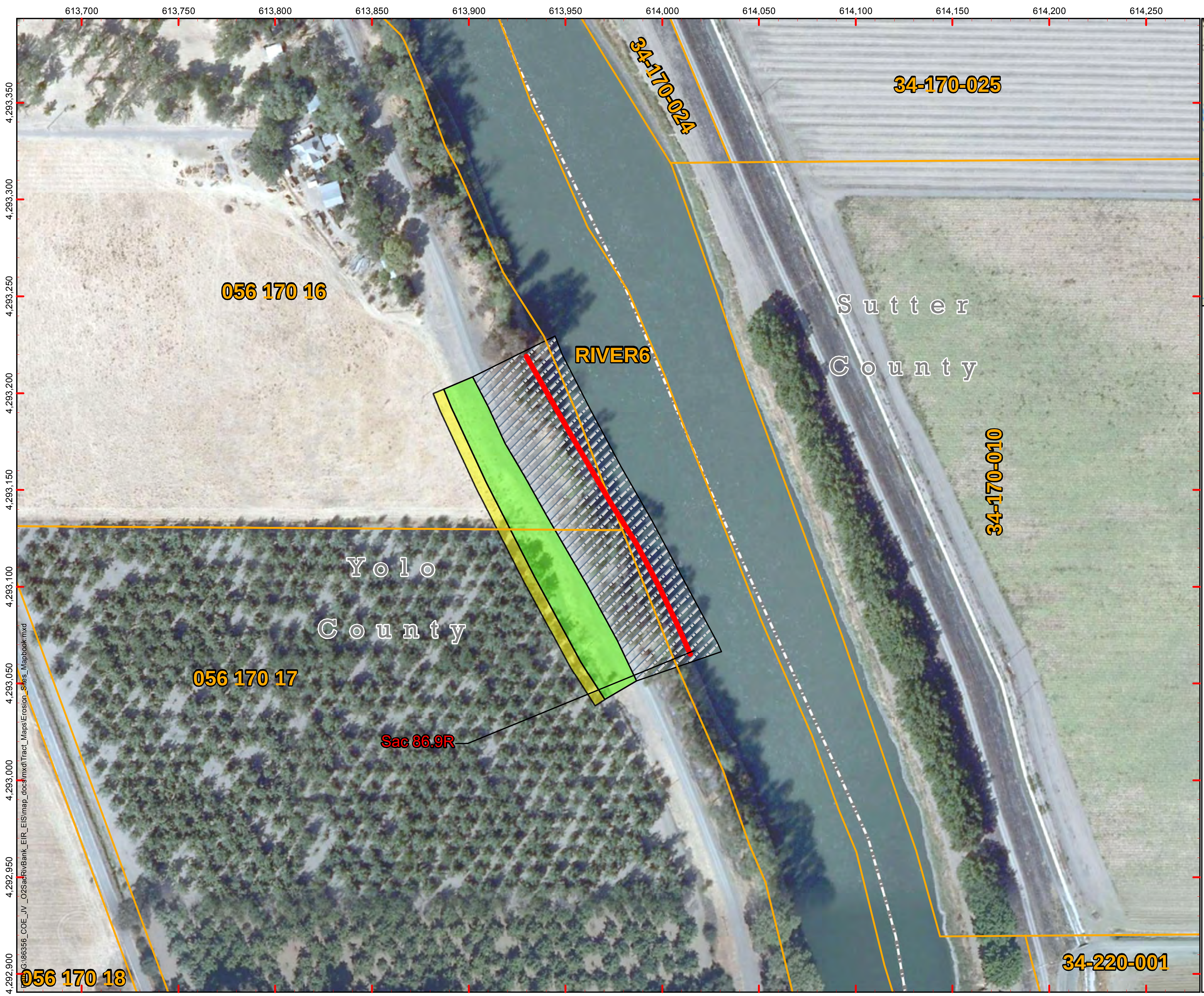

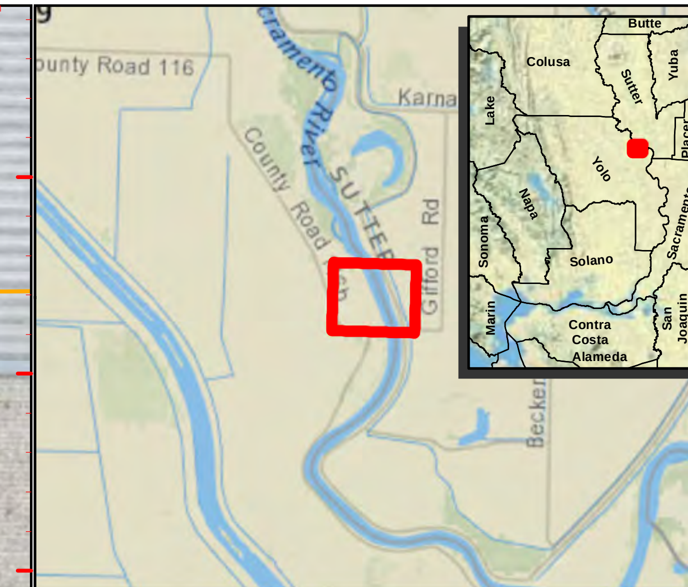

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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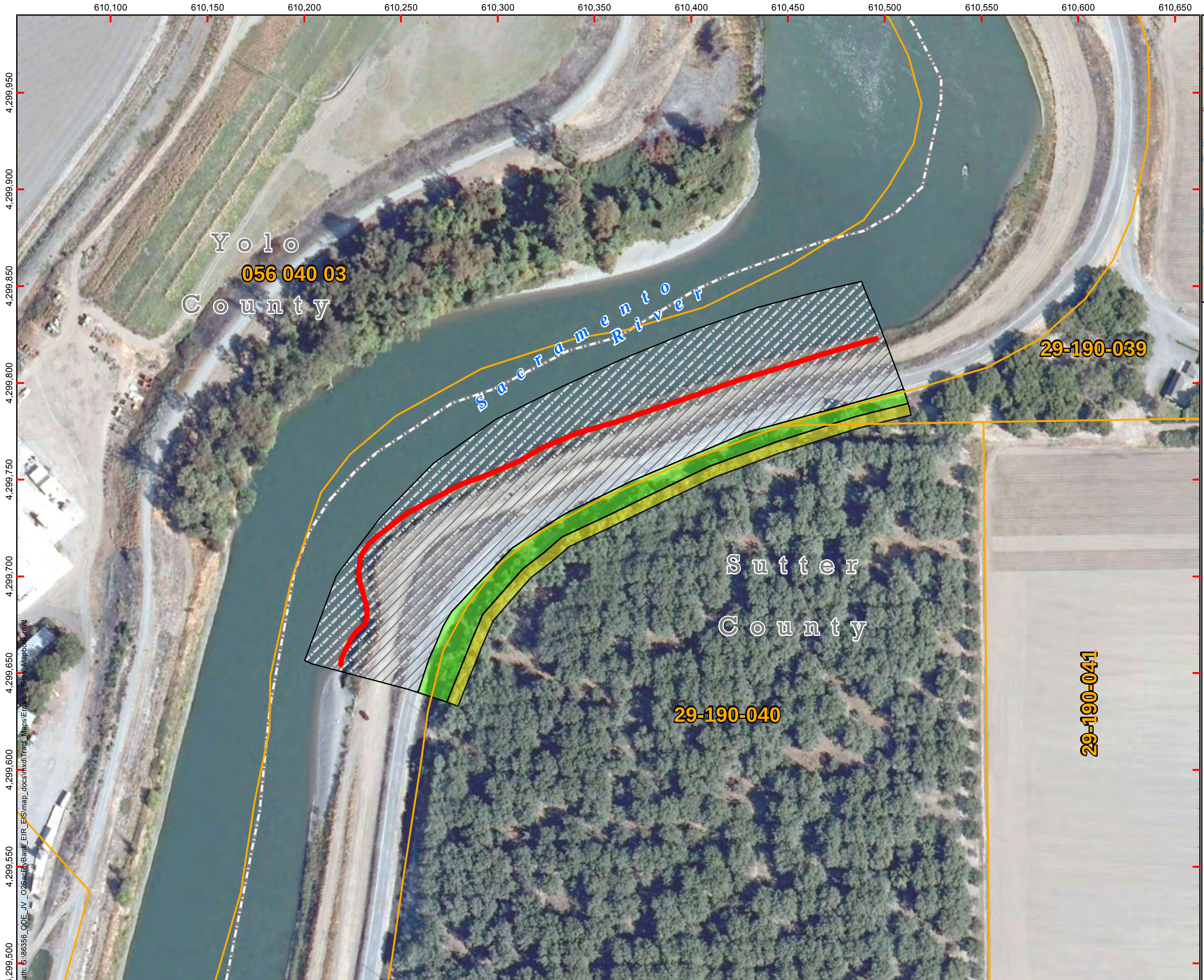
REAL ESTATE OWNERSHIP MAPS 2012

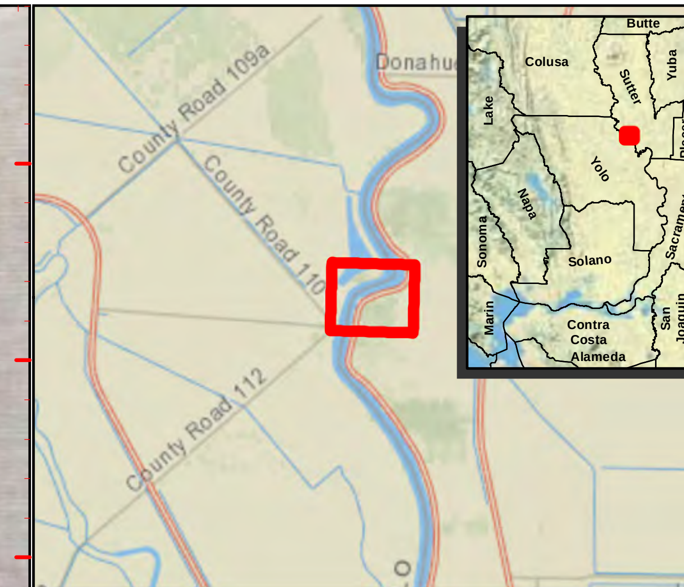
EROSION SITE: Sac 86.9R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 92.8L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
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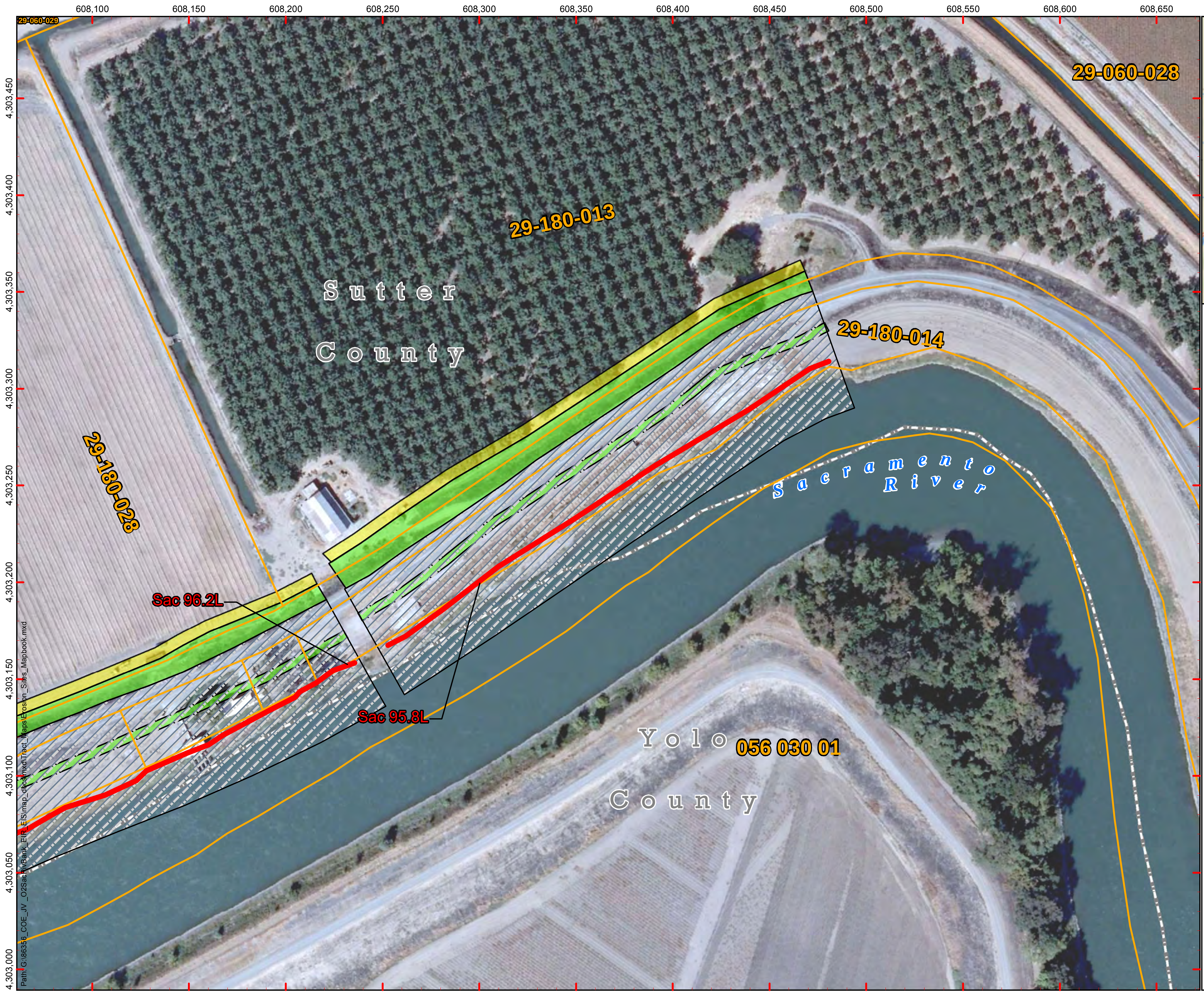

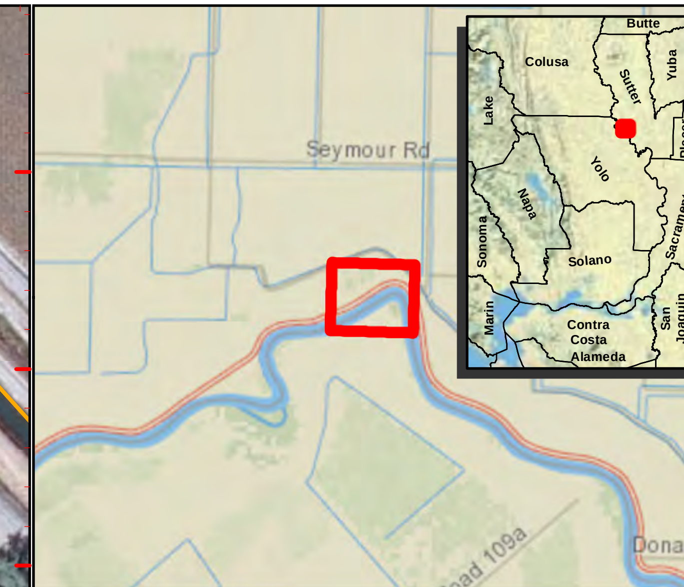

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 95.8L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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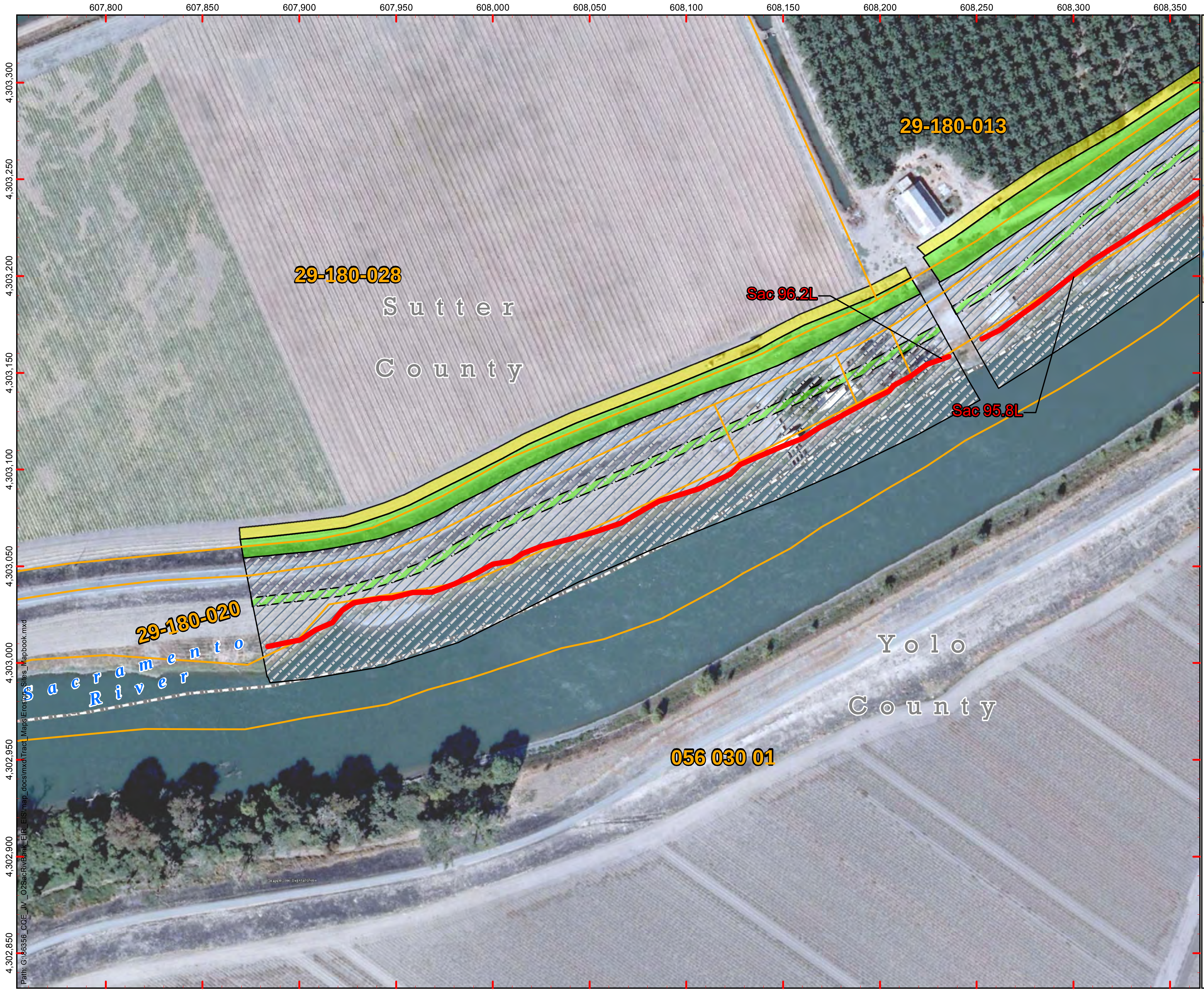

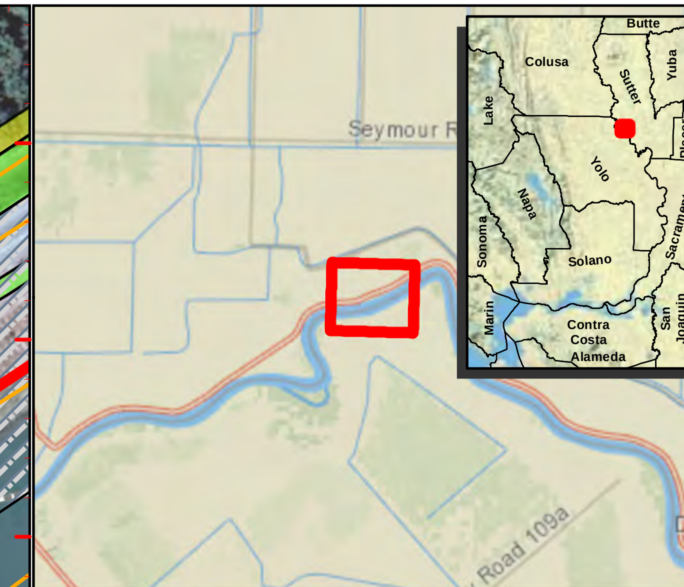

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

N

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 96.2L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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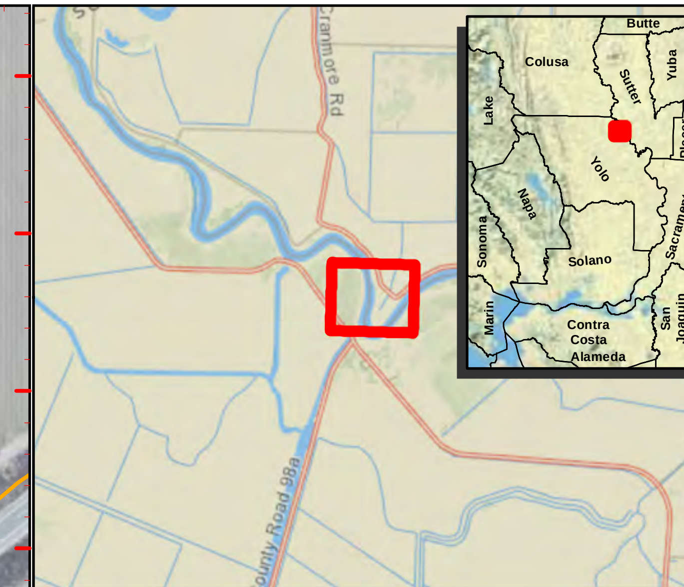

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 99.0L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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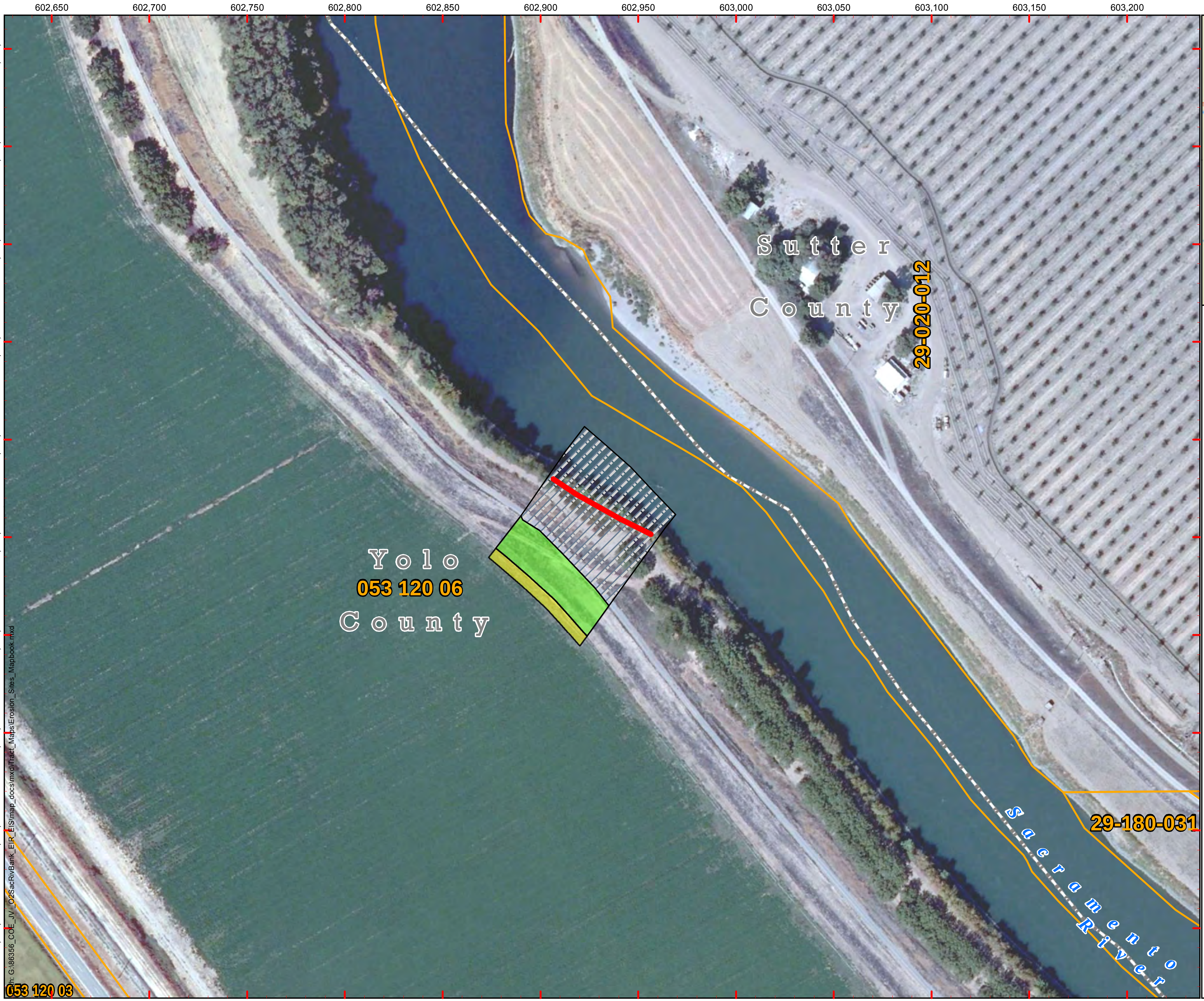

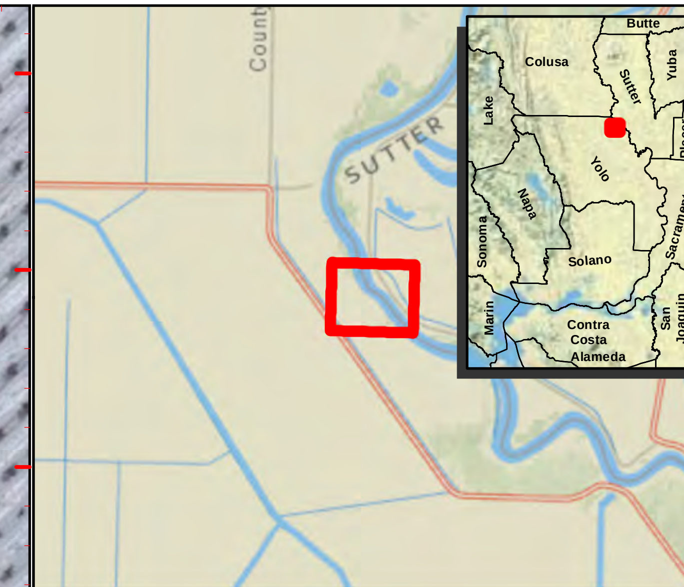

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 101.3R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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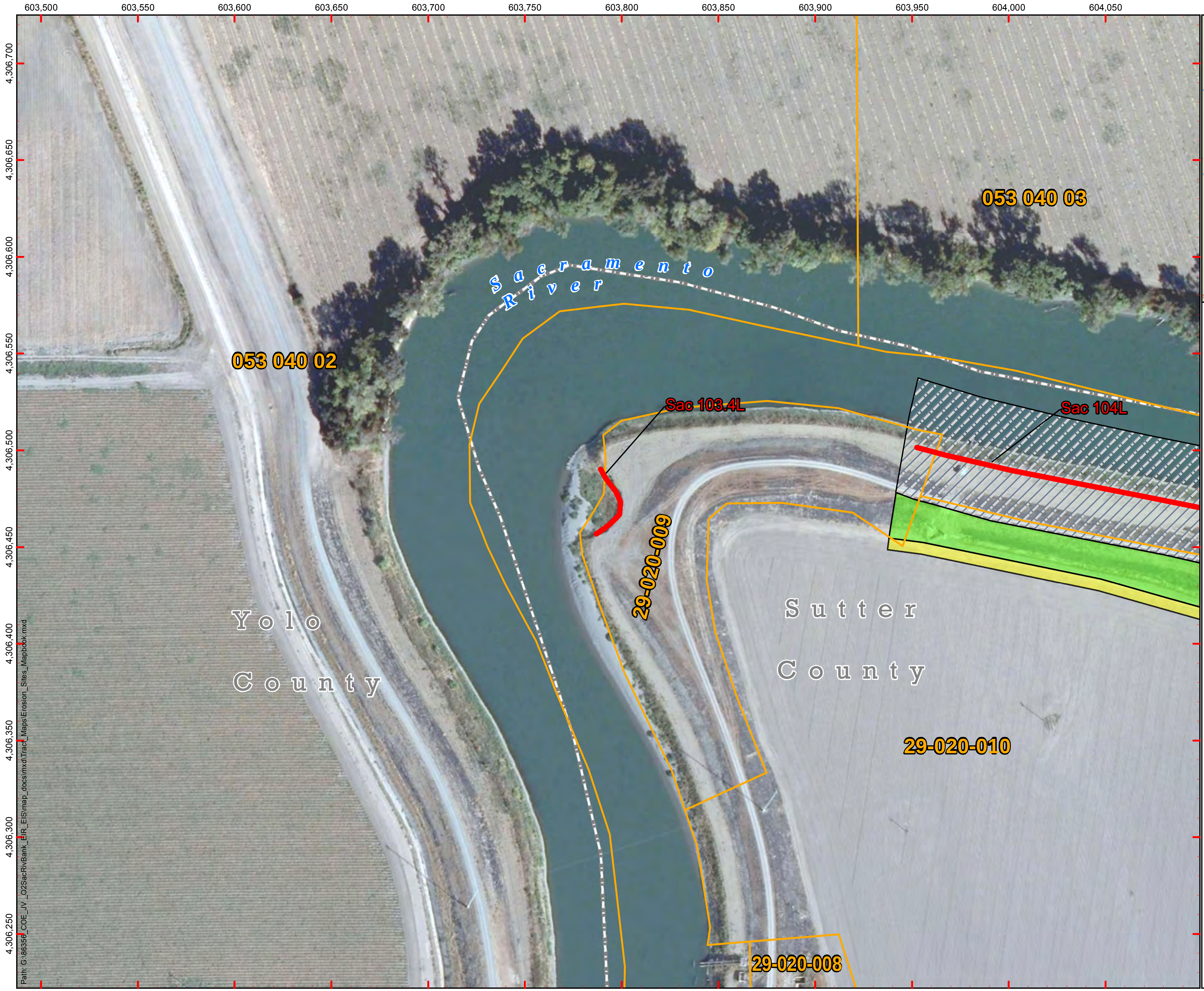
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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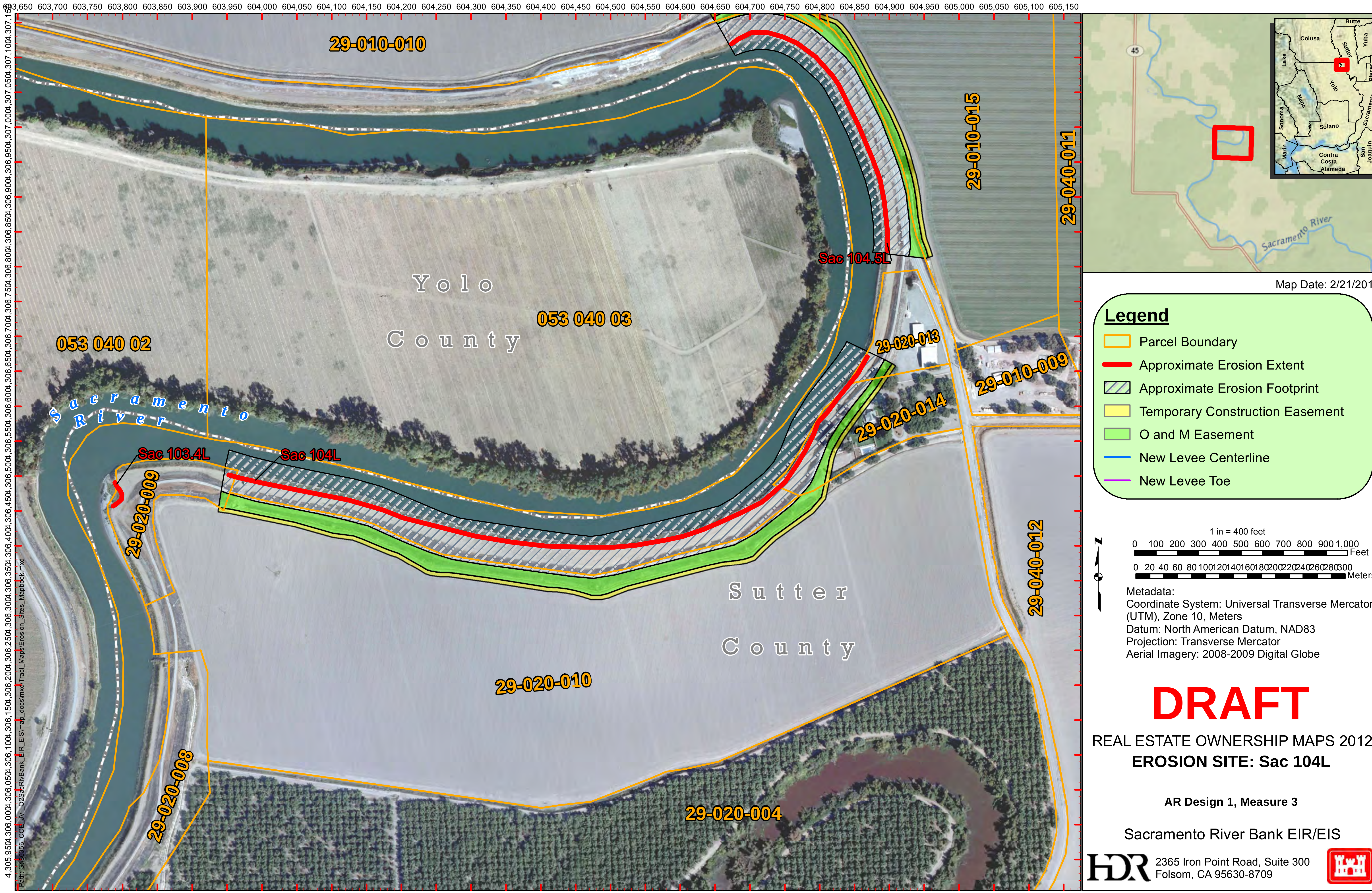
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 103.4L

No Action

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 104L

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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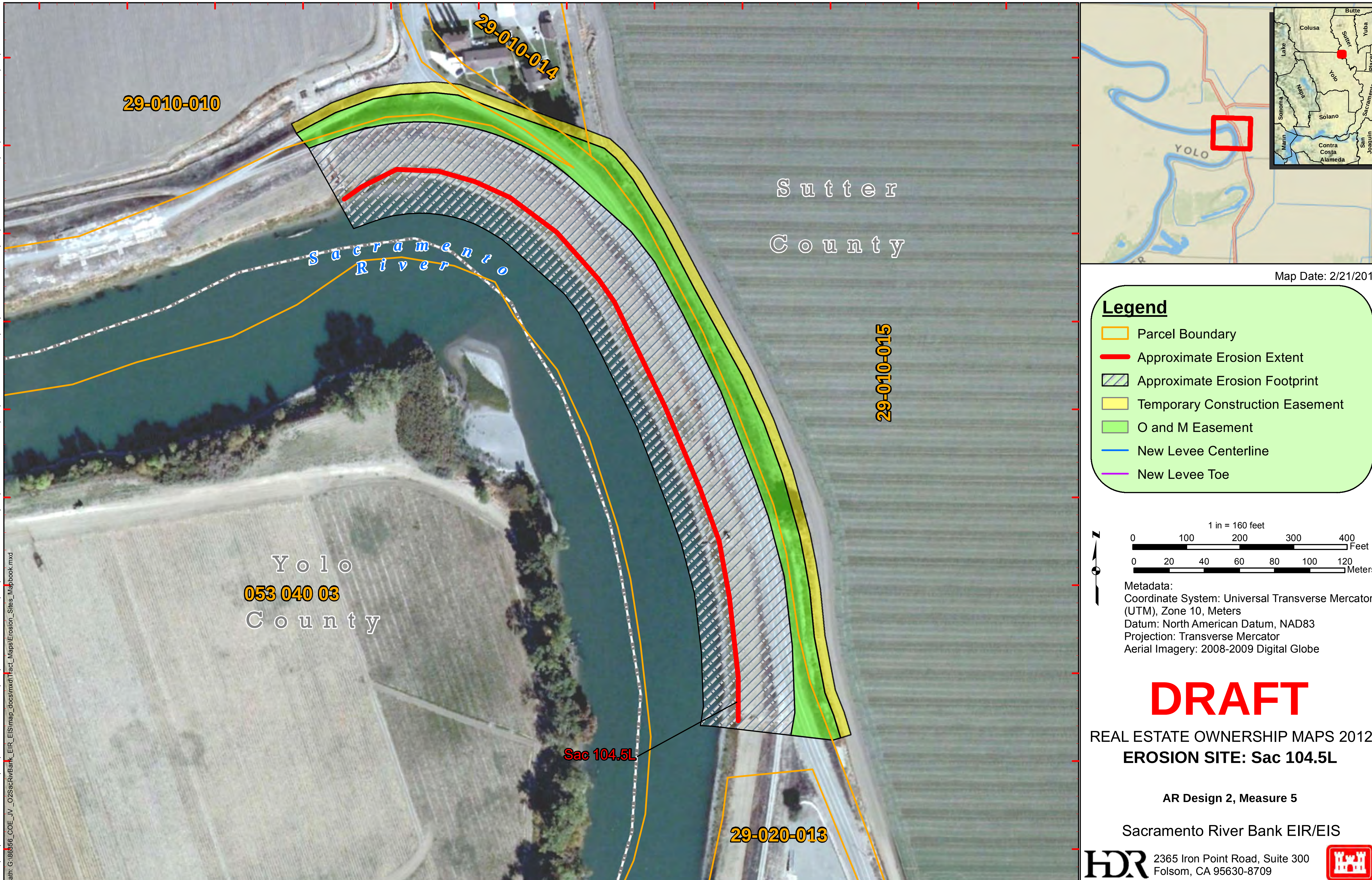
Folsom, CA 95630-8709



Map Date: 2/21/2012

Metadata:
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Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 104.5L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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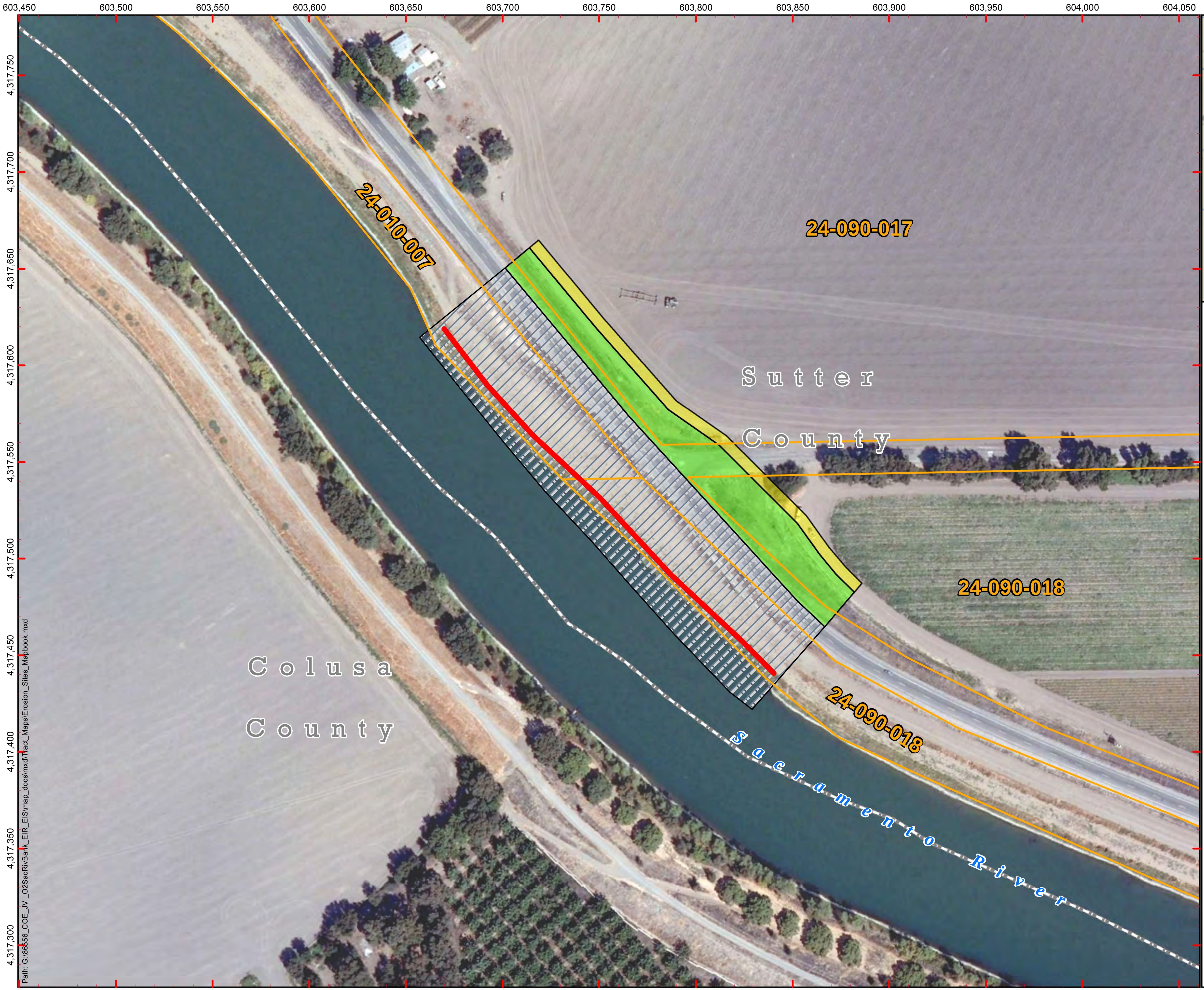

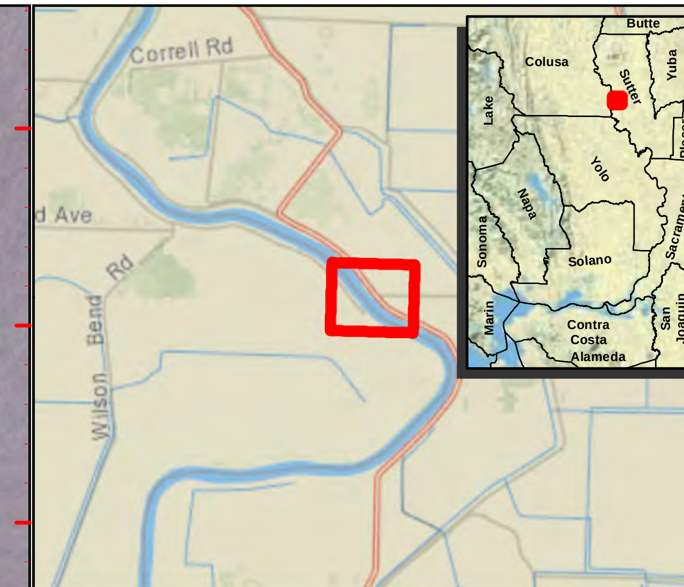

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 116L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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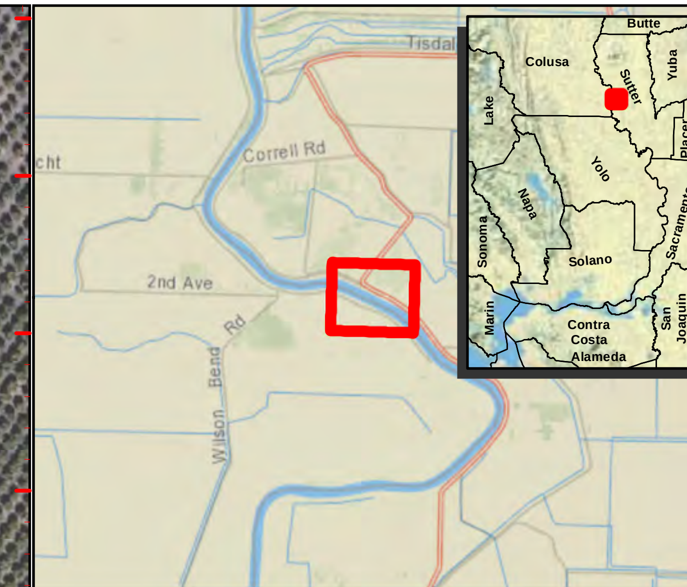

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 116.5L

AR Sedign 2, Measure 5

Sacramento River Bank EIR/EIS

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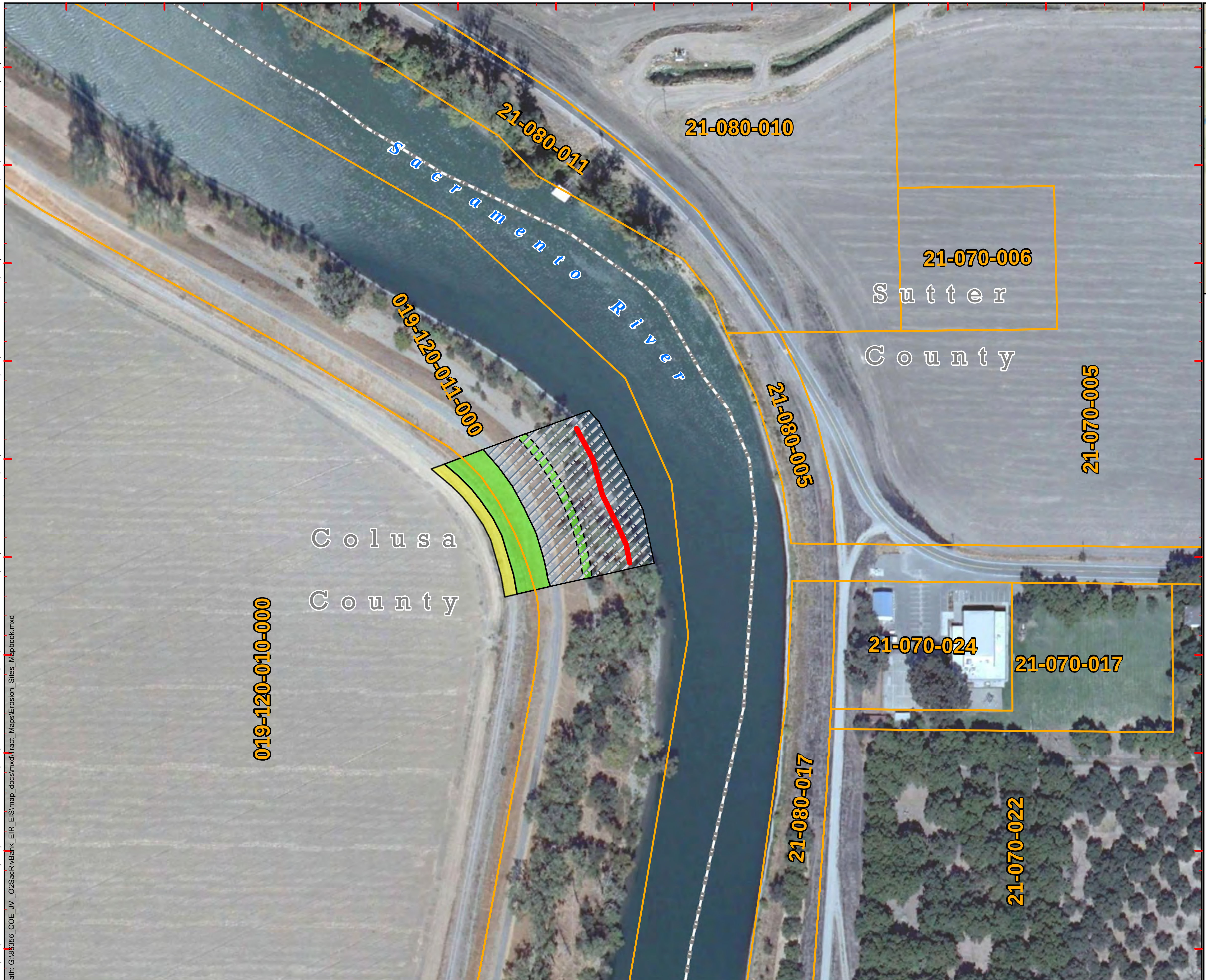

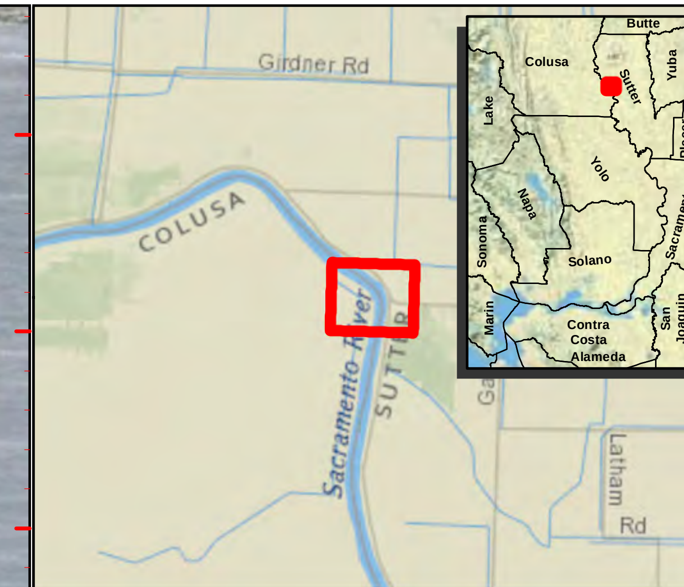

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 122.0R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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Folsom, CA 95630-8709

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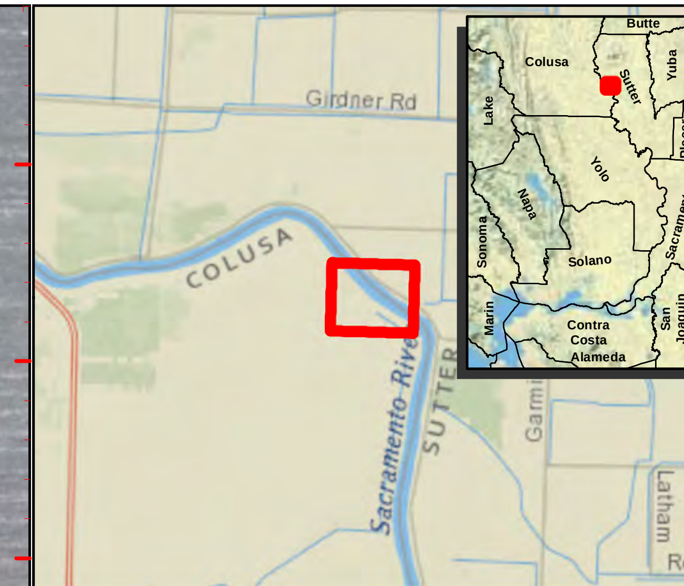

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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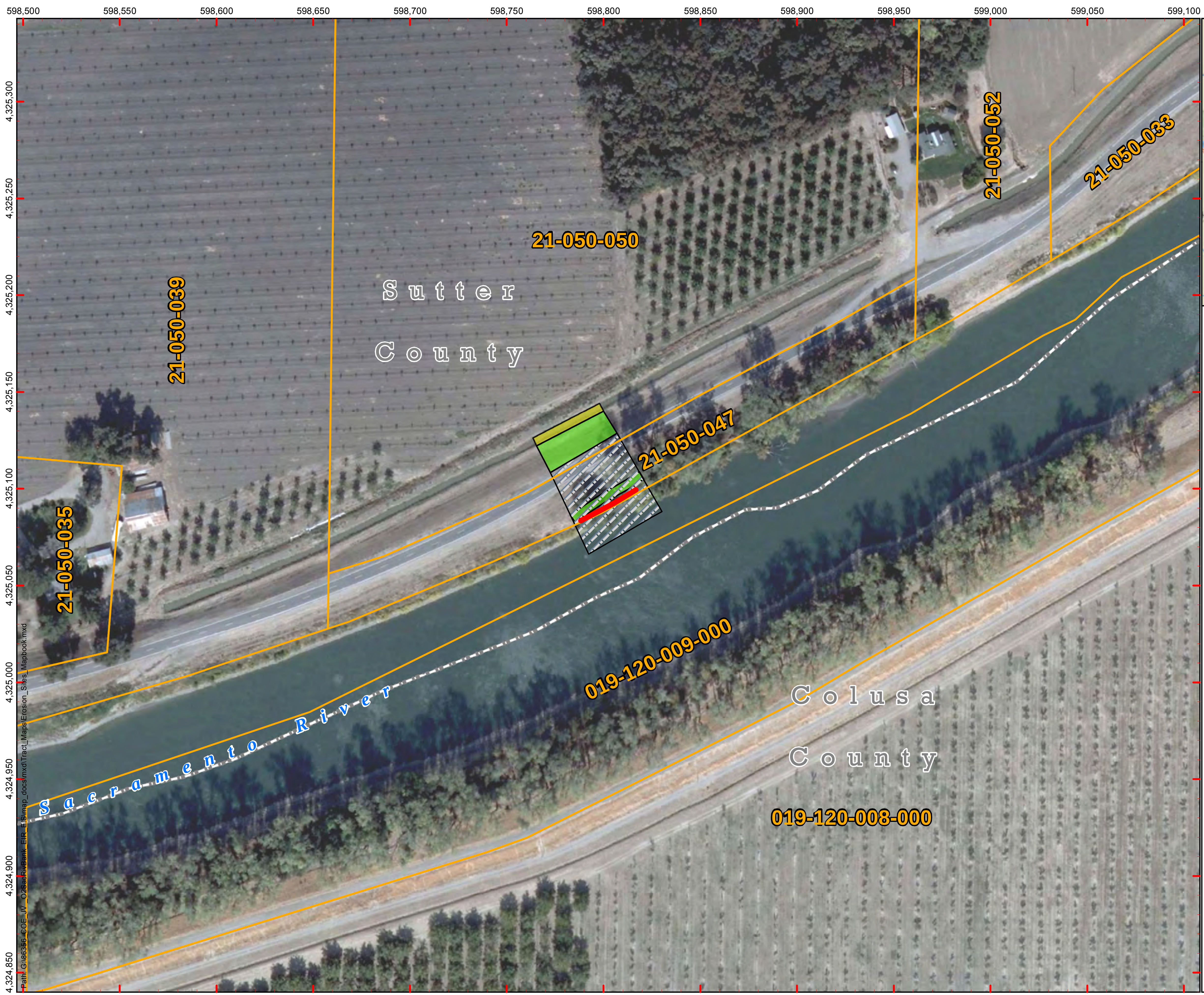
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 122.3R

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 123.3L

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

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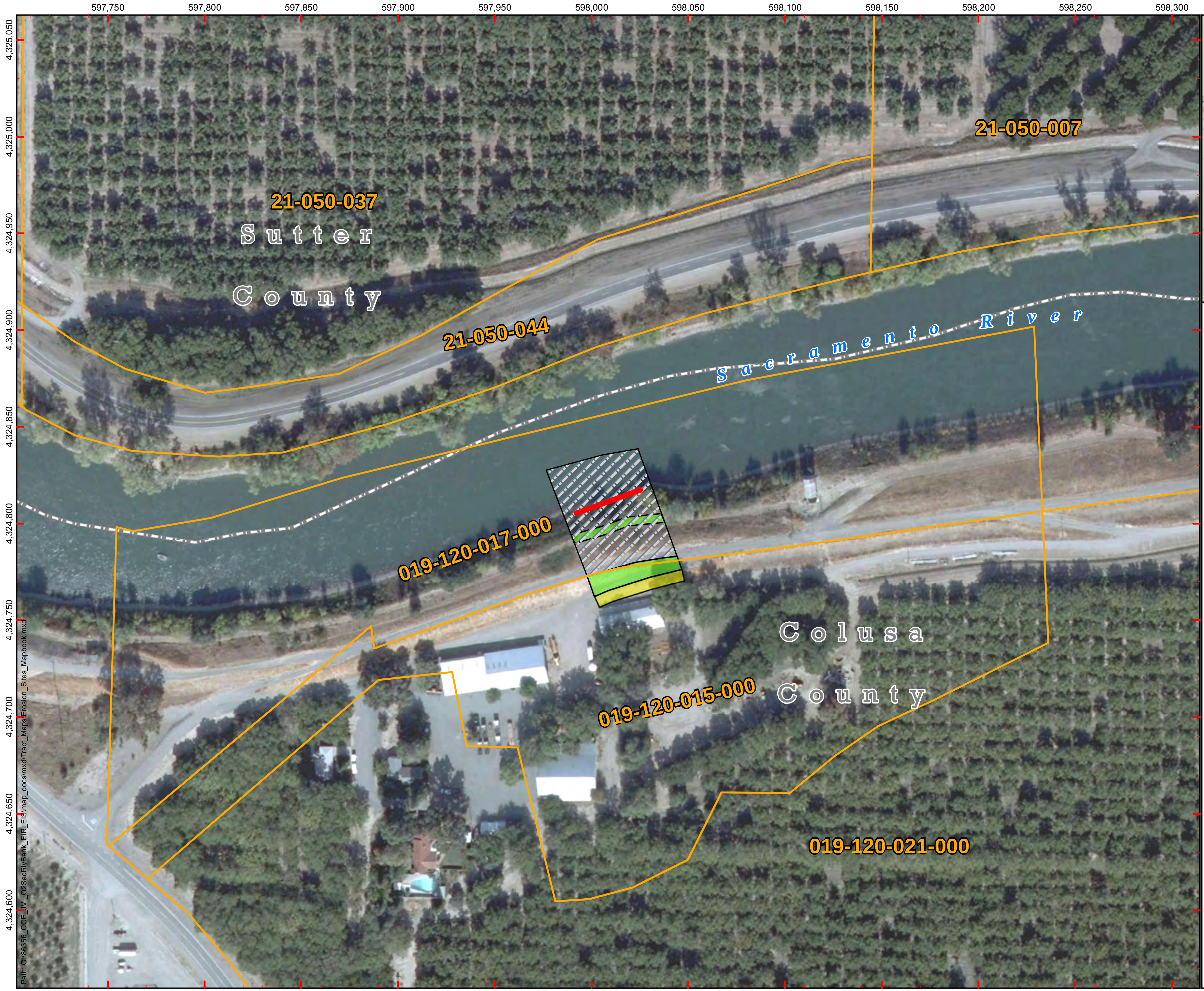
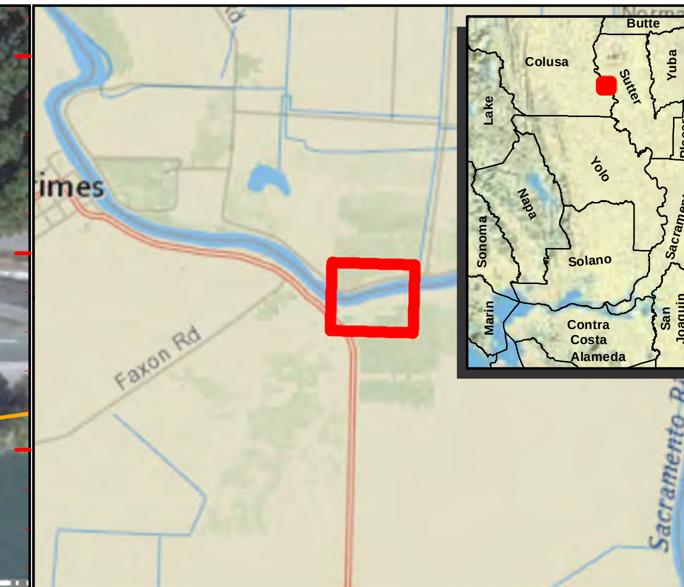
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 123.7R

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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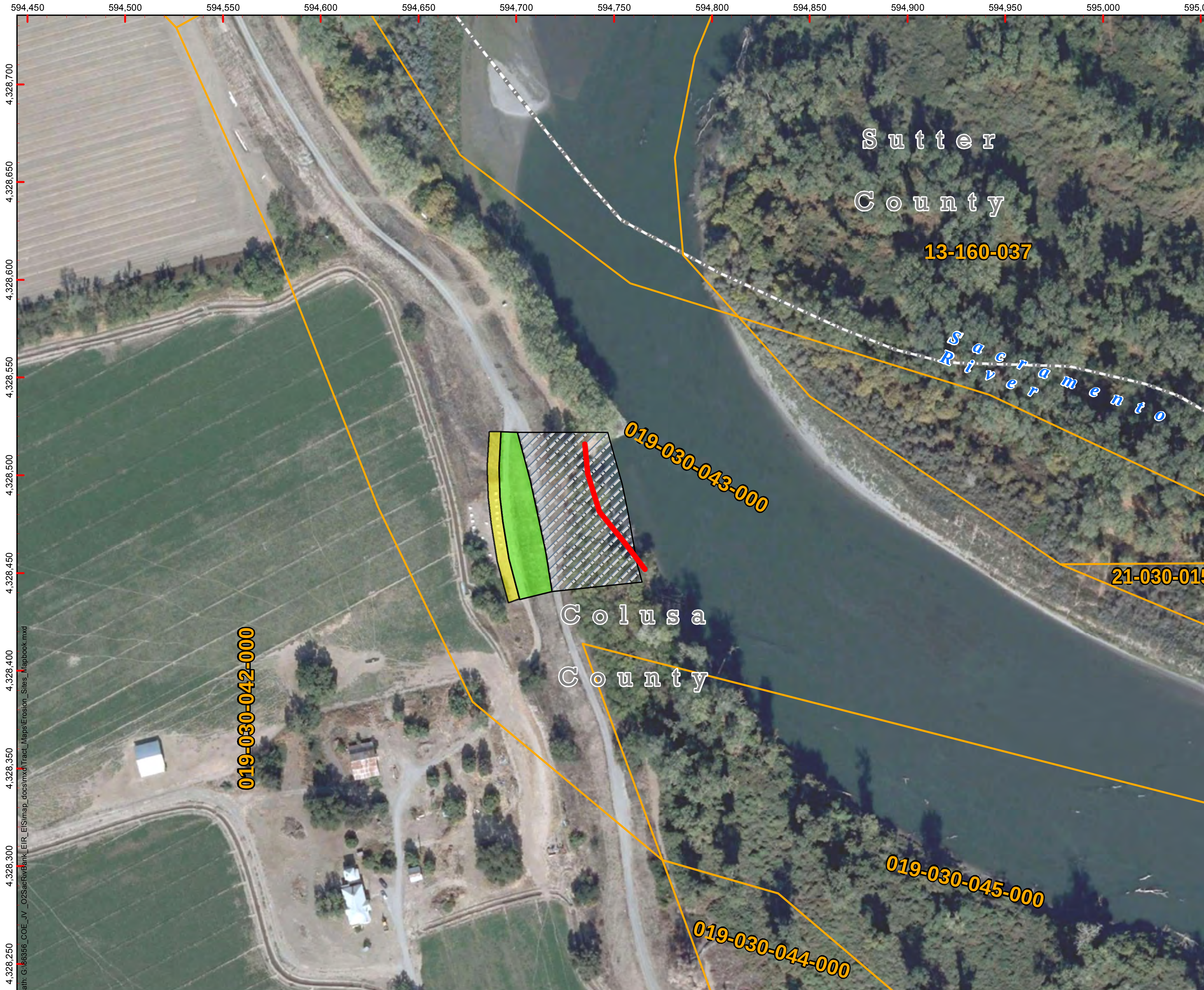

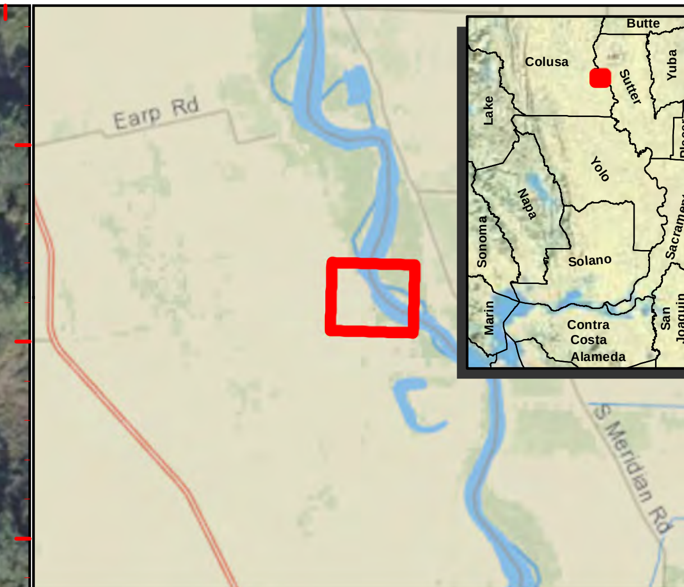

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 127.9R

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

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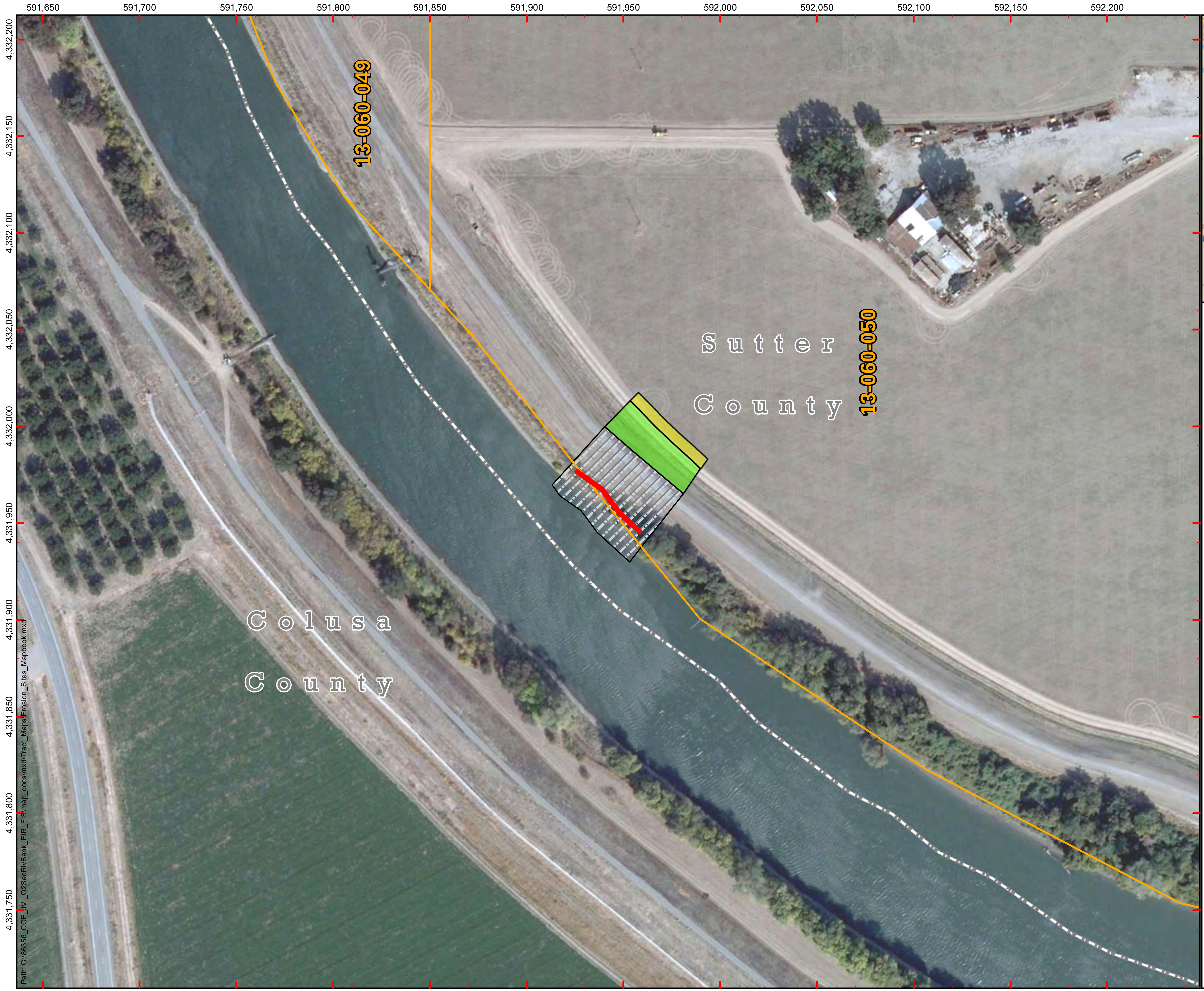

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 131.8L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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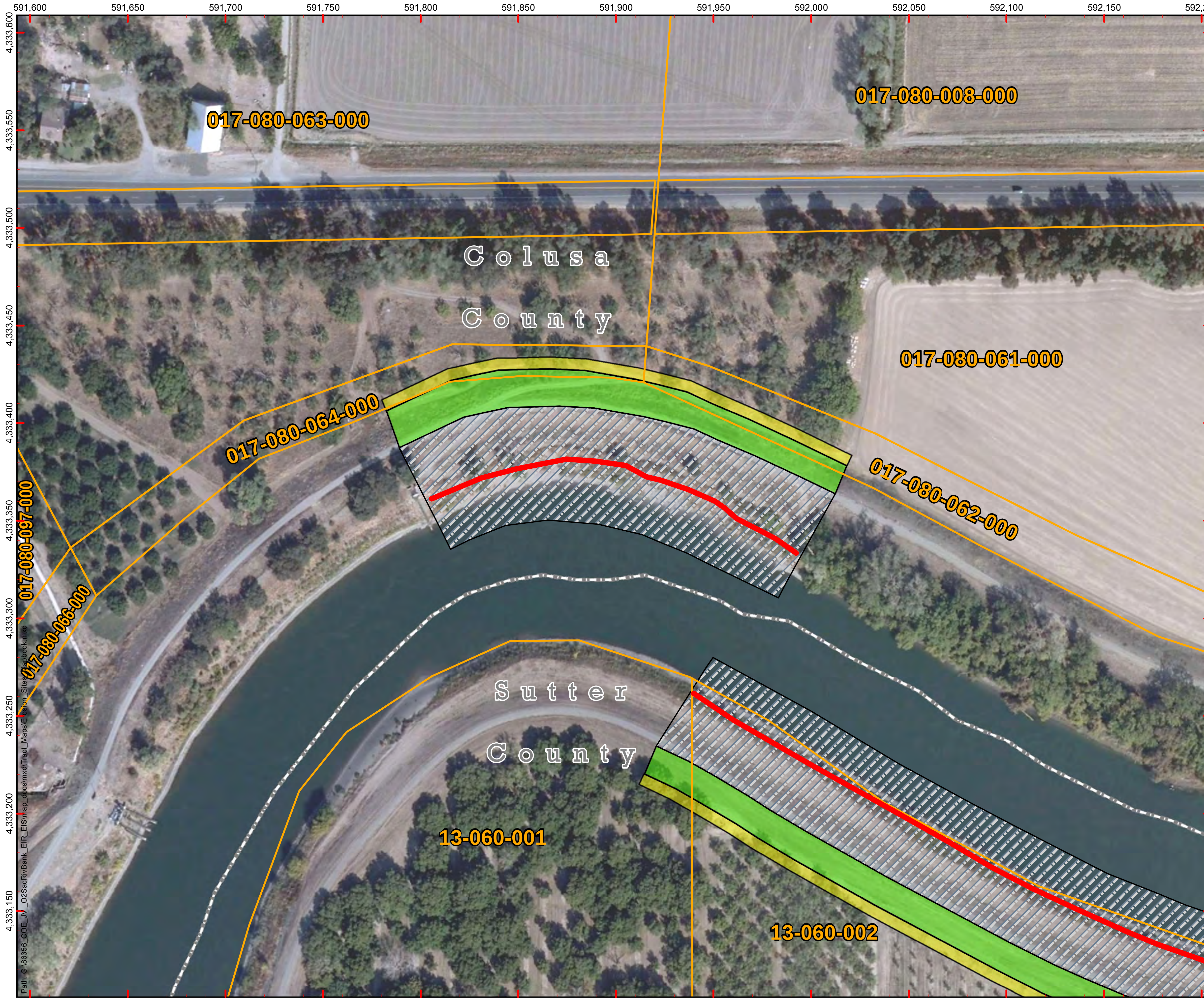
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 132.9R

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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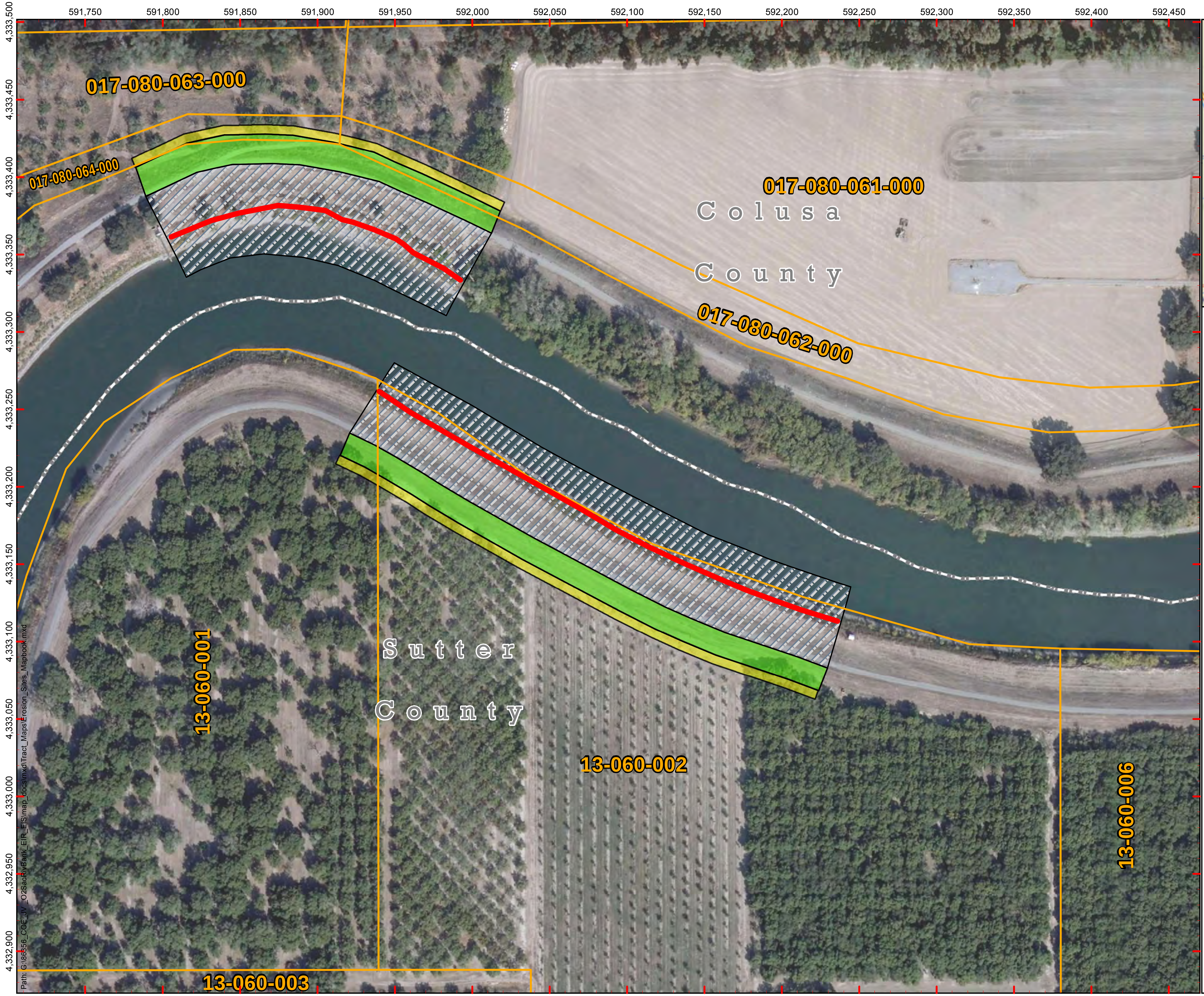

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 133L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
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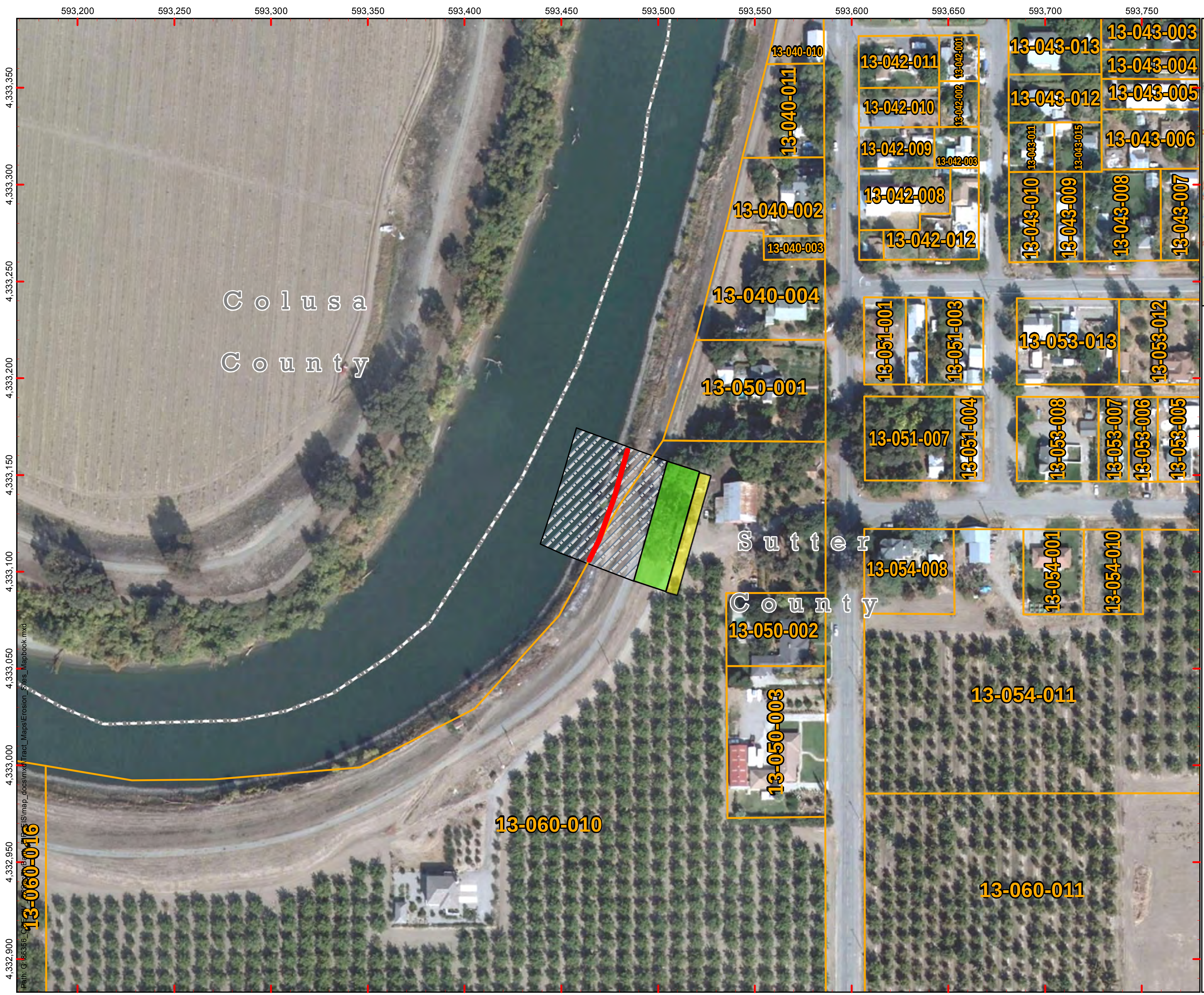

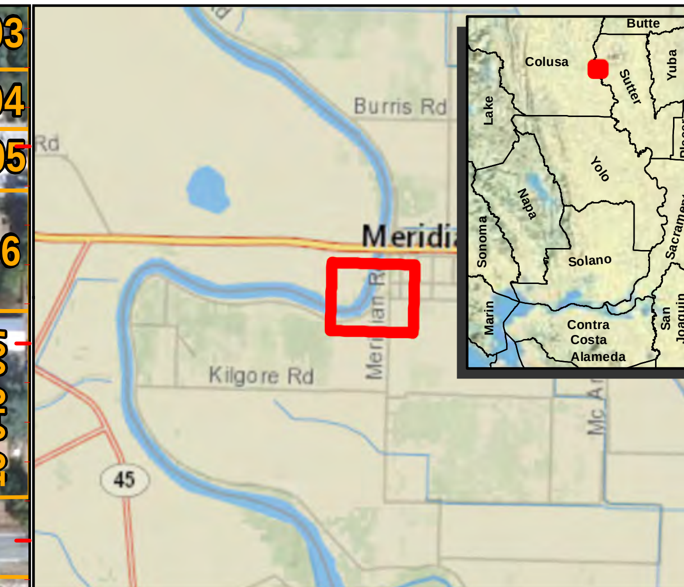

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 133.8L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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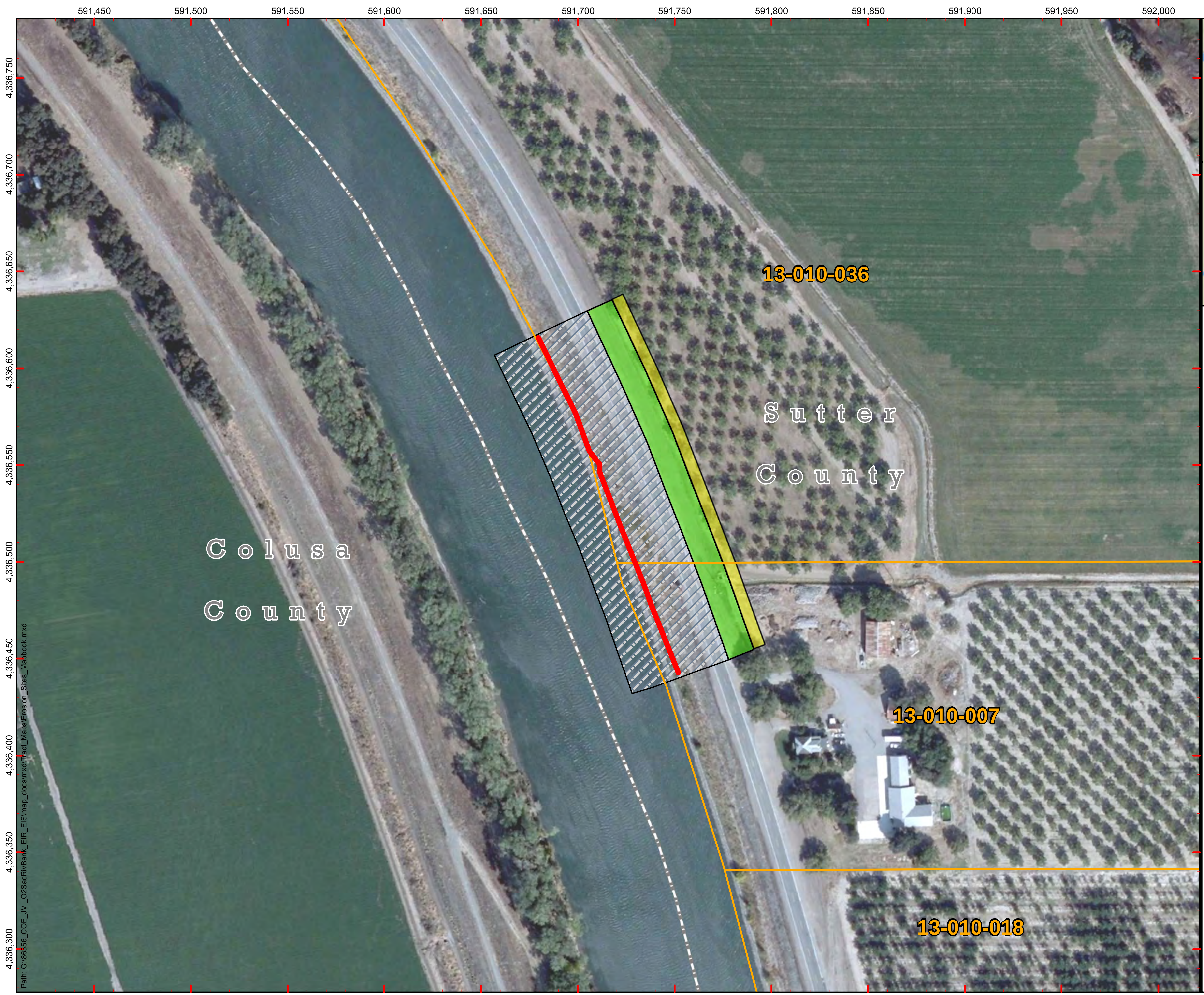

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 136.6L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

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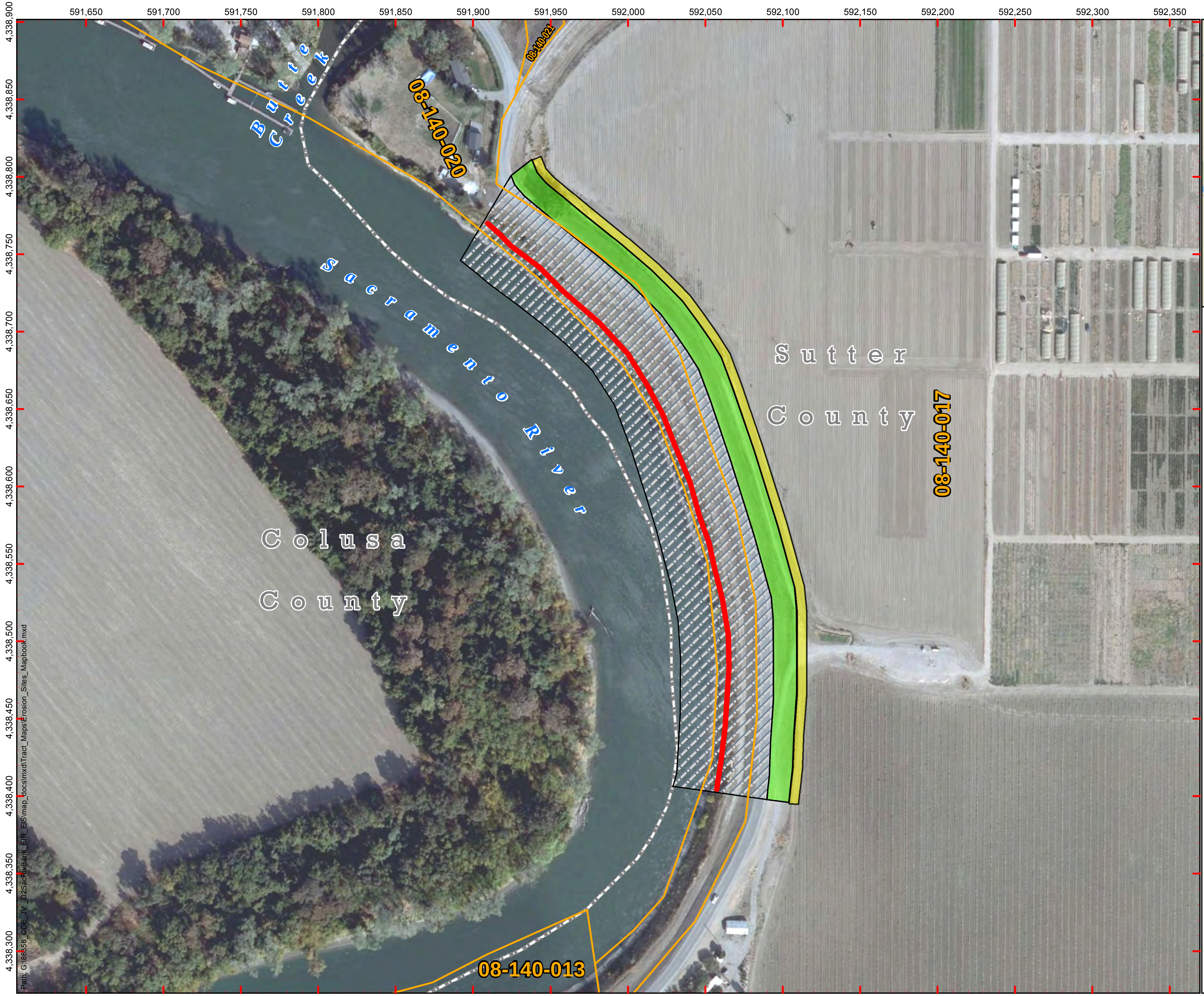

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

N

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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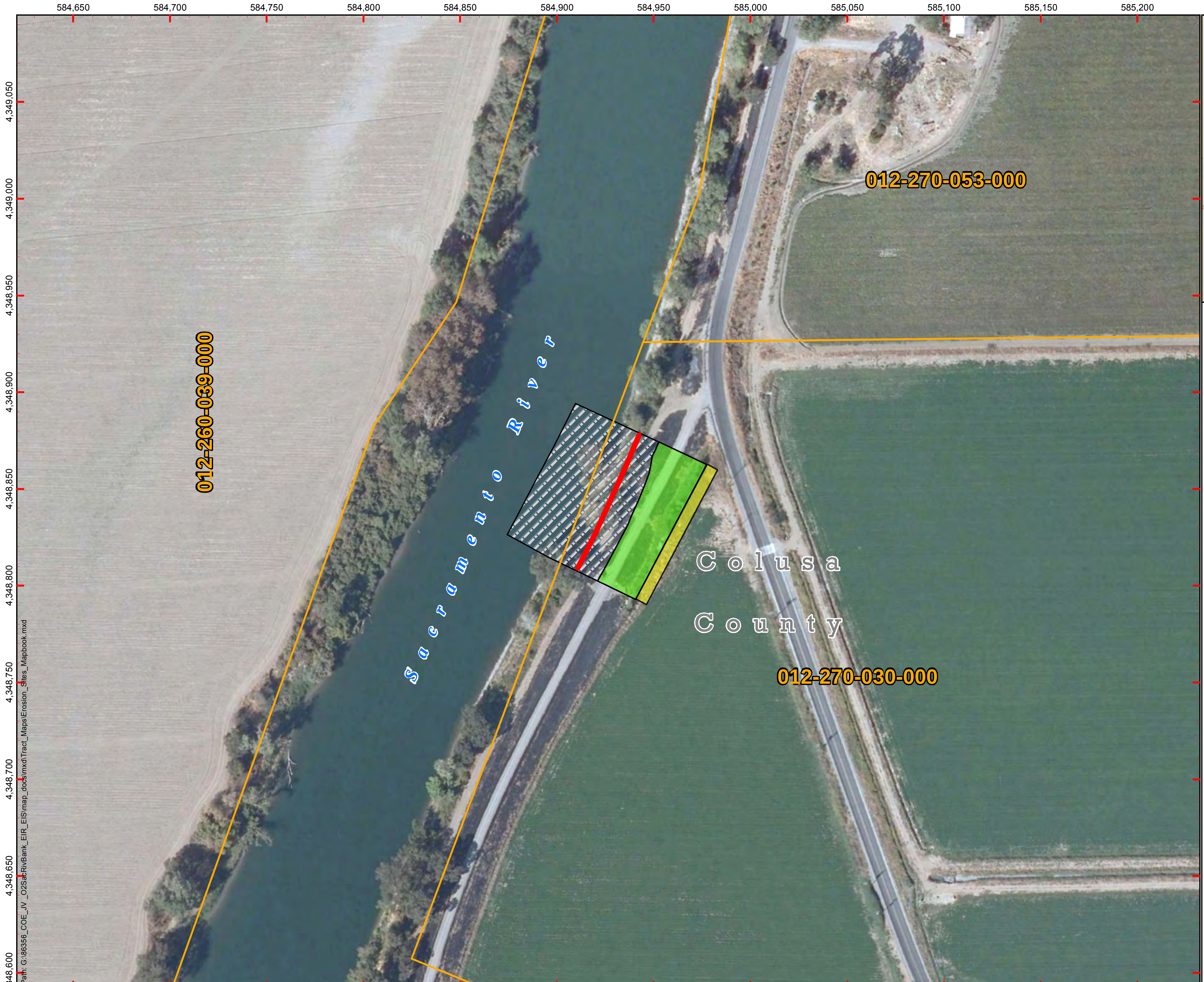
REAL ESTATE OWNERSHIP MAPS 2012

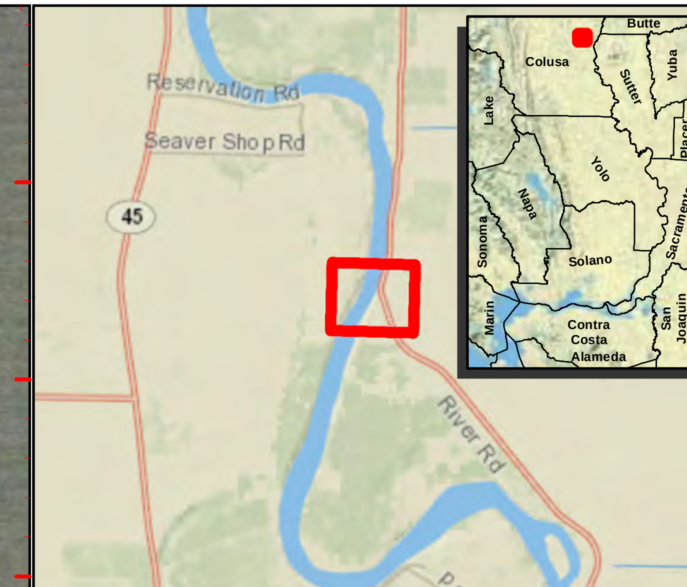
EROSION SITE: Sac 138.1L

AR Design 2, Measure 5

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

DRAFT

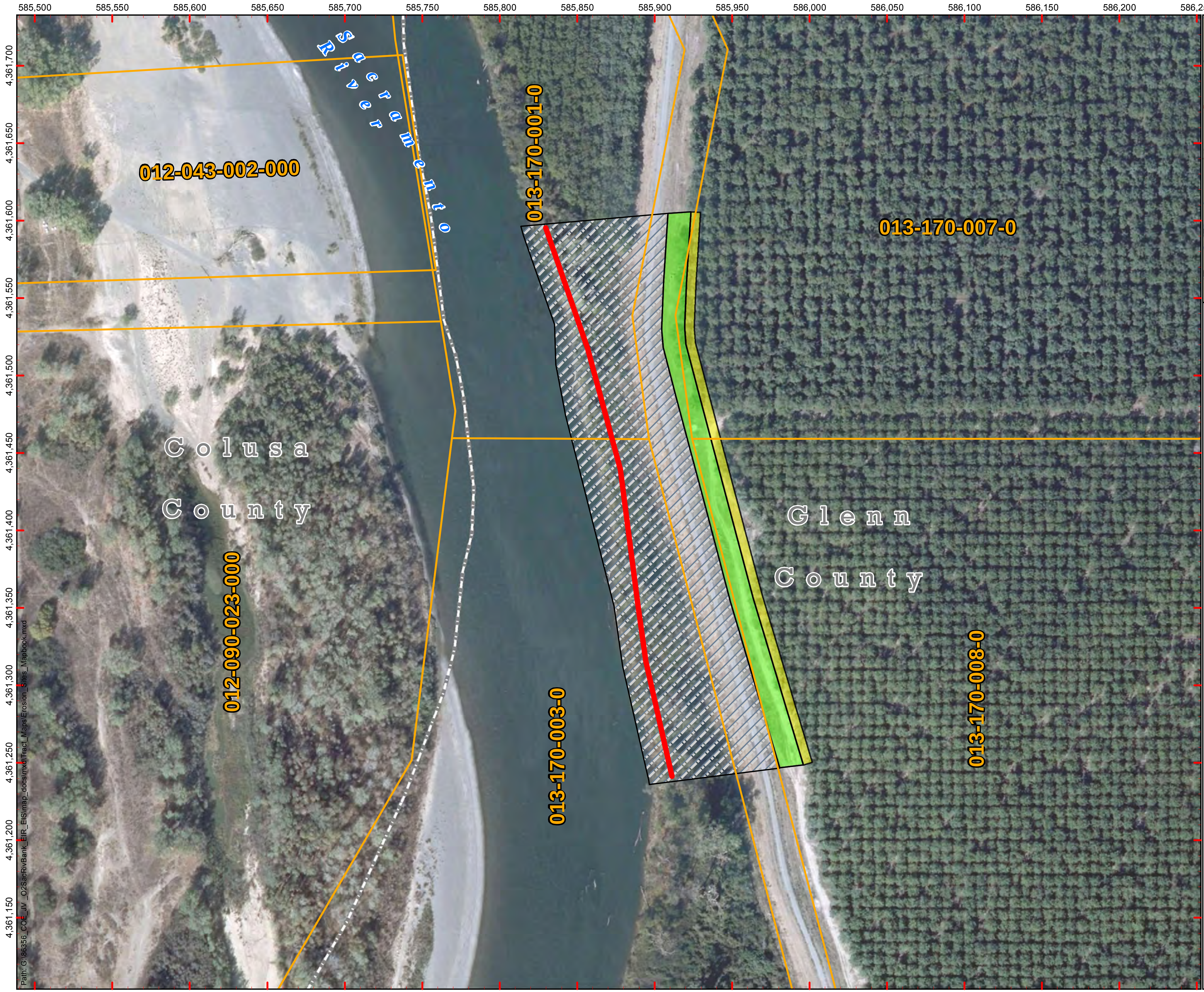
REAL ESTATE OWNERSHIP MAPS 2012

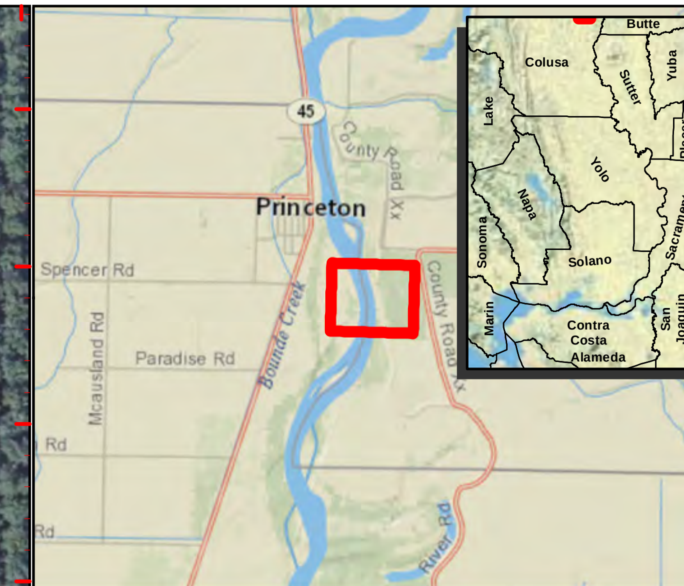
EROSION SITE: Sac 152.8L

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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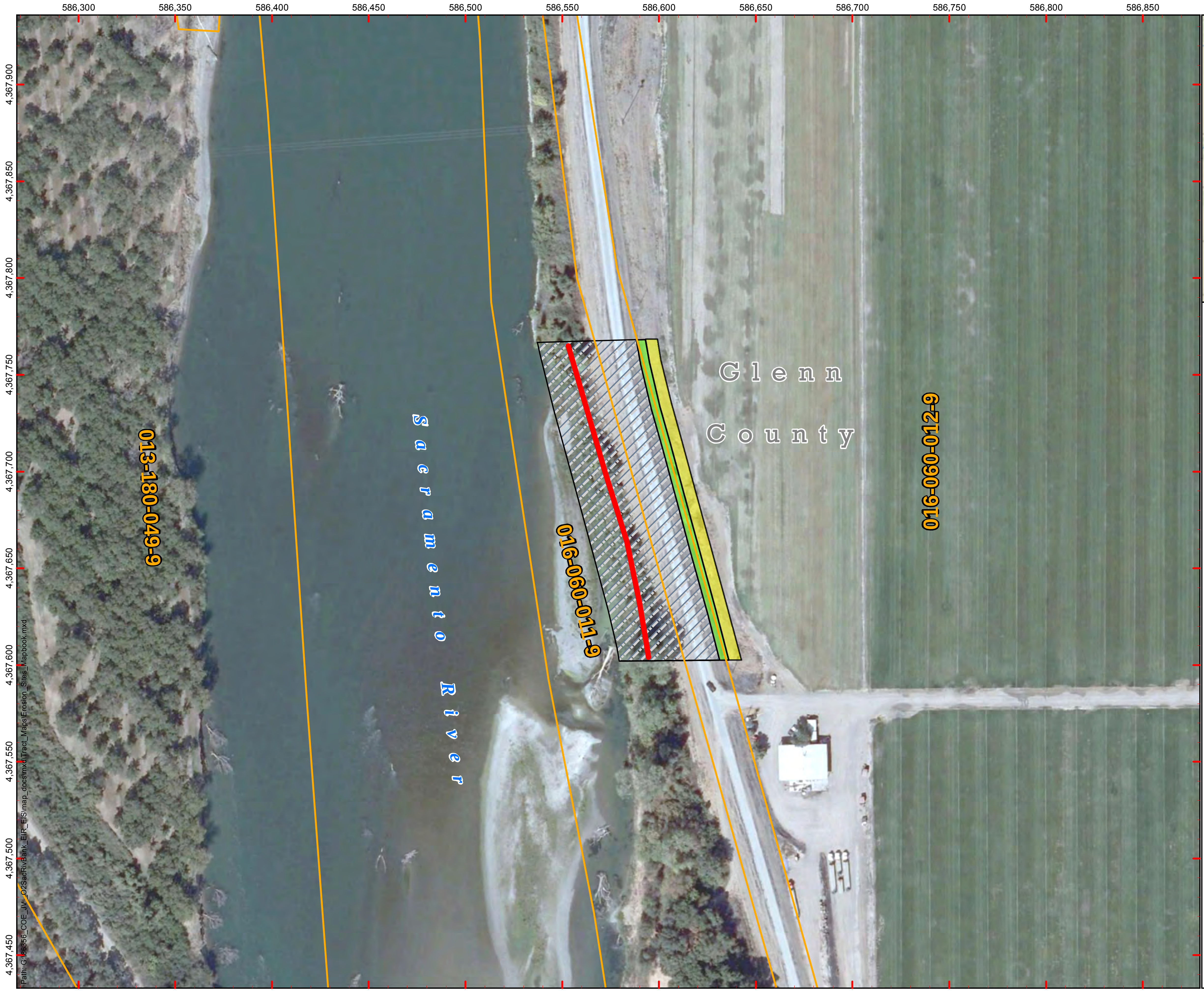
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 163L

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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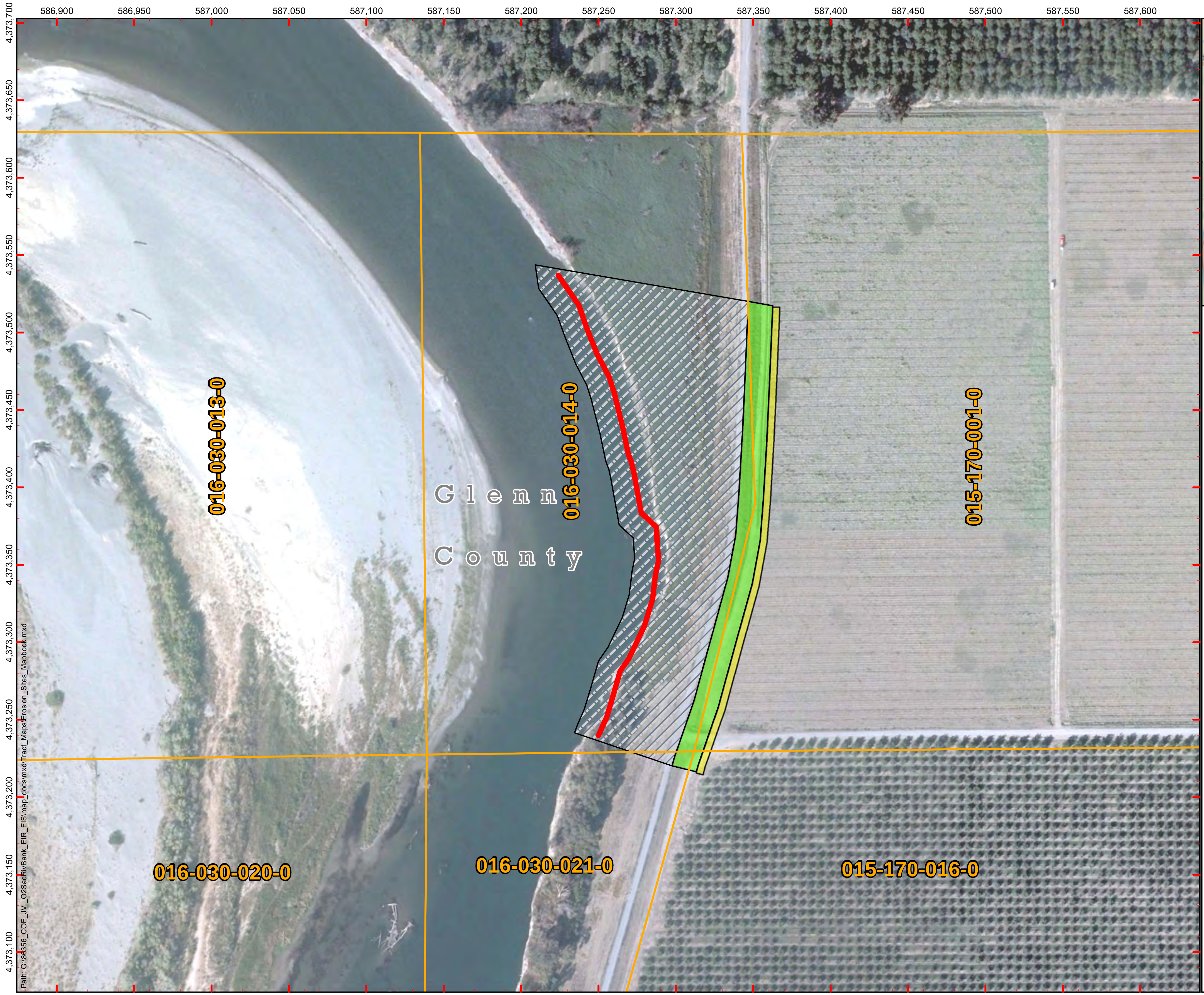
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 168.3L

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR
2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
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Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: Sac 172L

AR Design 3, Measure 7

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

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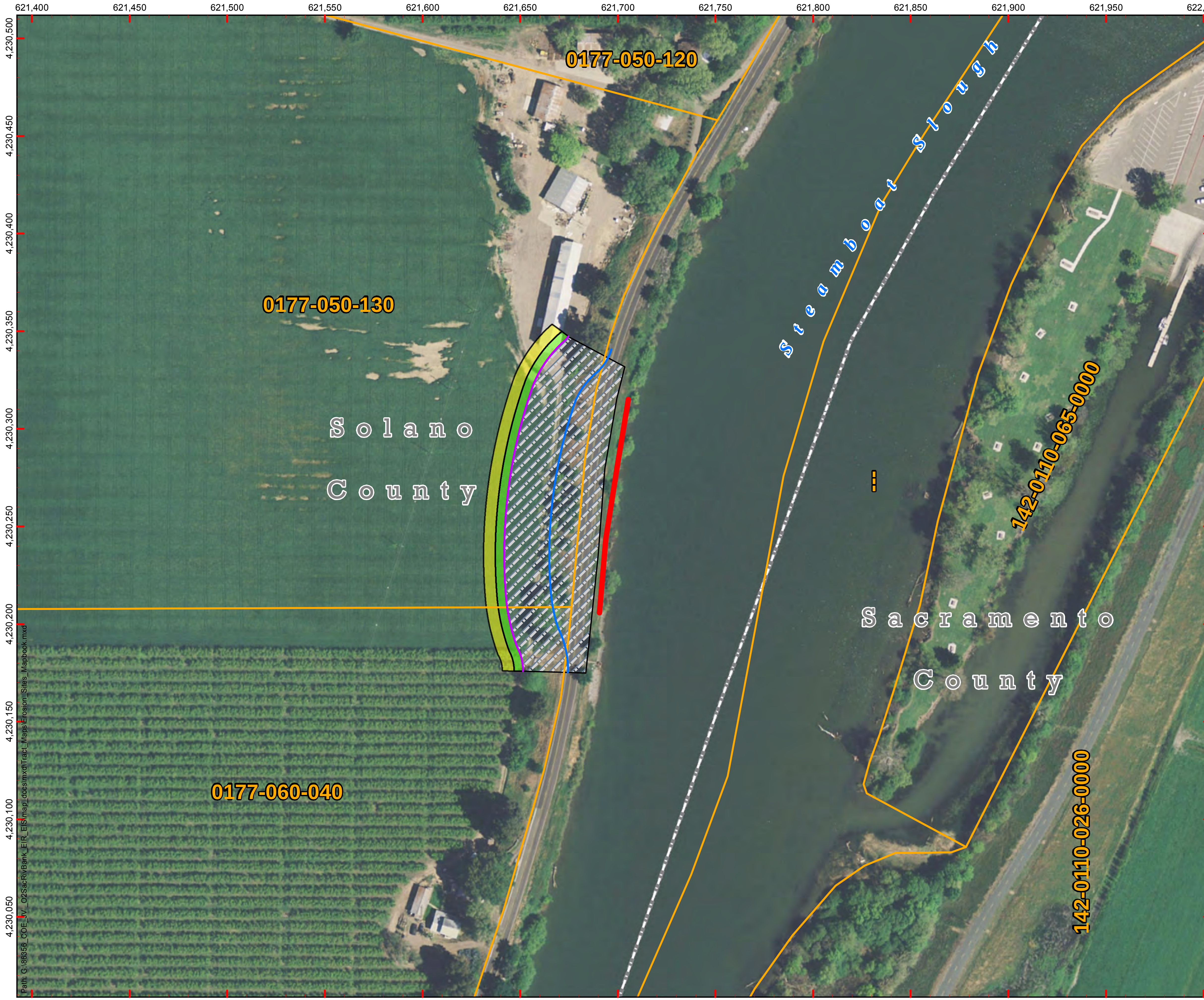

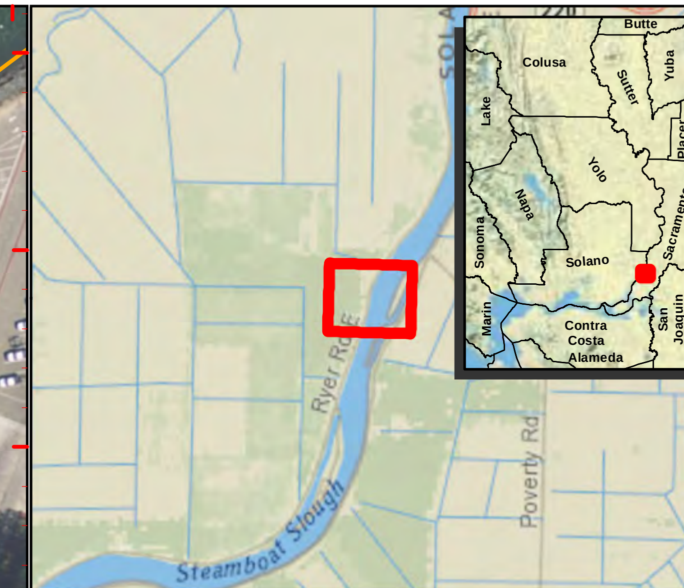

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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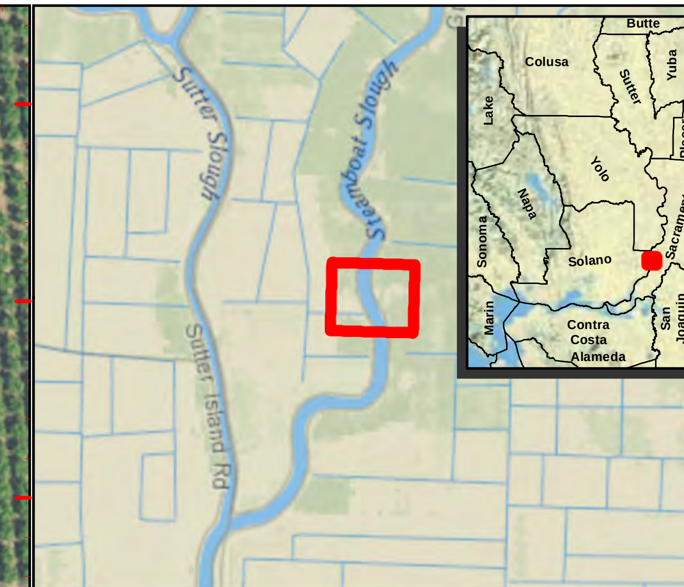
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: STM 18.8R

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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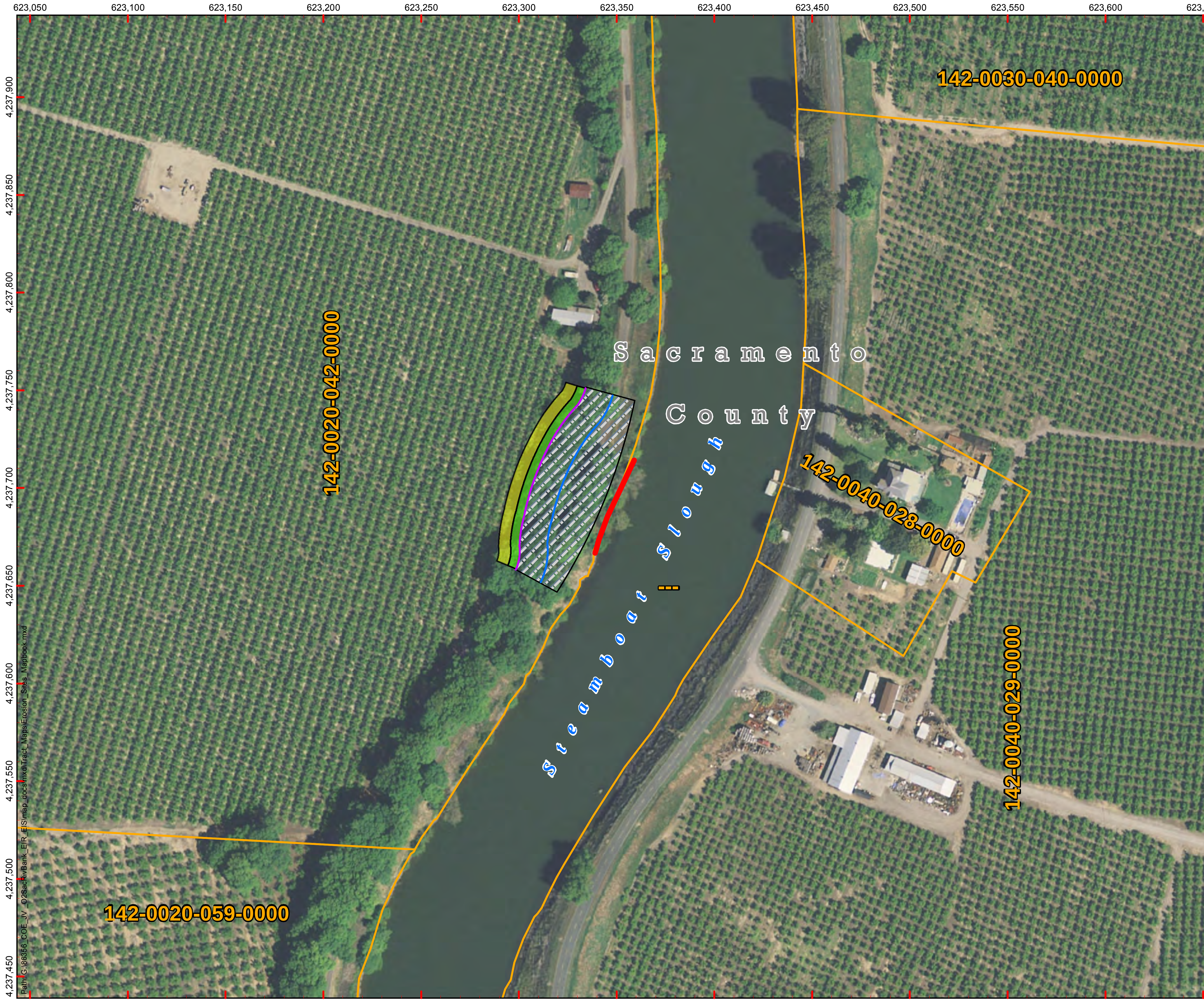
REAL ESTATE OWNERSHIP MAPS 2012

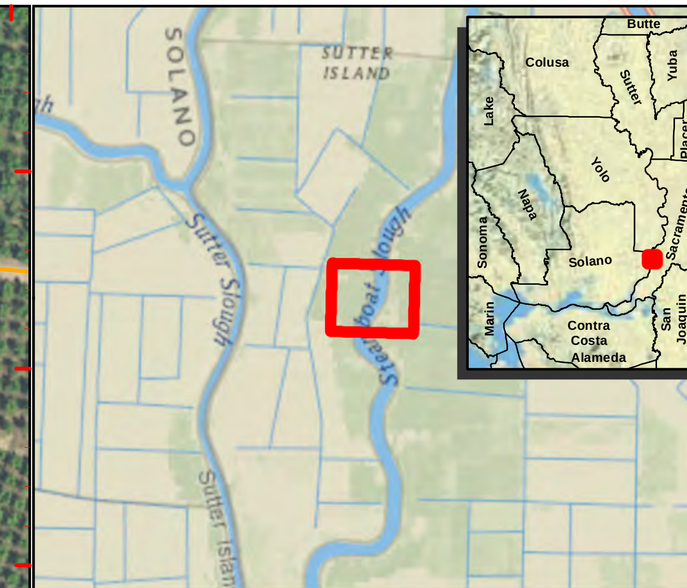
EROSION SITE: STM 23.2L

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709





Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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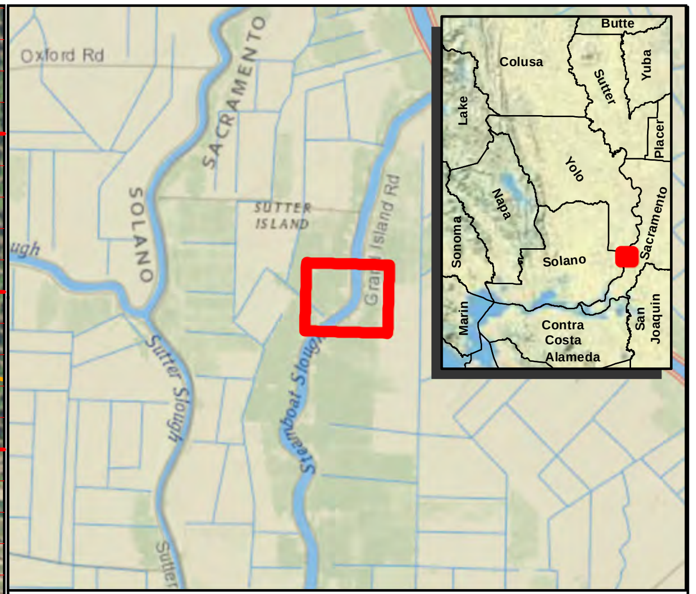
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: STM 23.9R

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

DRAFT

REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: STM 24.7R

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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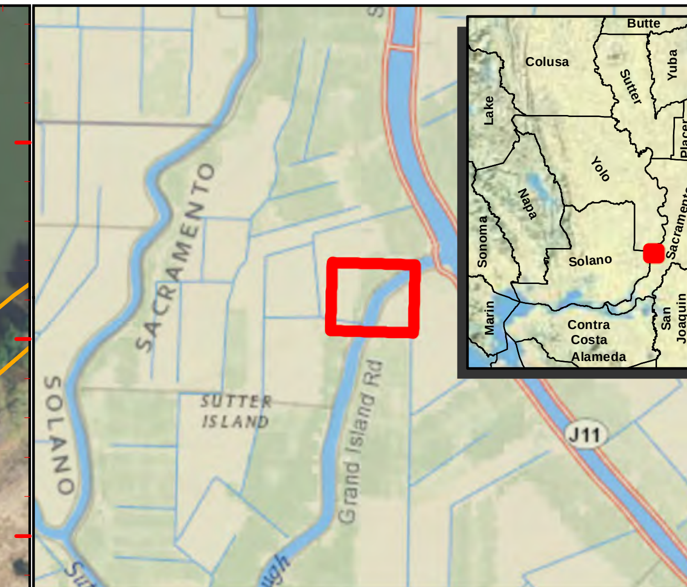
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: STM 25L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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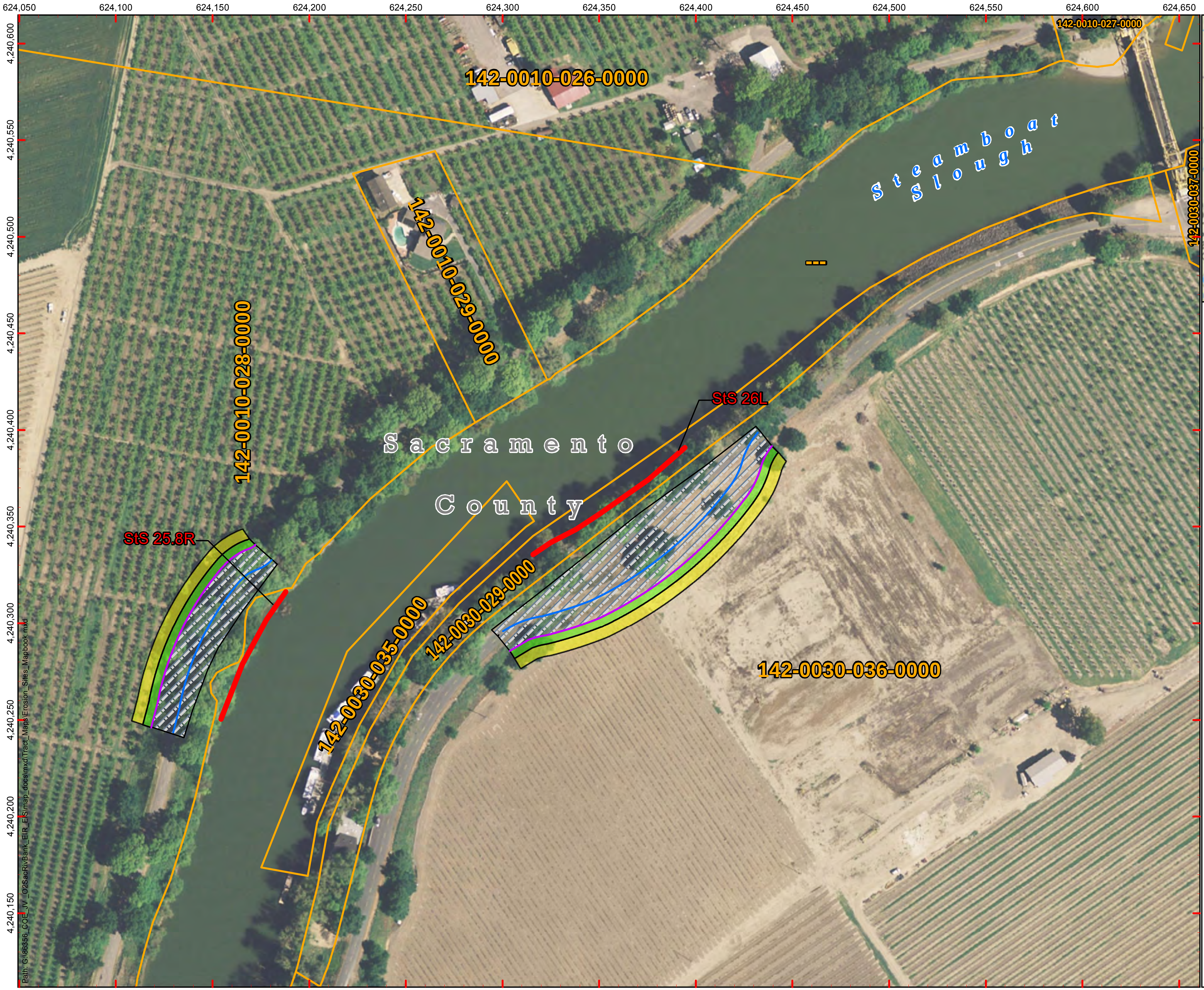
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: STM 25.8R

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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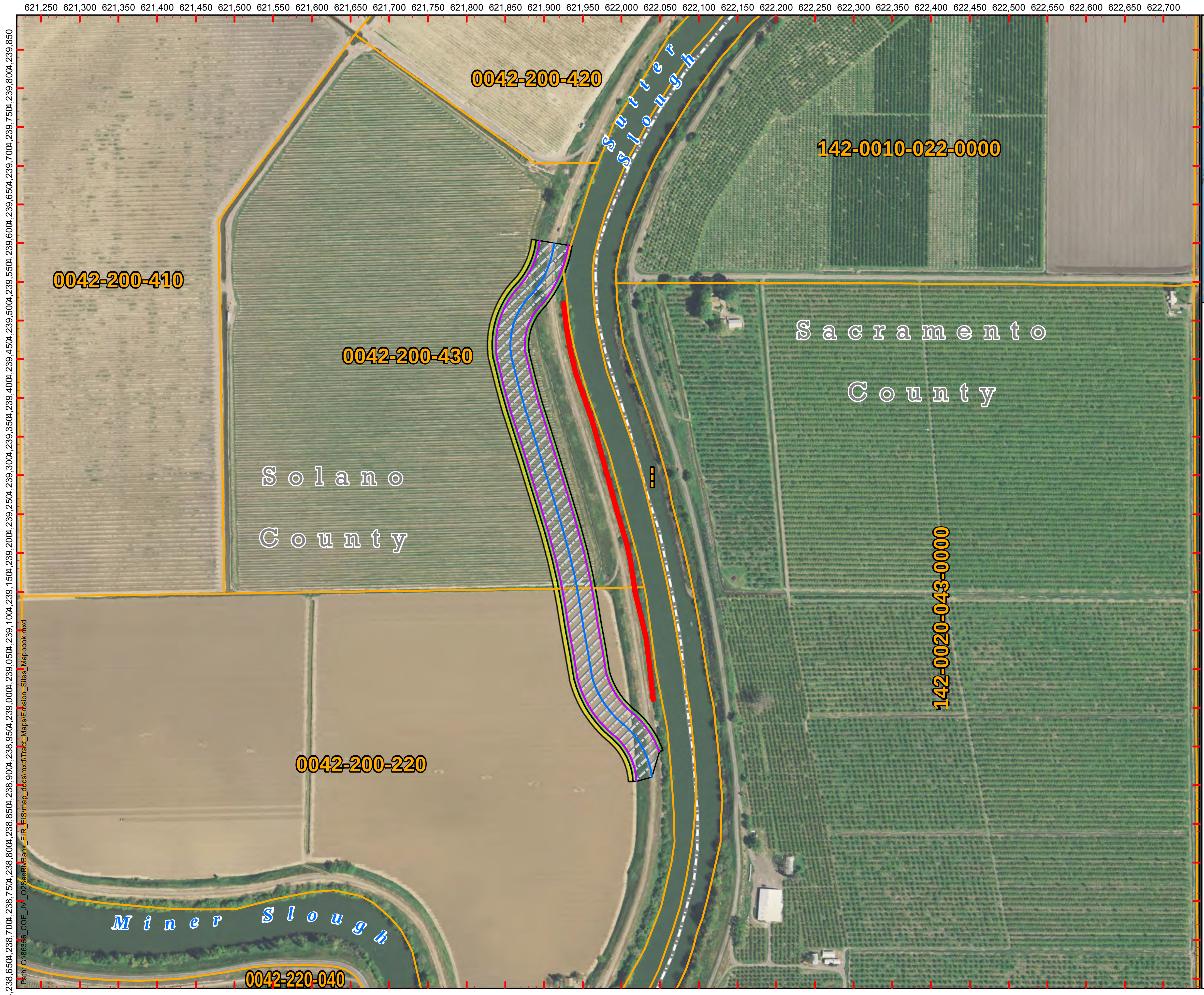
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: STM 26L

Revised to Measure 3: Adjacent Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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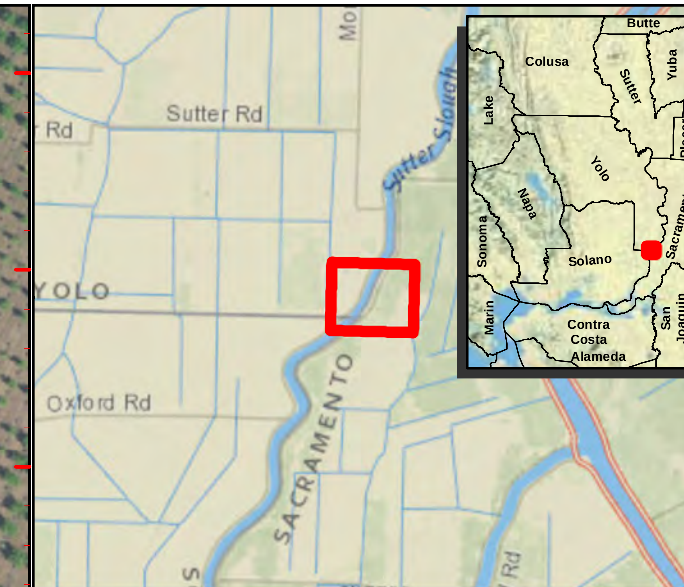
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: SS 24.7R

Revised to Measure 1: Setback Levee

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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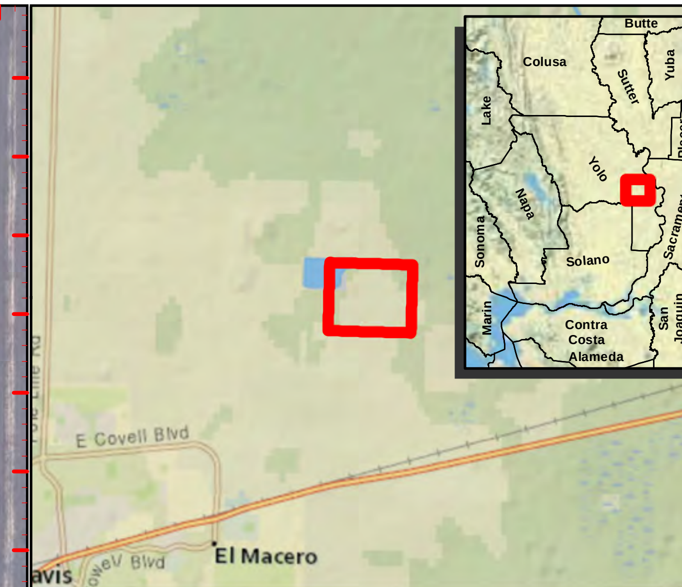
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: SS 26.5L

AR Design 4, Measure 9

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: WSB 0.2L

No Action

Sacramento River Bank EIR/EIS

2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 400 feet

0 100 200 300 400 500 600 700 800 900 1,000 Feet

0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 Meters

Metadata:
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Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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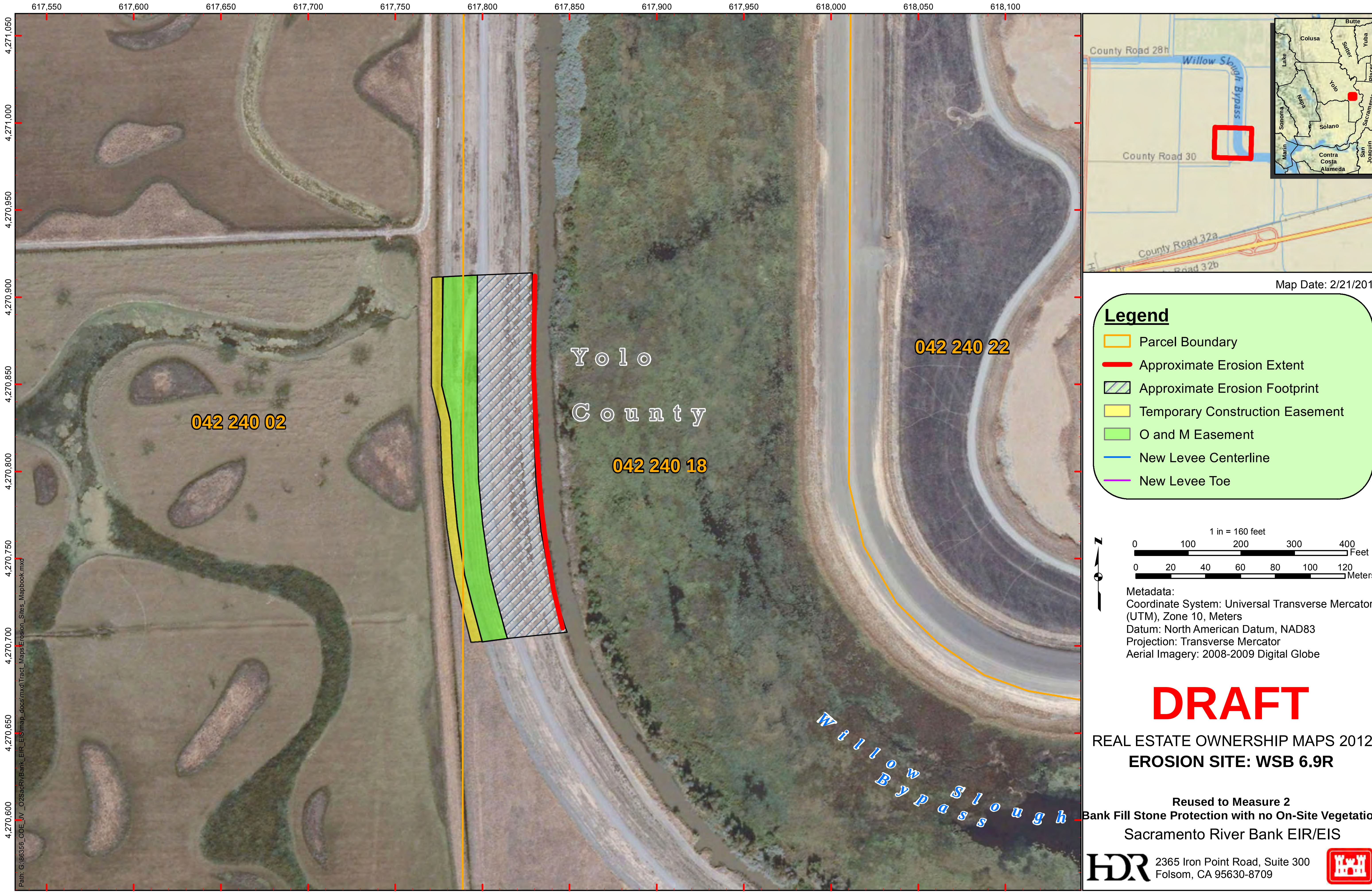
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: WSB 0.7L

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



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REAL ESTATE OWNERSHIP MAPS 2012

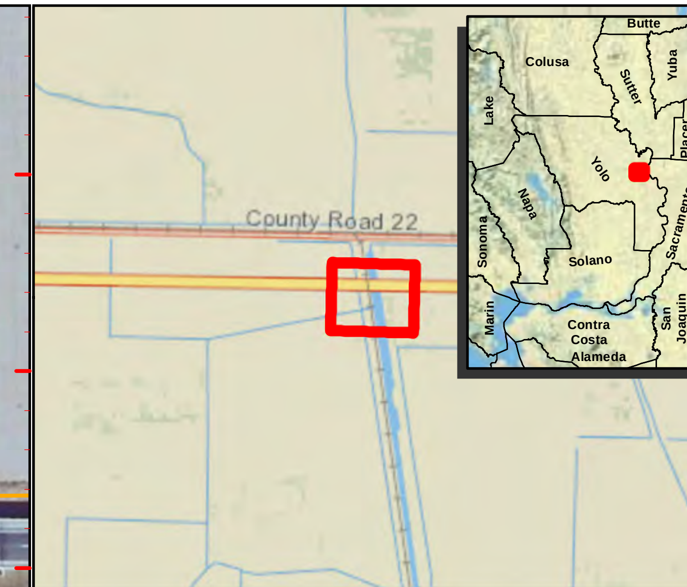
EROSION SITE: WSB 6.9R

Reused to Measure 2

Bank Fill Stone Protection with no On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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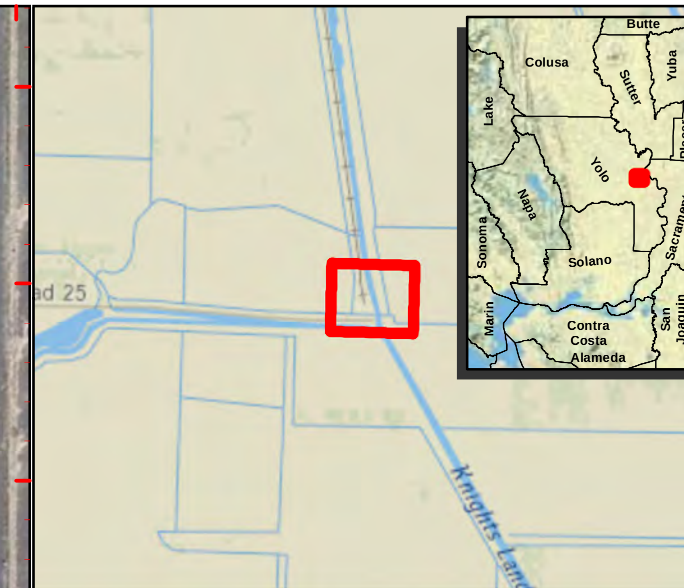
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: YOL2 0.1R

Reused to Measure 2
Bank Fill Stone Protection with no On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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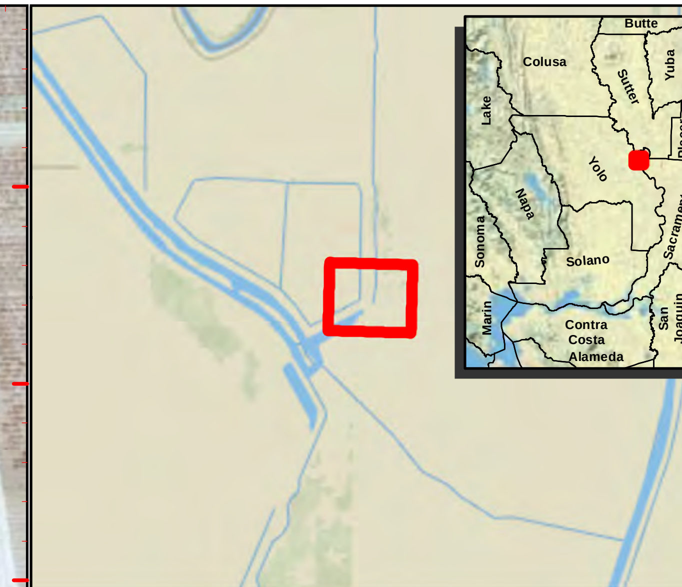
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: YOL2 2.0R

Reused to Measure 2
Bank Fill Stone Protection with no On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

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- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
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Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: YOL2 2.5R

AR Design 1, Measure 3

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 160 feet

0 100 200 300 400 Feet

0 20 40 60 80 100 120 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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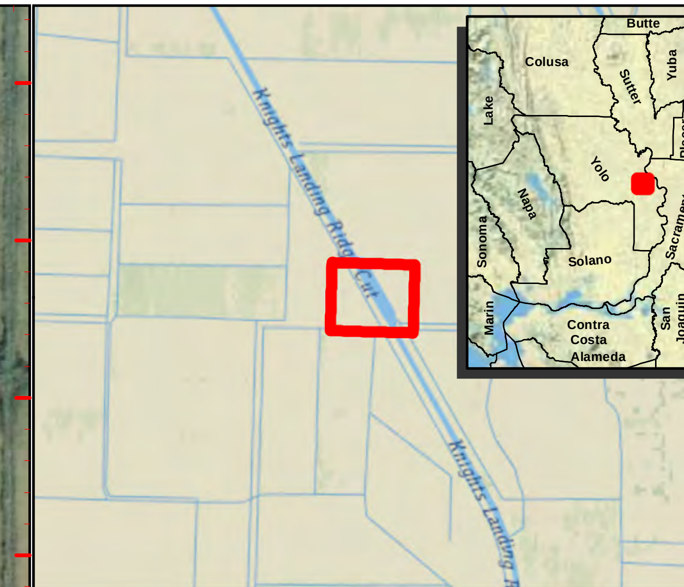
REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: YOL2 2.6R

No Action

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709



Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
Coordinate System: Universal Transverse Mercator (UTM), Zone 10, Meters
Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: YOL2 3.8R

Revised to Measure 2
Bank Fill Stone Protection with no On-Site Vegetation

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

Map Date: 2/21/2012

Legend

- Parcel Boundary
- Approximate Erosion Extent
- Approximate Erosion Footprint
- Temporary Construction Easement
- O and M Easement
- New Levee Centerline
- New Levee Toe

1 in = 200 feet

0 100 200 300 400 500 Feet

0 20 40 60 80 100 120 140 Meters

Metadata:
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Datum: North American Datum, NAD83
Projection: Transverse Mercator
Aerial Imagery: 2008-2009 Digital Globe

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REAL ESTATE OWNERSHIP MAPS 2012

EROSION SITE: YR 2.3L

AR: Rebuild

Sacramento River Bank EIR/EIS

HDR 2365 Iron Point Road, Suite 300
Folsom, CA 95630-8709

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Subappendix 7. Standard Procedure for Updating the Sacramento River Flood Control Project Supplemental O&M Manuals

STANDARD
OPERATION AND MAINTENANCE
MANUAL

FOR THE
SACRAMENTO RIVER
FLOOD CONTROL PROJECT

(REVISED MAY 1955)

SACRAMENTO DISTRICT

CORPS OF ENGINEERS
U. S. ARMY
SACRAMENTO, CALIFORNIA

CORPS OF ENGINEERS

U. S. ARMY

STANDARD

OPERATION AND MAINTENANCE MANUAL

SACRAMENTO RIVER FLOOD CONTROL PROJECT

Prepared by the Sacramento District

Corps of Engineers, U. S. Army

Sacramento, California dated May 1955

STANDARD OPERATION AND MAINTENANCE MANUAL
FOR THE SACRAMENTO RIVER FLOOD CONTROL PROJECT

TABLE OF CONTENTS

TABLE of CONTENTS, CONT.

EXHIBIT INDEX

Exhibit	Description
A	Flood Control Regulations, Maintenance and Operation of Flood Control Works
B	"As Constructed" drawings Unattached (to be contained in supplements)
C	Control of Sand Boils, caving and bank protection, etc. Plates 1 to 10, incl.
D	Levee Inspection Report, Check List No. 1
E	Check Lists of Levees, Channel and Structures Unattached (to be contained in supplements)
F	Letter of Acceptance by State Reclamation Board Unattached (to be contained in supplements)
G	Suggested Semi-annual Report Form Unattached (to be contained in supplements)

STANDARD OPERATION AND MAINTENANCE MANUAL

of the

SACRAMENTO RIVER FLOOD CONTROL PROJECT

SECTION I

INTRODUCTION

1-01. Authority. The Sacramento River Flood Control Project was authorized by the Flood Control Act of 1 March 1917, Public 367 - 64th Congress, (H. Doc. 81, 62nd Congress, lst Session, as modified by Rivers and Harbors Committee Doc. No. 5, 63rd Congress, lst Session), and modified by the Flood Control Act of 15 May 1928, Public No, 391-70th Congress, (S. Doc. No. 23, 69th Congress, lst Session), the River and Harbor Act of 26 August 1937, Public 392, 75th Congress, lst Session (Senate Committee Print 75th Congress, 1st Session), and the Flood Control Act of 18 August 1947, Public 228, 77th Congress, lst Session), (H, Doe. No. 205, 77th Congress, lst Session).

1-02. Purpose of the Manual. The purpose of this manual is to present general information for use by local interests who maintain and operate the various geographical units comprising the Sacramento River Flood Control Project. This general information applies to all units of the project and conforms with Section 208.10, Title 33 of the Code of Federal Regulations as approved by the Acting Secretary of Army on 9 August 1944, and published in the Federal Register of 17 August 1944. A copy of the approved regulations is bound in this volume: as Exhibit A. Detailed information for each separate unit will be furnished under a separate Supplement Manual to be prepared when each unit is completed.

1-03. Location and Description. The Sacramento River Flood Control Project is located on the Sacramento River and the lower reaches of its principal tributaries in north-central California. The principal features of the project extend from Ord Bend downstream to Collinsville near the mouth of the river, a distance of 184 miles, and include a comprehensive system of levees, overflow weirs, drainage pumping plants, and flood bypass channels. This composite flood control project represents many years of planning and incorporates many plans of Federal and State agencies and local interests. The present project provides for the enlargement of the Sacramento River channel below the mouth of Cache Slough (about 20 river miles upstream from Suisun Bay); for making two cutoffs between the mouth of the Feather River and Colusa; for the construction of four bypass weirs and the reconstruction of Tisdale Weir; for construction of outfall gates at the mouth of Butte Slough and at Knights Landing; for levees along certain reaches of the main river and tributaries; for drainage pumping plants on the east side of the Sutter Bypass; for bank protection work and levee setbacks on the main river and tributaries from Ord Bend to Collinsville; for maintenance of the enlarged river channel below Cache Slough during constructions including revetment of the banks of the cut; and for maintenance and operation of gaging stations on navigable rivers and streams during the construction period. The project also includes channel clearing, rectification, snagging, and bank protection along the Sacramento River and tributaries in Tehama County and from Red Bluff southerly. A map showing the location of the features of the project is included in the front of this manual.

1-04. Protection Provided. The Sacramento River Flood Control Projects, when completed, will provide adequate protection from all floods of record to about 800,000 acres of fertile agricultural lands; to the cities of Colusa, Yuba Citys Marysville, Sacramento, North Sacramento, West Sacramento and about eleven smaller communities; to other areas developed for residential and industrial purposes; to two transcontinental railways, one transcontinental highway, and other feeder railways and numerous State and County highways. It will make possible the reclamation of swamps and other areas which can be developed to a high degree when protection against flood hazard is assured.

1-0,5. Construction History. Prior to 1850, low levees were first constructed in the Sacramento Valley by a few individual landowners to protect their properties from inundation. Between the years 1855 and 1871 about 1,000,000 acres of swamp and overflow lands were transferred from Federal ownership to State ownership and in turn were sold to private interests. In an effort to reclaim these lands, levees were extended, encroaching on the streams and confining the waters. Landowners then formed reclamation districts around which they constructed higher and more substantial levees to provide more protection. Federal participation in the improvement of the Sacramento River for flood control began with the Act of l March 1917, and continued under subsequent Acts as mentioned in paragraph 1-0l.

SECTION II

LOCAL COOPERATION

2-01. Federal Requirements. The Act of 18 August 1941, provides that "The projects for the control of floods and other purposes in the Sacramento River, California, adopted by the Acts approved March 1, 1917, May 15, 1928, and August 26, 1937, Public 392 (Senate Committee Print, 75th Congress, lst Session), are hereby modified substantially in accordance with the recommendation of the Chief of Engineers in House Document Numbered 205, Seventy-seventh Congress, first session."

The recommendation of the Chief of Engineers contained in House Document 205, 77th Congress, lst Session, provides for the "com pletion of the Sacramento Valley Flood Control Project ____________________ ____________subject to the provisions that the State of California, or responsible local agencies give assurances satisfactory to the Secretary of War that they will provide, without cost to the United States, all lands, easements and rights-of-way necessary for the completion of the project; bear the expense of necessary highway, railroad, and bridge alterations; hold and save the United States free from claims for damages resulting from construction of the works; and maintain and operate all works, after completion, in accordance with regulations prescribed by the Secretary of War."

2-02. State Legislation.

a. Adoption of Federal Policy. The original legislation adopting Federal policy requiring local interests to give assurances of local cooperation was enacted by the State of California on 22 June 1939, as outlined in State Senate Bill No. 950, Chapter 656. This legislation was later incorporated under Chapter 1528, Statutes of 1947, which amends Article 2 and adds Articles 4, 5, and 6 to Chapter 3, Part 2, Division 5 of the State Water Code. The approval and adoption by and on behalf of the State of California of the conditions, plans construction and mode of maintenance and operation of works within the Sacramento River Flood Control Project set forth in Senate Committee Print, 75th Congress, lst Session, as authorized and approved by the Act of Congress, Public No. 392, 75th Congress, approved 26 August 1937, including the holding and saving the United States from damages due to construction works are continued in effect.

b. Powers and Duties of Department of Public Works and Reclamation Districts include the following:

"8360. On behalf of the State the Department of Public Works, acting by and through the State Engineer, has supervisory powers over the maintenance and operation of the flood control works of the Sacramento River Flood Control Project.

"8361. The department, acting by and through the State Engineer, shall maintain and operate on behalf of the State the following units or portions of the works of the Sacramento River Flood Control Project, and the cost of such maintenance and operation shall be defrayed by the State."

(a) The east levee of the Sutter By-pass north of Nelson Slough.

(b) The levees and channels of the Wadsworth Canal, the intercepting canals draining into it, and all structures incidental thereto.

(c) The collecting canals, sumps, pumps and structures of the drainage system of Project No. 6 east of the Sutter Bypass.

(d) The by-pass channels of the Butte Slough By-pass, the Sutter By-pass, the Tisdale By-pass, the Yolo By-pass and the Sacramento Bypass with all cuts, canals, bridges, dams and other structures and improvements contained therein and in the borrow pits thereof.

(e) The levees of the Sacramento By-pass.

(f) The channels and overflow channels of the Sacramento River and its tributaries within the Sacramento and San Joaquin Drainage District.

(g) The Knights Landing ridge cut flowage area.

(h) The flood relief channels controlled by the Moulton and Colusa Weirs and the training levees thereof.

(i) The levee on the left bank of the Sacramento River adjoining Butte Basin, from the Butte Slough outfall gates upstream to a point four miles northerly from the Moulton Weir, after completion.

(j) All weirs and relief structures.

(k) The west levee of the Yolo By-pass, extending from the west end of the Fremont Weir southerly to the Cache Creek Settling Basin and the east levee of the Yolo By-pass from the Fremont Weir southerly two miles.

(1) The levee on the west bank of Feather River extending a distance of about two miles southerly from the Sutter-Butte Canal headgate.

(m) The levees of Cache Creek and the easterly and westerly levees of Cache Creek settling basin.

"8370. It is the responsibility, liability and duty of the reclamation districts, levee districts, protection districts drainage districts, municipalities, and other public agencies within the Sacramento River Flood Control Project limits, to maintain and operate the works of the project within the boundaries of jurisdiction of such agencies, excepting only those works enumerated in Section 8361 and those for which provision for maintenance and operation is made by federal law.

c. Establishment of Maintenance Areas.

As amended by Chapter 7,5281, the State Water Code sets forth a procedure, available when necessary, whereby adequate and uniform maintenance of flood control projects may be secured. In substance, when the State Engineer finds that there is a failure on the part of local agencies to properly maintain project works or that a local agency no longer desires to carry out project maintenance, a report to that effect is made to the State Reclamation Board, which is empowered, after hearing, to form a "maintenance area" and thereafter the Department of Public Works maintains that particular unit of project works, and the Reclamation Board apportions the cost thereof upon the property benefited within the "maintenance area" on an ad valorem basis and the assessment is extended for collection together with county taxes on the county assessment roll.

SECTION III

GENERAL

3.01. General Rules and Procedures. The general rules for maintenance and operation of local flood-control works are, as follows:

a. The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

b. The State of California, the responsible local agency, which furnished assurance that it will maintain and operate flood control works of the Sacramento River Flood Control Project in accordance with regulations prescribed by the Secretary of Army as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the "Superintendent," who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all of the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during periods of low water, all without cost to the United States.

c. A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

d. No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the rights-of-way for the protective facilities.

e. No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works without prior determination by the District Engineer, Corps of Engineers, or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer, or if otherwise obtained, shall, be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished the District Engineer after completion of the work.

f. It shall be the duty of the superintendent to submit a semi-annual report to the District Engineer covering inspection, maintenance and operation of the protective works.

g. The District Engineer or his authorized representative shall have access at all times to all portions of the protective works.

h. Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made.

i. Appropriate measures shall be taken by local authorities to insure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the superintendent's organization during flood periods.

The District Engineer will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under these regulations. When special conditions do not permit full compliance with the general provisions of the Federal Control Regulations, or when conditions peculiar to a unit require additional care or attention, such supplement instructions will be contained in the supplement Manual concerned.

3-02. Clarification of Duties. Most of the general duties outlined above are self-explanatory; however, amplification of items b, e, f and i, is considered advisable to insure interpretation. Therefore, the remainder of this section of the manual furnishes suggestions for complying with those requirements.

3-0,3. Duties of Superintendent. Details of the duties of the Superintendent will be developed in other portions of the manual. The general duties should include the training of key personnel in such a manner that all contingencies may be handled in an expeditious manner. The Superintendent should ascertain that all of his key men have read those portions of the operation and maintenance manual pertaining to their duties. The Superintendent should have available the names, addresses and telephone numbers of all his key men and a reasonable number of substitutes therefor. These key men should, in turn, have similar data on all of the men necessary for assistance in the discharge of their duties. The key men should include the following:

a. An assistant to act for and in the absence of the Superintendent.

b. Section leaders in sufficient number to lead maintenance patrol work of the entire levee during flood fights. High qualities of leadership and responsibility are necessary for these positions.

The name and address of the Superintendent appointed by local interests to be responsible for the continuous inspection, operation and maintenance of the project works shall be furnished the District Engineer, and in case of any change of Superintendent, the District Engineer shall be so notified.

3-04. Proposed Improvements or Alterations. Drawings or prints or proposed improvements or alterations to the existing Flood Control Works must be submitted for approval to the District Engineer, Sacramento District, Corps of Engineers, Sacramcnto, California, sufficiently in advance of the proposed construction to permit adequate study and consideration of the work. Drawings or prints, in duplicate, showing any improvements or alterations as finally constructed should be furnished to the Corps of Engineers after completion of the work.

3-05. Semi-annual Report. The semi-annual reports required under Paragraph 208.10(a)(6) of the regulations should be submitted within a ten day period prior to 1 June and 1 December of each year and should include all dated copies of reports of inspections made during the period of report. Also, the nature, date of construction, and date of removal of all temporary repairs and the dates of permanent repairs should be included in this report. Other items and suggestions relative to public cooperation, public sentiment on the protection obtained, and other allied subjects are considered pertinent and desirable data for inclusion in the report, but are not required. A suggested form for the Semi-annual Report is included as Exhibit G of the Supplement Manuals.

3-06. Coordination with Operation of Public and Private Facilities. The Superintendent should have specific knowledge of all pertinent public utilities and private facilities located within the unit for which he is responsible in order to coordinate all phases of the flood fighting activities. Such knowledge should be extended to include the names, telephone numbers and addresses of all persons who might necessarily be contacted in case of damage to highway roads and bridges, railroads, power lines, telephone lines, gas lines or structures.

3-07. Safety Requirements. Since patroling of levees, maintenance of channels and operation of irrigation or drainage structures will expose operating personnel to certain hazards, it is suggested that all pertinent safety codes be incorporated into operating procedures and that permanent operating personnel or temporarily employed personnel be given the necessary protective equipment and apparel together with instructions to conduct their work without undue exposure to existing hazards. Watchmen or patrols employed during flood periods should consist of teams of not less than two men.

3-0$. Stream Flow Stages. Permanent arrangements should be made by the Superintendent with the Corps of Engineers at Sacramento, California, to secure stream flow stages and forecasts of stream flow stages and weather conditions of effected streams and drainage areas to properly plan adequate measures of protection.

3-09. Periodic inspections. Inspections should be made by the Superintendent at the times specified below:

a. During the month of October, which is prior to the beginning of the flood season.

b. Immediately following each major high water period.

c. In the absence of high water, at periods not exceeding 90 days.

d. At intermediate times as necessary.

3-10. Check Lists. The check lists shown in Exhibit D and E, should be used in each inspection to insure that no features of the protective system are overlooked. Items requiring maintenance should be noted thereon; if items are satisfactory they should be so indicated by a check. Exhibit E will be furnished by the Sacramento District Engineer as provided under paragraphs 403, 5-03, 6-03 and 7-03 of this manual.

3-11. Drawings. Detailed "As Constructed" record drawings and data necessary for the operation and maintenance of the protective works are included as Exhibit E of the supplement manuals.

SECTION IV

LEVEES

4-01. Description. The Sacramento River Flood Control Project has been divided into geographical units for ease of reference. These units usually conform to political subdivisions which are responsible for operation and maintenance of the project units within their boundaries. Levees of the various units are described in detail in the applicable Supplement Manuals which are prepared after completion of the construction work within the units. The extent of the levee system of the Sacramento River Flood Control Project is shown on the map in the front of this manual. The levees of the Project are constructed generally with a crown width of 20 feet, with landside slopes of 1 on 2 and riverside slopes of 1 on 3. Some bypass levees and some river levees do not have the standard slopes or crown widths. On the Sacramento River and tributaries the levee grade provides for a freeboard of 3 feet above adopted flood plane profile (5 feet freeboard below the mouth of Cache Slough) and on the bypass levees the freeboard is 6 feet. Reasons for departure from the standard conditions are explained in the Supplement Manuals. Patrol roads, earthen ramps, road crossings and turn-outs have been constructed at intervals or wherever necessary throughout *the* length of the levees.

4-02. Maintenance. Applicable portions of the Flood Control Regulations, paragraph 208.10(b)(1), pertaining to maintenance are quoted as follows:

> "(b) Levees - (1) Maintenance. The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to promote the growth of sod, exterminate burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. * * * * Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being carried out and further, to be certain that:
>
> (i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place;
>
> (ii) No caving has occured on either the land side or the river side of the levee which might affect the stability of the levee section;
>
> (iii) No seepage, saturated areas, or sand boils are occurring;

(iv) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged;

(v) Drains through the levees and gates on said drains are in good working condition;

(vi) No revetment work or riprap has been displaced, washed out, or removed; (gee also paragraph 4-05 a)

(vii) No action is being taken; such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod; (see paragraph 4-05 b)

(viii) Access roads to and on the levee are being properly maintained;

(ix) Cattle guards and gates are in good condition;

(x) Crown of levee is shaped so as to drain readily, and roadway thereon, if any, is well shaped and maintained;

(xi) There is no unauthorized grazing or vehicular traffic on the levees;

(xii) Encroachments are not being made on the levee right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Such inspections shall be made immediately prior to the beginning of the flood season; immediately following each major high water period, and otherwise at intervals not exceeding 90 days, and such intermediate times as may be necessary to insure the best possible care of the levee. Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent,"

4-03. Check Lists. A suggested check list form for reporting inspections of the levee is contained in this manual as Exhibit D. Additional check lists are contained in the Supplement Manuals as Exhibit E. As many copies of the form as are necessary to record all needed maintenance should be used for reporting such inspections.

4-O4. Operation. Applicable portions of the Flood Control Regulations, paragraph 208.10(b)(2), are quoted as follows:

> 11(2) Operation. During flood periods the levee shall be patrolled continuously to locate possible sand boils or unusual wetness of the landward slope and to be certain that:
>
> (i) There are no indications of slides or sloughs developing;
>
> (ii) Wave wash or scouring action is not occurring;
>
> (iii) No low reaches of levee exist which may be overtopped;
>
> (iv) No other conditions exist which might endanger the structure.
>
> Appropriate advance measures will be taken to insure the availability of adequate labor and materials to meet all contingencies. Immediate steps will be taken to control any condition which endangers the levee and to repair the damaged section."

4-05. Special Instructions.

a. Revetment work. Due to the fact that many reaches of levees with their contiguous banks have been constructed with stone protection work consisting of quarry stone or cobbles, the provisions of paragraph 4-02(b)(vi) are expanded to include the following:

1. Where scour, wash, settlement or failure of a portion of the originally provided stone protection has been noted, or where inspection indicates that such damage may result during the next flood or high water period, the scour or wash shall be filled with earth free from brush, roots, sod or other unsuitable material and additional stone shall be placed upon the earth fill to bring the stone protection to its original section. In case of emergency and when stone is not available, sand bags or bags filled with gravel may be used for temporary repair measures.

2. When permanent repair of the stone protection is made, the stone used shall, as far as possible, be similar to the kind and gradation as originally used, and shall be

placed to the thickness as shown on the drawings of Exhibit B. In the reach of the Sacramento River downstream from Walnut Grove where the levees are subject to excessive wave wash and at other locations where filter was originally placed or where it may be required, repair of stone protection will include the placement of a properly graded six inch filter layer under the stone protection.

3. In the event an inspection reveals that due to scour, settlement or other causes, stone protection on the levee or bank is required beyond the limits of the original construction or in reaches of the levee or bank not originally provided with such protection, local interests will provide additional sloping of the bank and placement of stone protection as needed to protect completed work. The work shall be done in a manner acceptable under standard engineering practice. Drawings or prints showing such improvements or alterations shall be furnished the District Engineer after completion of the work.

b. Care of vegetation on levee. Due to conditions peculiar to this area, the growth of sod on the levee slope is not practicable. Accordingly, the following special instructions are furnished in lieu of paragraph 4-02(b)(vii) of the prescribed general regulations:

1. The Superintendent shall provide for clearing of brush, trees, and other wild growth from the levee crown and slopes. Brush and small trees may be retained on the waterward slope where desirable for the prevention of erosion and wave wash.

2. Weeds, grasses, and debris on the levee may be burned during appropriate seasons, where not dangerous or impracticable, in order to permit the detection of cracks, holes, burrows, slips, and other damage and to permit the detection and extermination of burrowing animals. Grass and weeds on levee slopes should be mowed where removal by burning is dangerous or impracticable, such as on peat levees or where burning would constitute a hazard."

c. Repairs to Levee Embankment. Methods used for repair or reconstruction of the levee fill will depend on the extent of the damaged section. If of small extent, the most suitable method will be to bring the levee back to line and grade by a fill made in 6-inch layers of earth free from brush, roots, sod or other unsuitable matter. If of larger extent, the fill should be made in the same manner as the original construction, of selected material from borrow pits approved for the project, placed in uniform layers of loose material and not more than 6 inches in depth and compacted in accordance with the specifications under which the work was completed or compacted according to approved construction practices.

d. Depredations of Burrowing Animals. Dens and runways formed within the levee by burrowing animals are frequently the causes of levee failures during flood stages, Burrowing animals such as muskrats, ground hogs, ground squirrels, moles and gophers, found in the levee should be exterminated. The dens and runways should be opened up and thoroughly compacted as they are backfilled. Levees kept properly cleared are not seriously menaced by burrowing animals as they prefer areas where a protective cover, such as high grass, weeds, and brush, is found. Several methods of extermination are found effective, such as trapping, baiting, and poison gases, depending on the type of animal present and the time of year the work is done. Advice concerning the best methods in each locality can be obtained from the County Agricultural Agent.

e. Access Roads. Access roads to the levees shall be maintained in such condition that they will be accessible at all times to trucks used to transport equipment and supplies for maintenance of flood fighting.

Compliance with the provisions prescribed in the general regulations quoted in paragraph k-02 above and with the special instructions is essential for the efficient maintenance of the levee system covered by this manual and for the successful operation of the entire Sacramento River Flood Control Project.

SECTION V

IRRIGATION AND DRAINAGE STRUCTURES

5-01. Description. This section of the manual deals with the numerous irrigation and drainage structures which pass through, under or over the levees to provide for the passage of water from the waterway to the protected area for irrigation or other usage or from the protected area to the waterway for drainage purposes. In general, these structures are constructed of corrugated metal pipes, steel pipes or reinforced concrete pipes or culverts all controlled on the riverside with positive closure devices accessible during high water or with automatic flap gates. Detailed descriptions of the individual structures are contained in the applicable Supplement Manuals.

5-02. Maintenance

a. Flood Control Regulations. Applicable portions of the Flood Control Regulations, paragraph 208.10(d)(1) pertaining to maintenance of irrigation or drainage structures are quoted as follows:

"(d) Drainage Structures (1) Maintenance. Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash drift or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures shall be examined, oiled and trial operated at least once every 90 days. * * * * Periodic inspections shall be made by the Superintendent to be certain that:

(i) Pipes, gates, operating mechanism, riprap and headwalls are in good condition;

(ii) Inlet and outlet channels are open;

(iii) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;

(iv) Erosion is not occurring adjacent to the structures which might endanger its water tightness or stability.

Immedate steps will be taken to repair dsanage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspection."

b. At each inspection as required above, the following items, if applicable, shall be particularly noted:

(1) Debris or other obstructions to flow.

(2) Damage or settlement of pipe.

Condition of concrete-cracks, spalls, erosion.

c. Maintenance.

(1) All eroded concrete shall be repaired as soon as erosion reaches a depth of 4 inches or any reinforcing steel is exposed. All evidences of settlement, uplift, or failure of concrete should be referred to the State Engineer for analysis and recommendation of remedial measures.

(2) If the inspection shows that the automatic drainage structures have been, jammed in an open position by debris or other obstructions, they shall be thoroughly cleaned so that they swing freely to a true closure. If any parts of the gates have been damaged or broken, they shall be replaced by new parts.

(3) Compliance with the provisions prescribed above pertaining to drainage structures is essential for proper maintenance of the levee system covered by this manual. Levee failures caused by neglected drainage structures are of common occurrence; it is, therefore, of utmost importance that these structures always be kept in perfect working condition *in* accordance with the regulations.

(4) Care should be taken not to bury any of the side drainage inlets in the event that it becomes necessary to fill any of the lowlying pockets in back of the levee. Plans for the maintenance of drainage facilities at any such points should be submitted to the State Engineer for approval before such work is started.

5-03. Check Lists. A form suggested as a check list for reporting inspections of drainage structures will be found in the Supplement Manuals, Exhibit E. As many copies of the form as necessary to record all needed maintenance should be used for reporting such inspections.

5-04. Operation. Applicable portions of the Flood Control Regulations, paragraph 208.10(d)(2), are quoted as follows:

> "(2) Operation. Whenever high water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe and any object which might prevent closure of the gate shall be removed. Automatic gates and valves shall be closed as necessary to prevent inflow of flood water. All drainage structures in levees shall be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps shall be taken to correct any adverse condition."

5-05. Additional Requirements.

a. Inspection. Periodic inspections should be made to insure that all facilities are in good operating conditicm as follows:

(1) Since the outlets of pipes crossing under the levee are inundated at relatively low river stages, all pipes crossing under the levee should be inspected considerably in advance of the beginning of the flood season. The gates on these pipes should be checked at the same time.

(2) Tnspection of all drainage structures should also be made following each major high water period.

(3) Otherwise at periods not exceeding 90 days.

b. Check Lists for Inspection of Drainage Structures. Check lists suggested under Exhibit E of the Supplemental Manuals should be used in each inspection to insure that structures are kept in working condition at all times. Exhibit E will be furnished by the Sacramento District Engineer as provided under paragraph 5-03 of this manual.

e. Positive Closure Devices. It is essential that the prime function of the flood protection works cannot be nullified by back flow through irrigation and drainage structures. Accordingly, a reliable means of positive closure of conduits must be provided on the riverside of the protective works and such closure devices must be accessible during flood periods. Conduits through the flood protection works fall into two categories and the requirements for each are as follows:

(1) Those located through the levee above the project flood plane. Emergency closure devices will not be required on those structures where they connect canals and drains which have ample capacity to handle any flow which might pass through the pipe during floods. Where such outlets are not connected to canals or drains of ample capacity an accessible closure device will be required on the river side.

(2) Those located through the levee below the project flood plane. All structures installed by the Federal Government and all new structures to be installed under permit by local interests will be required to have an accessible closure device on the riverside of the levee. All existing structures which do not have an accessible closure device on the riverside of the levee will be modified by local interests to meet that criteria when the structure is rebuilt or modified in any way. Where it is evident that it may be some years before riverside closures will be provided on existing outlets which are at present ungated on that side, it is essential that local interests place, at an early date, an emergency flap gate on the riverside of each outlet now ungated on that side. The flap gate is to be equipped with a cable extension to be equipped with a cable extension to

the levee crown, or other device to hold it open except when necessary to be released for emergency closure of the pipe.

5-06. Safety Requirements. In removing large objects which have lodged against gate structures during periods of high water, exposed workmen should be provided with life vests and, if necessary, should have a safety line attached to their person attended by another worker. Similar hazardous work in the vicinity of structures shuuld not be attempted unless two or more persons are present.

Compliance with the maintenance provisions prescribed in Paragraph 5-02 above pertaining to drainage structures is essential for proper maintenance of the levee system covered by this manual. Levee failures caused by neglected drainage structures are of common occurrence; it is therefore of utmost importance that these structures always be kept in perfect working condition in accordance with the regulations.

SECTION VI

CHANNELS

6-Ol. Description. The channels of the Project constitute that part of the waterway which lies between the levees of the Sacramento River from Ords Ferry to Collinsville; the channels of the lower reaches of the Feather and American Rivers; and all tributary and distributary streams. The area in general is shown on the map located near the front of this manual. More complete detailed descriptions and limits of channels are contained in the Supplement Manuals.

6-02. Maintenance.

a. Flood Control Regulations. Applicable portions of the Federal Flood Control Regulations, Paragraph 208.10(g)(1), pertaining to maintenance of channels are quoted as follows:

"(g) Channels and Floodways--- (1) Maintenance.

Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

(i) The channel or floodway is clear of debris, weeds, and wild growth;

(ii) The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures or other encroachments;

(iii) The capacity of the channel or floodway is not being reduced by the formation of shoals;

(iv) Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred;

(v) Riprap sections and deflection dikes and walls are in good condition;

(vi) Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to perg.t proper functioning of the project works.

Such inspections shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. mediate steps will be taken to remedy any adverse conditions disclosed by such inspections. . .'°

b. Other Maintenance Requirements. The purpose of the floodflow channels inspection and maintenance is to insure that conditions which affect the channel capacity will remain substantially the same as those considered in the design assumptions and that no new conditions develop that may affect the stability of the project structures. Channel maintenance along navigable waterways relates to such maintenance as is required for flood control and is not to be confused with the snagging, clearing and dredging operations carried on by the United States in conjunction with maintenance of Federal navigation projects. Maintenance along channels which are not navigable waterways are the sole responsibility of local interests when such channels must be maintained to a certain capacity for flood control. Particular attention will, therefore, be given the following:

(1) Weeds and other vegetal growth in the channel shall be cut in advance of the flood season and, together with all debris, removed from the channel.

(2) Operations of any nature upstream from the project that would affect flow conditions.

(3) Shoaling or aggradation at the inlets or outlets of side drainage structures may render them inoperative. It is, therefore, imperative that all drains be kept cleaned out and unobstructed at all times.

(4) Dumped rock or other suitable types of protection should be placed at locations found by experience to be critical trouble points, with a view to stabilizing the channel alignment and preserving the general uniformity of the bank lines.

(5) Sediment, rubbish, industrial waste or any debris plugs or other obstructions should be removed from the channel to prevent any tendency for the flows to be deflected within the channel. The heavy material likely to accumulate in the new channel at the mouths of tributaries should be removed to keep the channel clear.

(6) All eroded concrete shall be repaired as soon as reinforcing steel is exposed or erosion reaches a depth of 4 inches. For this purpose, it is recommended that the repair be made by thoroughly cleaning the surface by sandblasting and building up the section with pneumatically placed Portland cement mortar. All evidence of settlement, deviation from grade, uplift, or failure of concrete structures shall be referred to the State Engineer for analysis and remedial measures.

(7) All damage to fencing, posts, barbed wire or galvanizing whether resulting from accidental or willful injuries or from corrosion, shall be promptly repaired with new material in order to maintain satisfactory protection to the public.

(8) Earth fills should be checked for settlement, erosion of levee slopes, excessive seepage or saturation area back of fills and condition of bank protection - concrete or stone blanket.

(9) Right-of-way should be checked for presence of dumped refuse and encroachment of trespass.

6-03. Check Lists. A form suggested as a check list for reporting inspections of the channel will be found in the Supplement Vsnual, Exhibit E. As many copies cf the form as necessary to record all needed maintenance should be used for reporting such inspections.

6-04. Operation.

a. Pertinent Requirements of the Code of Federal Regulations, Par. 208.10(g)(2), are quoted in part as follows:

> "(g) Channels and floodways .....(2) Operation. Both banks of the channel shall be patrolled during periods of high water .... Appropriate measures shall be taken to prevent the formation of jams..... of debris. Large objects which become lodged against the bank shall be removed. The improved channel or floodway, shall be thoroughly inspected immediately following each major high water period. As soon as practicable thereafter all snags and other debris shall be removed and all damage to .... walls, drainage outlets or other flood control structures repaired."

6-05. Safety Requirements.

a. Clearing of channels present hazards which, unless fore-seen and guarded against, may result in serious consequences. Clearing the channel of growing vegetal matter involves the use of axes, brush-hooks or other sharp edged hand tools. In order that the work may be accomplished with a minimum of exposure, the following precautions should be observed:

(1) Instruct employees in proper use of tools and equipment.

(2) Keep tools sharp and inspect tools for possible loose or warped handles or lack of proper wedges.

(3) Allow sufficient distance between workers.

(4) Clear area of branches or vines which might deflect swing of axe.

(5) When clearing channel of debris, workmen should be cautioned to keep a sharp lookout for poisonous snakes.

(6) Extra care should be taken to prevent exposure of susceptible workmen to poison oak.

(7) Should it become necessary to remove large objects which have lodged against the bank or which are causing an obstruction to the flow, during the period of high water, workmen who may be exposed to water hazards should be provided withlife vests and, if necessary, should have a safety line attached to their person, attended by another worker.

SECTION VII

MISCELLANEOUS FACILITIES

7-01. Description. Miscellaneous structures or facilities which are constructed as a part of, or exist in conjunction with the protective works, and which might affect their functioning, include bridges, utility crossings, hydrographic facilities, road crossings and other structures not classified as drainage or irrigation facilities. Detailed description of individual structures or facilities pertinent to each unit will be contained in the supplement manual.

7-02. Maintenance.

a. Applicable portions of the Federal Regulations, paragraph 208.10(h)(1), are quoted as follows:

> "(h) Miscellaneous Facilities. (1) Maintenance. Miscellaneous structures and facilities constructed as a part of the protective works and other structures and facilities which function as a part of, or affect the efficient functioning of the protective works, shall be periodically inspected by the Superintendent and appropriate maintenance measures taken. Damaged or unserviceable parts shall be replaced without delay. . ."

b. Inspection of the miscellaneous facilities and maintenance requirements shall be made at the same time that the inspection of the other features of the project are made, and shall be reported on check list Exhibit E, as shown in the Supplement Manuals.

c. The interest of the Corps of Engineers and the responsibility of the local interests in the existing highway and railroad bridges is primarily confined to their effect on the safety and functioning of the flood control works. However, any conditions noted in the inspections that may affect them in any way should, as a matter of courtesy, be brought to the attention of the responsible agencies. If the inspection of any miscellaneous structure (either existent or constructed in the future under permit) discloses any condition that indicates the probability of failure during periods of high water, the Superintendent shall address a letter to the owner of the structure, quoting this manual as authority and inviting attention to the conditions observed and requesting that immediate steps be taken to correct them. A copy of such letter shall be forwarded to the District Engineer for his information. A report on the action taken by the owner shall be submitted to the District Engineer to accompany the next semi-annual report.

7-03. Check Lists. A check list for miscellaneous structures has not been prepared. A check list similar to that found in the Supplement Manual, Exhibit E, may be used by local interests.

7-04. Operation.

a. Flood Control Regulations. Applicable portions of the Federal Flood Control Regulations, paragraph 208.10(h)(2), are quoted as follows:

> "(2) Operation. Miscellaneous facilities shall be operated to prevent or reduce flooding during periods of high water. Those facilities constructed as a part of the protective works shall not be used for purposes other than flood protection without approval of the District Engineer unless designed therefor."

SECTION VIII

SUGGESTED METHODS OF COMBATING FLOOD CONDITIONS

8-01. General. Most of the methods described herein have been developed during years of experience with the various problems that often come up during periods of high water, and they are not intended to restrict the Superintendent, or others concerned, to a rigid set of rules for every condition that may arise. The remarks are primarily concerned with the earthen portions of the levee system. If problems not covered by these suggestions arise, where the Superintendent is in doubt as to the procedure to be taken, he will be expected to consult the District Engineer, U. S. Corps of Engineers, Sacramento, California, and subsequently to follow standard engineering practices in meeting the situation. It should be noted that it is much better to be over-prepared for a "flood fight" than to find at the last moment that preparations are incomplete or unsatisfactory. Confidence of the protected persons and firms is a valuable asset that should not be carelessly lost through inefficient operation of the protection system in time of emergency.

8-02. Earthen Levees. An earthen levee is in danger whenever there is water against it. This danger increases with the height of the water the duration of the flood stage, and the intensity of either the current or wave action. A well-constructed levee of correct cross section should if properly maintained and not overtopped, hold throughout any major flood. Threatened failures, such as sand boils, sinking levees, slides, or sloughing can be met if prompt action is taken and proper methods of treatment are used.

8-03. Premeditated Damage. In the event of an extraordinary flood requiring *a* fight over long stretches of levee on both sides of a river, there is a natural temptation to attempt some relief from the strain by breaking the opposite levee. The Superintendent should continually guard against premeditated damage to the levee, and when the situation demands immediate action should be taken to establish adequate protective forces.

8-04. Security. Personnel of the Corps of Engineers, whether military or civilian, axe not vested with any civil police authority in the performance of their engineering duties, and they will not attempt to exercise any such authority. The responsibility for protecting flood control works against sabotage, acts of depredation, or other unlawful acts vests with the local interests through local and State Governmental agencies.

8-05. <u>Inspection of Flood Control Works</u>. Immediately upon receipt of information that a high water is imminent, the Reclamation Districts through their Superintendents, should form a skeleton organization, capable of quick expansion, and assign individuals (Sector Foremen) to have charge of definite sections of levees. As his initial activity, each Sector Foreman should go over his entire sector and parts of adjacent sectors, making a detailed inspection, particularly with reference to the following matters:

a. Sector limits; ascertain that the dividing line between sectors is plainly determined and., if necessary, marked.

b. Condition of new levees and recent repairs.

c. Condition of culverts, flap gates, and sluice gates.

d. Transportation facilities; roads, rail and water communications.

e. Material supply; quantity, location, and condition.

f. Comimnications; locate and check all necessary telephones in the sector.

8-06. <u>Preliminary Repair Work</u>. After the initial inspection has been made, each *Sector* Foreman should recruit a labor crew and provide it with tools such as shovels, axes, wheelbarrows, etc. In additions bulldozers, scrapers trucks, etc., should be located and made ready for use in case of emergency. Then immediate action should be taken to perform the following work:

a. Fill up holes or washes in the levee crown, slopes, and landslide berms. Where new construction has been completed during the year, rain washes and deep gullies may have developed. When the levee is new, preparations should be made in advance to combat wave wash along *the* exposed reaches.

b. Repair gaps where road crossings have been worn down and the levee is below grade. In filling the road crossings, it may be necessary to obtain material from landside borrow pits, in which case excavation for the material should be kept at least 50 feet from the toe of levee. Any filling done in this connection should be tamped in place and if in an exposed reach, subject to wave wash the new section should be faced with bags of sand.

c. Repair and close all flap gates on culverts and see that they are seated properly before they are covered with flood waters.

d. Ascertain that all roads to and along the levee are in a good state of repair. The Superintendent should obtain assistance from the county road forces to have all roads put in first-class condition.

e. Locate necessary tools and materials (sacks, sandbags, brush, lumber, lights, etc.), and distribute and store the same at points where active.maintenance is anticipated.

f. Check and obtain repair of all telephone lines necessary for operation, obtain lists of all team forces, motorboats, motor cars, and truck transportation that can be made available.

g. Make thorough arrangements with reliable citizens of the community for the supply, transportation, subsistence, and shelter for the necessary labor.

h. Communicate directly with owners of all stock pastured on the levee and direct that all stock be removed from the levee right-of-way. Cut all fences crossing the levee that do not have gates provided.

i. Investigate all drainage ditches on the landside of the levee and open these drains when obstructions exist. Prepare to cut the necessary seep drainage ditches; however, no attempt should be made to drain the levee slope until actual seepage takes place.

Remove all dynamite and explosives of any kind from the vicinity of the levee.

8-07. Disaster Relief. It is the primary responsibility of local, State, and municipal authorities, supported by or working in connection with the American Red Cross to adopt measures for the relief of flood disaster victims. The primary mission of this District is to maintain the integrity of flood control works. However, relief measures may be undertaken by the Sacramento District in extreme cases and under compelling circumstances where local resources are clearly inadequate to cope with the situation.

8-08. General Methods of Treatment. After the above preliminary organization and precautions have been corrtpleted, the "flood-fight" itself commences. The methods of combating various defects in an earthen levee as described in the following paragraphs have been proved effective during many years of use by the Corps of Engineers. The time, manpower and materials expended on the corrective measures shown below have an equal importance as attending the details of the closure structures, and other portions of the system as described elsewhere within this manual.

8-09. Sand Boils.

a. General. A sand boil is the result of a transfer of pressure head and seepage from the river through a pervious stratum near or at the surface of the landside of the levee. This seepage under pressure tends to push its way to the surface and actually floats the material through which it flows. If the weight of the more impervious soil overlying the pervious stratum, in which the flow under pressure is occurring is sufficient to counterbalance this pressure, no harmful effects results. When the soil stratum overlying the pervious layer fails to counterbalance the upward pressure, or when no such stratum exists, boils break through the landward surface. The sand boil may discharge relatively clear water or the discharge may contain quantities of sand and silt, depending upon the magnitude of the pressure and the size of the boil.

b. Effects of Sand oils. Sand boils can produce three distinctly different effects on the levee, as illustrated on Plate 6, Exhibit C. In Figure 1, the seepage flow develops a very definite pipe or tube under the levee which breaks out at the landward toe in the form of one or more large sand boils. Unless checked, a cavern is created under the levee, causing subsidence and subsequent overtopping. Slumping of the levee will identify this type. Figure 2 illustrates how pressurized seepage water flows under the levee without following a well-defined path and results in one or more boils outcropping at or near the landward toe. The flow from these boils tends to produce sloughing of the slope, and is evidenced by cutting and ravelling at the landward toe. Figure 3 shows a third type of effect of a sand boil, wherein numerous small boilsf many of which are scarcely noticeable, outcrop at or near the toe. While no boil may appear to be dangerous in itself, a group of boils causes flotation of the soil, erosion of the toe, and ultimate failure of the slope through sliding.

c. Method of Treatment.

(1) The accepted method of treating sand boils is to construct a ring of sandbags around the boil, building up a head of water within the ring sufficient to prevent further movement of sand and silt (see Plate 1, Exhibit C). The usual practice of ringing a sand boil is, as follows:

(a) The entire base for the sack ring is cleared *of* debris, in order to provide a watertight bond between the natural ground and the sack ring.

(b) The sacks are then laid in a ring around the boil, with joints staggered, and with loose earth between all sacks,

(c) The ring is carried only to a height sufficient to prevent material from being discharged. The ring should not entirely stop the flow of water, because of the probability of the excessive local pressure head causing additional ruptures of impervious strata and boils nearby.

(d) A V-shaped drain constructed of two boards, or a piece of sheet metal, is then placed near the top of the ring to carry off the water.

(2) Actual conditions at each sand boil will determine the exact dimensions of the ring. The necessary diameter and height of the ring will depend upon the size of the boil, and the flow of water from it. In general, the following considerations should govern:

(a) The base width should not be less than 1 1/2 times the contemplated height.

(b) "Weak" ground near the boil should be included within the ring, thereby preventing a break-through later.

(c) The ring should be of sufficient diameter to permit sacking operations to keep ahead of the flow of water.

(3) Where many boils are found to exist in a given area, a ring levee of sandbags should be constructed around the entire area and, if necessary, water should be pumped into the area to provide sufficient weight to counterbalance the upward pressure.

8-10. Sub-levees or Bow Levees. Sub-levees are smaller levees built to the landside of the main levee in order to form pools to reduce the effective water pressure on the landside and consequently prevent the formation of boils and movement of foundation material. If sub-levees in certain locations prove advisable, the following treatment is recommended: (a) siphons should be available for filling all sub-levees, and (b) when deemed necessary, the siphons should be put into operation and kept running until each sub-levee basin is filled. The siphons, of course, need not be run if the basin fills of its own accord from normal seepage.

8-11. Sloughs. If any sloughs develop in the levees, all soft areas should be thoroughly drained by excavating shallow ditches (see Plate No,7, Exhibit C), after which a single layer of willow brush, if obtainable, or any small trees or limbs should be laid up and down the slope, laying the butts up and tops down, and weighted with sacks (see Plate No. 10, Exhibit C). If the slope begins to slough down, a buttress of sacks should be built on the toe and extending up the slope. The buttress on the toe should be built in the shape of a small berm. No sacks or weight other than necessary to hold the brush in place should extend up the slope more than two-thirds of the distance from toe of slope to the fault.

8-12. Wave Wash. *The* Superintendent and Sector Foremen should study the levee beforehand to determine the possibility of wave wash. All such reaches will be located well in advance and for use in emergency, a reserve supply of filled sacks and rolls of cotton bagging will be kept on board flats.

If the slope is well sodded, a storm of an hour's duration should cause very little damage. During periods of high wind and high water, ample labor should stand by and experienced personnel should observe where the washouts are beginning by sounding or by actually wading along the submerged slope. Sections of cotton bagging should be placed over the washed areas, as shown on Exhibit C, Plate 3. As an alternative, filled sacks should be placed *in* the cut in an effective manner and as soon as possible. The filled sacks should be laid in sections of sufficient length to give protection well above the anticipated rise. Bagging so laid must be thoroughly weighted down to be effective. Plate 2, Exhibit C shows a movable type of wave wash protection, also used with good results. Its advantage is that it can rapidly be built at any convenient place and easily set in place on the job.

8-13, Scours, A careful observation should be made of the riverside of the levee at all localities where a current of more than two feet per second is observed. Trouble may be looked for at the ends of old levee dikes, road-crossing ramps, old traverses, and places where pipes, sewers and other structures penetrate the levee. If any sign of scour is observed in the pits or at the ends of the dikes, soundings should be taken to observe the amount and progress of the scour. The usual method of construction to check scour in the pits, on the slopes, or at the ends of dikes will be to construct deflection dikes using brush, treetops, or lumber, driving stakes and wiring together, and filling in between with brush and filled sacks or stone.

8..14. Topping. Immediate consideration should be given the grade line of each levee section by comparison of existing grades with those shown on the drawings, "As Constructed", Exhibit B of Supplement Manuals. If any reaches show a grade below the previous highest water, emergency topping should be undertaken at once to such a grade as may be established by the District Engineer, U, S, Engineer Office, Sacramento, California, as follows:

a. Sack topping. If lumber is not available, a sack topping may be used to raise the crown of the levee about three feet. The sacks should be laid stretcherwise or along the levee fort he first layer, crosswise for the second layer, and so on. Sacks should be lapped at least 1/3 either way and well mauled into place. When properly sacked and tamped, one sack will give about three to four inches of topping. If gravel is available, it should be used for the front facing so as to avoid washing out.

b. Lumber and sack topping. This is the most commonly used method of raising low reaches in emergencies. In putting on this topping, as well as other topping, a careful line of levels should be run and grade stakes set in advance. 21"x 4"x 6' stakes should then be driven on the riverside of the crown six feet apart, and 1"x 12" boards nailed to the landside of the stakes. This wall, backed with a single tier of sacks will hold out at least one foot of water. If a second foot is necessary, the layers of sacks will have to be increased in number and reinforced. The stakes should be driven three feet in the ground, and should project out three feet, thus providing, in extreme cases, a three-foot topping if properly braced behind with sacks and earth. In some instances, it may be practicable to back up the planking with tamped earth obtained in the vicinity in lieu of the sacks shown in the drawing, Exhibit C, Plate 5.

c. Mud Box. Two types of mud box levees are shown on Plates No. 8 and 9, Exhibit C, The size of box is controlled by the conditions under which the box will functions available materials, method of placing the dirt, and the time element.

d. Cut-Crown Topping. This form of work should never be resorted to except in extreme emergency, when filled sacks and lumber cannot be secured.

8-.15. Caving Bank Protection. As protection against active caving of riverbanks, rock-filled cribs are very effective if properly placed. Cribs are usually 14 by 14 feet in plan by 10 to 14 inches in inside depth. The cribs are constructed on a double thickness of 1" x 4" x 14' lumber, equivalent to 2" x 4" pieces, lapped rail fence fashion at all corners and intersections. They are divided into four compartments of about equal area by two perpendicular cross walls constructed in the same manner as the side walls. The floors and covers are built up of double l" x 4" boards spaced about 9" center-to-center. Under the floor and perpendicular to the direction of the floor boards are five equally spaced pairs of 1" x 4" boards about 3 feet center-to-center. On top of the cover, perpendicular to the direction of the cover boards, are three pairs of top boards, one over each of the side walls and one over the central division wall. All intersections are nailed with one 20d nail. The compartments are filled with rock before covering. Each wall intersection of the fabricated cribs is securely fastened by a loop of No. 9 wire. See Exhibit C, Plate 4.

8-16. Transportation. In instances where it is necessary to send equipment over roads that are impassable due to mud or sand, their passage may be provided by the use of a plank road or by means of steel or wire mats. Telephone or "walkie-talkie" communication should be provided along dangerous stretches of the levee when travel or other satisfactory means of communication cannot be maintained.

8-1?. Check Lists. The check lists shown in Exhibits D and E are furnished for reproduction and use by the local interests. These lists should be used in each inspection to insure that no features of the protective system are overlooked. Items requiring repairs should be noted thereon; if items are satisfactory, they should be indicated by a check mark, 8-18. Use of Government Plant. The District Engineer is authorized (Orders and Regulations, Par. 4227,12) to use or loan Governmnt plant in sudden emergencies when life is in danger. The use of such plant is also permitted to save private property provided that no suitable private plant is available and that the plant can be spared without detriment to Government workse

CODE OF FEDERAL REGULATIONS (EXTRACT)

TITLE 33—NAVIGATION AND NAVIGABLE WATERS

Chapter II — Corps of Engineers, Department of the Army

PART 208 — FLOOD CONTROL REGULATIONS

AUTHORITY: § 208.10 issued under Sec. 7, 58 Stat. 890; 33 U.S.C. 709.

§ 208.10 *Local flood protection works; maintenance and operation of structures and facilities* — (a) *General.* (1) The structures and facilities constructed by the United States for local flood protection shall be continuously maintained in such a manner and operated at such times and for such periods as may be necessary to obtain the maximum benefits.

(2) The State, political subdivision thereof, or other responsible local agency, which furnished assurance that it will maintain and operate flood control works in accordance with regulations prescribed by the Secretary of the Army, as required by law, shall appoint a permanent committee consisting of or headed by an official hereinafter called the "Superintendent," who shall be responsible for the development and maintenance of, and directly in charge of, an organization responsible for the efficient operation and maintenance of all of the structures and facilities during flood periods and for continuous inspection and maintenance of the project works during periods of low water, all without cost to the United States.

(3) A reserve supply of materials needed during a flood emergency shall be kept on hand at all times.

(4) No encroachment or trespass which will adversely affect the efficient operation or maintenance of the project works shall be permitted upon the rights-of-way for the protective facilities.

(5) No improvement shall be passed over, under, or through the walls, levees, improved channels or floodways, nor shall any excavation or construction be permitted within the limits of the project right-of-way, nor shall any change be made in any feature of the works without prior determination by the District Engineer of the Department of the Army or his authorized representative that such improvement, excavation, construction, or alteration will not adversely affect the functioning of the protective facilities. Such improvements or alterations as may be found to be desirable and permissible under the above determination shall be constructed in accordance with standard engineering practice. Advice regarding the effect of proposed improvements or alterations on the functioning of the project and information concerning methods of construction acceptable under standard engineering practice shall be obtained from the District Engineer or, if otherwise obtained, shall be submitted for his approval. Drawings or prints showing such improvements or alterations as finally constructed shall be furnished the District Engineer after completion of the work.

(6) It shall be the duty of the Superintendent to submit a semiannual report to the District Engineer covering inspection, maintenance, and operation of the protective works.

(7) The District Engineer or his authorized representatives shall have access at all times to all portions of the protective works.

(8) Maintenance measures or repairs which the District Engineer deems necessary shall be promptly taken or made.

(9) Appropriate measures shall be taken by local authorities to insure that the activities of all local organizations operating public or private facilities connected with the protective works are coordinated with those of the Superintendent's organization during flood periods.

(10) The Department of the Army will furnish local interests with an Operation and Maintenance Manual for each completed project, or separate useful part thereof, to assist them in carrying out their obligations under this part.

(b) *Levees* — (1) *Maintenance.* The Superintendent shall provide at all times such maintenance as may be required to insure serviceability of the structures in time of flood. Measures shall be taken to promote the growth of sod, exterminate burrowing animals, and to provide for routine mowing of the grass and weeds, removal of wild growth and drift deposits, and repair of damage caused by erosion or other forces. Where practicable, measures shall be taken to retard bank erosion by planting of willows or other suitable growth on areas riverward of the levees. Periodic inspections shall be made by the Superintendent to insure that the above maintenance measures are being effectively carried out and, further, to be certain that:

(i) No unusual settlement, sloughing, or material loss of grade or levee cross section has taken place;

(ii) No caving has occurred on either the land side or the river side of the levee which might affect the stability of the levee section;

(iii) No seepage, saturated areas, or sand boils are occurring;

(iv) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged;

(v) Drains through the levees and gates on said drains are in good working condition;

(vi) No revetment work or riprap has been displaced, washed out, or removed;

(vii) No action is being taken, such as burning grass and weeds during inappropriate seasons, which will retard or destroy the growth of sod;

(viii) Access roads to and on the levee are being properly maintained;

(ix) Cattle guards and gates are in good condition;

(x) Crown of levee is shaped so as to drain readily, and roadway thereon, if any, is well shaped and maintained;

(xi) There is no unauthorized grazing or vehicular traffic on the levees;

(xii) Encroachments are not being made on the levee right-of-way which might endanger the structure or hinder its proper and efficient functioning during times of emergency.

Such inspections shall be made immediately prior to the beginning of the flood season; immediately following each major high water period, and otherwise at intervals not exceeding 90 days; and such intermediate times as may be necessary to insure the best possible care of the levee. Immediate steps will be taken to correct dangerous conditions disclosed by such inspections. Regular maintenance repair measures shall be accomplished during the appropriate season as scheduled by the Superintendent.

(2) *Operation.* During flood periods the levee shall be patrolled continuously to locate possible sand boils or unusual wetness of the landward slope and to be certain that:

(i) There are no indications of slides or sloughs developing;

(ii) Wave wash or scouring action is not occurring;

(iii) No low reaches of levee exist which may be overtopped;

(iv) No other conditions exist which might endanger the structure.

Appropriate advance measures will be taken to insure the availability of adequate labor and materials to meet all contingencies. Immediate steps will be taken to control any condition which endangers the levee and to repair the damaged section.

(c) *Flood walls.* — (1) *Maintenance.* Periodic inspections shall be made by the Superintendent to be certain that:

(i) No seepage, saturated areas, or sand boils are occurring;

(ii) No undue settlement has occurred which affects the stability of the wall or its water tightness;

(iii) No trees exist, the roots of which might extend under the wall and offer accelerated seepage paths;

(iv) The concrete has not undergone cracking, chipping, or breaking to an extend which might affect the stability of the wall or its water tightness;

(v) There are no encroachments upon the right-of-way which might endanger the structure or hinder its functioning in time of flood;

(vi) Care is being exercised to prevent accumulation of trash and debris adjacent to walls, and to insure that no fires are being built near them;

(vii) No bank caving conditions exist riverward of the wall which might endanger its stability;

(viii) Toe drainage systems and pressure relief wells are in good working condition, and that such facilities are not becoming clogged.

Such inspections shall be made immediately prior to the beginning of the flood season, immediately following each major high water period, and otherwise at intervals not exceeding 90 days. Measures to eliminate encroachments and effect repairs found necessary by such inspections shall be undertaken immediately. All repairs shall be accomplished by methods acceptable in standard engineering practice.

(2) *Operation.* Continuous patrol of the wall shall be maintained during flood periods to locate possible leakage at monolith joints or seepage underneath the wall. Floating plant or boats will not be allowed to lie against or tie up to the wall. Should it become necessary during a flood emergency to pass anchor cables over the wall, adequate measures shall be taken to protect the concrete and construction joints. Immediate steps shall be taken to correct any condition which endangers the stability of the wall.

(d) *Drainage structures*—(1) *Maintenance.* Adequate measures shall be taken to insure that inlet and outlet channels are kept open and that trash, drift, or debris is not allowed to accumulate near drainage structures. Flap gates and manually operated gates and valves on drainage structures shall be examined, oiled, and trial operated at least once every 90 days. Where drainage structures are provided with stop log or other emergency closures, the condition of the equipment and its housing shall be inspected regularly and a trial installation of the emergency closure shall be made at least once each year. Periodic inspections shall be made by the Superintendent to be certain that:

(i) Pipes, gates, operating mechanism, riprap, and headwalls are in good condition;

(ii) Inlet and outlet channels are open;

(iii) Care is being exercised to prevent the accumulation of trash and debris near the structures and that no fires are being built near bituminous coated pipes;

(iv) Erosion is not occurring adjacent to the structure which might endanger its water tightness or stability.

Immediate steps will be taken to repair damage, replace missing or broken parts, or remedy adverse conditions disclosed by such inspections.

(2) *Operation.* Whenever high water conditions impend, all gates will be inspected a short time before water reaches the invert of the pipe and any object which might prevent closure of the gate shall be removed. Automatic gates shall be closely observed until it has been ascertained that they are securely closed. Manually operated gates and valves shall be closed as necessary to prevent inflow of flood water. All drainage structures in levees shall be inspected frequently during floods to ascertain whether seepage is taking place along the lines of their contact with the embankment. Immediate steps shall be taken to correct any adverse condition.

(e) *Closure structures*—(1) *Maintenance.* Closure structures for traffic openings shall be inspected by the Superintendent every 90 days to be certain that:

(i) No parts are missing;

(ii) Metal parts are adequately covered with paint;

(iii) All movable parts are in satisfactory working order;

(iv) Proper closure can be made promptly when necessary;

(v) Sufficient materials are on hand for the erection of sand bag closures and that the location of such materials will be readily accessible in times of emergency.

Tools and parts shall not be removed for other use. Trial erections of one or more closure structures shall be made once each year, alternating the structures chosen so that each gate will be erected at least once in each 3-year period. Trial erection of all closure structures shall be made whenever a change is made in key operating personnel. Where railroad operation makes trial erection of a closure structure infeasible, rigorous inspection and drill of operating personnel may be substituted therefor. Trial erection of sand bag closures is not required. Closure materials will be carefully checked prior to and following flood periods, and damaged or missing parts shall be repaired or replaced immediately.

(2) *Operation.* Erection of each movable closure shall be started in sufficient time to permit completion before flood waters reach the top of the structure sill. Information regarding the proper method of erecting each individual closure structure, together with an estimate of the time required by an experienced crew to complete its erection will be given in the Operation and Maintenance Manual which will be furnished local interests upon completion of the project. Closure structures will be inspected frequently during flood periods to ascertain that no undue leakage is occurring and that drains provided to care for ordinary leakage are functioning properly. Boats or floating plant shall not be allowed to tie up to closure structures or to discharge passengers or cargo over them.

(f) *Pumping plants*—(1) *Maintenance.* Pumping plants shall be inspected by the Superintendent at intervals not to exceed 30 days during flood seasons and 90 days during off-flood seasons to insure that all equipment is in order for instant use. At regular intervals, proper measures shall be taken to provide for cleaning plant, buildings, and equipment, repainting as necessary, and lubricating all machinery. Adequate supplies of lubricants for all types of machines, fuel for gasoline or diesel powered equipment, and flash lights or lanterns for emergency lighting shall be kept on hand at all times. Telephone service shall be maintained at pumping plants. All equipment, including switch gear, transformers, motors, pumps, valves, and gates shall be trial operated and checked at least once every 90 days. Megger tests of all insulation shall be made whenever wiring has been subjected to undue dampness and otherwise at intervals not to exceed one year. A record shall be kept showing the results of such tests. Wiring disclosed to be in an unsatisfactory condition by such tests shall be brought to a satisfactory condition or shall be promptly replaced. Diesel and gasoline engines shall be started at such intervals and allowed to run for such length of time as may be necessary to insure their serviceability in times of emergency. Only skilled electricians and mechanics shall be employed on tests and repairs. Operating personnel for the plant shall be present during tests. Any equipment removed from the station for repair or replacement shall be returned or replaced as soon as practicable and shall be trial operated after reinstallation. Repairs requiring removal of equipment from the plant shall be made during off-flood seasons insofar as practicable.

(2) *Operation.* Competent operators shall be on duty at pumping plants whenever it appears that necessity for pump operation is imminent. The operator shall thoroughly inspect, trial operate, and place in readiness all plant equipment. The operator shall be familiar with the equipment manufacturers' instructions and drawings and with the "Operating Instructions" for each station. The equipment shall be operated in accordance with the above-mentioned "Operating Instructions" and care shall be exercised that proper lubrication is being supplied all equipment, and that no overheating, undue vibration or noise is occurring. Immediately upon final recession of flood waters, the pumping station shall be thoroughly cleaned, pump house sumps flushed, and equipment thoroughly inspected, oiled and greased. A record or log of pumping plant operation shall be kept for each station, a copy of which shall be furnished the District Engineer following each flood.

(g) *Channels and floodways* — (1) *Maintenance.* Periodic inspections of improved channels and floodways shall be made by the Superintendent to be certain that:

(i) The channel or floodway is clear of debris, weeds, and wild growth;

(ii) The channel or floodway is not being restricted by the depositing of waste materials, building of unauthorized structures or other encroachments;

(iii) The capacity of the channel or floodway is not being reduced by the formation of shoals;

(iv) Banks are not being damaged by rain or wave wash, and that no sloughing of banks has occurred;

(v) Riprap sections and deflection dikes and walls are in good condition;

(vi) Approach and egress channels adjacent to the improved channel or floodway are sufficiently clear of obstructions and debris to permit proper functioning of the project works.

Such inspections shall be made prior to the beginning of the flood season and otherwise at intervals not to exceed 90 days. Immediate steps will be taken to remedy any adverse conditions disclosed by such inspections. Measures will be taken by the Superintendent to promote the growth of grass on bank slopes and earth deflection dikes. The Superintendent shall provide for periodic repair and cleaning of debris basins, check dams, and related structures as may be necessary.

(2) *Operation.* Both banks of the channel shall be patrolled during periods of high water, and measures shall be taken to protect those reaches being attacked by the current or by wave wash. Appropriate measures shall be taken to prevent the formation of jams of ice or debris. Large objects which become lodged against the bank shall be removed. The improved channel or floodway shall be thoroughly inspected immediately following each major high water period. As soon as practicable thereafter, all snags and other debris shall be removed and all damage to banks, riprap, deflection dikes and walls, drainage outlets, or other flood control structures repaired.

(h) *Miscellaneous facilities*—(1) *Maintenance.* Miscellaneous structures and facilities constructed as a part of the protective works and other structures and facilities which function as a part of, or affect the efficient functioning of the protective works, shall be periodically inspected by the Superintendent and appropriate maintenance measures taken. Damaged or unserviceable parts shall be repaired or replaced without delay. Areas used for ponding in connection with pumping plants or for temporary storage of interior run-off during flood periods shall not be allowed to become filled with silt, debris, or dumped material. The Superintendent shall take proper steps to prevent restriction of bridge openings and, where practicable, shall provide for temporary raising during floods of bridges which restrict channel capacities during high flows.

(2) *Operation.* Miscellaneous facilities shall be operated to prevent or reduce flooding during periods of high water. Those facilities constructed as a part of the protective works shall not be used for purposes other than flood protection without approval of the District Engineer unless designed therefor. (Sec. 3, 49 Stat. 1571, as amended; 33 U.S.C. 701C) [9 F.R. 9999, Aug. 17, 1944; 9 F.R. 10203, Aug. 22, 1944]

EXHIBIT B
"AS CONSTRUCTED" DRAWINGS
(See Supplement Manuals)

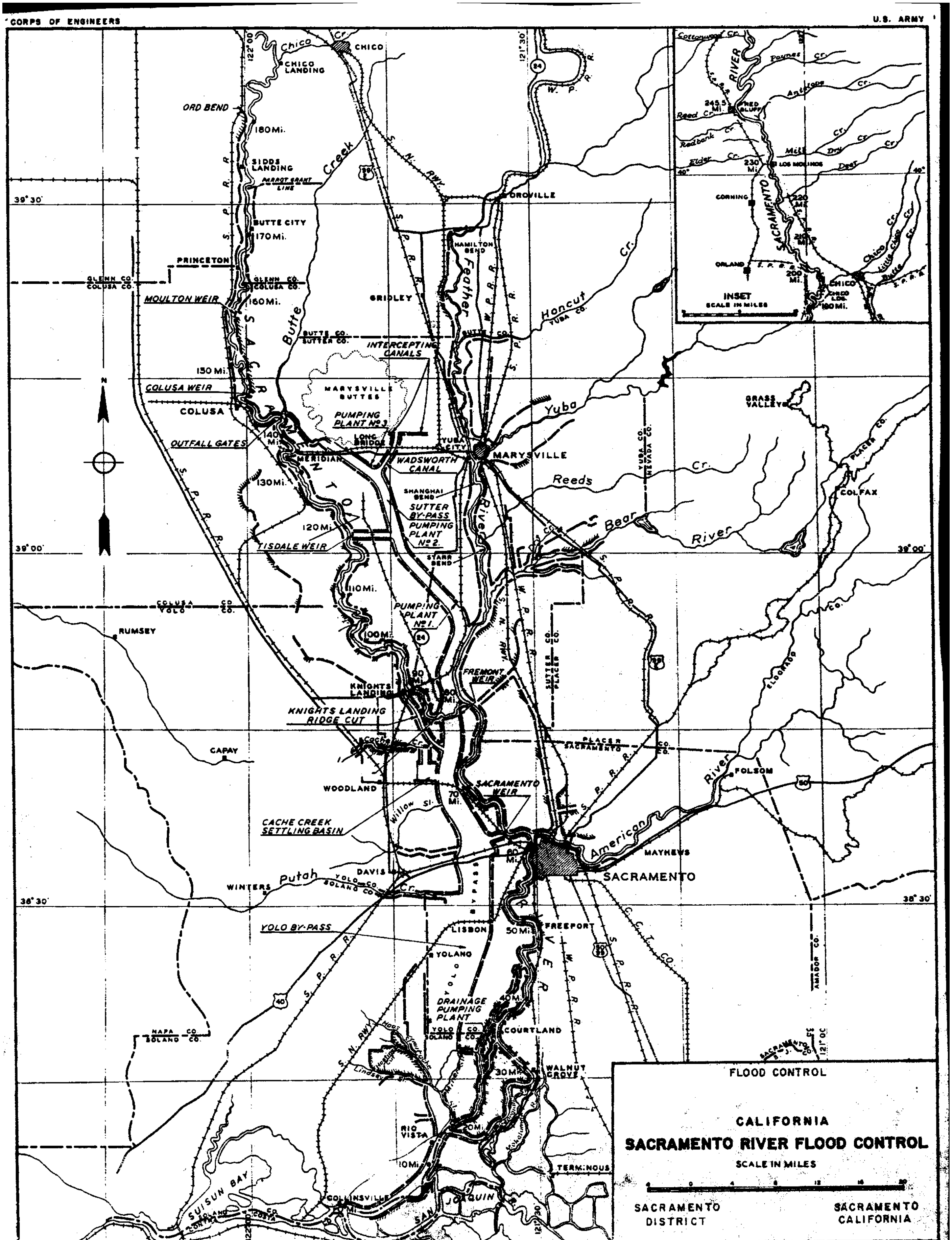
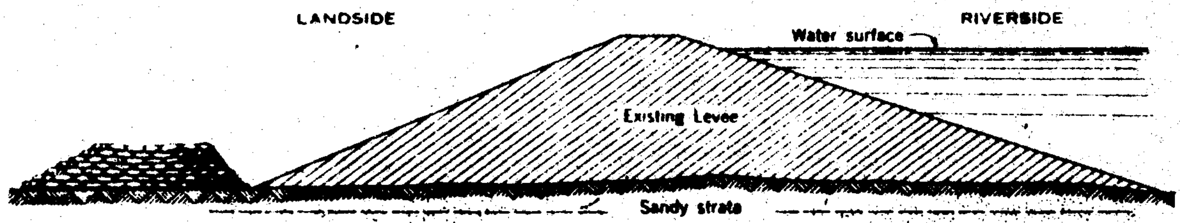

CORPS OF ENGINEERS
U.S. ARMY
FLOOD CONTROL
CALIFORNIA
SACRAMENTO RIVER FLOOD CONTROL
SCALE IN MILES
SACRAMENTO DISTRICT
SACRAMENTO CALIFORNIA
INSET
SCALE IN MILES
CHICO
CHICO LANDING
ORD BEND
180 Mi.
SIDDS LANDING
PARROT GRANT LINE
BUTTE CITY
170 Mi.
PRINCETON
GLENN CO.
COLUSA CO.
MOULTON WEIR
160 Mi.
150 Mi.
COLUSA WEIR
COLUSA
OUTFALL GATES
140 Mi.
MERIDIAN
130 Mi.
120 Mi.
TISDALE WEIR
110 Mi.
100 Mi.
90 Mi.
80 Mi.
70 Mi.
60 Mi.
50 Mi.
40 Mi.
30 Mi.
20 Mi.
10 Mi.
KNIGHTS LANDING
KNIGHTS LANDING RIDGE CUT
RUMSEY
CAPAY
WOODLAND
CACHE CREEK SETTLING BASIN
DAVIS
WINTERS
Putah Cr.
YOLO BY-PASS
LISBON
YOLANO
FREEPORT
DRAINAGE PUMPING PLANT
COURTLAND
WALNUT GROVE
RIO VISTA
COLLINSVILLE
SUISUN BAY
TERMINOUS
SAN JOAQUIN
OROVILLE
HAMILTON BEND
GRIDLEY
Butte Creek
Feather River
Honcut Cr.
INTERCEPTING CANALS
MARYSVILLE BUTTES
PUMPING PLANT No 3
LONG BRIDGE
YUBA CITY
MARYSVILLE
WADSWORTH CANAL
SHANGHAI BEND
SUTTER BY-PASS
PUMPING PLANT No 2
STARR BEND
PUMPING PLANT No 1
FREMONT WEIR
SACRAMENTO WEIR
Yuba
Reeds Cr.
Bear River
GRASS VALLEY
COLFAX
FOLSOM
American River
MAYHEWS
SACRAMENTO
SACRAMENTO RIVER
39° 30'
39° 00'
38° 30'
122° 00'
121° 30'
121° 00'
RED BLUFF
CORNING
ORLAND
LOS MOLINOS
Cottonwood Cr.
Paynes Cr.
Antelope Cr.
Reed Cr.
Redbank Cr.
Elder Cr.
Mill Cr.
Deer Cr.
Chico Cr.
Butte Cr.

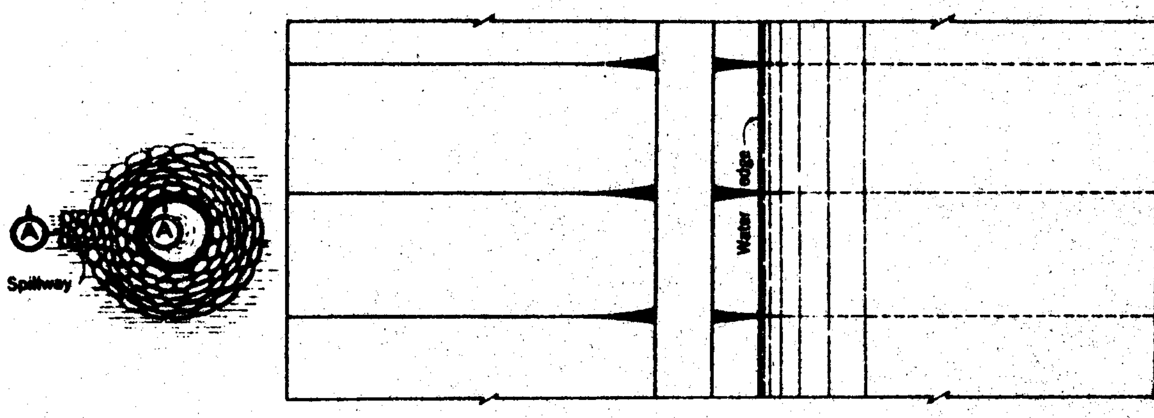
EXHIBIT C
PLATES OF SUGGESTED FIGHTING METHODS



Note:
Bottom width to be no less than 1½ times height.
Be sure to clear sand discharge.
Tie into levee if boil is near toe.

ELEVATION

SECTION A-A

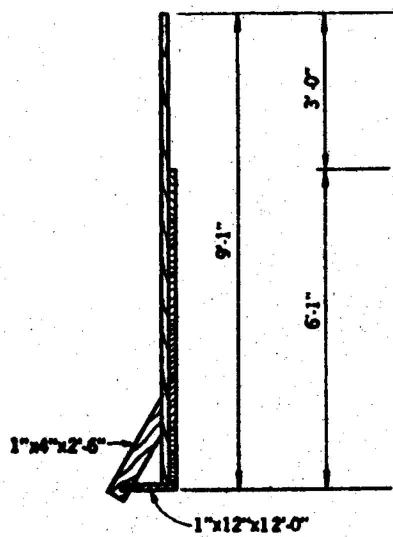


PLAN

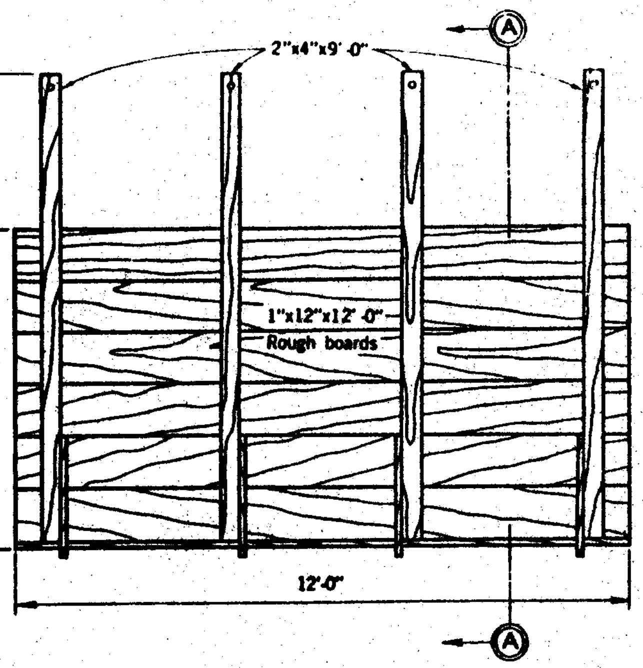
Note:
Do not sack boil which does not put out material.
Height of sack loop or ring should be only sufficient to create enough head to slow down flow through boil so that no more material is displaced and boil runs clear.
Never attempt to completely stop flow through boil.

CONTROL OF SAND BOILS

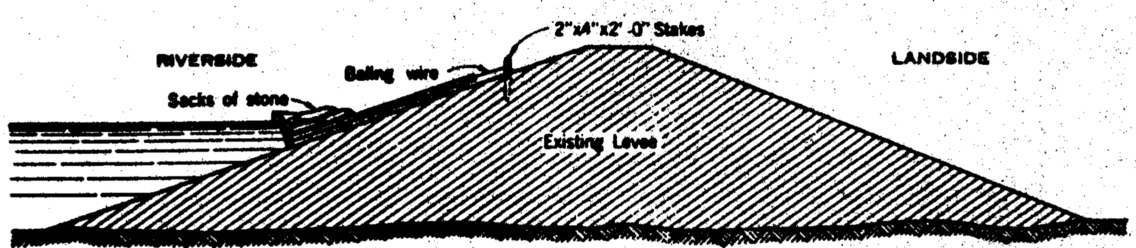
U.S. ENGINEER OFFICE, SACRAMENTO, CALIF.



SECTION A-A



PLAN

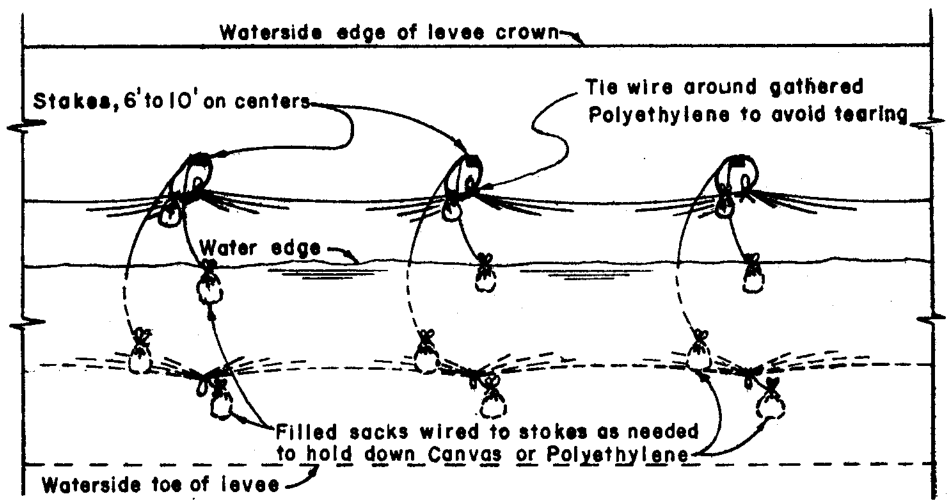


SECTION

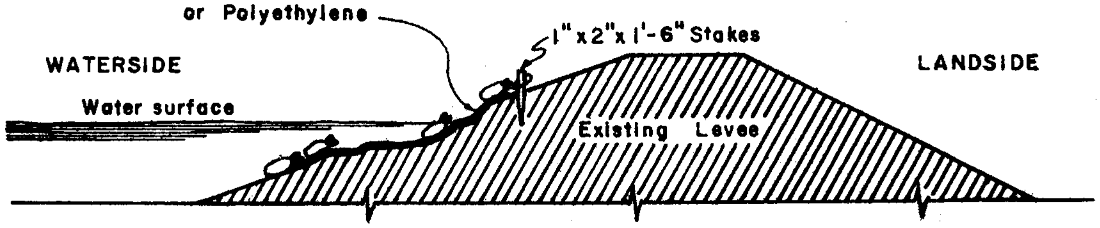
BILL OF MATERIAL FOR 100 FEET
LUMBER
56 pieces 1"x12"x12'-0" 32 pieces 1"x4"x2'-6" 32 pieces 2"x4"x9'-0" • 32 pieces 2"x4"x2'-0" • (Sharpened)
WIRE
200' baling wire
NAILS
4½ lbs.-8d nails

MOVABLE WAVE WASH PROTECTION

U. S. ENGINEER OFFICE, SACRAMENTO, CALIF.



PLAN



SECTION

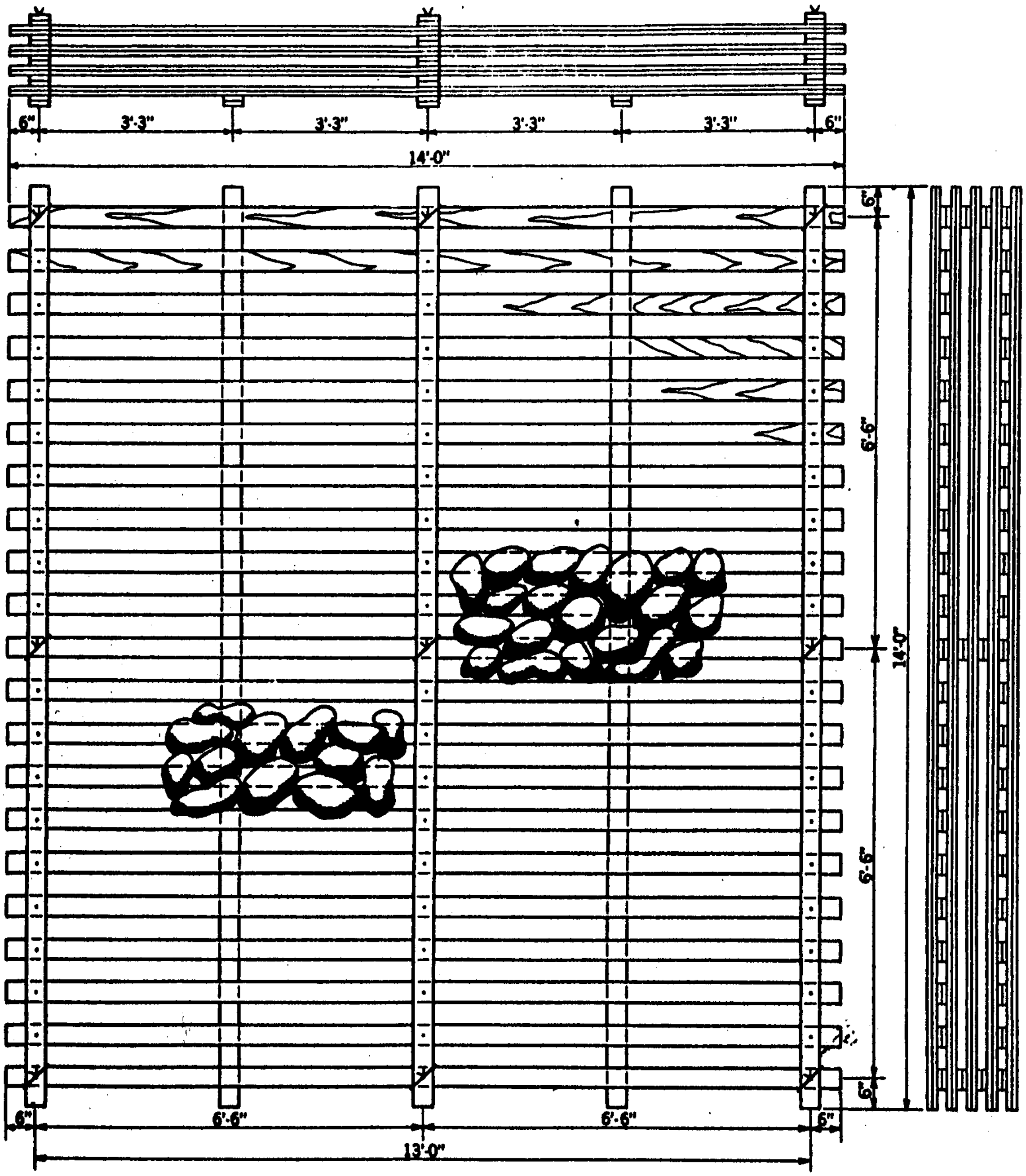
NOTE:

Use Polyethylene sheets, preferably 16' to 20' wide available in std. 100' long rolls, approx. 6 mil thickness, or canvas as available. Lay chosen length of Polyethylene sheeting or canvas parallel with levee slope, tie upper edge to stakes, tie sacks to bottom edge. Crew will then toss all bottom sacks over damaged slope at the same time to avoid tearing. Intermediate filled sacks will be immediately placed to hold down canvas or plastic. HAVE ALL ITEMS PREPARED BEFOREHAND.

MATERIAL REQUIRED FOR 100 LINEAR FEET OF LEVEE
LUMBER
* 30 Stakes 1"x2"x1'-6" * (Sharpened)
SANDBAGS
120 sandbags Canvas or Polyethylene sheeting as required

WAVE WASH PROTECTION

US Army Engineer District
Sacramento, California



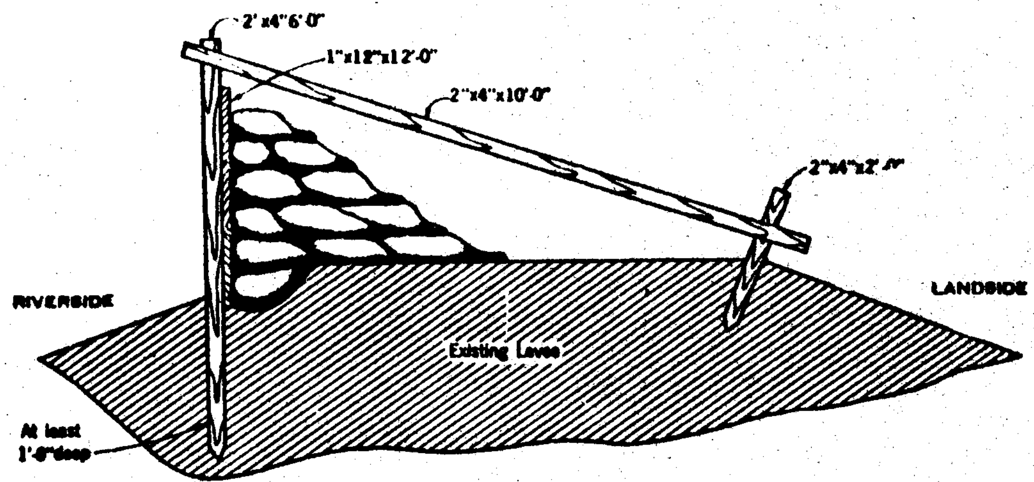
Note:

Cribs constructed of double thickness of 1"x4"x14'-0" lumber. Nail all intersections with 1-20d nail. Each intersection of walls securely fastened by a loop of No. 9 wire, tightly twisted.

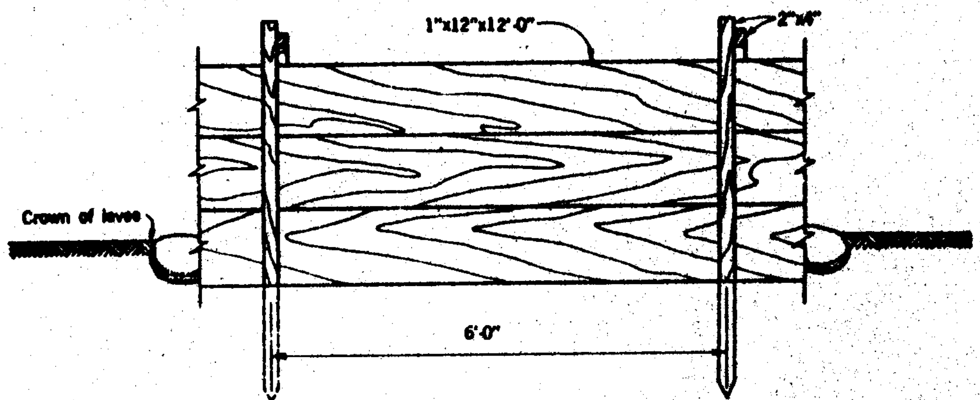
BILL OF MATERIAL FOR ONE CRIB 13'-0"
LUMBER
130 pieces 1"x4"x14'-0"
WIRE
30' No. 9 wire
NAILS
12½ lbs.-20d nails

CAVING BANK PROTECTION

U.S. ENGINEER OFFICE, SACRAMENTO, CALIF.



SECTION



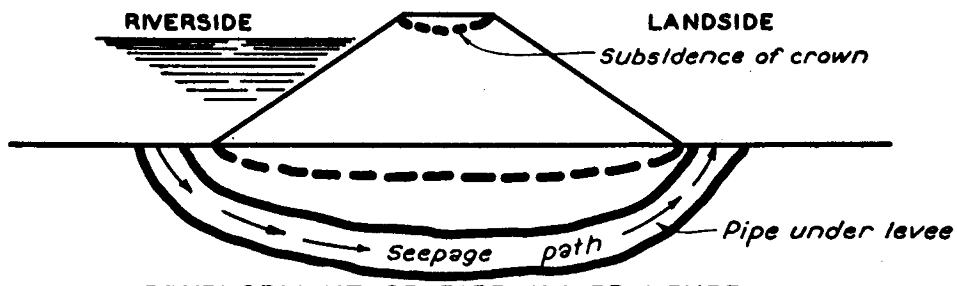
FRONT ELEVATION

BILL OF MATERIAL FOR 100 LINEAR FEET OF LEVEE
LUMBER
26 pieces 1"x12"x12'-0" 17 pieces 2"x4"x10'-0" • 17 pieces 2"x4"x6'-0" • 17 pieces 2"x4"x2'-0" • (Sharpened)
NAILS
1 lb. 8d nails 2 lbs. 16d nails
SANDBAGS
1100 bags

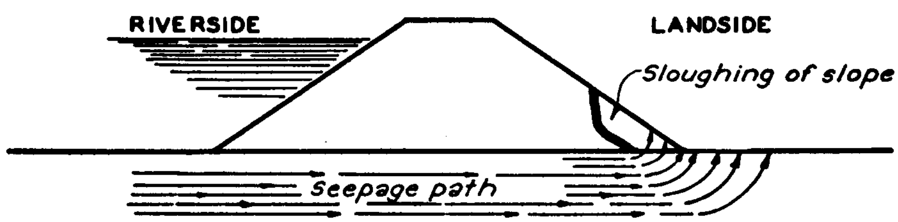
FLOOD CONTROL PROJECT

LUMBER AND SACK TOPPING

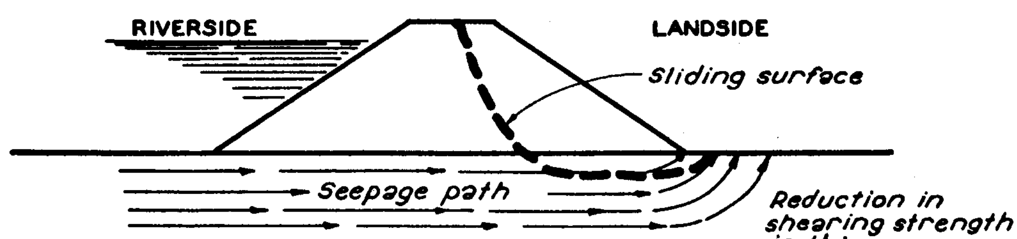
U.S. ENGINEER OFFICE, SACRAMENTO, CALIF.



DEVELOPMENT OF PIPE UNDER LEVEE
FIG. 1



SLOUGHING OF LANDSLIDE SLOPE DUE TO RAVELLING AND UNDERCUTTING OF TOE
FIG. 2

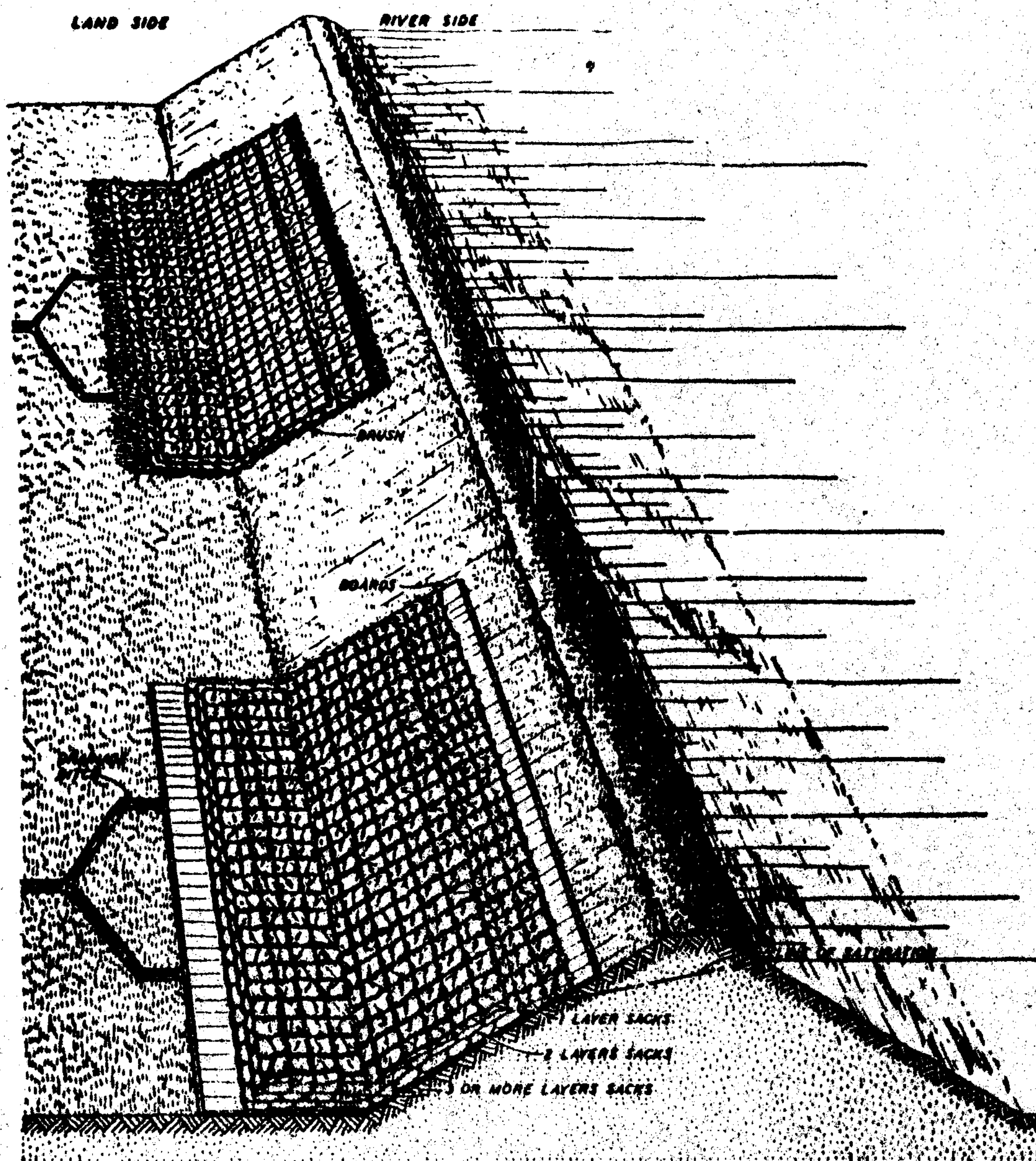


DEVELOPMENT OF SHEAR SLIDE
FIG. 3

SACRAMENTO RIVER, CALIFORNIA
FLOOD CONTROL PROJECT

EFFECTS OF SAND BOILS ON LEVEE

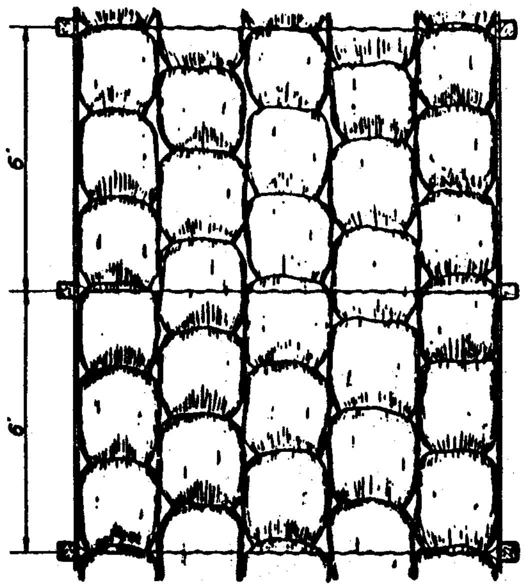
U.S. CORPS OF ENGINEERS, SACRAMENTO, CALIF.



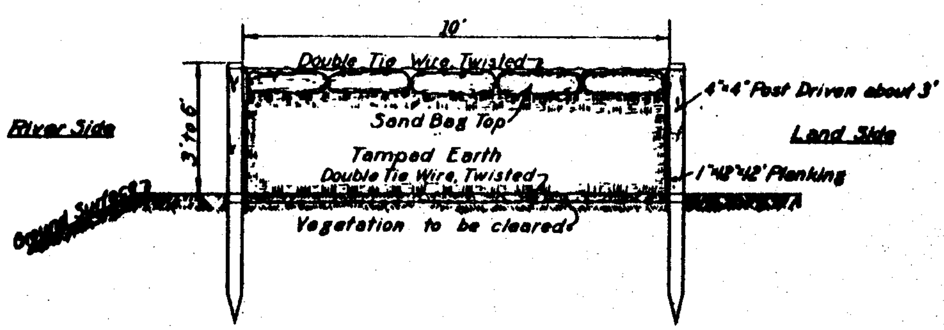
FLOOD CONTROL PROJECT

BRUSHING AND SACKING THE LANDSIDE SLOPE

U.S. CORPS OF ENGINEERS, SACRAMENTO, CALIF.



PLAN



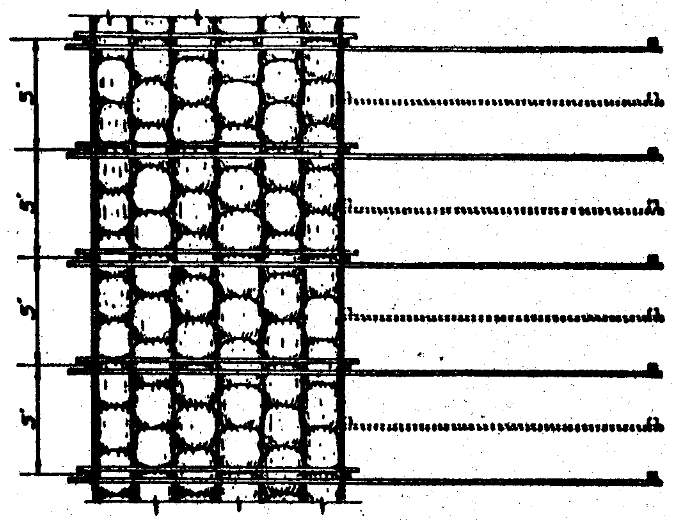
END ELEVATION

MATERIAL REQUIRED FOR 100 LINEAR FEET OF LEVEE		
4FT HIGH	5FT HIGH	6FT HIGH
34 pieces 4"x4"x7' (sharpened) 67 pieces 1"x12"x12' 1122 board feet 25 lbs. wire #12 gage 13 lbs. 10d nails 600 sand bags 148 cu. yds. earth	34 pieces 4"x4"x8' (sharpened) 84 pieces 1"x12"x12' 1371 board feet 25 lbs. wire #12 gage 15 lbs. 10d nails 600 sand bags 185 cu. yds. earth	34 pieces 4"x4"x9' (sharpened) 100 pieces 1"x12"x12' 1608 board feet 25 lbs. wire #12 gage 17 lbs. 10d nails 600 sand bags 222 cu. yds. earth

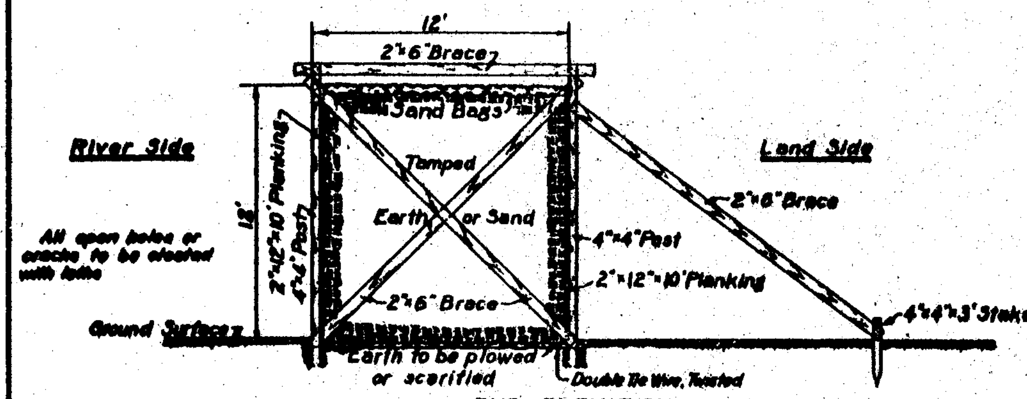
FLOOD CONTROL PROJECT

3–6FT. MUD BOX LEVEE CONSTRUCTION DETAILS

U.S. CORPS OF ENGINEERS, SACRAMENTO, CALIF.



PLAN



END ELEVATION

MATERIAL REQUIRED FOR 100 LINEAR FEET OF LEVEE			
LUMBER	SAND BAGS	NAILS	EARTH or SAND
40 Posts 4"x4"x14' 240 Planks 2"x12"x10' 20 Braces 2"x6"x14' 60 Braces 2"x6"x10' # 20 Stakes 4"x4"x3' 5 bundles laths	700	120 lbs.-20d 4 lbs.-3d fine WIRE 20 lbs #12 gage	534 cu. yds.

Total Lumber 6587 board feet

ADDITIONAL MATERIAL FOR BRACING BACK SIDE IN BETWEEN BENTS			
LUMBER	SAND BAGS	NAILS	EARTH or SAND
20 Posts 4"x4"x14' 20 Braces 2"x6"x10' # 20 Stakes 4"x4"x3'		6 lbs.-20d	

Total Lumber 813 board feet

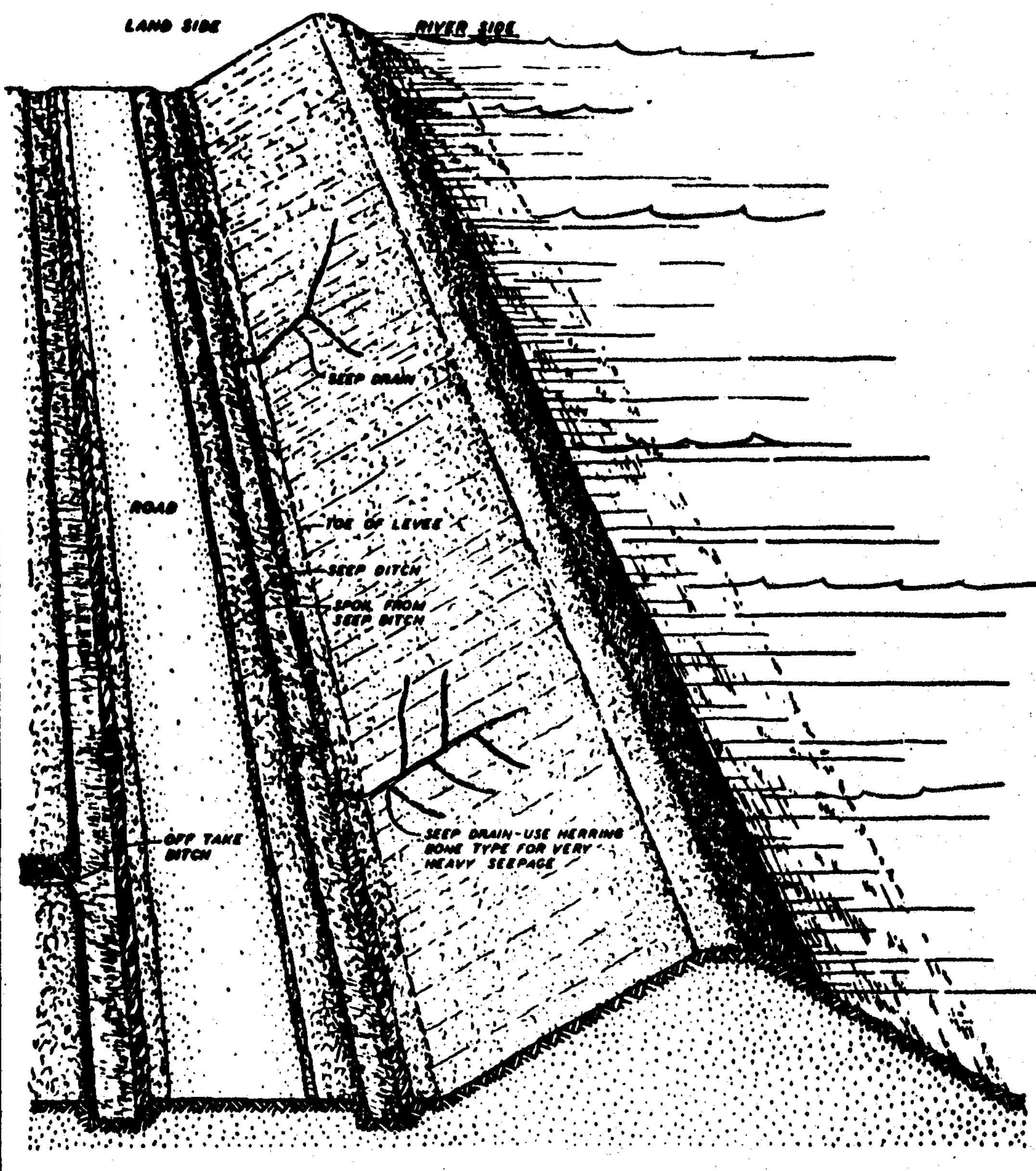
Sharpened

SACRAMENTO RIVER AND MAJOR AND MINOR TRIBUTARIES

FLOOD CONTROL PROJECT

MUD BOX BULKHEAD LEVEE CONSTRUCTION DETAILS

U.S. CORPS OF ENGINEERS, SACRAMENTO, CALIF.



FLOOD CONTROL PROJECT

METHOD OF DRAINING LEVEE SLOPE

U.S. CORPS OF ENGINEERS, SACRAMENTO, CALIF.

CHECK LIST NO. 1

LEVEE INSPECTION REPORT

Date__________________________________

Inspected by__________________________________

Report number of places requiring maintenance work opposite each item listed below. A separate report should be submitted descrlbing the necessary maintenance work for each location.

Reference Manual No._____________________

Item No.	Description	Number of Places
1.	**Settlement, sloughing, or loss of grade……………………………………………**	____________
2.	**Caving, (either side of levee)……………………………………………………..**	____________
3.	**Seepage, saturation…………………………………………………………………**	____________
4.	**Rip-rap ………………………………………………………………………………**	____________
5.	**Sod ……………………………………………………………………………………**	____________
6.	**Access roads and road ramps ………………………………………………………**	____________
7.	**Cattle guards and gates ……………………………………………………………..**	____________
8.	**Crown of Levee ……………………………………………………………………...**	____________
9.	**Unauthorized grazing or traffic ……………………………………………………**	____________
10.	**Unauthorized encroachment on rights-of-way ……………………………………**	____________
11.	**Unauthorized excavation and loose backfill ………………………………………**	____________
12.	**Accumilations of drift, trash or debris ……………………………………………**	____________
13.	**Weed or undesirable vegetation ……………………………………………………**	____________
14.	**Miscellaneous pipe crossings ………………………………………………………**	____________
15.	**Inappropriate burning of grass ……………………………………………………**	____________
16.	**Other items not included above ……………………………………………………**	____________

Inspected by ______________________________________

Exhibit D

EXHIBIT E

CHANNEL AND STUCTURES

(See Supplement Manuals)

EXHIBIT F

LETTER OF ACCEPTANCE

BY STATE RECLAMATION BOARD

(See Supplement Manuals)

EXHIBIT G

SUGGESTED SEMI - ANNUAL REPORT FORM
(See Supplement Manuals)

Operations and Maintenance Manual Template

SACRAMENTO RIVER BANK PROTECTION PROJECT
PHASE II, 80,000 LINEAR FEET

Prepared for:
U.S. Army Corps of Engineers
Sacramento District

January 25, 2012

Prepared by:
HDR Engineering, Inc.

2365 Iron Point Road, Suite 300
Folsom, CA 95630

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Contents

Figures

Tables

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1.0 Introduction

1.1 Purpose

This information report and template is an appendix to the Engineering Document Report, Sacramento River Bank Protection Project (SRBPP) (currently in preparation). This template provides information on revising and adding new material to the existing operations and maintenance (O&M) manuals to take into account new bank protection along the Sacramento River Flood Control Project (SRFCP) that is constructed under the SRBPP authority.

1.2 Use of Operations and Maintenance Manual Template

This template has been developed to be used as guidance for future SRBPP O&M manual preparers and provides general information to Corps of Engineers (Corps) personnel and local interests. This manual template is meant to be used as a general guide; it may be considered a template that can facilitate O&M manual preparation. The use of this as a template will encourage preserving consistency among the O&M manuals as they are individually revised. Future O&M manual revisions and additions will occur as bank protection becomes known and is constructed.

1.3 Background

Operation and maintenance manuals are often prepared to inform local interests in the O&M of levees and other flood risk management facilities. Engineering Regulation ER 1150-2-301 Local Cooperation Policies and Procedures provides for the preparation of O&M manuals. Manuals are described as follows in the regulation:

- The purpose of the O&M manual is to assist the responsible authorities in carrying out their obligations through provision of information and advice with respect to the operation and maintenance requirements of the project.
- Manuals will be prepared sufficiently in advance of completion of the project to ensure their readiness for transmission to local interest at the time of formal transfer of the project from the Corps to the non-Federal sponsor.

Since bank protection constitutes modifications to the SRFCP, it has been the practice to modify and amend the SRFCP O&M manuals. This practice avoids redundancy and confusion, and is expected to continue with the SRBPP Phase II 80,000 LF as well.

2.0 Sacramento River Flood Control Project Manuals

2.1 SRFCP O&M Manual organization

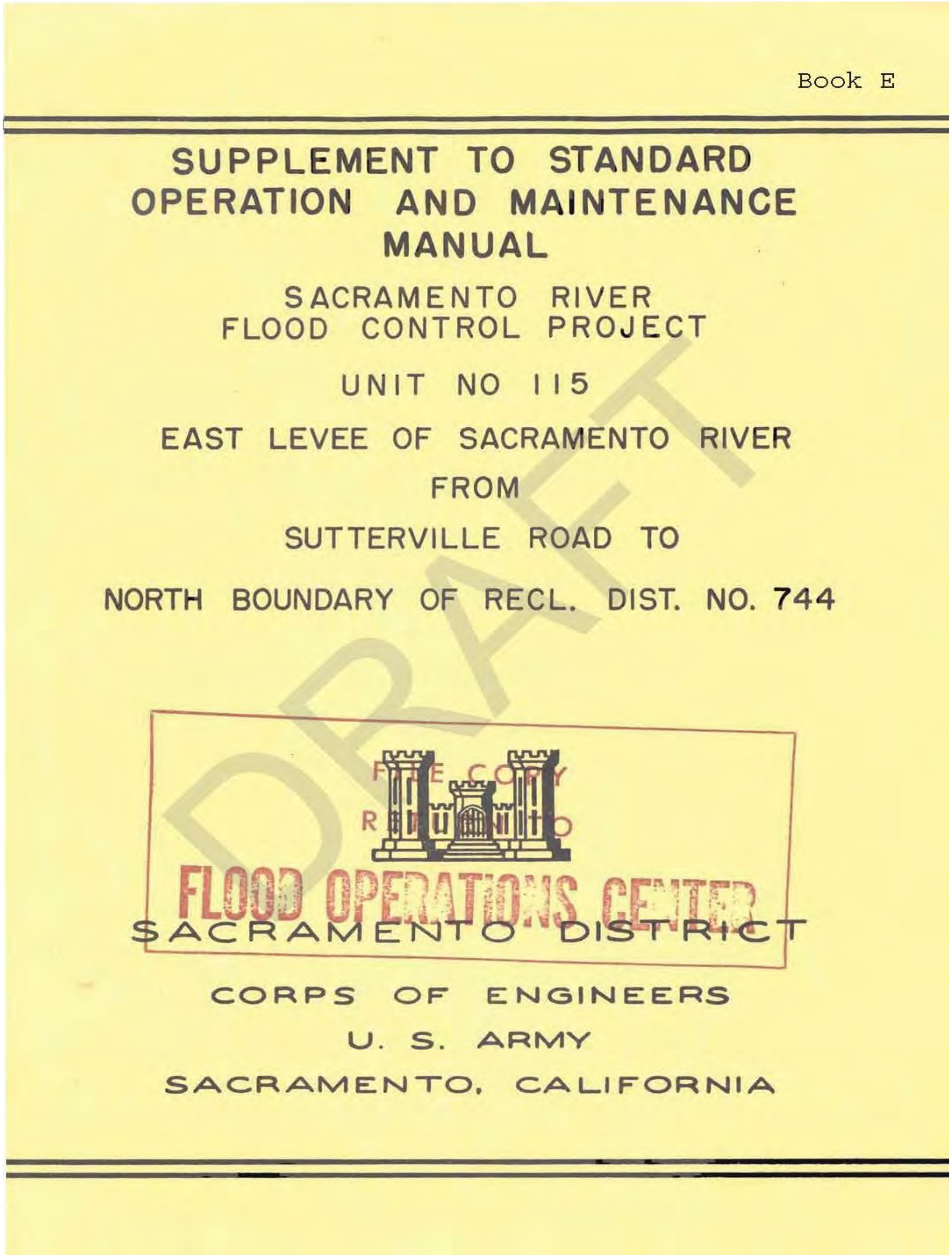
There is one overarching manual for the SRFCP, and a series of manuals covering specific levee units in more detail. The overarching manual is the Standard Operations and Maintenance Manual, referred to as the "Standard Manual." The Standard Manual is dated

May 1955. It has an addendum dated April 1995 and a supplement to the addendum dated March 1996.

For each levee unit (defined below) a Supplemental Operations and Maintenance Manual (referred to herein as "Supplemental Manual") is prepared. **Figure 1** shows an example cover page of a Supplemental Manual. When the Sacramento Bank Protection Project constructs bank protection, amendments and revisions are made to the Supplemental Manual that covers the unit in which the construction is located. No amendment is made to the Standard Manual.

The SRFCP is subdivided into maintenance units generally corresponding to levees associated with a protected floodplain or reclaimed land. The units are numbered starting from Unit 101, Sherman Island levees, near the mouth of the Sacramento River. The units are numbered sequentially, generally south to north, up to Unit 165. The units cover both the Sacramento River and its tributaries and distributaries. **Figure 2** is a map showing the levee maintenance units locations along the SRFCP.

Figure 1 – Cover to Sample Supplemental Manual



Book E

SUPPLEMENT TO STANDARD OPERATION AND MAINTENANCE MANUAL

SACRAMENTO RIVER
FLOOD CONTROL PROJECT

UNIT NO 115

EAST LEVEE OF SACRAMENTO RIVER

FROM

SUTTERVILLE ROAD TO

NORTH BOUNDARY OF RECL. DIST. NO. 744

SACRAMENTO DISTRICT

CORPS OF ENGINEERS

U. S. ARMY

SACRAMENTO, CALIFORNIA

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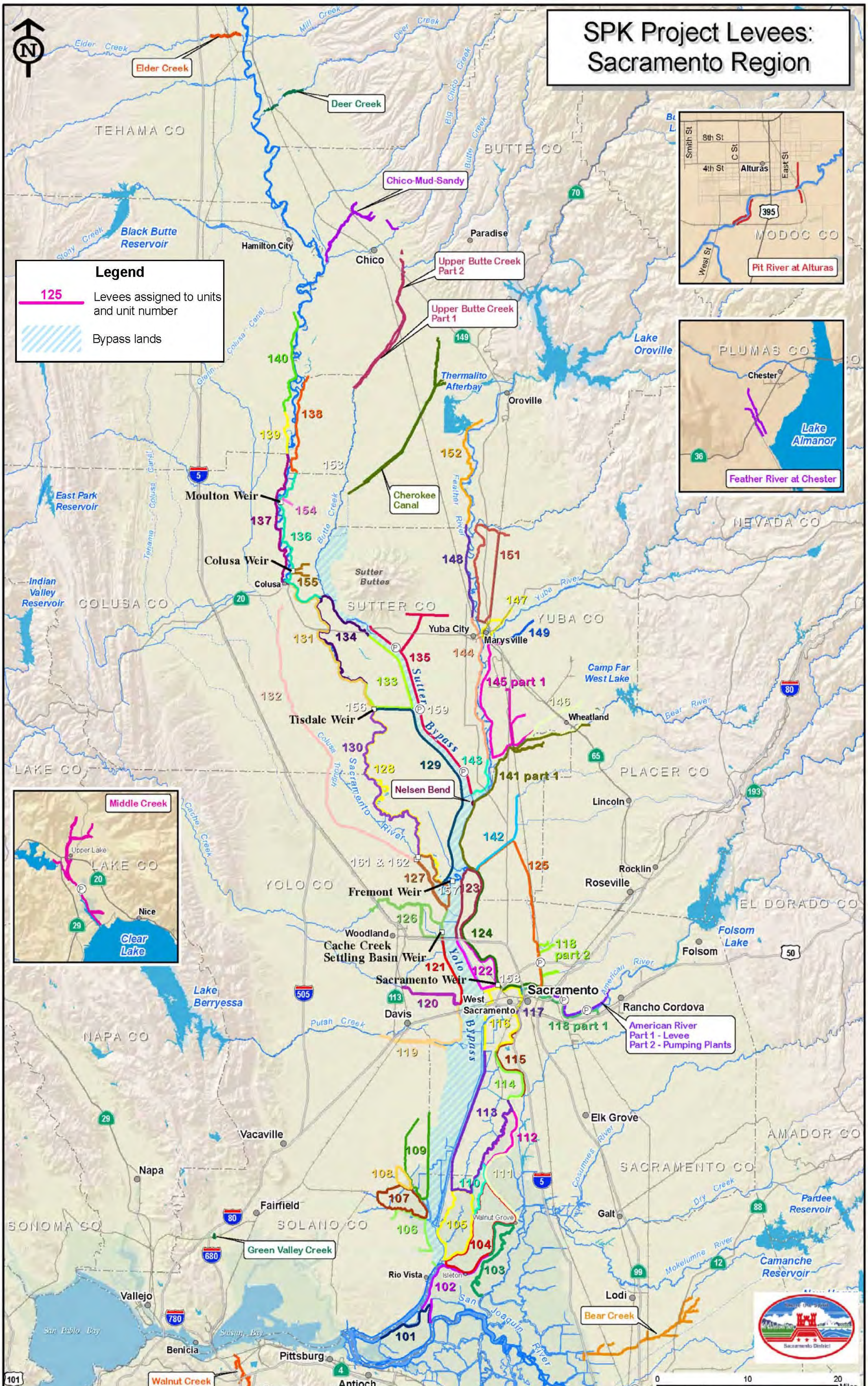
Figure 2 – SRFP Maintenance Unit Map



Prepared by J.S.M

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3.0 Amendments and Revisions

3.1 Typical Amendments and Revisions

Changes to the Supplemental Manuals are completed to document and identify new bank protection features, including engineered structures and vegetation plantings. In most cases O&M practices will remain the same as before bank protection. Addition of special advice or instructions due to the new construction may be appropriate if it differs from the O&M practice already in place.

The following is a list of new information that is typically added to Supplemental Manuals when bank protection is constructed:

- Location and extent of construction, including left or right bank, river miles, and latitude and longitude coordinates (optionally may also provide northing and easting coordinates)
- References to "as constructed" or "as-built" drawings, including drawing file numbers
- Construction contract information, including contractor and contract number
- Pertinent correspondence, including formal project transfer and project acceptance
- Identification and location of construction drawings
- Environmental mitigation description and location
- Citation of source of mitigation requirements (e.g. Environmental Impact Statement, or Biological Opinion)
- Reference to cultural resources recovery information and identification of cultural resource sites (if it is determined, on a case-by-case basis, that there is need for O&M personnel to be aware of cultural resource sites)
- Care and management of mitigation vegetation and in-stream woody material (IWM) that differs from established instructions
- Amendments to Project Partnership Agreement
- Revised map of levee if there is a change to levee alignment
- Changes to non-project features in connection with bank protection (e.g. utility relocations, recreation facilities)

3.2 Real Estate Acquisitions and Permits

Often additional rights of way and easements are acquired for construction of bank protection and for mitigation. Existing easements may be modified and/or new easements/property rights may be acquired to accommodate the new bank protection requirements. For instance, flood control easements may be revised to include management and preservation of riparian vegetation. Supplemental manuals are a good venue to inform O&M managers of these changes. Temporary construction easements (TCE) should not be reported, as these are terminated after a period of time; however, if said TCEs are required for an extended period of time due to mitigation establishment requirements, the TCE termination date and requirements should be noted. Lands and easements are the purview of the State of California. Permits are managed by the non-Federal sponsor, the Central Valley Flood Protection Board. Contact information should be referenced in case there is a need for further information on real estate acquisitions and permits.

Negotiated settlements with adjoining property owners and/or utility companies may involve new encroachment permits, joint use agreements, etc., therefore, reference to these new requirements and property rights can be included in the supplemental manual.

Environmental mitigation banks are often used as off-site mitigation. It is generally not the duty of O&M managers to inspect or otherwise contact mitigation banks; therefore, there generally is no practical need to provide information on off-site mitigation banks.

4.0 Preparation, Review and Approval

Authority for approval of O&M manuals is delegated from the South Pacific Division Engineer to the Sacramento District. Delegation of this authority is covered in a memorandum dated June 18, 2010, subject: Delegation of Approval Authority for Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) Manuals.

The maintenance of O&M manuals is the responsibility of Operations Division, Sacramento District. Revisions are typically assigned to Civil Engineering Branch, Engineering Division, in the Sacramento District.

5.0 Supplemental Manual Template

The SRFCP Supplemental Manuals are organized in a standard fashion. When bank protection projects are added to a levee in a maintenance unit, changes to sections of manuals should be done with care to preserve organization, consistency, and readability. Changes should be noted on a schedule at the beginning of the manual.

The following table is a template for revisions to Supplemental Manuals in response to new bank protection. This template is meant as a guide for where additions and revisions are to be placed. The table follows the organization of a typical Supplemental Manual. Annotations are highlighted in *grey italics* that show where information regarding bank protection should (or could) be added. If there is no highlighted annotation, this template does not anticipate a need for additions or revisions due to SRBPP construction. This does not preclude changes and additions to these sections if later found to be useful and appropriate.

The template table used as a sample the Supplemental Manual to unit number 115, East Levee of Sacramento River from Sutterville Road to North Boundary of Reclamation District Number 744. However, a Section 2-06, Real Estate, was added to accommodate changes to rights of way, etc.

Table 1 - Supplemental Manual Template

LISTING	ITEM	NOTES, Bank Protection Revisions-Addendums
	Cover	
	Additions / Revisions Log	• Table noting revisions to the Supplemental Manual. • *Revisions & additions due to bank protection are included.*
	Table of Contents	
	Section I - Introduction	
1-01	Location	
1-02	Project Works	• Extent of levee, identification of other major SRFCP features. • *Bank Protection authority, bank protection works are listed.*
1-03	Protection Provided	• Brief description of flood plain behind levee, design flow
1-04	Construction Data and Contractor	• Listing of history of levee work, including description, location, contract number, reference to contract drawings. • *Bank protection construction should be added here.*
1-05	Flood Flows	• Definition of floodflows, for the purposes of the manual. Example is high water at a specified elevation and location.
1-06	Assurances Provided by Local Interests	• May be state legislation citation or other source of assurance.
1-07	Acceptance by Central Valley Flood Protection Board	• Correspondence that formally accepts the project is cited. • *Acceptance of a bank protection project is noted here. Copies of correspondence are included in Exhibit F,* Letter of Acceptance by Central Valley Flood Protection Board
1-08	Superintendent	• Name and address of local levee superintendent that the Corps may contact.
	Section II – Features of the Project Subject to Flood Control Regulations	
2-01	Levees	• Brief description, reference to O&M requirements and special instructions in the Standard Manual, reference to check list in the Supplemental Manual. • *If bank protection results in a major modification such as a setback levee or adjacent levee, the levee description should be edited as appropriate.*
2-02	Drainage and Irrigation Structures	• List of pipes and other structures that extend through the levee, and references to drawings. • *Revise if pipes or structures are relocated due to construction.*
2-03	Channel	• Description of the channel (e.g. Sacramento River) • References to O&M requirements check lists in the Standard and Supplemental Manuals. • Patrolling and other operational requirements during times of flood flow.
2-04	Miscellaneous Facilities	• Detailed instructions for inspections, O&M of levee cutoff walls, observation wells. • References to O&M requirements in the Standard Manual. • List of bridges, utilities, local drainage, and recreation facilities owned & operated by other entities. • *This section would need to be revised if the bank protection results in changes to facilities.*

Table 1 - Supplemental Manual Template (continued)

LISTING	ITEM	NOTES, Bank Protection Revisions-Addendums
2-05	Environmental Protection	• Preservation/removal/replacement of live or fallen trees & vegetation. • Disposition of in-stream woody material. • Identification of mitigation areas. • Citation of sources of mitigation requirements (e.g. Biological Opinion, Environmental Impact Statement). • *On-site or near-site bank protection mitigation should be identified and special O&M requirements, if any, described. Mitigation banks need not be included.*
2-06	*Real Estate*	• *Lands acquisitions, changes to rights of way, modified and/or new easements that are connected with the bank protection* • *Changes to encroachment permits connected with bank protection* • *Temporary construction easements with extended termination dates that are required for bank protection*
	Section III – Repair of Damage to Project Works and Suggested Methods of Combating Flood Conditions	
3-01	Repair of Damage	• First responder procedure In the event of serious damage to public works.
3-02	Applicable Methods of Combating Floods	• Reference to the Standard Manual.
Exhibit A – Flood Control Regulations		• Reference to the Standard Manual.
Exhibit A1 – Location Drawing		• Map of the alignment and extend of the levee that is in the O&M unit. Reclamation District boundaries, towns, bridges, and major roads are shown. • *In the case of a setback or adjacent levee, the map is revised.* • *For fix in place bank protection the map need not be revised, but possibly the location of new bank protection could be noted.*
Exhibit B – "As Constructed" Drawings		• Drawings are listed by file number and title. • *Add bank protection drawings including file number, to this list.*
Exhibit C – Plates of Suggested Flood Fighting Methods		• Reference to the Standard Manual.
Exhibit D – Check List No. 1 – Levee Inspection Report		• Reference to the Standard Manual.
Exhibit E – Check Lists, Channels and Structures		• Check list forms for inspections of facilities, with instructions.
Exhibit F – Letter of Acceptance by Central Valley Flood Protection Board		• Correspondence on notification of project completions, emergency repairs, acceptance by sponsor, sponsor requests. • *Correspondence on formal notice of bank protection project completion by the Corps and acceptance by the sponsor are to be included here.*
Exhibit G – Semi Annual Report Form		• Sample Semi Annual Report Form.
Exhibit H – Local Cooperation Agreement		• Local cooperation agreements, declarations of financial capability. • *For bank protection construction, add local cooperation agreements, project partnership agreements, declarations of financial capability, and associated pertinent correspondence.*

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Subappendix 8. Safety Assurance Plan Outline

SAFETY ASSURANCE PLAN OUTLINE
SACRAMENTO RIVER BANK PROTECTION PROJECT

1) **Preface**
   a) Public safety is a primary Corps of Engineers (USACE) concern.
      i) The term "public safety" includes public health and welfare
      ii) Public safety is a primary consideration for every flood risk management (FRM) project
   b) Independent External Peer Review , Safety Assurance Review
      i) Sacramento River Bank Protection Project (SRBPP) may be subject to an Independent External Peer Review (IEPR) Type II, also referred to as a Safety Assurance Review (SAR).
      ii) The purpose of the SAR is to ensure that good science, sound engineering, and public health, safety and welfare are the most important factors that determine a project's fate.
      iii) The intent of the SAR is to establish the procedures for ensuring the quality and credibility of USACE decision documents through independent review.
      iv) SAR Description
         (1) An SAR will be conducted on design and construction activities for Flood Risk Management projects.
         (2) A review will be conducted prior to initiating construction & periodically thereafter until construction activities are completed (WRDA 2007).
         (3) The review is accomplished by an independent panel of experts that are shown to have no conflicts of interest.
      v) Basis for SAR – Authority and Guidance
         (1) The review plan was established by Section 2035 of the Water Resource Development Act (WRDA) of 2007.
         (2) Current USACE guidance on conduct of SARs (guidance at the time of this outline) is Engineering Circular (EC) 1165-2-209, Civil Works Review Policy.
            (a)
   c) Program Background, Description of SRBPP

2) **Purpose of this Safety Assurance Plan**
   a) Provides a strategy of review of public safety factors associated with the SRBPP in a comprehensive fashion (not site-by-site).
   b) Serves as a guide or checklist to assure that bank protection design and construction reduce as much as practicable risk to public health and safety, and thus facilitate Type II IEPR SAR (if a SRBPP SAR is conducted) .
   c) This plan might be provided to the Type II IEPR independent panel of experts as introductory material to demonstrate how public safety was considered in design and construction.
   d) Discuss SRBPP public safety effects in context with the Sacramento River Flood Control Project (SRFCP), and the overall Sacramento River flood control system.

3) **Public Safety Factors**
   a) WRDA 2007 lists the following public safety factors, used to determine if a project should undergo a SAR.
      i) The failure of the project would pose a significant threat to human life;

ii) The project involves the use of innovative materials or techniques;
iii) The project design lacks redundancy;
iv) The project has a unique construction sequencing or a reduced or overlapping design construction schedule.

b) Other Public Safety Factors That Apply to SRBPP
   i) Resiliency of the project to a range of flooding patterns and magnitudes.
   ii) Other public safety threats in the event of project failure, besides threat to human life, such as threats to public health and welfare
   iii) Potential public safety threats due to construction
   iv) Local public safety threats caused by project facilities and their operation.

4) Sacramento River Flood Control Project Safety Assurance

a) The SRBPP is constructed within the context of the SRFCP
b) Description of the SRFCP (or reference description)
   i) Large system of levees, weirs, bypasses
c) Public Safety Aspects of the SRFCP
   i) Hydrology depends on control of flows by dams
   ii) Risk and uncertainty connected with levees
   iii) Inherent resiliency and redundancy limitations of levees, of the levee and bypass system.
   iv) Areas of high population
   v) Public safety aspects of flooding of agricultural land
   vi) Public safety aspects of flooding of infrastructure protected by levees

5) Sacramento River Bank Protection Project Safety Assurance

a) Public safety aspects of the SRBPP
   i) Erosion leading to levee failure as a factor of public safety
   ii) Importance of banks as a line of defense against erosion of levees
   iii) Innovative, unique aspects of incorporation of vegetation in bank protection designs.
   iv) Assurances that state and Federal erosion monitoring is comprehensive, effective, and responds to public safety
   v) Assurances that site selection and prioritization process is responsive to public safety.
   vi) Assurances that the annual upward reporting process to justify funding is responsive to public safety.
   vii) Bank protection measures' effectiveness and resiliency
      (1) other measures, alternatives considered
b) SRBPPP Construction effects to public safety
   i) Risk of levee failure during construction
   ii) Other public safety aspects of construction
c) SRBPP facilities effects to public safety.
   i) Concerns about localized public access to bank protection facilities.
   ii) Operations and maintenance, including inspection, public safety aspects.
   iii) Flood fighting effect to public safety.

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Sacramento River Bank Protection Project

Site Selection and Implementation Procedure for Bank Repairs

1.0 Introduction and Purpose

This memorandum documents the proposed site implementation procedure for bank repair under the Sacramento River Bank Protection Project (SRBPP). Currently there are 206[1] erosion sites identified (accounting for over 200,000 linear feet) in the Sacramento River Flood Control System (SRFCS). A procedure is needed to prioritize site repairs since it is not possible to design and construct repairs for all the sites within the current authorizations. The proposed procedure builds upon the existing site implementation practice which needed to be updated to adapt to new guidance and changing work environment. This document provides a general outline of the procedure and may not contain all the details. Many of these details will be worked out during the implementation process by the site implementation working group, which includes representatives from all the USACE's disciplines relative to this project. California Department of Water Resources (DWR) Real Estate will be included at the inception of the site selection process as the real estate component is a significant element of the implementation schedule. The unresolved details will be addressed in the future, but the team recommends the general process outlined in this document be adopted for future bank repairs.

This document and the flow chart in **Attachment A** describe the proposed procedure. This procedure was developed by the site implementation working group.

2.0 Background

The levees and banks of the Sacramento River and Tributaries have been repaired under the authority of the Sacramento River Bank Protection Project since the original authorization in 1960. The original authorization (Phase I) was for the repair of 435,000 linear feet. Phase II was authorized for an additional 405,000 linear feet in 1974. At this time, fewer than 3,000 linear feet from the Phase II authorization remain. In 2007, Water Resources Development Act amended the 1974 Phase II authorization to add an additional 80,000 linear feet. The procedure described in this memorandum is proposed to select sites for repair for the additional linear footage.

It is not clear how sites were chosen for repair after the original 1960 authorization. Following the 1996-1997 large flood events, which resulted in a levee breach and many flood fighting efforts throughout the system, the US Army Corps of Engineers (USACE) decided it needed to inventory all the erosion within the system to direct repairs towards the sites most in need of repair.

In 1997, the first annual erosion reconnaissance occurred and a list of erosion sites was developed. Every year thereafter a reconnaissance trip was performed to inventory all the new erosion sites and update the existing erosion sites. The number of erosion sites continued to grow at a steady pace.

[1] The 206 sites are based on the 2011 Annual Erosion Inventory Draft Report.

However the number of sites repaired declined to only 5 sites between 1998 and 2005. Bank repairs were limited during this time due to many factors, including funding, real estate, and concerns over the environment and endangered species. With the limited construction, the banks of the system continued to erode and many of the previously identified erosion sites became critical, meaning there was concern that a breach might occur from the next large flood event.

On February 24, 2006, following sustained heavy rainfall and runoff, Governor Arnold Schwarzenegger declared a State of Emergency for California's levee system. Following this declaration the USACE and the DWR repaired the critical erosion sites. Repairs of non-critical erosion sites continue, but with the backlog and new sites identified each year, the number of erosion sites is still outpacing the repairs.

In 2004, a set of four ranking methodologies were developed as part of the annual erosion inventory to assist with prioritizing and selecting bank repair sites. These methodologies have served the intended purpose, but a better procedure incorporating new guidance and addressing all disciplines was needed. This document outlines a new procedure that incorporates new guidance and addresses all disciplines.

3.0 Site Implementation Procedure

Listed below is the step-by-step procedure that the SRBPP is proposing in order to select erosion sites for repair. A flow chart of the steps and a timeline are provided as attachments.

3.1 Step 1 –Annual Reconnaissance/Erosion Inventory

The site implementation procedure begins with the erosion inventory reconnaissance. The erosion inventory consists of a visual reconnaissance of the levees and banks of the SRFCS by the Engineering Division of the USACE. The primary inspection method is by boat to have the best view of the levees and banks. However the entire system is not navigable, so some portions are inspected by car.

There are two parts to the erosion inventory; these two parts are typically referred to as the "annual erosion inventory" and the "extended erosion inventory". The annual erosion inventory includes the portions of the system that are inspected every year. This includes the reaches that convey flow through the system on an annual basis. The extended inventory is only inspected after high flow events or every five years. The extended erosion inventory includes portions of the system that either convey seasonal flow or do not typically convey flow on an annual basis, such as the bypasses. Table 1 shows reaches of the system inspected annually and inspected under the extended inventory, as well as the method of inspection.

During the reconnaissance trip, the team reviews the existing erosion sites, identifies new sites, and checks the previously repaired sites. Existing sites are checked for changes from the previous year, and checked for additional erosion or slumping, exposed tree roots, increased site length, changes in vegetation, changes in bank width or slope, or if the site is starting to heal (i.e. new deposition, or erosion has shifted to the opposite bank).

For new sites, in addition to the erosion details, basic information is collected, such as: location, berm width, bank slope, site length, soil material, erosion mechanism, revetment details, visible encroachments, and general notes. The site length is calculated with GPS points, but the berm width and bank slope are visually estimated using engineering judgment. Photo documentation is taken at each of the erosion sites.

Repaired sites are checked to make sure the repairs are still in good condition, no new erosion has formed at the upstream or downstream transitions, and for anything else of concern or significance. Sites repaired within the previous year are removed from the erosion inventory and moved to a revetment database. Occasionally a site will be removed from the erosion inventory based on more detailed information, changing site conditions (e.g. a site has changed from erosional to depositional and no longer qualifies), or a repair under a different program.

Table 1. Inspected Reaches of the Sacramento River Flood Control System

SRFCS Reach	River Miles or Length	Inspection Frequency	Inspection Method
American River	RM 0 - 13	Annual	Boat
Arcade Creek	2 miles	Extended	Car
Bear River	RM 0 - 14	Annual	Car
Best Slough	2 miles	Extended	Car
Butte Creek	15 miles	Annual	Car
Butte Slough	7 miles	Extended	Car
Cache Creek and Cache Creek Settling Basin	11 miles	Annual	Car
Cache Slough	14 miles	Annual	Boat
Cherokee Canal	20 miles	Extended	Car
Chico/Sycamore Creek	2 miles	Extended	Car
Colusa Basin Drainage Canal and Sycamore Slough	35 miles	Extended	Car
Colusa Weir Bypass	1 mile	Extended	Car
Coon Creek Interceptor	5 miles	Extended	Car
Cottonwood Creek	1 mile	Extended	Car
Deer Creek	5 miles	Extended	Car
Dry Creek (North)	9 miles	Extended	Car
Dry Creek (South)	2 miles	Extended	Car
East Interceptor Canal	3 miles	Extended	Car
Elder Creek	4 miles	Extended	Car
Elk Slough	9 miles	Annual	Boat
Feather River	RM 0 - 34	Annual	Boat
Feather River	RM 34 - 60	Extended	Car

Table 1. cont. Inspected Reaches of the Sacramento River Flood Control System

SRFCS Reach	River Miles or Length	Inspection Frequency	Inspection Method
Georgiana Slough	12 miles	Annual	Boat
Hass Slough	8 miles	Extended	Car
Honcut Creek	4 miles	Extended	Car
Jack Slough	6 miles	Extended	Car
Knights Landing Ridge Cut	6 miles	Extended	Car
Lindsey Slough	7 miles	Extended	Car
Marysville Ring Levee	7 miles	Extended	Car
Miner Slough	7 miles	Annual	Boat
Moulton Weir Bypass	2 miles	Extended	Car
Mud Creek	7 miles	Extended	Car
Natomas Cross Canal	5 miles	Extended	Car
Natomas East Main Drainage Canal	4 miles	Extended	Car
Pleasant Grove Canal	4 miles	Extended	Car
Putah Creek	9 miles	Extended	Car
Sacramento Bypass	2 miles	Extended	Car
Sacramento River	RM 3 - 196	Annual	Boat
Steamboat Slough	11 miles	Annual	Boat
Sutter Bypass	34 miles	Extended	Car
Sutter Slough	6 miles	Annual	Boat
Three Mile Slough	3 miles	Annual	Boat
Tisdale Weir Bypass	4 miles	Extended	Car
Ulatis Creek	4 miles	Extended	Car
Wadsworth Canal	5 miles	Extended	Car
West Interceptor Canal	2 miles	Extended	Car
Western Pacific Interceptor Canal	6 miles	Extended	Car
Willow Slough Bypass	8 miles	Extended	Car
Yankee Slough	4 miles	Extended	Car
Yolo Bypass	37 miles	Extended	Car
Yuba River	RM 0 - 5	Extended	Car

3.2 Step 2 – Critical and Non-Critical Erosion Site Decision

Decision step 2 of the site implementation procedure will identify critical erosion sites (if any) throughout the system and allow for an expedited path for the critical sites and a non-expedited path for non-critical sites. Critical sites are identified through engineering judgment based on concern that a breach may occur from the next high flow event. The term “critical” refers only to the likelihood of a breach occurring and not the consequences of a breach. Therefore it is not a term that describes risk, which is comprised of both the likelihood of failure and the consequence of failure. Final selection of sites for repair includes both the likelihood of failure and the consequence of the failure. Therefore it is possible that critical sites may not be selected for repair if the consequences of failure do not justify construction in accordance with USACE policy. For example, if the site is deemed critical but is located in a basin that is not economically justified, the project will not select the site for repair.

Sites deemed critical and located in an economically justified basin as defined by the most current Economic Update will follow the path to Step 4 (Expedited). Step 3 (Expedited) is included in this path for site documentation purposes and will not delay the implementation process. Sites deemed critical which are not located in economically justified basins will be elevated to Corps management, and the Sponsor (DWR/CVFPB and Levee Maintaining Agencies) to determine alternative program or project authorities which can conduct the repair. After Step 4 (Expedited) economically justified critical sites will continue onto Step 5 (Expedited). Step 6 (Expedited) will be bypassed to avoid implementation delays and proceed to Step 7 (Expedited). Critical sites will be documented in an addendum to the lock-in list documentation and proceed onto decision point “Selected for Repair”. At the “Selected for Repair” decision point, critical site will move forward to step 8. Non-critical sites will be selected based on available resources and prioritized based on their ranking from previous steps. The non-critical sites will proceed though the non-expedited steps that are further explained below and are shown in the attachment A flow chart.

3.3 Step 3 – Engineering Ranking and Report

The third step of the site implementation process is to develop a report and engineering site ranking based on the results of the information collected during the annual erosion reconnaissance. An aerial atlas will also be created which provides a visual representation of all the erosion sites in the system. The Engineering Ranking and Report occurs annually based on the annual field reconnaissance.

The site prioritization, or ranking, is based on engineering factors that contribute to levee breach or failure. These are site length, berm width, bank slope, soil type, velocity, erosion rate, and additional factors such as trees with exposed roots, holes, slumping, vertical sections, or cracks. Scores will be assigned to each factor to compile a total score, where the higher the score the worse the site and the higher priority for repair. There will be no tie breakers if two or more sites end up with the same score. The engineering score in the engineering ranking is essentially an estimate of the condition of a site relative to the other sites and is not a site implementation score. Site justification in step 4 and other opportunities and constraints identified in step 5 are critical for prioritizing and selecting sites for repair.

Once the report and atlas are finalized, the list of erosion sites will be provided to the Project Delivery Team. At this time the PDT[2] begins to perform preliminary research into the ownership of affected parcels. This will include researching encroachment permits and existing data sources to determine whether the existing real property rights in each parcel are held by the State entities through fee, easements, joint or common use agreements that can be utilized to affect repair.

3.4 Step 4 –Justification Screening

This step includes an economic analysis and any other work necessary to determine if repairing a site is justified using a risk based approach. While Step 3 looks only at the likelihood of breach, this step looks at the consequences as well. Unlike Step 3 Engineering and Ranking Report this step is anticipated to occur once every five years on average. However, if a new site is identified in an economic impact area that has not been analyzed previously a new justification analysis will be conducted to include this new repair site. The risk based justification screening will be based on erosion sites identified in the latest Engineering Ranking and Report from Step 3. Only repair sites located in justified basins will be repaired unless the repair site can be shown to be incrementally justified. Only justified sites will continue on to step 5.

3.5 Step 5 – Identify Opportunities and Constraints

During this step of the process we identify all the potential issues and opportunities associated with each site. This will address the following:

- Life Safety – Community and population considerations
- Real Estate – Right of Way issues, Easements, Encroachments, etc….
- Environmental – Affected habitat, mitigation requirements (onsite or offsite mitigation), listed species (Federal and State), re-establish habitat, etc….
- Constructability – What types of repairs are feasible or not possible, is there an opportunity to do a setback levee, etc…
- Cultural Resources – Identify historic and pre-historic properties
- Another Program/Agency is planning a repair
- Grouping of sites for more efficient repairs
- Other issues and opportunities – anything else that should be noted that could impact or enhance the repair
- USACE Guidance, Policies, and Budget

Under this step each USACE discipline in the PDT will identify any potential issues and opportunities which may affect, delay, or otherwise influence the repair of the site.

[2] The USACE real estate section and DWR real estate, along with a representative from the design team, are anticipated to be the PDT members performing the preliminary research into the ownership of affected parcels during step 3 after a process is developed for DWR real estate to be involved sooner than they currently are.

3.6 Step 6 – Conceptual Level Alternatives

Under step 6, the PDT will develop conceptual level designs and costs. For each site, multiple design alternatives will be generated based on engineering judgment. Conceptual cross sections and footprints will be generated. These will be based on the latest available topography. This topography may not match the present day bankline, so estimated present day banklines will be added to the sketch. Preliminary, simplified, cost estimates will be developed. These costs will be approximate based on engineering judgment.

3.7 Step 7 – Site Lock-in Procedure

Step 7 will select which of the non-critical sites will move on to the "lock-in" list for site repairs. The sites on the "lock-in" list are generally anticipated to be repaired over a three year period which makes up a construction cycle (see section 4.0 for more on construction cycles).This step will start with the engineering ranking developed in Step 3. Next the PDT[3] step will investigate all the issues identified in step 5 and see if any sites should be moved up or down in the ranking. For example, a site may be moved up if there is a justification for why a repair cannot wait or if a site is adjacent to a higher ranked site and the two sites could be repaired together. Another example could be a repair that is moved down on the list if there is a justification that the repair could cause more negative impacts than positive impacts. This step has an iterative component where conceptual level alternatives may be modified.

In addition, if another program, project, or entity is planning to repair an identified erosion site in the near future, the site will drop out of the locked-in list. However, the site will remain in the inventory until repaired.

The top identified sites will move on to Step 8 and be locked in, the remaining sites will continue to be evaluated in the annual erosion inventory and be considered for lock-in during the next cycle. If a site becomes critical (critical only in terms of likelihood of breach and not considering consequences) before the next site implementation cycle, then it may be fast-tracked to Step 8. If this occurs in the years between site selection cycles, an addendum to the latest Site Selection Lock-in List and Report will be prepared for these fast tracked critical erosion sites. A critical site that is fast tracked means it will be moved to construction as quickly as possible. However, construction could be delayed due to site-specific issues and the site may not be repaired for some time as a result. Sites identified as critical between site-lock in documentations will be added to the latest lock-in list documentation as an addendum. As noted previously, critical sites are identified in the annual Engineering Ranking and Report and considers likelihood of breach only and not the consequences of the breach.

3.8 Step 8 – Site Selection Lock-in List and Report

[3] This will include DWR Real Estate once the process to involve them earlier is established.

For step 8, the top sites chosen in step 7 and the fast-tracked critical sites will be considered the locked-in sites selected for repair in this construction cycle (see section 5.0 for information on construction cycles). The number of selected sites will vary depending on a number of factors, such as construction limitations (e.g. funding, location, length, etc.). A report will be written to document how and why the "locked-in" sites were selected for repair. This report will primarily be for USACE use and to keep a historical record of the process. The identified sites will be grouped into construction cycle-years, based on the required time needed to acquire real estate and similar construction repair methods or site proximity in order to enhance the value per dollar spent. See section 5.0 for information on construction phases within a construction cycle.

3.9 Step 9 – Data Collection

For this step the PDT will start collecting the data needed to develop the designs. The exact information and the level of detail collected at each site will vary from site to site. Some of the data to be collected includes topographic surveys, geotechnical explorations, tree inventory, potentially impacted endangered species and associated habitat, HTRW, cultural information, and utility survey.

Topographical surveys, including bathymetry of the underwater portion of the river, will be needed for each site. The topography should cover the entire project area, capture the landside toe, extend to cover the opposite bank, and extend far enough upstream and downstream of the site for the hydraulic modeling needs.

During the survey and follow-up activities, the design team will identify all existing visible encroachments on the levee that may interfere with proposed repairs, such as gas/oil pipelines, telecommunication lines, utilities, boat docks, stairs, intake and discharge facilities, and other improvements or structures. The design team will note if removal or relocation is the appropriate option for encroachments. Based on the data collected in the field, USACE real estate and DWR real estate will develop a timeline and process for an encroachment that needs to be removed or relocated[4].

Geotechnical data may be acquired if needed.

A tree survey will be completed to determine which trees will be protected and which trees will be removed. This survey will include tagging every tree in the project footprint as well as roughly 100 ft upstream and downstream of the footprint. The survey will also include a GPS point for each tree and a description of the type and condition (e.g. health, age, etc.) of the tree.

A survey and database search of all Federal and State listed species and associated habitats will be performed. This will include a survey of all threatened and endangered species, special status species, and sensitive habitat for fish, wildlife, and flora.

[4] This will include DWR Real Estate once the process to involve them earlier is established.

A Hazardous Toxic Radioactive Waste survey will determine if we have any environmental hazards.

Cultural resources surveys and database searches will be performed to identify any cultural resources located in each project footprint.

A real estate survey will be conducted to identify all potential impediments to securing the site for repair. This review will include an in-depth inspection of both the waterside and landside of the levee. It will be conducted jointly between USACE real estate personnel, DWR real estate personnel[5], and the responsible Reclamation District or Levee Maintaining Agency. A representative from the USACE design team and the DWR Flood Management personnel will join in the field review.

3.10 Step 10 – Preliminary Designs and Draft EA/IS

Step 10 will begin the design process and the draft EA/IS. The design alternatives will be selected and 30% designs (plans, specifications, and Design Document Report (DDR) and cost estimate will be completed. Following that, the hydraulic modeling will begin. District Quality Control, Agency Technical Review (ATR), and Independent External Peer Review (IEPR) reviews on the 30% designs will be conducted and the comments incorporated into the 60% designs. The DQC, ATR, and IEPR reviews will continue for subsequent designs such as 60% and 90%.

After the 60% designs, subject to USACE procedures, the construction footprints will be handed off to real estate to develop the take-letters for DWR Real Estate to begin the certification process. In addition, the sites will be grouped into cycle-years based on ability to acquire real estate and similar construction repair methods or site proximity in order to enhance the value per dollar spent. See also section 5.0 for information on construction cycles and phases. In general, it is anticipated that phase 1 will include higher priority sites with no significant issues that could delay construction, such as real estate issues. In general, it is anticipated that phase 3 will include lower priority sites and/or higher priority sites with issues that take longer to resolve, such as real estate issues. In general, it is anticipated phase 2 will include the remaining sites.

For example, phase 1 may include sites with existing rights and no encroachments (or encroachments that can be protected in-place), phase 2 may include sites without existing rights and no encroachments (or encroachments that can be protected in-place), and phase 3 may include sites without existing rights and encroachments or setback levee sites.

During this step, the draft Environmental Assessment/Impact Statement (EA/IS) will be developed and released for public review and comment for compliance under NEPA and CEQA. In conjunction with the EA, the cultural resources section will consult with the State Historic Preservation Office and the Native American Tribes.

[5] This will include DWR Real Estate once the process to involve them earlier is established.

3.11 Step 11 – Draft Final Design, Final EA/IS, and Pre-Construction Activities

Under this step the 60% Plans and Specifications will be reviewed, and the cost estimate updated. The team will finish writing the draft DDR. After an internal review of the plans, the 90% Plans and Specifications will be developed. The hydraulic modeling, cost estimate, and real estate requirements will be adjusted as needed. Following an internal review, the 90% Plans, Specifications, and DDR will be sent for reviews. The final EA/IS will be completed with signed Finding of No Significant Impact (FONSI) and Mitigated Negative Declaration (MND).

3.12 Step 12 – Review and Final Design

The official ATR and Independent External Peer Review (Type II IEPR, Safety Assurance Review (SAR)) will be performed throughout the development of the Plans and Specifications and the DDR. The ATR will serve as the Biddability, Constructability, Operability, Environmental, and Sustainability (BCOES) characteristics review of the plans, specifications, and EA/IS. Revisions to the designs and contract documents will be made based on these reviews, resulting in the 100% DDR and Plans and Specifications for Contract advertisement.

3.13 Step 13 – Contracting Procedure

For this step, USACE will compile the final plans and specifications, provide the signed BCOE, and process the funding element for construction. Real estate certification will be complete with a statement from DWR real estate and certification by USACE real estate. These items are provided to Contracting who then prepares the bid documents and solicits bids based on the chosen contracting vehicle. The contract is awarded and the chosen Contractor is given a Notice to Proceed.

3.14 Step 14 – Construction

For step 14, the contractor will construct the bank repair following the Notice to Proceed from step 13.

3.15 Step 15 – Mitigation Monitoring

On-site mitigation will require monitoring to ensure the establishment criteria is met for vegetation growth and survival. The monitoring period must be sufficient to demonstrate that the compensatory mitigation has met performance standards, but not less than five years (see 33 CFR 332.6(b)). Monitoring reports are required on a yearly basis. If the compensatory mitigation has met its performance standards in less than five years, the monitoring period length can be reduced, if there are at least two consecutive monitoring reports that demonstrate that success.

3.16 Step 16 – Site Turn-over

Once the construction and mitigation monitoring is complete, the USACE will turn the site over to the Central Valley Flood Protection Board, which will then turn the site over to the local maintaining agency. The USACE will provide the as-built drawings, Project Cooperation Agreement letter, and addendum to the supplemental O&M Manual, and letter of transmittal.

4.0 Economically Justified Basins Decision Point

As discussed in Step 3, all erosion sites will be documented in a report and ranked, but only the sites located in economically justified basin, as defined by the most current Economic Update will move to Step 5. Erosion sites not located in economically justified basins will be reconsidered in future economic updates (5 year construction cycle, or as additional data is obtained that warrant an earlier economic update using new methods that supersedes the 2011 Economic Update).

5.0 Construction Cycles

To implement the site implementation procedure, the process will be applied in a series of overlapping construction cycles. A single construction cycle is shown in the figure below and **Attachment B** shows a timeline illustrating the multiple overlapping construction cycles. The construction cycles are five years long, and includes three (3) years, or phases, of construction. The construction will be broken into these three phases (years) and the sites distributed among the three phases. The first year of the cycle produces the site lock-in list and data collection. The second year includes: 1) developing the preliminary plans, specifications, and DDR for all the sites in the construction cycle, 2) the EA/IS, and 3) the final plans, specifications, and DDR for the first construction phase. The third year will include the construction of the phase 1 sites and the final plans, specifications, and DDR of the phase 2 sites. The fourth year will include the construction of the phase 2 sites and the final plans, specifications, and DDR of the phase 3 sites. The fifth year will include the construction of the phase 3 sites. A new construction cycle will begin in Year 4 of the current cycle to ensure on-going construction. These overlapping cycles will allow SRBPP to continuously construct repairs every year assuming funding is available.

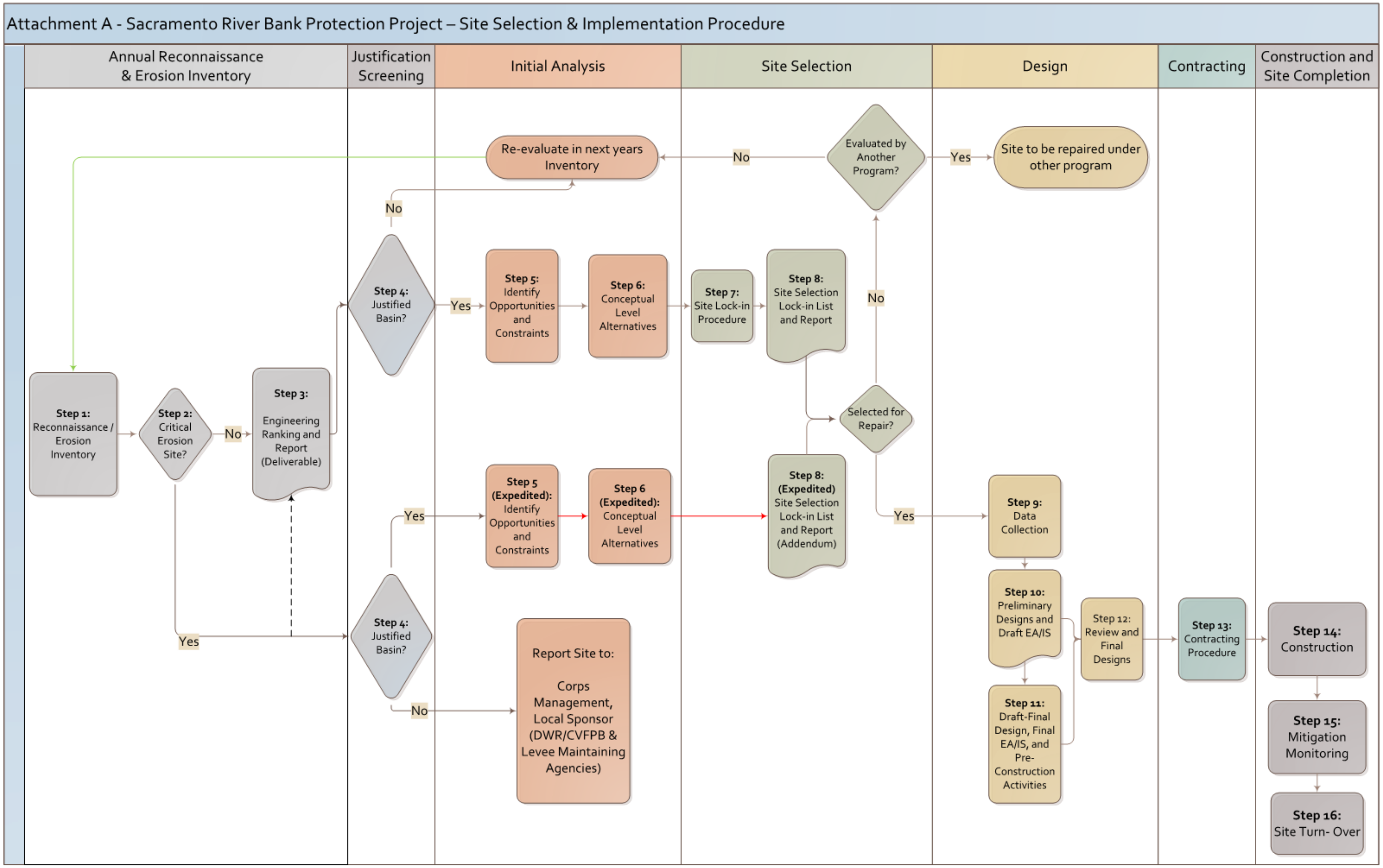
Construction Cycle 1				
Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Site Lock-In List and Report Data Collection (Phase 1 - 3 Sites)	Preliminary Plans, Specifications, DDR, and EA/IS (Phase 1 - 3 Sites) Plans, Specifications, and DDR (Phase 1 Sites)	Construction (Phase 1 Sites) Plans, Specifications, and DDR (Phase 2 Sites)	Construction (Phase 2 Sites) Plans, Specifications, and DDR (Phase 3 Sites)	Construction (Phase 3 Sites)

6.0 Conclusion

New guidance and changing work environment requires the current site implementation practice to be updated. The site implementation working group developed and recommends the process outlined in this report. This process includes a site selection and implementation procedure that is applied in multiple construction cycles. Each construction cycle will last five (5) years and a new cycle begins in the fourth (4^{th}) year of the previous cycle. This process may need to be modified in the future to adapt and meet future changes to project requirements and conditions. However the team recommends adopting the general procedure outlined in this document for identifying and repairing erosion sites for the Sacramento River Bank Protection Project at this time.

Attachment A

Site Selection and Implementation Procedure Flow Chart


Attachment A - Sacramento River Bank Protection Project – Site Selection & Implementation Procedure
Annual Reconnaissance & Erosion Inventory
Justification Screening
Initial Analysis
Site Selection
Design
Contracting
Construction and Site Completion
Re-evaluate in next years Inventory
No
Evaluated by Another Program?
Yes
Site to be repaired under other program
No
Step 4: Justified Basin?
Yes
Step 5: Identify Opportunities and Constraints
Step 6: Conceptual Level Alternatives
Step 7: Site Lock-in Procedure
Step 8: Site Selection Lock-in List and Report
No
Step 1: Reconnaissance / Erosion Inventory
Step 2: Critical Erosion Site?
No
Step 3: Engineering Ranking and Report (Deliverable)
Selected for Repair?
Yes
Step 5 (Expedited): Identify Opportunities and Constraints
Step 6 (Expedited): Conceptual Level Alternatives
Step 8: (Expedited) Site Selection Lock-in List and Report (Addendum)
Yes
Step 9: Data Collection
Step 10: Preliminary Designs and Draft EA/IS
Step 12: Review and Final Designs
Step 13: Contracting Procedure
Step 14: Construction
Yes
Step 4: Justified Basin?
No
Report Site to: Corps Management, Local Sponsor (DWR/CVFPB & Levee Maintaining Agencies)
Step 11: Draft-Final Design, Final EA/IS, and Pre-Construction Activities
Step 15: Mitigation Monitoring
Step 16: Site Turn- Over

REAL ESTATE PLAN

SACRAMENTO RIVER BANK PROTECTION PROJECT
IN SUPPORT OF THE
POST AUTHORIZATION REPORT

July 2014

PREPARED
BY THE
SACRAMENTO DISTRICT
REAL ESTATE DIVISION
SOUTH PACIFIC DIVISION

TABLE OF CONTENTS

SACRAMENTO RIVER BANK PROTECTION PROJECT
REAL ESTATE PLAN
30 May 2014

1. Statement of Purpose

The Sacramento River Bank Protection Project (SRBPP) is a long-term project to enhance public safety and protect property along the Sacramento River and its tributaries by periodic levee rehabilitation that protects the Sacramento River Flood Control Project from erosion failures. The U.S. Army Corps of Engineers, Sacramento District (Corps) is responsible for implementing the SRBPP together with its non-Federal sponsor (NFS), the California Central Valley Flood Protection Board.

This report is tentative in nature, focuses on the Bank Protection Plan (BPP), and is to be used for planning purposes only. The Real Estate Plan is intended to support the Post Authorization Change Report (PACR) for the SRBPP and is written to the same level of detail. **Once specific sites are identified for construction, Corps real estate will update the information listed in Exhibit D - Site Specific Real Estate Inventory Check-List. The updated Addendum will be reviewed and approved at the District level however Division will be notified which specific sites will be worked. This Addendum will better define the impacted parcels, costs of acquisition, schedule, etc.**

The BPP indicates that erosion sites represent a wide variety of site conditions and pose a variety of challenges to the delivery of the real estate necessary to accomplish and maintain the necessary repairs. This Real Estate Plan adheres to the Engineer Regulations for a Real Estate Plan (ER 405-1-12). The Real Estate Plan addresses what procedures should be implemented to guide and support the acquisition of real estate necessary to complete the PACR for the SRBPP and the measures that will be taken when specific sites are identified for construction.

2. Project Authority

The SRBPP was originally authorized by Section 203 of the Flood Control Act of 1960 and completed in 1975. Phase II, for 405,000 linear feet of bank protection, was authorized by the River Basin Monetary Authorization Act of 1974. Bank protection under this act will be completed in 2013. The SRBPP is a continuing construction project that requires ongoing planning and development to achieve project goals of providing erosion protection to the existing levee and flood control facilities of the Sacramento River Flood Control Project, which includes the Sacramento River and its tributaries.

An additional eighty thousand (80,000) linear feet was added to Phase II through a 2007 re-authorization. The 80,000 additional linear feet of river bank will be repaired along the Sacramento River and its tributaries to protect the existing levees and associated flood risk management infrastructure within the SRBPP area from stream erosion. The scope of this Real

Estate Plan is the 80,000 linear feet. This report is part of the overall PACR for Phase II 80,000 linear feet, which supports a new or amended Project Partnership Agreement (PPA) between the Corps and the NFS.

A bank protection plan for the 80,000 linear feet was developed as described in the SRBPP Phase II 80,000 Linear Feet Engineering Documentation Report (EDR). The bank protection plan is comprised of representative bank protection measures at 106 sites. Because erosion is dynamic and unpredictable, the 106 sites and repair measures are prototypical. Actual sites and measures identified during implementation may be different from what is included in the bank protection plan.

3. Project Description

The attached maps in Exhibit A indicate the scope of the SRBPP. Attached Exhibit B (Erosion Site Summary) provides a summary of the estimated 106+ sites required for the 80,000 linear feet project. Information included in this summary identifies the ownership, location, and assessor parcel numbers for all potential sites. Parcel Information Sheets are attached (Exhibit C-1) providing examples of the typical site within the Project. *These summaries were created by the consulting firm of Bender-Rosenthal.*

Due to the dynamic and uncertain nature of erosion, sites needing bank protection are identified and selected on an annual basis. Since it is impossible to predict future erosion, this real estate plan addresses the global issues for the project area. The actual sites and bank erosion measures that will be constructed during the implementation phase will vary from the sites and measures known at this time. **Once specific sites are identified for construction, Corps real estate will update the information listed in Exhibit D - Site Specific Real Estate Inventory Check-List. The updated Addendum will be reviewed and approved at the District level however Division will be notified which specific sites will be worked. This Addendum will better define the impacted parcels, costs of acquisition, schedule, etc.**

4. Description of LERRDs

Personnel from the Corps, California Central Valley Flood Protection Board, and the California Department of Water Resources (DWR) have conducted an annual field reconnaissance review of the Sacramento River Flood Control Project (Exhibit A- Map attached). The primary purposes of the review have been to: (a) monitor and document the condition of previously identified erosion sites; (b) inventory any new erosion sites; (c) identify critical erosion sites that appear to pose an imminent threat to the structural integrity of the flood control system; and (d) inventory sites better suited for maintenance practices.

Each site is essentially a “project” in itself. Repair options include: (1) waterside rip-rap; (2) construction of an adjacent landside levee, (3) construction of a setback levee; (4) construction of a landside berm and toe drain and (5) environmental mitigation measures. **When the specific**

sites are identified for construction, a standard take letter will be issued to the non-federal sponsor identifying the required estates and area necessary for the project. Typical required estates may include but not be limited to, permanent flood protection levee easements and temporary easements for access/haul routes and construction. If non-standard estates are required Division and Headquarters will be notified. It is not anticipated that non-standard estates will be required.

5. LERRDs Owned by the NFS and Crediting

Once the specific sites are identified, the extent of NFS-owned property and crediting implications can be determined. The NFS is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the LER is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government. In addition, the specific requirements relating to valuation and crediting contained in the executed PPA for a project must be reviewed and applied.

6. Standard Federal Estates and Non-Standard Estates

The SRBPP will acquire the minimum interests in real estate to support the construction, operation and maintenance of the project. The following standard estates are anticipated to be required for the project.

- **FLOOD PROTECTION LEVEE EASEMENT (FPLE):** A perpetual and assignable right and easement in (the land described in Schedule A) (Tracts Nos, ____, ____ and ____) to construct, maintain, repair, operate, patrol and replace a flood protection (levee) (floodwall)(gate closure) (sandbag closure), including all appurtenances thereto; reserving, however, to the owners, their heirs and assigns, all such rights and privileges in the land as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **BANK PROTECTION EASEMENT (BPE):** A perpetual and assignable easement and right-of-way in, on, over and across the land hereinafter described for the location, construction, operation, maintenance, alteration, repair, rehabilitation and replacement of a bank protection works, and for the placement of stone, riprap and other materials for the protection of the bank against erosion; together with the continuing right to trim, cut, fell, remove and dispose therefrom all trees, underbrush, obstructions, and other vegetation; and to remove and dispose of structures or obstructions within the limits of the right-of-way; and to place thereon dredged, excavated or other fill material, to shape and grade said land to desired slopes and contour, and to prevent erosion by structural and vegetative methods and to do any other work necessary and incident to the project; together with the right of ingress and egress for such work; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

- **TEMPORARY WORK AREA EASEMENT (TWAE):** A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed ___________________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the ____________________ Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

7. Description of any Existing Federal Projects in or Partially in the Proposed Project

There are two existing federal projects in the project area. Any potential overlap with these existing federal projects will be evaluated once specific sites are identified for construction. Below is a brief summary of each existing federal project.

West Sacramento

The West Sacramento Project encompasses levee improvements along portions of the Sacramento River, the Yolo Bypass, the Sacramento Bypass, and the Sacramento Deep Water Ship Channel (DWSC). The project aims to bring 50 miles of perimeter levees surrounding West Sacramento into compliance with applicable Federal and State standards for levees protecting urban areas.

A few years ago levee improvements were completed that were intended to provide an increased level of flood risk management for the City of West Sacramento. Since those upgrades were completed, under seepage deficiencies have been discovered with some of the levees surrounding the city. While levee improvements authorized for construction were redesigned to address any under seepage deficiencies, the remaining levees were not authorized to be reevaluated. As a result, the West Sacramento Area Flood Control Agency (WSAFCA) initiated a thorough state and locally-funded review of its flood risk management system. Since 2009, the Corps of Engineers has been conducting a General Reevaluation Report in cooperation with project sponsors (WSAFCA and the Central Valley Flood Protection Board) to evaluate the levee system and determine the federal interest in reducing the flood risk for the City of West Sacramento.

Approximately 4 of the 106+ prototypical sites lie within the West Sacramento project area.

<u>American River Common Features</u>
The Sacramento Area Flood Control Agency (SAFCA), in cooperation with the State of California, DWR through the Central Valley Flood Protection Board, has initiated urgently needed improvements to the Federal project levee system protecting the Natomas Basin. These improvements address identified deficiencies in the levee system based on changing engineering standards that have caused experts to significantly downgrade the system's performance capability. In July 2006, the Corps withdrew the certification of the Natomas Levee System. In response, FEMA withdrew the 100-year flood protection certification that was granted to the levee system only a decade ago. A catastrophic failure of the levee system around the Natomas Basin would imperil the health and safety of 80,000 residents, shut down Sacramento International Airport and two of California's most important interstate freeways (I-80 and U.S. Highway 50), severely damage an emerging Federal wildlife refuge, and cause a loss of over $7 billion in residential, commercial and industrial property damage. SAFCA and the State are addressing these challenges by moving aggressively forward with the Natomas Levee Improvement Program.

Approximately 3 sites overlap with the American River Common Features project area.

8. Description of any Federally-owned Land Needed for the Project

There are no anticipated Federally-owned lands needed for the Project.

9. Application of Navigational Servitude to the LERRDs Requirement

The determination of the availability of the navigation servitude is a two-step process. First the Government must determine whether the project feature serves a purpose which is in the aid of commerce. Such purposes recognized by the courts include navigation, flood control and hydro-electric power. If it is so determined, then the second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable watercourse. Navigational servitude may be applicable in instances where barges will be used to place material or where below mean high water mark armoring of the bank will occur. Barges will only be utilized at project sites downstream of the confluence of the American and Sacramento Rivers.

10. Project Map

(See attached Exhibit A). These maps indicate the overall project site. Once specific sites are determined, maps will be generated and provided to the NFS.

11. Anticipated Increased Flooding and Impacts

As the design for each site is refined, an analysis for potential impacts will be performed.

12. <u>Baseline Cost Estimate</u>

Baseline Cost Estimates for the selected sites will be obtained prior to construction. This information will be provided to the PDT and incorporated in the total project cost estimates. The State of California, DWR has provided the following generalized cost estimate: *The estimated cost for all parcels cannot be referenced until further field review and project impacts are determined. Prior to construction, a cost estimate will occur and provided to the PDT.*

Typical Repair Site	Description of Typical Repair Sites	Average NFS Cost to Acquire Rights [1 2]	Average NFS Administrative Cost [2 3]	Average Federal Administrative Cost
1	***Waterside Rock Slope Repair Site where:*** A. Sponsor has existing levee rights in place that allows for construction B. Need to acquire waterside planting rights C. Need to acquire 10' easement for O&M requirements (Title 23)	$8,000/parcel	$75,000/parcel	$10,000/parcel
2	***Waterside Rock Slope Repair Site where:*** A. Need to acquire all necessary real property rights including waterside planting rights B. Need to acquire 10' easement for O&M requirements (Title 23)	$12,000/parcel	$120,000/parcel	$10,000/parcel
3	***Land Side Berm Repair Site where:*** A. Need to acquire all necessary real property rights including waterside planting rights B. Need to acquire 10' easement for O&M requirements (Title 23)	$35,000/parcel	$150,000/parcel	$10,000/parcel

4	***Setback Levee Repair Site where:*** A. Need to acquire all necessary real property rights including waterside planting rights B. Need to acquire 10' easement for O&M requirements (Title 23)	$75,000/parcel	$250,000/parcel	$10,000/parcel

1 Costs shown represent an estimate of average expenditures per parcel to acquire easements, access, staging, planting, O&M, and spoil site rights.

2 All figures shown in this table to do NOT include costs associated with any potential condemnation process or eminent domain proceedings.

3 The administrative cost shown, represent the average labor costs of DWR's Real Estate office only for site analyses, appraisals, negotiations, phase site assessments, legal coordination, environmental support, negotiations with respect to existing utility relocations, and closing of escrow. These figures do NOT include cost associated with efforts that may be required of the Geodetics Branch, Division of Environmental Services, and/or Division of Flood Management offices.

13. Relocation Assistance Benefits

The NFS must comply with the Uniform Relocation Assistance and Real Properties Acquisition Policies Act of 1970, as amended, 42 U.S.C. 4601 *et seq.* (P.L. 91-646, "the Uniform Act") and provide relocation assistance to qualifying residences and businesses within the project area that are displaced, as defined in the Uniform Act, as a consequence of USACE project implementation. A setback levee is the only type of repair that is anticipated to include possible relocation assistance benefits under P.L. 91-646.

14. Mineral/Timber Activity

There are no mineral or timber impacts associated with the project.

15. Project Sponsor Responsibilities and Capabilities

The California Central Valley Flood Protection Board will be the NFS for the project. The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project. The sponsor will have operation and maintenance responsibility for the project after construction is completed.

Title to any acquired real estate will be retained by the NFS and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit E) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s).

The NFS should not acquire lands required for the project prior to execution of the PPA. Should the NFS proceed with acquisition of lands prior to execution of the PPA, it is at the risk of not receiving credit or reimbursement for any costs incurred in the connection with the acquisition process should the PPA not be signed. There is also risk in acquiring lands either not needed for the project or not acquired in compliance with requirements for crediting purposes in accordance with 49 CFR Part 24, dated March 2, 1989. Letters advising the NFS of the risks of early acquisition will be sent as appropriate.

16. <u>Zoning Anticipated in Lieu of Acquisition</u>

There is no zoning in lieu of acquisition planned in connection with this Project.

17. <u>Acquisition Schedule</u>

Schedules will be completed once the specific sites are selected.

18. <u>Description of Facility and Utility Relocations</u>

As specific sites are selected for potential construction, the Corps will identify the specific locations and the nature of the potential impact to the facility/utility. The NFS will be responsible to insure the facility/utility is relocated prior to the completion of the construction, as required in the Corps regulations. Sample Parcel Information Sheets (Exhibit C-1) illustrate the type of documentation which will be provided to Corps Office of Counsel for their completion of the required Opinion of Compensability when a utility or facility is impacted by the specific construction site. A complete inventory of all utility/facilities has not been completed for all 106 sites.

ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REPORT THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NFS AS PART OF ITS LERRD RESPONSIBILITIES IS PRELIMINARY ONLY. THE GOVERNMENT WILL MAKE A FINAL DETERMINATION OF THE RELOCATIONS NECESSARY FOR THE CONSTRUCTION, OPERATION, OR MAINTENANCE OF THE PROJECT AFTER FURTHER ANALYSIS AND COMPLETION AND APPROVAL OF FINAL ATTORNEY’S OPINIONS OF COMPENSABILITY FOR EACH OF THE IMPACTED UTILITIES AND FACILITIES.

19. Hazardous, Toxic and Radiological Waste (HTRW)

While there is minimal likelihood of HTRW on these sites; soil sampling will be conducted for any borrow material required. In addition, Underground Service Alter (USA) will be consulted prior to digging at any site and all site workers will be made aware of the proximity of any natural gas production operations which will also be communicated in the Site Safety and Health Plan (HTRW Reconnaissance Report, Corps, 2007; see section 8.1.2 of the PACR).

20. Attitude of Land Owners and Community

This on-going project has been supported by the local reclamation districts and the local land owners. Once specific sites are identified, determination of local attitudes will be addressed as provided in Exhibit D.

21. Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

SPONSOR: State of California, Central Valley Flood Protection Board

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **Yes**

b. Does the sponsor have the power of eminent domain for this project? **Yes**

c. Does the sponsor have "quick-take" authority for this project? **Ye**s

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? **No**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **No**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended? **No**

b. If the answer to II.a. is "yes," has a reasonable plan been developed to provide such training? **N/A**

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **Yes**

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any, and the project schedule? **Yes**

e. Can the sponsor obtain contractor support, if required, in a timely fashion? **Yes**

f. Will the sponsor likely request USACE assistance in acquiring real estate? **No**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **Yes**

b. Has the sponsor approved the project real estate schedule/milestones? **N/A**

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects? **Yes**

b. With regard to this project, the sponsor is anticipated to be: **State of California Central Valley Flood Protection Board**

V. Coordination:

a. Has this assessment been coordinated with the sponsor? **Yes**

b. Does the sponsor concur with this assessment? **Yes**

Prepared by:

Kelly Boyd
Realty Specialist
Acquisition & Management Branch

Reviewed and Approved by:

Sharon Caine
Chief, Real Estate Division
U.S. Army Engineer District, Sacramento

EXHIBIT A

PROJECT MAPS

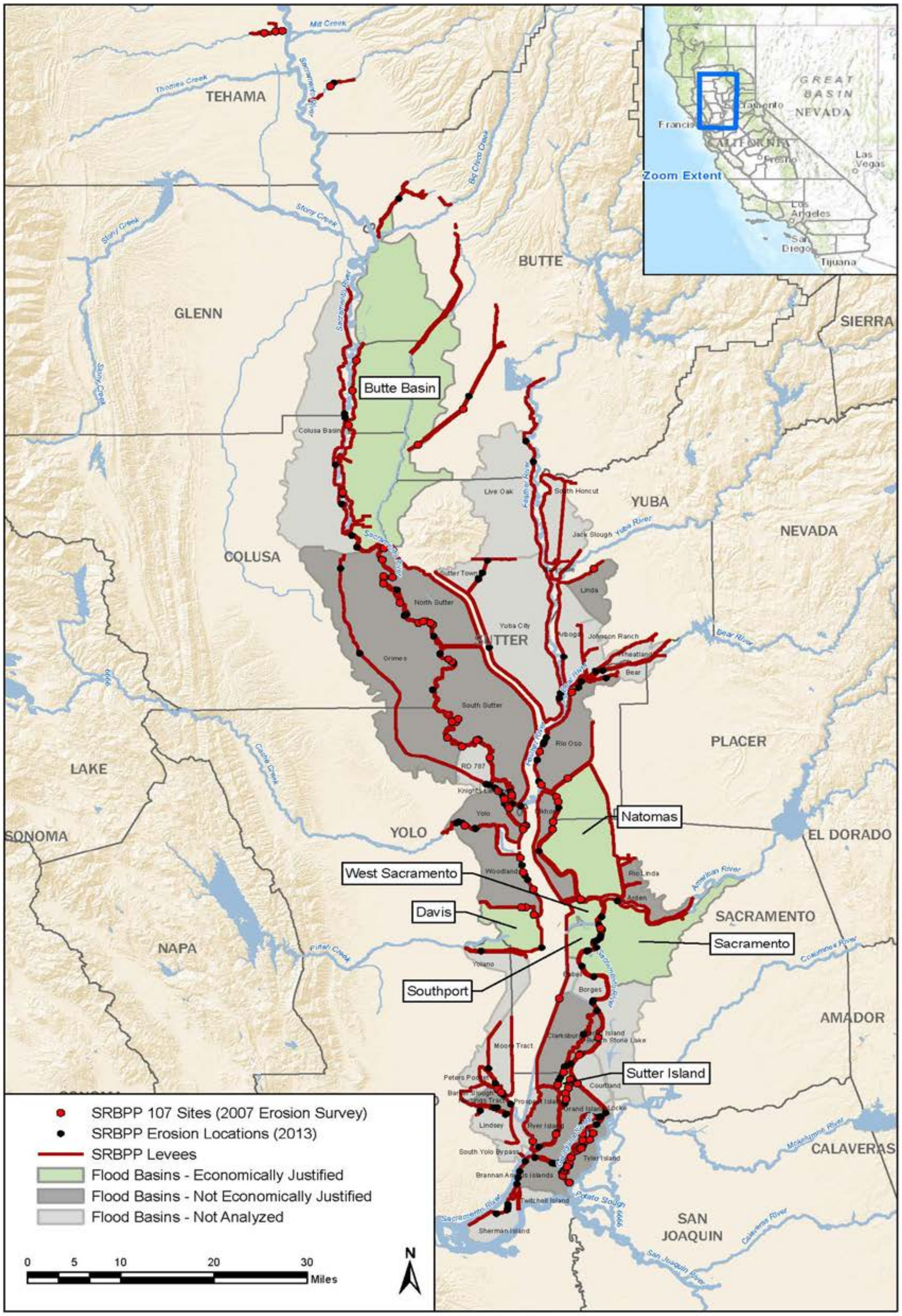

TEHAMA
BUTTE
GLENN
Butte Basin
COLUSA
YUBA
NEVADA
SIERRA
SUTTER
PLACER
LAKE
YOLO
SONOMA
EL DORADO
Natomas
West Sacramento
Davis
SACRAMENTO
Sacramento
NAPA
Southport
AMADOR
Sutter Island
CALAVERAS
SAN JOAQUIN
Zoom Extent
GREAT BASIN
NEVADA
Las Vegas
Los Angeles
San Diego
Tijuana
SRBPP 107 Sites (2007 Erosion Survey)
SRBPP Erosion Locations (2013)
SRBPP Levees
Flood Basins - Economically Justified
Flood Basins - Not Economically Justified
Flood Basins - Not Analyzed
0 5 10 20 30 Miles
N

EXHIBIT B

EROSION SITES SUMMARY

107 Erosion Sites																
					USL (USACE)		DSL (USACE)									
Site No.	River	Mile Marker	Left or Right Bank	River Mile or Levee Mile	Lat	Long	Lat	Long	Evaluated Alternatives	APN	Acres	Land Use	County	Owner Name	Site Address	Owner Address
1	BR	0.8	L	RM	38.9470	-121.5637	38.9465	-121.5641	1,2,3,10	SSJJD?		Ag				
2	CC	3.9	L	LM	38.7282	-7937.0000	38.7276	-121.7803	1,2,10	027-170-39-1	20.28	Ag	Yolo		39475 County Road 17A, Woodland Ca 95695	
3	CS	15.9	L	RM	38.2000	-121.6557	38.1995	-121.6558	1,8,9	0177-060-08	266.9	Ag	Solano		3338 State Highway 84, Walnut Grove, CA 95690	
3	CS	15.9	L	RM	38.2000	-121.6557	38.1995	-121.6558	1,8,9	0177-060-01	252.16	Ag	Solano		3452 State Highway 84, Walnut Grove, CA 95690	
4	CS	22.8	R	RM	38.2819	-121.7170	38.2814	-121.7166	1,8,9	0042-160-13	647.42	Ag	Solano		Solano Ca 94571	
5	CS	23.6	R	RM	38.2883	-121.7246	38.2865	-121.7230	1,8,10	0042-140-22	314.05	Ag	Solano		Solano Ca 94571	
6	ChC	14	L	LM	39.4223	-121.7724	39.4218	-121.7727	1	022-120-044-00	50	Ag	Butte		Biggs Ca, 95917	
7	ChC	21.9	L	LM	39.3653	-121.8617	39.3625	-121.8673	1,2,3	022-060-035-00	6	Ag	Butte		Biggs Ca, 95917	
8	DWSC	5	L	LM	38.4377	-121.5977	38.4374	-121.5977	1	044-110-21	216.03	Ag	Yolo		Willow Point Road	
9	DWSC	5.01	L	LM	38.4374	-121.5978	38.4372	-121.5979	1	033-180-19					West Sacramento	
10	DC	2.4	L	LM	39.9629	-121.0314	39.9627	-122.0317	1,2,3,10	079-130-11-1	120	Ag	Tehama		Corning , Ca 96021	
11	EC	1.4	L	LM	40.0516	-122.1642	40.0520	-122.1631	1,4,5,10	064-060-03-1	28.13	Ag	Tehama		Gerber Ca 96035	
12	EC	3	R	LM	40.0548	-122.1407	40.0550	-122.1403	1,4,5,10	064-260-29-1	133.14	Ag	Tehama		Gerber Ca 96035	
13	EC	4.1	L	LM	40.0553	-122.1279	40.0547	-122.1272	1,10	064-040-06-1	88.76	Ag	Tehama		24460 E Chard Ave, Gerber Ca 96035	
13	EC	4.1	L	LM	40.0553	-122.1279	40.0547	-122.1272	1,10	064-260-14-1	257.57	Ag	Tehama		9050 Holmes Roaf, Gerber, Ca 96035	
14	FR	0.6	L	RM	38.7937	-121.6285	38.7934	-121.7934	1,4,5							
15	FR	4.9	L	RM	38.8503	-121.6295	38.8478	-121.6304	1,4,5	33-050-001	145.71	Ag	Sutter		4606 Garden Hwy, Nicolaus Ca 95659	
16	GS	0.3	L	RM	38.1300	-121.5865	38.1303	-121.5823	1,8,9,10	156-0070-001	622.35	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
17	GS	1.7	L	RM	38.1435	-121.5998	38.1403	-121.5972	1,8,9,10	156-0070-001	622.35	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
18	GS	2.5	L	RM	38.1508	-121.5936	38.1512	-121.5947	1,8,10	156-0070-001	623.35	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
19	GS	3.6	L	RM	38.1561	-121.5918	38.1529	-121.5913	1,8,9,10	156-0060-018	460.49	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
20	GS	3.7a	L	RM	38.1570	-121.5913	38.1564	-121.5917	1,8,9,10	156-0060-018	461.49	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
21	GS	3.7b	L	RM	38.1570	-121.5906	38.1569	-121.5908	1,8,9,10	156-0060-018	462.49	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
22	GS	4	L	RM	38.1571	-121.5874	38.1572	-121.5891	1,8,9,10	156-0060-018	463.49	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
23	GS	4.3	L	RM	38.1600	-121.5853	38.1576	-121.5867	1,8,9,10	156-0060-018	463.49	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
23	GS	4.3	L	RM	38.1600	-121.5853	38.1576	-121.5867	1,8,9,10	156-0050-034	187	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
24	GS	4.5	L	RM	38.1612	-121.5845	38.1611	-121.5846	1,8,9,10	156-0050-034	187	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
25	GS	4.6	L	RM	38.1645	-121.5832	38.1616	-121.5846	1,8,9,10	156-0050-032	181	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
25	GS	4.6	L	RM	38.1645	-121.5832	38.1616	-121.5846	1,8,9,10	156-0050-033	179	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
25	GS	4.6	L	RM	38.1645	-121.5832	38.1616	-121.5846	1,8,9,10	156-0050-034	187	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
26	GS	5.3	L	RM	38.1763	-121.5801	38.1680	-121.5817	1,8,9,10	156-0050-014	78.82	Ag	Sacramento		16021 Tyler Island Road, Isleton Ca 95641	
26	GS	5.3	L	RM	38.1763	-121.5801	38.1680	-121.5817	1,8,9,10	156-0050-030	172	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
26	GS	5.3	L	RM	38.1763	-121.5801	38.1680	-121.5817	1,8,9,10	156-0050-031	151	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
27	GS	6.1	L	RM	38.1821	-121.5703	38.1815	-121.5761	1,8,9,10	156-0050-001	79.6	Ag	Sacramento		Tyler Island Road, Isleton Ca 95641	
27	GS	6.1	L	RM	38.1821	-121.5703	38.1815	-121.5761	1,8,9,10	156-0030-008	146.24	Ag	Sacramento		Tyler Island Road, Walnut Grove Ca 95690	
28	GS	6.4	L	RM	38.1834	-121.5679	38.1827	-121.5690	1,8,9,10	156-0030-008	146.24	Ag	Sacramento		Tyler Island Road, Walnut Grove Ca 95690	
29	GS	6.6	L	RM	38.1855	-121.5634	38.1852	-121.5645	1,8,9,10	156-0030-008	146.24	Ag	Sacramento		Tyler Island Road, Walnut Grove Ca 95690	
30	GS	6.8	L	RM	38.1880	-121.5588	38.1860	-121.5617	1,8,9,10	156-0030-002	546.55	Ag	Sacramento		Tyler Island Road, Walnut Grove Ca 95690	
31	GS	8.3	L	RM	38.2008	-121.5426	38.2007	-121.5428	1,8,9,10	156-0030-002	546.55	Ag	Sacramento		Tyler Island Road, Walnut Grove Ca 95690	
32	GS	9.3	L	RM	38.2139	-121.5377	38.2117	-121.5356	1,8,9,10	156-0020-025	169.2	Ag	Sacramento		Levee Road, Walnut Grove Ca 95690	
33	KLRC	0.2	R	LM	38.7223	-121.6663	38.7189	-121.6639	1, 2, 3	057-090-06-1	140.16	Ag	Yolo		Woodland, Ca 95695	
33	KLRC	0.2	R	LM	38.7223	-121.6663	38.7189	-121.6639	1, 2, 3	057-090-08-1	43	Ag	Yolo		Woodland, Ca 95695	
33	KLRC	0.2	R	LM	38.7223	-121.6663	38.7189	-121.6639	1, 2, 3	057-130-02-1	218.32	Ag	Yolo		West Sacramento, CA 95695	
34	KLRC	3	L	LM	38.7579	-121.6930	38.7549	-121.6926	1, 2, 3	056-230-07-1	185.3	Ag	Yolo		11750 County Road 116B, Woodland Ca 95776	
35	KLRC	3.1	L	LM	38.7595	-121.6940	38.7586	-121.6933	1, 2, 3	056-230-07-1	185.3	Ag	Yolo		11750 County Road 116B, Woodland Ca 95776	
36	KLRC	4.2	L	LM	38.7719	-121.7018	38.7709	-121.7015	1, 2, 3	056-220-04-1	85.85	Ag	Yolo		Woodland, Ca 95695	
37	KLRC	5.3	L	LM	38.7926	-121.7240	38.7758	-121.7038	1, 2, 3	056-360-06-1	1.39	Ag	Yolo		Woodland CA 95776	
37	KLRC	5.3	L	LM	38.7926	-121.7240	38.7758	-121.7038	1, 2, 3	056-350-28-1	11.82	Ag	Yolo		Woodland CA 95776	
37	KLRC	5.3	L	LM	38.7926	-121.7240	38.7758	-121.7038	1, 2, 3	056-350-13-1	15.76	Vacant	Yolo		42490-8 Ridge Cut Rd, Woodland CA 95776	
37	KLRC	5.3	L	LM	38.7926	-121.7240	38.7758	-121.7038	1, 2, 3	056-170-37-1	472.6	Ag	Yolo		Woodland CA 95776	
37	KLRC	5.3	L	LM	38.7926	-121.7240	38.7758	-121.7038	1, 2, 3	056-220-05-1	146.06	Ag	Yolo		11300 County Road 116B, Woodland CA 95776	
38	LAR	7.3	R	RM	38.5610	-121.4154	38.5614	-121.4168	1	295-0040-012	7.08	Public	Sacramento		Sacramento, Ca 95825	
38	LAR	7.3	R	RM	38.5610	-121.4154	38.5614	-121.4168	1	295-0040-004	16.03	Public	Sacramento		1000 University Ave, Sacramento Ca 95825	
39	NCC	3	L	LM	38.8042	-121.5745	38.8039	-121.5751	1, 4, 5	35-130-001	95.93	Vacant	Sutter		Hwy 99 Pleaseant Grove CA 95668	
40	Sac	21.5	L	RM	38.2006	-121.5577	38.2002	-121.5578	1, 8, 9	156-0030-001	137.82	Ag	Sacramento		15277 Isleton Road, Isleton CA 95641	
41	Sac	22.5	L	RM	38.2134	-121.5573	38.2111	-121.5571	1, 8, 9	156-0020-016	50	Ag	Sacramento		Isleton Road, Sacramento Ca 95841	
41	Sac	22.5	L	RM	38.2134	-121.5573	38.2111	-121.5571	1, 8, 9	156-0020-066	67.85	Ag	Sacramento		14901 Isleton Road, Isleton Ca 95641	
42	Sac	22.7	L	RM	38.2190	-121.5568	38.2181	-121.5569	1, 8, 9	156-0020-065	45.67	Ag	Sacramento		Isleton Road, Isleton CA 95641	
43	Sac	23.2	L	RM	38.2249	-121.5558	38.2232	-121.5558	1, 8, 10	156-0010-023	100.15	Ag	Sacramento		Isleton Road, Sacramento Ca 95841	

43	Sac	23.2	L	RM	38.2249	-121.5558	38.2232	-121.5558	1, 8, 10	156-0020-001	76.22	Ag	Sacramento		14825 Isleton Road, Isleton Ca 95641	
44	Sac	23.3	L	RM	38.2273	-121.5557	38.2266	-121.5557	1, 8, 9, 10	156-0010-023	100.15	Ag	Sacramento		Isleton Road, Sacramento Ca 95841	
45	Sac	24.8	L	RM	38.2405	-121.5441	38.2408	-121.5468	1, 8, 10	156-0010-008	45.07	Ag	Sacramento		14001 Isleton Road, Isleton CA 95641	
45	Sac	24.8	L	RM	38.2405	-121.5441	38.2408	-121.5468	1, 8, 10	156-0010-050	78.86	Ag	Sacramento		14087 Isleton Road, Isleton CA 95641	
46	Sac	25.2	L	RM	38.2391	-121.5377	38.2393	-121.5388	1, 8, 9, 10	156-0010-044	44.56	Ag	Sacramento		Isleton Road, Sacramento Ca 95841	
46	Sac	25.2	L	RM	38.2391	-121.5377	38.2393	-121.5388	1, 8, 9, 10	156-0010-043	2	SFR	Sacramento		13851 Isleton Road, Isleton Ca 95641	
46	Sac	25.2	L	RM	38.2391	-121.5377	38.2393	-121.5388	1, 8, 9, 10	156-0010-010	40	SFR	Sacramento		13783 Isleton Road, Isleton Ca 95641	
47	Sac	31.6	R	RM	38.2957	-121.5662	38.2948	-121.5653	1, 2, 3	142-0030-005	49.82	Ag	Sacramento		12710 State Highway 160, Walnut Grove CA 9569	
47	Sac	31.6	R	RM	38.2957	-121.5662	38.2948	-121.5653	1, 2, 3	142-0030-004	0.56	SFR	Sacramento		12680 State Highway 160, Walnut Grove CA 95690	
48	Sac	35.3	R	RM	38.3421	-121.5614	38.3416	-121.5617	1, 4, 5, 10	043-070-13-1	71.79	Ag	Yolo		40918 S River Road, Clarksburg Ca 95612	
49	Sac	35.4	R	RM	38.3438	-121.5597	38.3437	-121.5599	1, 4, 5, 10	034-070-12-1	197	Ag	Yolo		4073034S River Road, Clarksburg CA 95612	
50	Sac	38.5	R	RM	38.3719	-121.5235	38.3709	-121.5230	1, 2, 3, 10	043-090-10-1	243.18	Ag	Yolo		S River Road, Clarksburg CA 95612	
51	Sac	56.5	R	RM	38.5513	-121.5143	38.5503	-121.5140	1, 6, 7	046-010-14-1	6.19	Resider	Yolo		2590 S River Road, West Sacramento CA 95691	
52	Sac	56.6	L	RM	38.5520	-121.5123	38.5518	-121.5122	1, 4, 5	012-0010-032	1.07	Public	Sacramento		Sacramento CA 95818	
53	Sac	56.7	R	RM	38.5541	-121.5156	38.5524	-121.5150	1, 6, 7	046-010-44-1	9.09	Recreat	Yolo		S River Road, West Sacramento CA 95691	
54	Sac	58.4	L	RM	38.5934	-121.5063	38.5922	-121.5058	1, 2, 3	009-0012-073	2.18	Public	Sacramento		Sacramento, CA 95818	
54	Sac	58.4	L	RM	38.5934	-121.5063	38.5922	-121.5058	1, 2, 3	009-0012-045	0.55	Public	Sacramento		Sacramento, CA 95818	
55	Sac	60.1	L	RM	38.5716	-121.5136	38.5710	-121.5145	1, 4, 5	001-0190-009	1.62	Public	Sacramento		Jibboom Street, Sacramento CA 95811	
55	Sac	60.1	L	RM	38.5716	-121.5136	38.5710	-121.5145	1, 4, 5	001-0190-001	0.92	Public	Sacramento		Sacramento CA 95814	
55	Sac	60.1	L	RM	38.5716	-121.5136	38.5710	-121.5145	1, 4, 5	001-0190-012	0.14	Public	Sacramento		Sacramento CA 95814	
56	Sac	62.9	R	RM	38.6013	-121.5532	38.6009	-121.5528	1, 6, 7	014-600-34-1	1.4	Vacant	Yolo		N Harbor Blvd, West Sacramento CA	
56	Sac	62.9	R	RM	38.6013	-121.5532	38.6009	-121.5528	1, 6, 7	014-980-03		Unknov	Yolo		West Sacramento, CA 95605	
57	Sac	63	R	RM	38.6018	-121.5541	38.6016	-121.5539	1, 6, 7	014-600-34-1	1.4	Vacant	Yolo		N Harbor Blvd, West Sacramento, CA	
57	Sac	63	R	RM	38.6018	-121.5541	38.6016	-121.5539	1, 6, 7	014-600-15-1	2	Service	Yolo		N Harbor Blvd, West Sacramento, CA	
58	Sac	74.4	R	RM	38.7213	-121.6064	38.7177	-121.6079	1, 6, 7	057-110-03-1	319.13	Ag	Yolo		14914-28CR 117, West Sacramento Ca 95691	
58	Sac	74.4	R	RM	38.7213	-121.6064	38.7177	-121.6079	1, 6, 7	057-120-01-1	254.03	Ag	Yolo		15124 County Road 117/ 15090, West Sacramento CA 95691	
59	Sac	75.3	R	RM	38.7105	-121.6123	38.7084	-121.6150	1, 2, 3	057-060-07-1	485.68	Ag	Yolo		1405284 County Road 117, West Sacramento, CA 95691	
59	Sac	75.3	R	RM	38.7105	-121.6123	38.7084	-121.6150	1, 2, 3	057-110-01-1	100.56	Ag	Yolo		1413038 County Road 117, West Sacramento, CA 95691	
59	Sac	75.3	R	RM	38.7105	-121.6123	38.7084	-121.6150	1, 2, 3	057-110-03-1	319.13	Ag	Yolo		14914-28CR 117, West Sacramento Ca 95691	
60	Sac	77.7	R	RM	38.7653	-121.5950	38.7648	-121.5948	1, 2, 3	057-040-02-1	585.72	Ag	Yolo		County Road 107A, West Sacramento Ca 95697	
61	Sac	78.3	L	RM	38.7745	-121.5989	38.7729	-121.5978	1, 2, 3	35-020-010	6.82	Ag	Sutter		CA	
62	Sac	86.3	L	RM	38.7773	-121.6860	38.7704	-121.6906	1, 2, 3	34-022-007	1.76	Vacant	Sutter		Knights Landing CA 95645	
63	Sac	86.5	R	RM	38.7773	-121.6866	38.7771	-121.6865	1, 6, 7	056-170-17-1	22.14	Ag	Yolo		Knights Landing Ca 95645	
63	Sac	86.5	R	RM	38.7773	-121.6866	38.7771	-121.6865	1, 6, 7	056-220-20-1	45.88	Ag	Yolo		County Road 116B, Woodland CA 95776	
64	Sac	86.9	R	RM	38.7804	-121.6882	38.7790	-121.6873	1, 6, 7	056-170-16-1	27.1	Ag	Yolo		10785 County Road 116B, Woodland CA 95776	
64	Sac	86.9	R	RM	38.7804	-121.6882	38.7790	-121.6873	1, 6, 7	056-170-17-1	22.14	Ag	Yolo		Knights Landing CA 95645	
65	Sac	92.8	L	RM	38.8404	-121.7269	38.8388	-121.7302	1, 2, 3, 10	29-190-040	29	Ag	Sutter		Cranmore Road, Knights Landing Ca 95645	
65	Sac	92.8	L	RM	38.8404	-121.7269	38.8388	-121.7302	1, 2, 3, 10	29-190-039	33	Ag	Sutter		19760 Cranmore Road, Knights Landing, Ca 95645	
66	Sac	95.8	L	RM	38.8706	-121.7521	38.8719	-121.7493	1, 2, 3	29-180-014	2.34	Ag	Sutter		Cranmore Road, Knights Landing Ca 95645	
67	Sac	96.2	L	RM	38.8692	-121.7564	38.8705	-121.7522	1, 2, 3	29-180-014	2.34	Ag	Sutter		Cranmore Road, Knights Landing Ca 95645	
67	Sac	96.2	L	RM	38.8692	-121.7564	38.8705	-121.7522	1, 2, 3	29-180-003	0.82	Utilities	Sutter		Cranmore Road, Knights Landing Ca 95645	
67	Sac	96.2	L	RM	38.8692	-121.7564	38.8705	-121.7522	1, 2, 3	29-180-027	1.06	Utilities	Sutter		Cranmore Road, Knights Landing Ca 95645	
67	Sac	96.2	L	RM	38.8692	-121.7564	38.8705	-121.7522	1, 2, 3	29-180-020	17.79	Vacant	Sutter		Knights Landing CA 95645	
68	Sac	99	L	RM	38.8619	-121.7841	38.8574	-121.7839	1, 2, 3, 10	29-180-015	98.92	Vacant	Sutter		Cranmore Road, Knights Landing Ca 95645	
69	Sac	101.3	R	RM	38.8751	-121.8136	38.8749	-121.8130	1, 6, 7, 10	053-120-06-1	234.36	Ag	Yolo		4795 Hwy 45, Knights Landing Ca 95645	
70	Sac	103.4	L	RM	38.9011	-121.8026	38.9009	-121.8027	1	29-020-009	4.13	Ag	Sutter		Knights Landing CA 95645	
71	Sac	104	L	RM	38.9027	-121.7909	38.9014	-121.8012	1, 2, 3	29-020-013	2.69	Ag	Sutter		Cranmore Road, Knights Landing Ca 95645	
71	Sac	104	L	RM	38.9027	-121.7909	38.9014	-121.8012	1, 2, 3	29-020-014	5.74	Ag	Sutter		15503 Cranmore Road, Knights Landing CA 95645	
71	Sac	104	L	RM	38.9027	-121.7909	38.9014	-121.8012	1, 2, 3	29-020-010	105.26	Ag	Sutter		Knights Landing CA 95645	
71	Sac	104	L	RM	38.9027	-121.7909	38.9014	-121.8012	1, 2, 3	29-020-009	4.13	Ag	Sutter		Knights Landing CA 95645	
72	Sac	104.5	L	RM	38.9066	-121.7928	38.9040	-121.7904	1, 4, 5	SSJJD?						
73	Sac	116	L	RM	39.0014	-121.8029	38.9997	-121.8009	1, 4, 5	SSJJD?						
73	Sac	116	L	RM	39.0014	-121.8029	38.9997	-121.8009	1, 4, 5	24-090-017						
73	Sac	116	L	RM	39.0014	-121.8029	38.9997	-121.8009	1, 4, 5	24-090-018	150	Vacant	Sutter		9260 Cranmore Road, Meridian CA 95957	
74	Sac	116.5	L	RM	39.0062	-121.8125	39.0033	-121.8050	1, 4, 5	24-010-006	1	Grazing	Sutter		Cranmore Road, Meridian CA 95957	
74	Sac	116.5	L	RM	39.0062	-121.8125	39.0033	-121.8050	1, 4, 5	24-009-001	112	Vacant	Sutter		Meridian Ca 95957	
75	Sac	122	R	RM	39.0640	-121.8393	39.0634	-121.8389	1, 6, 7, 10	19-120-011	12	Ag	Colusa		CA	
76	Sac	122.3	R	RM	39.0663	-121.8436	39.0659	-121.8429	1, 6, 6, 10	19-120-011	12	Ag	Colusa		CA	
76	Sac	122.3	R	RM	39.0663	-121.8436	39.0659	-121.8429	1, 6, 6, 10	19-120-009	17	Ag	Colusa		Colusa CA 95932	
77	Sac	123.3	L	RM	39.0692	-121.8580	39.0693	-121.8576	1, 6, 7	21-050-047	4	Ag	Sutter		Meridian Ca 95957	
78	Sac	123.7	R	RM	39.0666	-121.8672	39.0667	-121.8668	1, 4, 5	19-120-017	2.9	Ag	Colusa		Colusa CA 95932	
79	Sac	127.9	R	RM	39.1007	-121.9042	39.1001	-121.9039	1, 2, 3, 10	19-030-043	18.5	Ag	Colusa		Colusa CA 95932	
80	Sac	131.8	L	RM	39.1320	-121.9365	39.1317	-121.9362	1, 4, 5	13-060-038	314.1	Vacant	Sutter		17288 Kilgore Road, Meridian CA 95957	
81	Sac	132.9	R	RM	39.1442	-121.9356	39.1445	-121.9376	1, 4, 5	17-080-062	7.7	Ag	Colusa		Colusa CA 95932	
81	Sac	132.9	R	RM	39.1442	-121.9356	39.1445	-121.9376	1, 4, 5	17-080-064	3.8	Ag	Colusa		Colusa CA 95932	
82	Sac	133	L	RM	39.1424	-121.9327	39.1438	-121.9360	1, 4, 5	13-060-002	58.8	Ag	Sutter		17077 Kilgore Road, Meridian CA 95957	

83	Sac	133.8	L	RM	39.1427	-121.9184	39.1422	-121.9187	1, 4, 5	13-060-010	53.59	Ag	Sutter		900 S Meridian Road, Meridian Ca 95957	
84	Sac	136.6	L	RM	39.1739	-121.9388	39.1723	-121.9379	1, 4, 5	13-010-036	58	Ag	Sutter		3207B N Meridian Road, Meridian CA 95957	
84	Sac	136.6	L	RM	39.1739	-121.9388	39.1723	-121.9379	1, 4, 5	13-010-007	20.25	Ag	Sutter		2991 N Meridian Road, Meridian Ca 95957	
85	Sac	138.1	L	RM	39.1932	-121.9358	39.1900	-121.9342	1, 4, 5, 10	08-140-020	2.3	Ag	Sutter		4500 Marty Road, Meridian CA 95957	
86	Sac	152.8	L	RM	39.2852	-122.0153	39.2846	-122.0157	1, 6, 7	12-270-030	59.07	Ag	Colusa		Colusa CA 95932	
87	Sac	163	L	RM	39.3996	-122.0035	39.3964	-122.0026	1, 6, 7	013-170-001-0	5	Ag	Glenn		Butte City, Ca 95920	
87	Sac	163	L	RM	39.3996	-122.0035	39.3964	-122.0026	1, 6, 7	013-170-003-0	40.45	Waste I	Glenn		CA	
88	Sac	168.3	L	RM	39.4552	-121.9944	39.4536	-121.9943	1, 6, 7, 10	016-060-011-9	9.83	Ag	Glenn		Butte City, Ca 95920	
89	Sac	172	L	RM	39.5566	-122.0035	39.5539	-122.0026	1, 6, 7	016-030-014	20.3	Waste I	Glenn		Butte City, Ca 95920	
89	Sac	172	L	RM	39.5566	-122.0035	39.5539	-122.0026	1, 6, 7	016-030-021	11.36	Waste I	Glenn		Butte City, Ca 95920	
90	StS	18.8	R	RM	38.2126	-121.6097	38.2116	-121.6098	1, 8, 9	0177-050-130	141.14	Ag	Solano		3645 Ryer Road E, Walnut Grove CA 95690	
90	StS	18.8	R	RM	38.2126	-121.6097	38.2116	-121.6098	1, 8, 9	0177-060-040	37.4	Ag	Solano		3585 Ryer Road E, Walnut Grove Ca 95690	
91	StS	23.2	L	RM	38.2693	-121.5890	38.2786	-121.5898	1	142-0040-011	3.64	Restaur	Sacramento		13415 Grand Island Road, Walnut Grove, CA 95690	
91	StS	23.2	L	RM	38.2693	-121.5890	38.2786	-121.5898	1	142-0040-016	0.66	Public	Sacramento		Isleton Ca 95690	
92	StS	23.9	R	RM	38.2790	-121.5895	38.2865	-121.5849	1, 8, 9	142-0020-042	59.52	Ag	Sacramento		15169 Sutter Island Road, Courtland Ca 95615	
93	StS	24.7	R	RM	38.2887	-121.5837	38.2865	-121.5849	1, 8, 9	142-0020-053	38.48	Ag	Sacramento		Sutter Island Road, Sacramento, Ca 95815	
93	StS	24.7	R	RM	38.2887	-121.5837	38.2865	-121.5849	1, 8, 9	142-0020-054	1.46	SFR	Sacramento		15473 Sutter Island Road, Courtland CA 95615	
94	StS	25	L	RM	38.2934	-121.5800	38.2927	-121.5829	1, 8, 9	142-0030-013	55	Ag	Sacramento		12805 grand Island Road, Walnut Grove Ca 95690	
94	StS	25	L	RM	38.2934	-121.5800	38.2927	-121.5829	1, 8, 9	142-0030-016	83.63	Ag	Sacramento		12579 Grand Island Road, Walnut Grove CA, 95690	
95	StS	25.8	R	RM	38.3023	-121.5300	38.3017	-121.5796	1, 8, 9	142-0010-028	59.04	Ag	Sacramento		Sutter Island Road, Courtland Ca 95615	
96	StS	26	L	RM	38.3031	-121.5774	38.3026	-121.5783	1, 8, 9	142-0030-029	3.13	Marina	Sacramento		12530 Grand Island Road, Walnut Grove CA 95690	
97	SS	24.7	R	RM	38.2955	-121.6056	38.2909	-121.6044	1, 8, 9	0042-200-430	80.26	Ag	Solano		Solano CA 95620	
97	SS	24.7	R	RM	38.2955	-121.6056	38.2909	-121.6044	1, 8, 9	0042-200-220	100.65	Ag	Solano		Solano Ca 95620	
98	SS	26.5	L	RM	38.3154	-121.5915	38.3140	-121.5922	1, 8, 9	142-0010-033	179.8	Ag	Sacramento		Sutter Slough Road, Courtland Ca 95615	
99	WS	0.2	L	LM	38.5908	-121.6649	38.5909	-121.6597	1	042-140-13-1	224.38	Ag	Yolo		23 Russell Blvd, Davis CA 95616	
100	WS	0.7	L	LM	38.5905	-121.6751	38.5907	-121.6678	1	042-140-09-1	190.44	Ag	Yolo		45400 County Road 28H, Davis CA 95618	
101	WS	6.9	R	LM	38.5789	-121.6474	38.5770	-121.6472	1, 2, 3	042-240-18-1	199.82	Ag	Yolo		Woodland, Ca 95695	
102	YBP2	0.1	R	LM	38.6732	-121.6717	38.6721	-121.6715	1, 2, 3	057-190-11-1			Yolo			
103	YBP2	2	R	LM	38.6489	-121.6667	38.6482	-121.6664	1, 2, 3	042-180-03-1	472.8	Ag	Yolo		County Road 25, Woodland Ca 95776	
104	YBP1	2.5	R	LM	38.7269	-121.6601	38.7264	-121.6601	1, 2, 3	057-070-02-1	195.21	Ag	Yolo		Woodland, Ca 95695	
104	YBP1	2.5	R	LM	38.7269	-121.6601	38.7264	-121.6601	1, 2, 3	057-090-07-1	26.42	Ag	Yolo		Woodland, Ca 95695	
104	YBP1	2.5	R	LM	38.7269	-121.6601	38.7264	-121.6601	1, 2, 3	057-100-01-1	920	Ag	Yolo		T10N R3E Por Sec 4 & 5, Woodland Ca	
105	YBP1	2.6	R	LM	38.7255	-121.6620	38.7244	-121.6645	1	057-090-07-1	26.42	Ag	Yolo		Woodland Ca 95695	
105	YBP1	2.6	R	LM	38.7255	-121.6620	38.7244	-121.6645	1	057-100-05-1	124.5	Ag	Yolo		Woodland Ca 95695	
106	YBP2	3.8	R	LM	38.6222	-121.6483	38.6183	-121.6454	1, 2, 3	042-210-01-1	160	Ag	Yolo		Woodland Ca 95695	
106	YBP2	3.8	R	LM	38.6222	-121.6483	38.6183	-121.6454	1, 2, 3	042-210-02-1						
107	YR	2.3	L	LM	39.1532	-121.5143	39.1504	-121.5174	1, 2, 10	18-190-001-0	26	Ag	Yuba		Marysville, Ca 95901	
107	YR	2.3	L	LM	39.1532	-121.5143	39.1504	-121.5174	1, 2, 10	18-140-040-0	280.63	Ag	Yuba		7015 Dantoni Road, Marysville CA 95901	

EXHIBIT C

PARCEL INFORMATION SHEET

BENDER ROSENTHAL, INC.
COMMERCIAL VALUATION AND RIGHT OF WAY SERVICES

4400 Auburn Boulevard, Suite 102
Sacramento, CA 95841
main: 916.978.4900 • *fax:* 916.978.4904
www.benderrosenthal.com

SRBPP - Project Site Information Sheet

BRI Site No. ______________ **DWR Site No.** ______________

Site Location: Sacramento River RM 77.2L **Site Length:** 377 Feet

	Upstream Waypoint	Downstream Waypoint	Midpoint
Latitude:	-121.5919669	-121.5921838	N/A
Longitude:	38.76106172	38.75920993	N/A

Type of Repair: ☐ rip-rap ☐ rock benches ☐ setback levee ☐ other

Construction: ☐ landside ☐ waterside

Construction Contract Work:

Ayres Memorandum dated January 19, 2008

Design Submittal:

Plats: Date ______________ Received Date ______________

Legals: Date ______________ Received Date ______________

Construction Plans:	**30%**	**60%**	**90%**	**100%**
Date:				
Received Date:				

No. of Parcels per Project Site: 2 parcels (2 property owners)

Rights Required:	(Owner 1)	(Owner 2)	(Owner 3)
Last Name			
APN:	35-030-008	35-362-001	
Scoping PTE			
Secured? Y/N			
Effective Date			
Expiration Date:			
Fee (acres)			
Easement (type)			
Size (acres):			
TCE (acres):			
Timeline:			
Mitigation (type)			
Size (acres):			

Encroachment Ranking # ______________

Technical Priority Ranking # ______________

RE Delivery Ranking # ______________

SRBPP – Parcel Information Sheet

Owner No. 1 **BRI Site No. ________ DWR Site No. ____________**

Name: ____
Mailing Address: ____________________________________
APN: 35-030-008

Existing Rights:
Preliminary Title Report: ☒ Not ordered ☐ Ordered Date: ____________
Easement interest: ____________________________________

Agreements (JUA, CCUA, etc) with: ____________________________
Leases: ____________
Zoning: ____________
Encroachments: Permitted ☐ Yes ☐ No ☐ Both
Describe Encroachments: See attached
Modification/Relo/Removal Notification Request sent to Owner: ____________________

Encroachment Ranking # ________

Rights Required:
Scoping PTE: Secured (Y)____ (N)____(Effective date__________ & Expiration date __________)
Fee ____ ac Easement____ac (Type) _______________ Setback Levee ________ac
Mitigation ____ ac TCE ____ ac (Timeline________________)
Description of work/mitigation fulfillment: ____________________________

Technical Priority Ranking #____

RE Impact Analysis:
Improvements impacted: (Description) ____________________________
Damages: ☐ Yes ☐ No ____________________________

RAP required: ☐ Yes ☐ No ____________________________

Improvement modification/removal: ☐ Yes ☐ No ____________________________

Construction Contract Work: ____________________________

RE Delivery Ranking # ______ Rank 1 (6-12 months), Rank 2 (12-18 months), Rank 3 (18-24 months)

Property Detail Report for:

DIGITAL MAP PRODUCTS | Beyond Mapping

RIEGO RD, SACRAMENTO CA , 95837-

Owner Information:

Owner Name:			
Mailing Address:			
Vesting Code:	TRUST	Phone Number:	

Location Information:

Legal Description:					
County:	SUTTER	FIPS Code:	06101	Census Trct/Blk:	0071002 / 2
APN:	35030008	Alternative APN:	35030008	Map Ref:	-
Twnshp-Rnge-Sect:	- -	Legal Book/Page:	35-03 /	Tract No:	
Legal Lot:	64	Legal Block:			
Subdivison:	NATOMAS BENNETT				

Last Market Sale Information:

Sale Date:		Sale Price:		1st Mtg Amount:	
Sale Doc No:		Price Per SqFt:		1st Mtg Int Type:	
Transfer Doc No:	0000027246	Price Per Acre:		2nd Mtg Amount:	
Multi/Split Sale:		1st Mtg Doc No:		2nd Mtg Int Type:	
Sale Type:					
Deed Type:					
Title Company:					
Lender:					
Seller Name:					

Property Characteristics:

Building Area:		Total Rooms:		Construction:	
Living Area:		Bedrooms		Heat Type:	
Garage Area:		Baths:		Air Cond:	
Basement Area:		Fireplace:		Roof Type:	
Parking Type:		No of Stories:		Roof Material:	
Yr Built/Effective:	/	Quality:		Style:	
Pool Code:					

Tax and Value Information:

Assessed Value:	$244,375	Assessed Year:	2008	Est Market Val:	
Land Value:	$239,692	Property Tax:	$3,796	Assessor Appd Val:	
Improvement Value:	$4,683	Improvement %:	1.91		
Total Taxable Value:	$244,375	Tax Exemption:			

Site Information:

Assessor Acres:	72.58	Zoning:		Land Use:	400
Assessor Lot SqFt:	3,161,585	No of Buildings:		Land Use Desc:	VACANT LAND (NEC)
Assessor Lot W/D:	/	Res/Comm Units:		County Use Code:	
Calculated Acres:	76.2614	Sewer Type:			
Calculated Lot SqFt:	3,321,946	Water Type:			

Not in Fault Zone Hazard
Not in One Mile Industrial Commercial Zone
In 100yr. FEMA Flood Zone
In Dam Inundation Hazard
Not in Wildland Fire Hazard
Not in Severe Fire Hazard

SRBPP – Parcel Information Sheet

Owner No. 2 **BRI Site No. ________ DWR Site No. ____________**

Name: ________________________________

Mailing Address: ________________________________

APN: 35-362-001

Existing Rights:

Preliminary Title Report: ☒ Not ordered ☐ Ordered Date: ____________

Easement interest: ________________________________

Agreements (JUA, CCUA, etc) with: ________________________________

Leases: ____________

Zoning: ____________

Encroachments: Permitted ☐ Yes ☐ No ☐ Both

Describe Encroachments: See attached

Modification/Relo/Removal Notification Request sent to Owner: ____________________

Encroachment Ranking # ________

Rights Required:

Scoping PTE: Secured (Y)____ (N)____(Effective date__________ & Expiration date __________)

Fee _____ ac Easement_____ ac (Type) ________________ Setback Levee ________ac

Mitigation_____ ac TCE _____ ac (Timeline________________)

Description of work/mitigation fulfillment: ________________________________

Technical Priority Ranking # _____

RE Impact Analysis:

Improvements impacted: (Description) ________________________________

Damages: ☐ Yes ☐ No ________________________________

RAP required: ☐ Yes ☐ No ________________________________

Improvement modification/removal: ☐ Yes ☐ No ________________________________

Construction Contract Work: ________________________________

RE Delivery Ranking # ______ **Rank 1 (6-12 months), Rank 2 (12-18 months), Rank 3 (18-24 months)**

Property Detail Report for:

DIGITAL MAP PRODUCTS Beyond Mapping

, NICOLAUS CA , 95659-

Owner Information:

Owner Name:			
Mailing Address:			
Vesting Code:	TRUST	Phone Number:	

Location Information:

Legal Description:

County:	SUTTER	FIPS Code:	06101	Census Trct/Blk:	/
APN:	35362001	Alternative APN:	35362001	Map Ref:	-
Twnshp-Rnge-Sect:	- -	Legal Book/Page:	35-36 /	Tract No:	
Legal Lot:	25	Legal Block:			
Subdivison:	LAUPPE				

Last Market Sale Information:

Sale Date:	12/01/1976	Sale Price:		1st Mtg Amount:	
Sale Doc No:	0000881096	Price Per SqFt:		1st Mtg Int Type:	
Transfer Doc No:	0000026414	Price Per Acre:		2nd Mtg Amount:	
Multi/Split Sale:		1st Mtg Doc No:		2nd Mtg Int Type:	
Sale Type:					
Deed Type:					
Title Company:					
Lender:					
Seller Name:					

Property Characteristics:

Building Area:		Total Rooms:		Construction:	
Living Area:		Bedrooms		Heat Type:	
Garage Area:		Baths:		Air Cond:	
Basement Area:		Fireplace:		Roof Type:	
Parking Type:		No of Stories:		Roof Material:	
Yr Built/Effective:	/	Quality:		Style:	
Pool Code:					

Tax and Value Information:

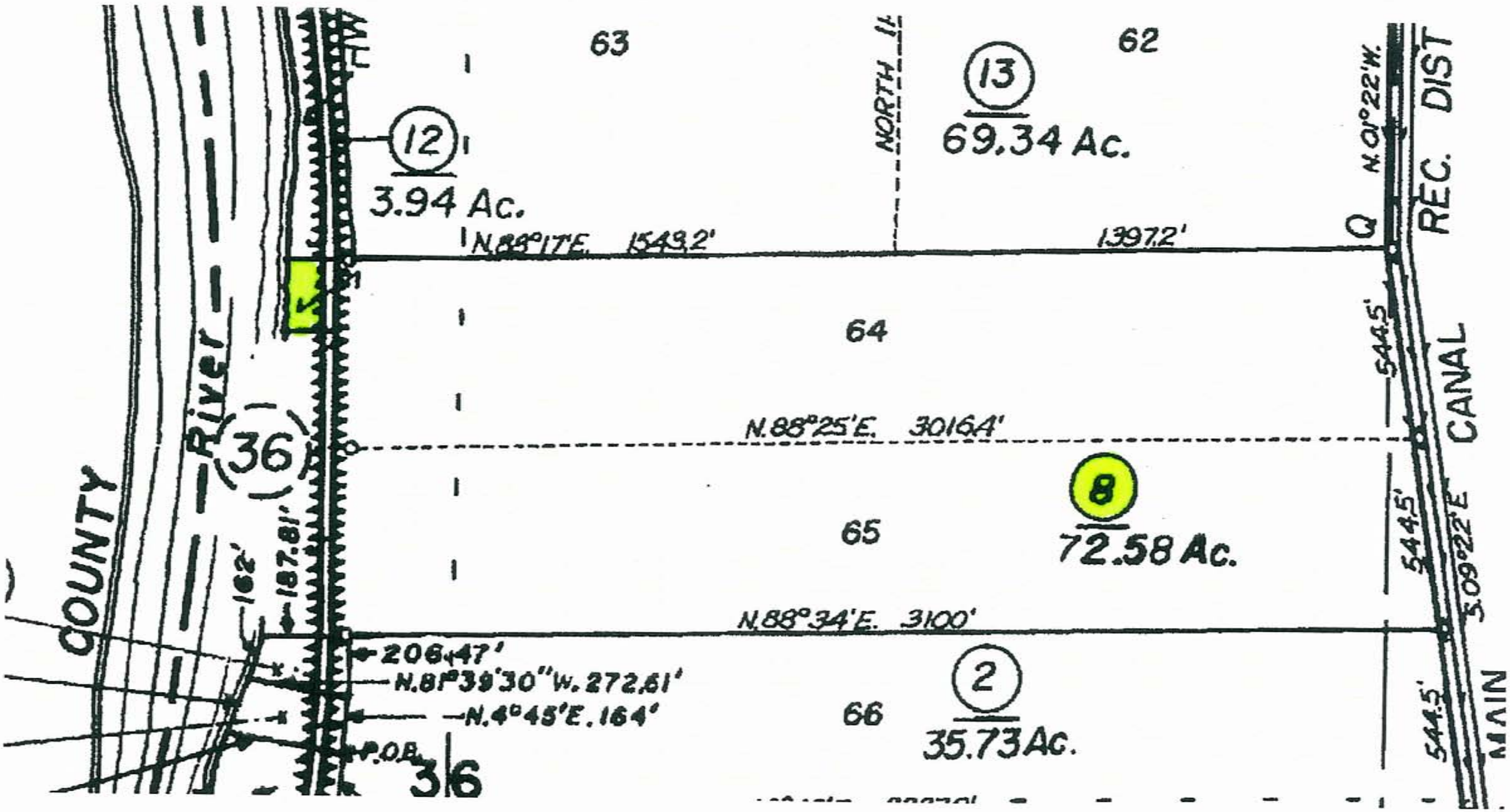
Assessed Value:	$12,559	Assessed Year:	2008	Est Market Val:	
Land Value:	$12,559	Property Tax:	$158	Assessor Appd Val:	
Improvement Value:		Improvement %:			
Total Taxable Value:	$12,559	Tax Exemption:			

Site Information:

Assessor Acres:	0.62	Zoning:		Land Use:	400
Assessor Lot SqFt:	27,007	No of Buildings:		Land Use Desc:	VACANT LAND (NEC)
Assessor Lot W/D:	/	Res/Comm Units:		County Use Code:	
Calculated Acres:	0.6404	Sewer Type:			
Calculated Lot SqFt:	27,895	Water Type:			

Not In Fault Zone Hazard
Not In One Mile Industrial Commercial Zone
In 100yr. FEMA Flood Zone
In Dam Inundation Hazard
Not In Wildland Fire Hazard
Not In Severe Fire Hazard

RM 77.2L (U)
RM 77.2L (D)
Image U.S. Geological Survey
© 2009 Tele Atlas
©2009 Google
Imagery Date May 2002
38°45'37.49" N 121°35'33.93" W elev 25 ft
Eye alt 10675 ft



63
62
13
69.34 Ac.
12
3.94 Ac.
NORTH
N.01°22'W.
REC. DIST
Q
N.88°17'E. 1543.2'
1397.2'
64
544.5'
CANAL
N.88°25'E. 3016.4'
8
72.58 Ac.
65
S.09°22'E.
River
36
COUNTY
162'
187.81'
N.88°34'E. 3100'
206.47'
N.81°39'30"W. 272.61'
N.4°45'E. 164'
P.O.B.
2
35.73 Ac.
66
36
MAIN

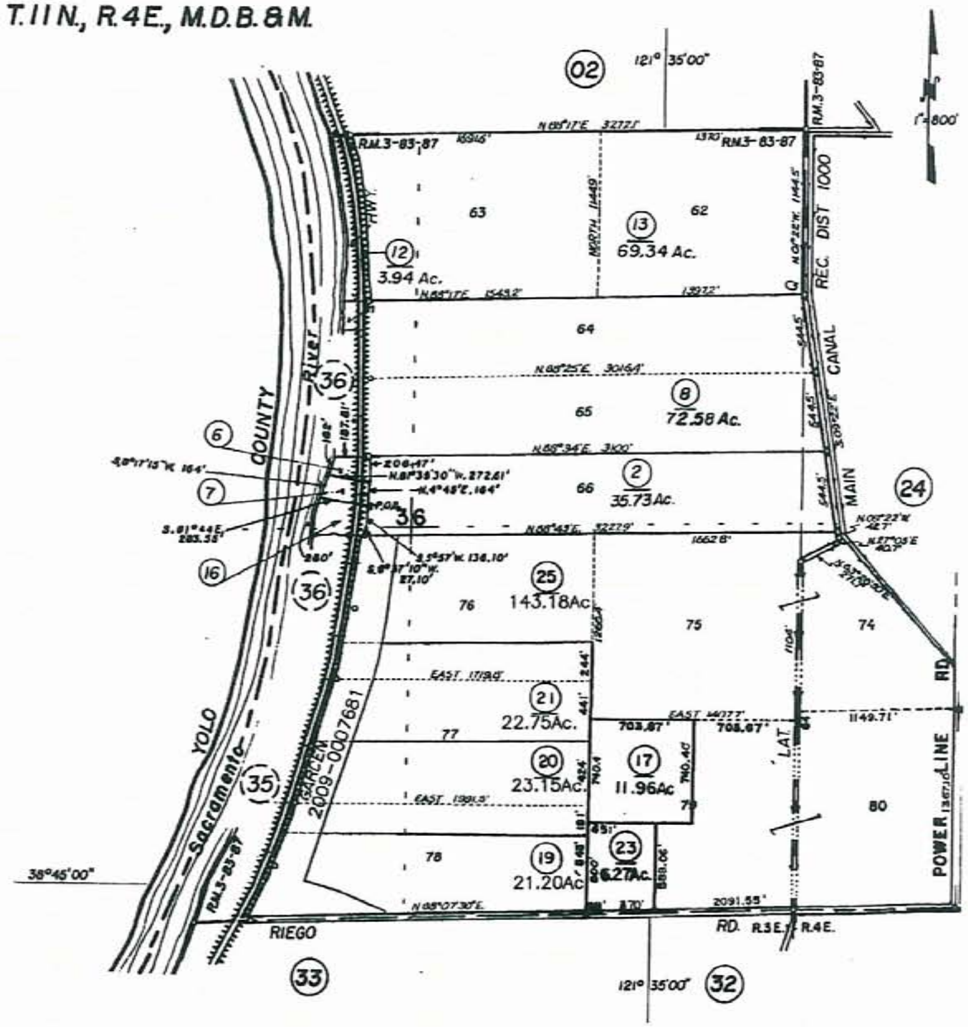
NATOMAS BENNETT SUB.

R.M. Bk. 3, Pgs. 83-87

POR. SEC. 36, T.11 N., R.3E., M.D.B.&M.

POR. SEC. 31, T.11 N., R.4E., M.D.B.&M.

Tax Area Code 62-004 **35-03**



Assessor's Map Bk. 35 - Pg. 03

County of Sutter, Calif.

2009-1

JUN 2 2 2009

NOTE—Assessor's Block Numbers Shown in Ellipses

Assessor's Parcel Numbers Shown in Circles

BENDER
ROSENTHAL, INC.
COMMERCIAL VALUATION AND RIGHT OF WAY SERVICES

N

1" = 123'

LandVision

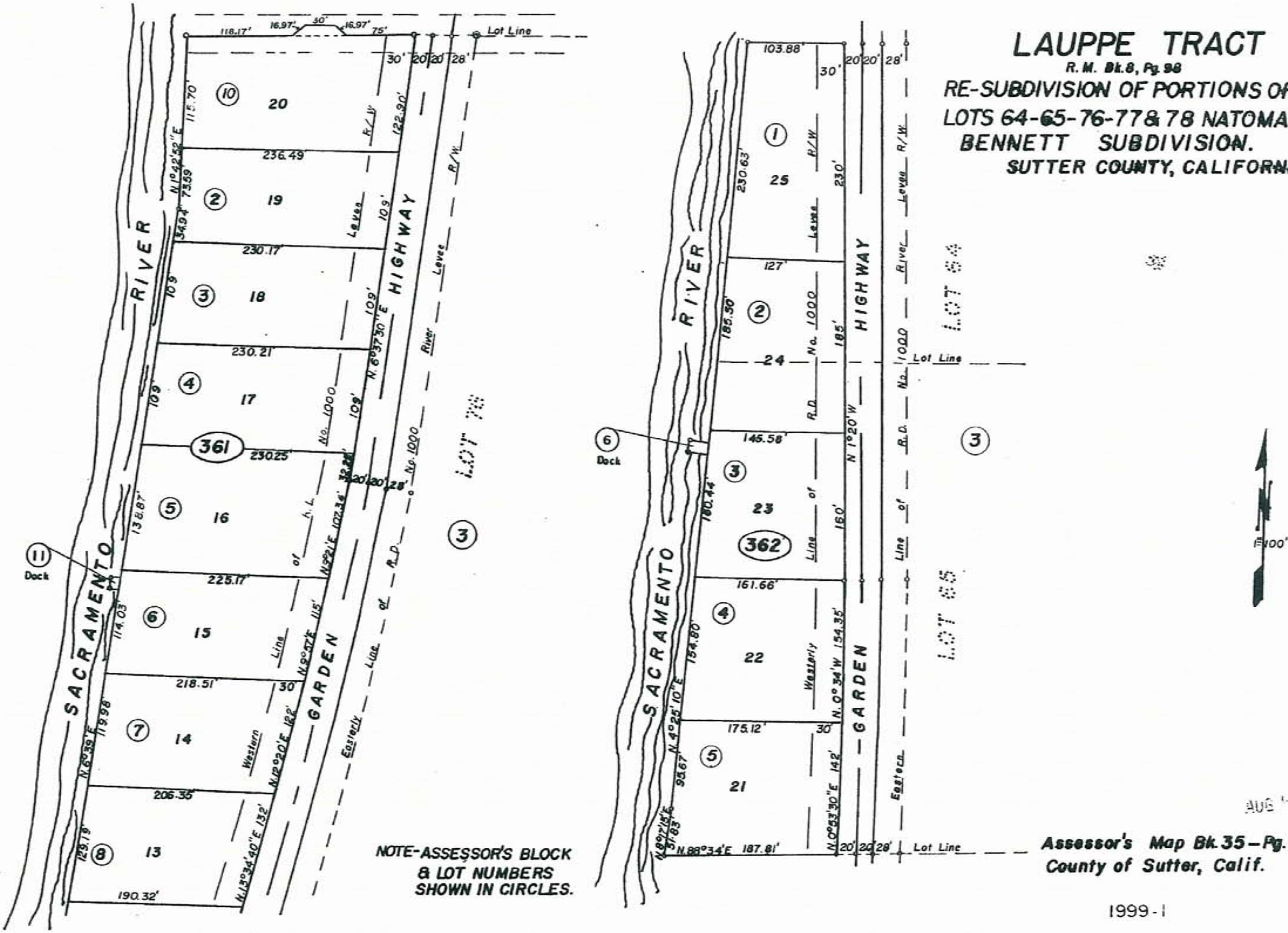
Tax Area Code 62-004

35-36

LAUPPE TRACT

R. M. Bk. 8, Pg. 98

RE-SUBDIVISION OF PORTIONS OF LOTS 64-65-76-77 & 78 NATOMAS BENNETT SUBDIVISION.
SUTTER COUNTY, CALIFORNIA.



NOTE-ASSESSOR'S BLOCK & LOT NUMBERS SHOWN IN CIRCLES.

Assessor's Map Bk. 35 - Pg. 36
County of Sutter, Calif.

1999-1

P.M.H.

AYRES ASSOCIATES

MEMORANDUM

To: Mark Boedtker, PE, Sacramento District of the Corps of Engineers

Cc: Thomas W. Smith, PE, GE

From: Anthony Alvarado, PE

Date: January 19, 2008

Re: Relocation Design Memorandum for the Pump Structure at Sacramento River Mile (SAC RM) 77.2L as part of Contract 3 of the 2008 Erosion Sites of the Sacramento River Bank Protection Project. Contract # W91238-07-D-0038 Task Order 0002.

EXISTING CONDITIONS

The erosion site at SAC RM 77.2L is located on the left bank of the Sacramento River less than 2 miles south of Verona and the confluence with the Feather River. **Figure 1** shows the project location of the erosion site. **Figure 2** shows the pump structure in the middle of the site near the largest erosion pocket. The site at SAC RM 77.2L is similar to a previously repaired erosion site at SAC RM 78.0L. There is no existing revetment apart from sporadic concrete rubble dumped within the project limits, but there is rock revetment upstream of the site. The site was added in 2000 to the erosion inventory because of the erosion pocket at the structure. There are numerous tree popouts and leaning trees.

Figure 3 shows the existing cross section at the location of the pump structure.

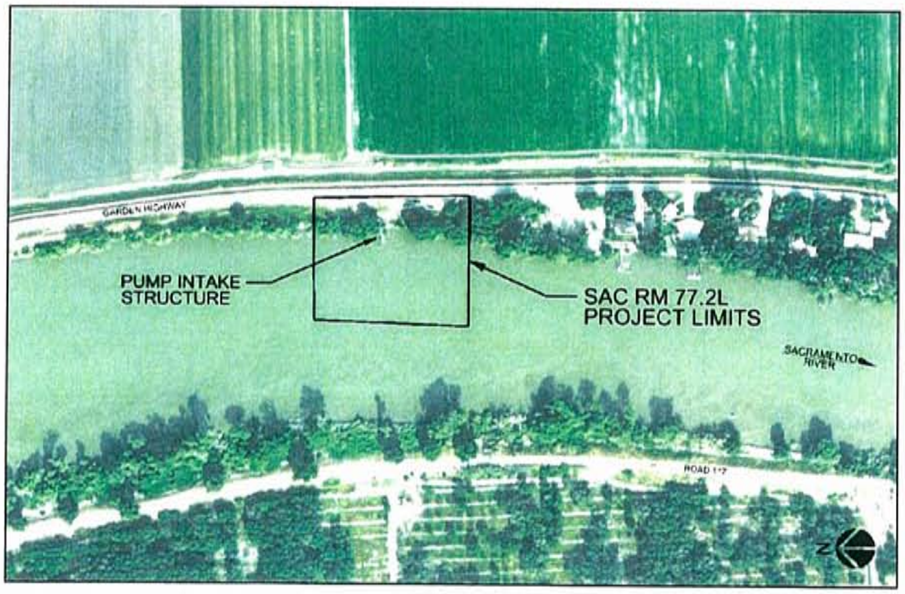


Figure 1. Plan view of the erosion site at SAC RM 77.2L.

Memorandum (continued)

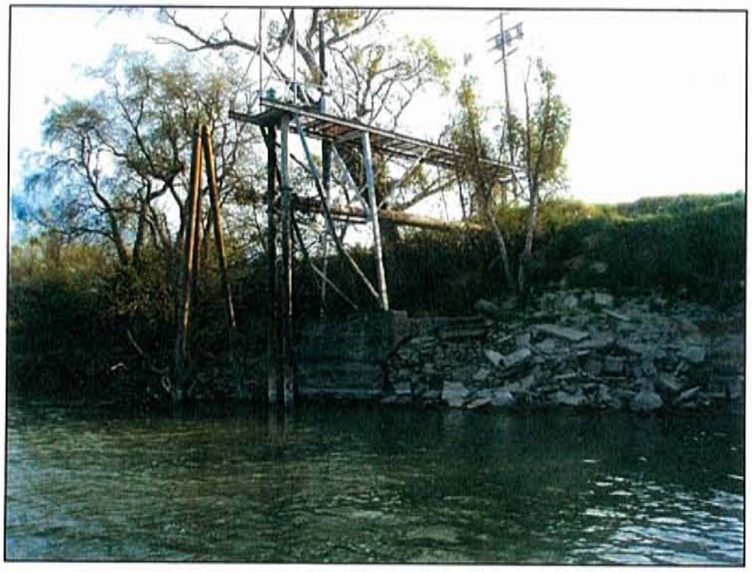


Figure 2. View from river of pump structure at SAC RM 77.2L.

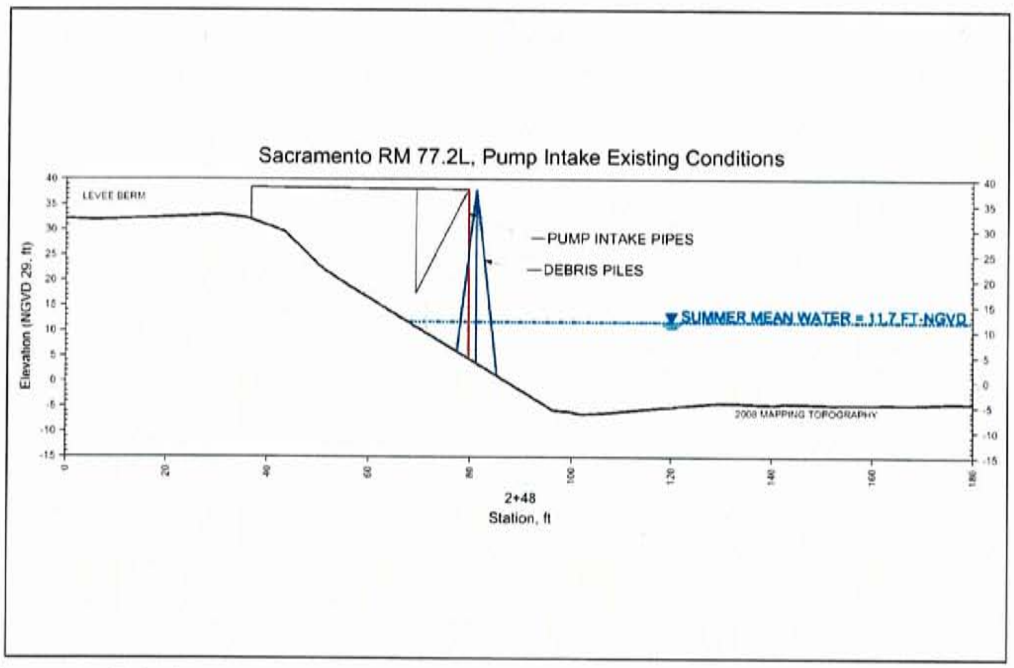


Figure 3. Existing conditions cross section at SAC RM 77.2L at the pump structure.

DESIGN CONDITIONS

In order to protect the site from further bank erosion and to stabilize the slope, bank protection has been designed for the site incorporating a mix of quarry stone, soil-filled quarry stone, and environmental features.

Figure 4 shows the design cross section along with where the pipe inlet is relative to the design. The design has a 2:1 sloped quarry stone lower surface along with roughly a 12 ft bench for planting, environmental features, and vegetation. The upper slope is designed to be 3 ft thick and also at a 2:1 slope.

As currently designed, the pipe structure inlet would be significantly buried by quarry stone due to the amount of quarry stone needed to adequately protect the slope from further erosion and slope failure.

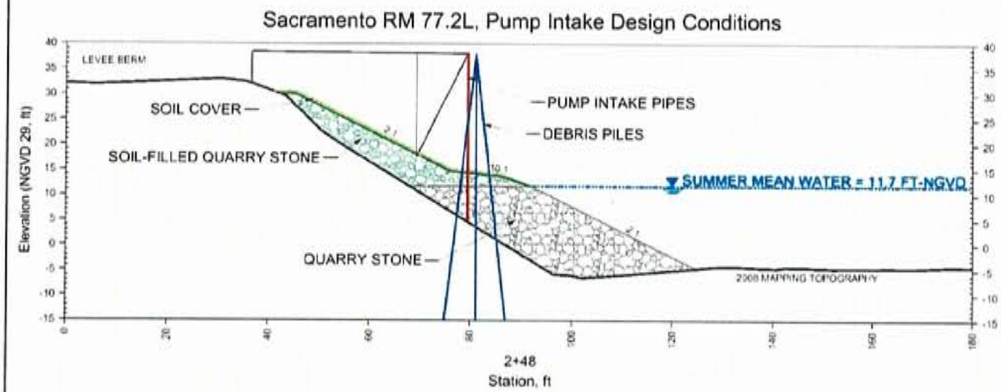


Figure 4. Design conditions cross section at SAC RM 77.2L at the pump structure location.

RECOMMENDATIONS

Ayres has analyzed 2 alternatives for the relocation of the pump structure to coordinate with the bank protection design. The bank protection design cannot be altered and must be maintained in this area otherwise the integrity of the erosion protection will be compromised. Therefore, 2 alternatives are proposed.

Alternative #1 is to build the bank protection around the existing structure after removing the pump inlet. Then the platform could be extended further out past the bank protection and a new pump inlet installed. This may be feasible but the risk is the potential damage to the existing structure during the construction of the bank protection. It will also be difficult to build a new footing on top of the quarry stone.

Alternative #2 is to remove the pump structure entirely. The designed bank protection would then be constructed. After construction, a new pump structure would be installed using new pilings or concrete footings past the toe of the quarry stone and a new structure footing at the berm with a new platform and pipe intake. Alternative #2 is shown in **Figure 5.**

Ayres recommends Alternative #2. In Alternative #1, there is too much risk of damage to the existing structure during construction and also other structural instability issues. Alternative #2 is significantly more expensive but is necessary.

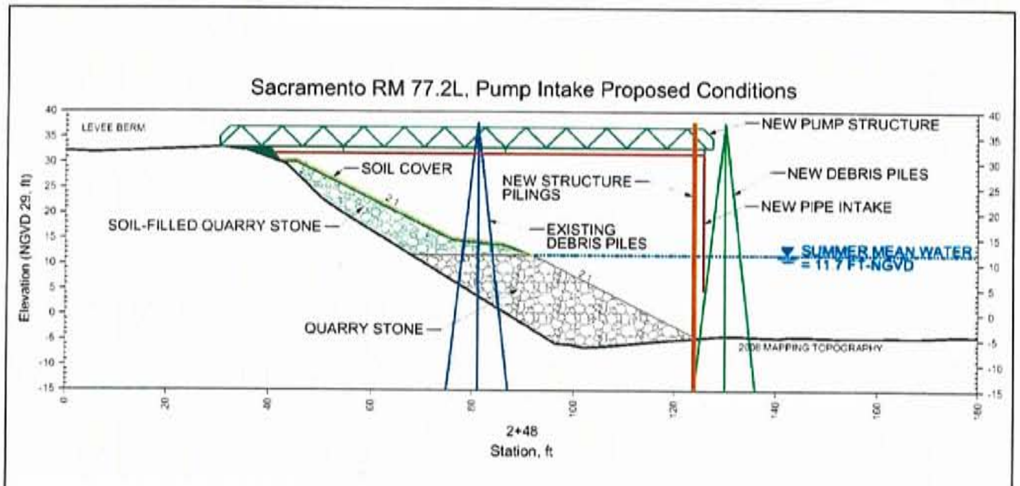


Figure 5. Proposed conditions cross section at SAC RM 77.2L at the pump structure location.

ESTIMATED RELOCATION COSTS

The cost to remove and replace the pump structure is estimated to be $391,435 and the cost for a temporary pump during construction is estimated to be about $10,000. Cost information was developed with assistance from Rain for Rent (temporary set-up) and West Coast Docks, Inc, in Walnut Grove, CA, and is summarized in **Table 1** below.

Table 1. Cost Summary.	
Temporary Pumping Setup (3 Months)	$ 10,000
Pipe Removal and Re-Installation	$391,435
Total	$401,435

Recorded Deeds

BRI Site No.:	Not assigned	(APN 35-030-008 and 35-362-001)		
Site Description:	Sacramento River, RM 77.2L (377 feet)			
Reclamation District:	RD No. 1000			
County:	Sutter			

Rights Acquired by SSJDD:	_X_ Easement	__ Fee	
DWR Deed No.:	2062	10623	13205
Deed Recording Date:	08-02-56	01-08-74	01-15-98
Book and Page:	3131 OR 148*	821 OR 92	Instr. # 199800548
Tracing No.:	---	2-1044, 6/15	2-1114, Sht. 31 of 36

Rights Acquired by RD 1000:	_X_ Easement	__ Fee		
RD 1000 Deeds:				
Deed Recording Date:	4-12-1913*	5-19-1913	9-06-1917	7-29-1992
Book and Page:	371/395	50/387	59/277	1488/300

* Recorded in Sacramento County

EXHIBIT D

SITE SPECIFIC REAL ESTATE INVENTORY CHECK LIST

SITE SPECIFIC REAL ESTATE INVENTORY CHECK LIST

The following topics will be updated and the information provide to the PDT when sites are identified and selected prior to construction. A Real Estate Addendum to this Real Estate Plan will be provided to SPD real estate for review and approval.

The numbering references the categories listed in the Table of Contents to this Real Estate Plan.

4. DESCRIPTION OF LERRD'S
5. LERRD'S OWNED BY THE NFS AND CREDITING
7. DESCRIPTION OF ANY EXISTING FEDERAL PROJECT IN OR PARTIALLY IN THE PROPOSED PROJECT
11. ANTICIPATED INCREASED FLOODING AND IMPACTS
12. COST ESTIMATE
13. RELOCATION ASSISTANCE BENEFITS
17. ACQUISITION SCHEDULE
18. DESCRIPTION OF FACILITY AND UTILITY RELOCATIONS
19. HAZARDOUS, TOXIC, AND RADIOLOGICAL WASTE IMPACTS
20. ATTITUDE OF LAND OWNERS AND COMMUNITY

EXHIBIT E

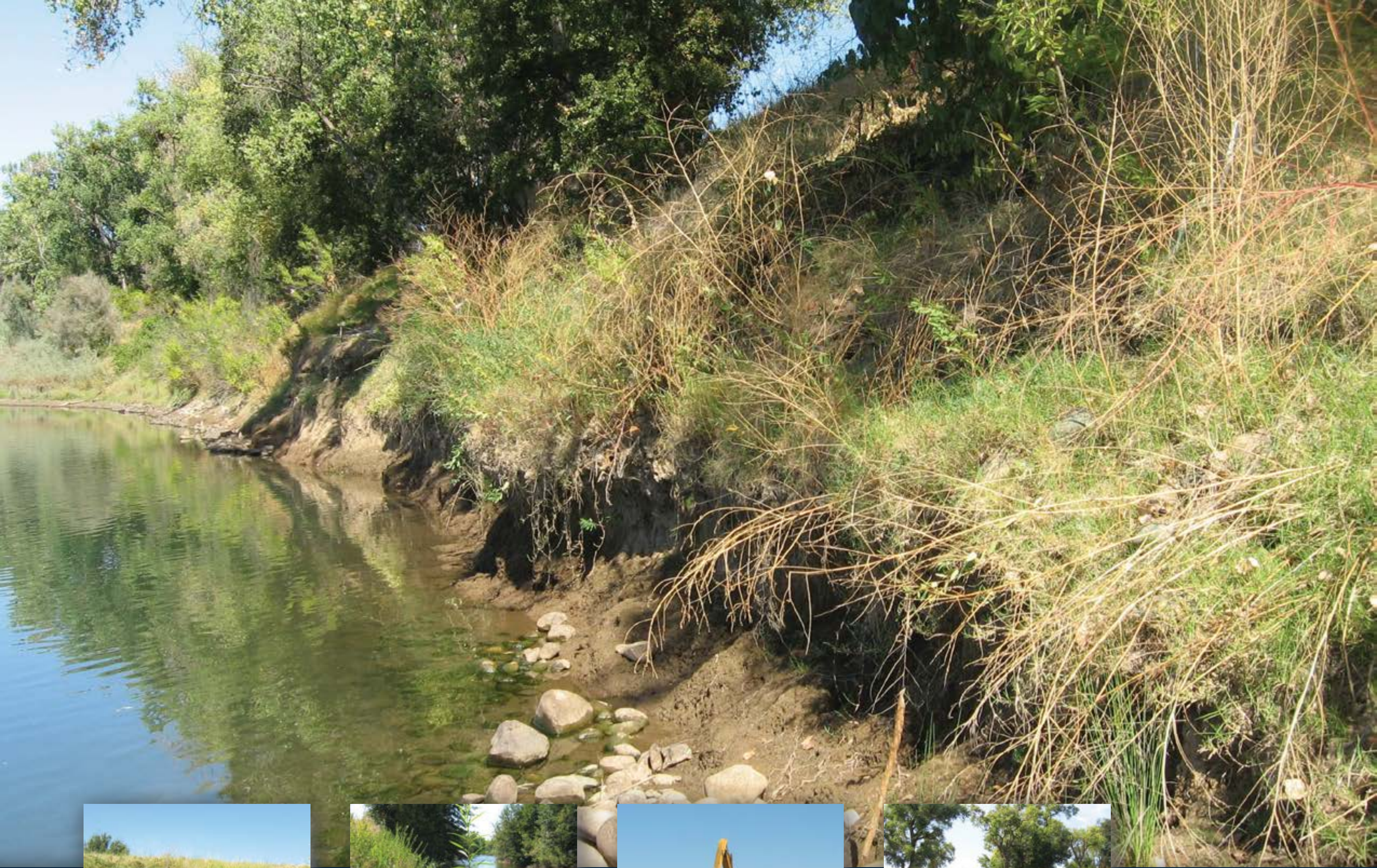
AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I, ___(*name of accountable official*)___, ______(*title*)______ for ____*(name of non-Federal sponsor)*_____, do hereby certify that the __ *(name of non-Federal sponsor)*____ has acquired the real property interests required by the Department of the Army, and construction of __*(project name, specifically identified project features, etc.)*. Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon ___*(identify tracts)*___ to construct ___*(project name, specifically identified project features, etc)*__ as set forth in the plans and specifications held in the U.S. Army Corps of Engineers'________________ District Office, ___*City and State*__.

WITNESS my signature as ____*(title)*____ for __*(name of non-Federal sponsor)*__ this _____________, 20____.

BY: ___________________________________






Economic Appendix
Draft for Agency Technical Review
Post Authorization Change Report

Sacramento River Bank Protection Project
Sacramento River Basin, California

December 2014

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Sacramento River Bank Protection Project

US Army Corps of Engineers
Sacramento District

Contents

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1. PURPOSE

This report describes the assumptions, data, methodologies, and techniques used to perform the economic analysis as part of the Sacramento River Bank Protection Project (SRBPP) Post-Authorization Change Report (PACR). The results and conclusions of the analysis are also presented in this report.

The economic analysis was originally completed in 2011 for the primary purpose of determining benefit-to-cost ratios to be used for the U.S. Army Corps of Engineers' (USACE) annual program/project economic justification. The 2011 analysis and report were essentially carried forward to this PACR but updated for price level (benefits) in 2013; costs were also revised at that time. The results of the last update in 2013 indicated that eight sub-basins (Butte Basin, Natomas, Sacramento, Southport, Sutter Island, Yolo, West Sacramento, and Rio Oso) were economically feasible. The main purposes of this report, then, are to:

- Update damages and benefits for price level, focusing on the eight sub-basins that were determined to be economically feasible from the last update
- Incorporate revised costs into the economic analysis, focusing on the eight sub-basins that were determined to be economically feasible from the last update
- Update and verify the benefit-to-cost ratios of the eight sub-basins

This document reflects several updates that have occurred during the planning process leading up to the public release. While prior analyses encompassed the entire study area, the primary focus of the updates were those economic impact areas/sub-basins determined to be economically feasible. Therefore, the analysis/values shown in Sections 9-13 below, which cover all economic impact areas/sub-basins, were not updated for price level or discount rate; these values are based on an October 2012 price level and a 3.75% federal discount rate, which was the prevailing rate at the time of the initial update (2013). Section 13 of this report describes the eight economically feasible sub-basins that were determined to be economically feasible during a second update. Finally, Section 14 describes the seven sub-basins that were determined to be economically feasible during the latest update. The updated benefits and costs for the latest update are in October 2013 prices; a federal discount rate of 3.50% was used.

2. BACKGROUND

The SRBPP is a federal program which recognizes that bank erosion control and stabilization are necessary to ensure the integrity of the Sacramento River Flood Control Project (SRFCP), which includes approximately 1,300 miles of project levees that protect approximately 2.1 million acres of agricultural and urban land uses.

The SRBPP originally consisted of two phases. Phase I was initially authorized by the Flood Control Act of 1960 and consisted of approximately 430,000 feet of levee work; Phase I work has since been completed. Phase II was authorized by the River Basin Monetary Authorization Act of 1974 and consisted of approximately 405,000 feet of levee work; there is approximately 15,646 feet of levee work remaining under the 1974 authorization, but an additional 80,000 feet was authorized by the Water Resources Development Act (WRDA) of 2007 and added to the SRBPP's Phase II work. The economic analysis presented in this report addresses the economic feasibility of potential levee stabilization work authorized under the WRDA of 2007. The USACE Sacramento District identified 106 erosion sites for this analysis; these sites were selected through field observations originally conducted in the year 2007. The original 106 erosion sites used for the aforementioned 2011 economic analysis were also used for the PACR analysis.

For purposes of providing an idea of the geographic scope, Figure 1 on the following page is a map of the SRBPP study area and levees; Figure 2 below displays the 106 erosion sites.

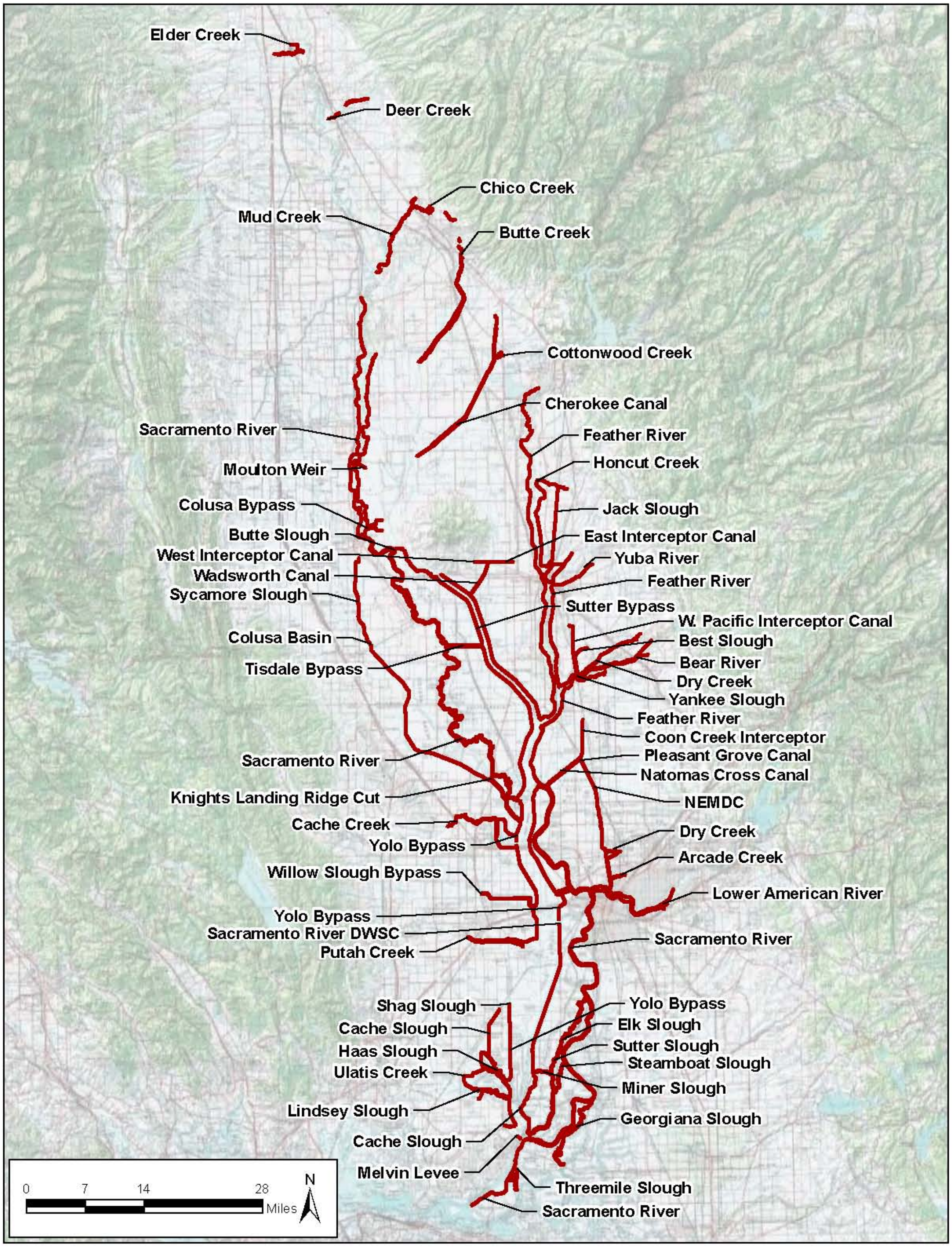

Figure 1: Geographic scope of SRBPP levees.

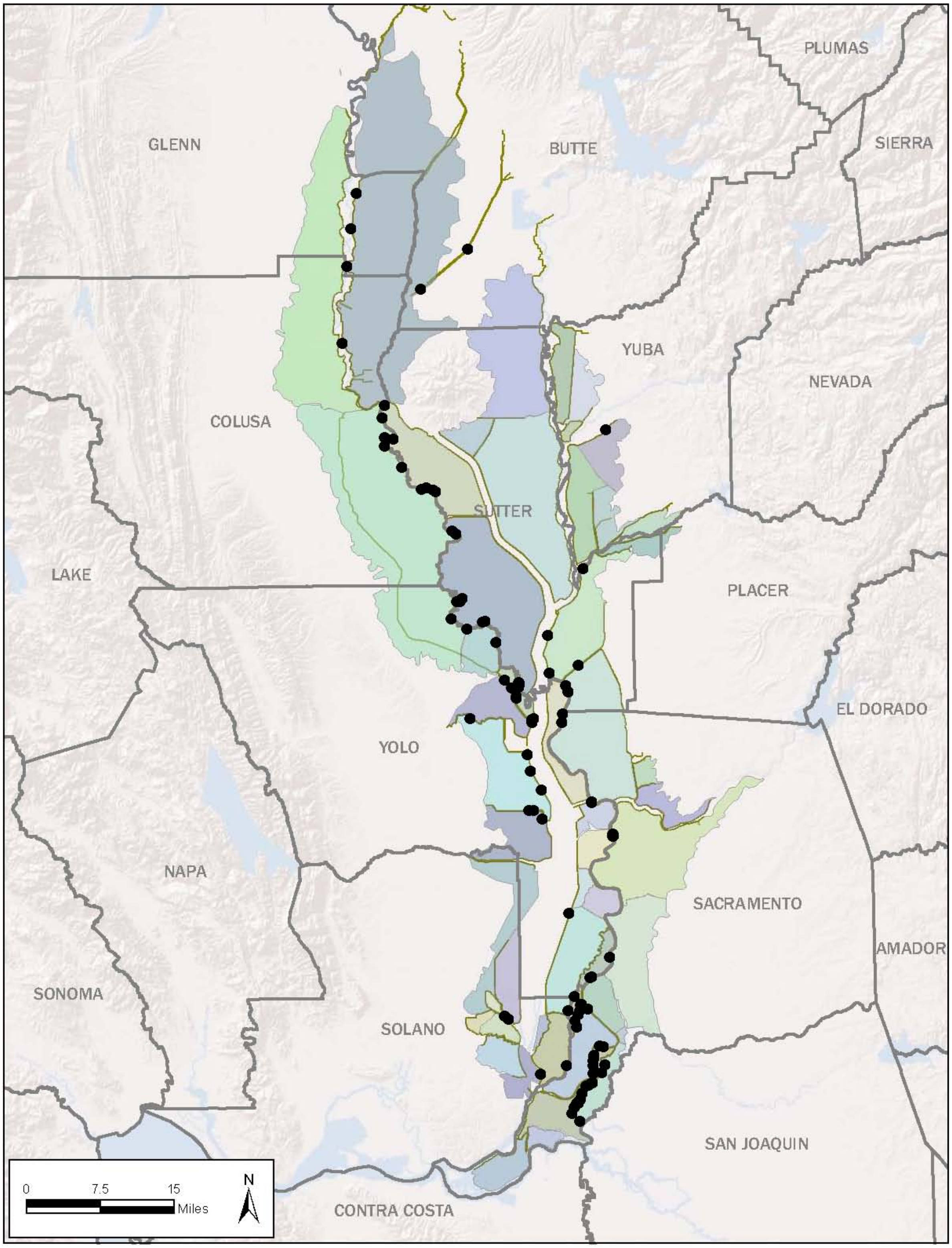

Figure 2: Geographic scope and approximate locations of 106 erosion sites.

3. PREVIOUS SRBPP ECONOMIC ANALYSES AND COMPLIANCE WITH CURRENT GUIDANCE

Previous economic analyses for the SRBPP were performed using methods that would not necessarily be relevant or sufficient under current USACE guidance. Some of the past analytical approaches used to economically justify the SRBPP include:

- Determining operation and maintenance (O&M) costs and computing benefits based on a reduction (or savings) in these costs once erosion work was completed
- Estimating benefits based on the reduction of potential inundation losses (damages prevented); damages were calculated based on the potential number of acres inundated throughout the system (assuming levee failures due to erosion) and applying gross losses per acre for rural and urban areas to the estimated number of acres
- Providing qualitative descriptions of the potential accomplishments of the SRBPP, which include protecting a large human population, protecting a significant amount of physical property, and protecting high-value agricultural acreage
- Extrapolating damages/benefits calculated by analyzing only small sections of levee repair and by assuming unusually high without-project damaging flood probabilities (annual exceedance probabilities or AEPs) normally associated with levees requiring immediate emergency repair; high AEPs are not necessarily applicable to the SRBPP levees

The economic analysis presented in this report was performed using current USACE guidance. Defined economic impact areas (rather than one large area as has been used in the past), a current economic inventory, a risk analysis approach (incorporating exceedance probability discharge curves with uncertainty, hydraulic floodplains, geotechnical fragility curves, and economic stage-damage curves), and clear, transparent descriptions of both the assumed without-project and with-project conditions were used in the analysis to estimate project benefits both as an entire system and incrementally by impact area/basin. These are discussed in more detail in the following sections of this report.

4. CONSISTENCY WITH REGULATIONS AND POLICIES

This economic analysis was performed in accordance with standards, procedures, and guidance of the USACE. The *Planning Guidance Notebook* (Engineering Regulation, ER 1105-2-100) serves as the primary source for evaluation methods for flood risk management (FRM) studies and was used as reference for this analysis. Additional guidance for risk analysis was obtained from Engineering Manual (EM) 1110-2-1619 (*Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies*, August 1996) and ER 1105-2-101 (*Planning Risk-Based Analysis for Flood Damage Reduction Studies*, revised January 2006).

5. PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Monetary values presented in Sections 9-13 are in October 2012 prices (since the last update was performed in calendar year 2013). Costs and benefits of the various alternatives were amortized over a 50-year period of analysis using a federal discount rate of 3.75%, which was the prevailing rate at the time of the last update. The base year, or the year in which stabilization work of an erosion site is assumed to be completed, was assumed to be 2014. Costs used in the benefit-to-cost analysis include project costs, which were calculated by the Cost Engineering Section (SPK) and interest during construction (IDC), which were also calculated by the Cost Engineering Section (SPK).

Section 14 highlights the eight economically feasible sub-basins, which are the main focus of this current update and report. Updated benefits and costs are presented at October 2014 price levels and were calculated using the current federal discount rate of 3.50% and a 50-year period of analysis. The base year is assumed to be 2015.

6. DEFINITION OF ANNUAL EXCEEDANCE PROBABILITY (AEP)

The economic analysis relies heavily on assumed annual exceedance probability (AEP) information derived specifically for the SRBPP or for other on-going studies in the Sacramento District. The AEP is the probability that flooding will occur in any given year considering the full range of possible annual floods. Within the HEC-FDA model, AEPs are computed by integrating hydrologic/ hydraulic and geotechnical data in the form of exceedance probability-discharge-stage curves and geotechnical fragility curves/target top of levee stages.

7. SUMMARY OF MAJOR ASSUMPTIONS UNDERLYING THE ECONOMIC ANALYSIS

This major assumptions underlying and driving the economic analysis are summarized below:

- The target annual exceedance probability (AEP) information for the without-project condition was obtained from the contractor-developed report, *Annual Exceedance Probability of Failure and Sensitivity Analysis Due to Bank Erosion* (URS Corporation, February 2011). The primary purpose of this information is to estimate without-project damages and benefits for the SRBPP; the AEP information is not meant to serve as a detailed, authoritative engineering analysis of conditions at each erosion site. (More details on the AEP analysis and results can be found in the URS-developed report, which is attached as Enclosure 1 to this report.)

- The economic analysis assumed a without-project condition equivalent to Condition A as described in the URS report. Condition A describes the existing condition at the 106 erosion sites in 2010 assuming no flood event has occurred that would have caused the erosion sites to worsen. Existing project performance levels in terms of annual exceedance probabilities (AEP) presented in the contractor-provided report for Condition A were used to model the without-project condition in the economic model (HEC-FDA). Annual exceedance probability values presented in the URS report assume failure due to erosion only; other mechanisms of failure such as under seepage, through seepage, and stability were not accounted for in the AEP assessment.

- The URS report also lays out AEP information for several other conditions, all of which make different assumptions. In particular, Condition C is also a without-project condition, but unlike in Condition A, Condition C is a most likely future condition for the year 2025 and assumes that a flood event has occurred that would cause a particular erosion site to worsen. At most erosion sites, estimated AEP levels associated with Condition C are either 1) the same as those estimated for Condition A (at the same erosion site) or 2) are exceeded by or equal to the Condition A AEP estimate of another erosion site associated with the same economic impact area. For economic analysis purposes, then, existing without-project and most likely future without-project conditions were assumed to be Condition A in terms of hydrology, hydraulics, and geotechnical data inputs into the HEC-FDA. Using the AEP information from Condition A allows for a more conservative estimate of damages and benefits than using the AEP information from either Condition B or from Conditions A and C in combination. Using the lower AEP associated with Condition A translates into lower without-project expected annual damages (EAD) and therefore, of all the conditions presented in the URS report, has the lowest potential risk of overstating benefits.

- The AEPs associated with the with-project condition were assumed to be equal to the without-project AEPs developed for the 2002 Sacramento and San Joaquin Basins Comprehensive Study for those economic impact areas where more current HEC-FDA input data (exceedance probability-discharge and geotechnical fragility curves) are not available. In areas where there is more current data, these data (and corresponding AEP information) were used in the analysis. The idea behind this assumption is that once erosion sites within an impact area are fixed, the AEP associated with a particular impact area improves to the AEP estimated by either the (without-project) AEP of the Comprehensive Study or the AEP estimated by a study more current than the Comprehensive Study.

- The same hydrologic exceedance probability-discharge curves and hydraulic floodplains were used for the without-project and with-project conditions.

- The difference between the without-project and with-project expected damages is controlled by the difference in AEP between the two conditions, which in turn is driven by the difference in geotechnical fragility curves between the two conditions. For each impact area, the geotechnical fragility curves used to represent the SRBPP with-project condition were taken from either the Comprehensive Study without-project analysis or from a more current Corps analysis depending on the particular study area; these SRBPP “with-project” fragility curves were then adjusted in HEC-FDA in order to obtain the appropriate “without-project” AEP as outlined by Condition A in the URS report. This process is described in more detail in a subsequent section entitled, *Economic Model and Analytical Approaches/Techniques*.

- For each economic impact area, expected damage analysis were computed in HEC-FDA using data (exceedance probability-discharge curves, geotechnical fragility curves, and economic stage-damage curves) at the index point locations delineated either for the Comprehensive Study or another more current study and do not necessarily correspond to the exact erosion site location. Index points are used in HEC-FDA for damage aggregation purposes and for the purposes of characterizing risk (chance of flooding) in terms of AEP for an economic impact area.

- The construction period for fixing an erosion site was assumed to be one year. This assumption affects interest during construction (IDC) calculations.

- Benefit-to-cost ratios are based on the assumption that all known problems (erosion sites) within an impact area are fixed; the assumption that all known problems are fixed is based upon taking all precautions to ensure that the recommendations are comprehensive in nature.

8. ECONOMIC IMPACT AREAS

The economic impact areas used for this analysis follow closely those delineated for the 2002 Sacramento and San Joaquin River Basins Comprehensive Study primarily because much of the engineering data used in this economic analysis was developed for the Comprehensive Study. There were some minor adjustments made that combined certain Comprehensive Study impact areas into one area for the purposes of the SRBPP analysis. For example, in the Comprehensive Study, the Colusa Basin was separated into two areas; for this analysis, the Colusa Basin was considered one impact area. As another example, the Knights Landing area was delineated into two impact areas in the Comprehensive Study, but is considered as only one impact area for this analysis.

Table 1 below displays the economic impact areas (number from Comprehensive Study and geographic location), all of the waterways along which erosion sites have been identified (per impact area), and the number of erosion sites associated with each impact area. As mentioned previously, 106 erosion sites, each associated with one of 24 economic impact areas, have been identified for this analysis. Of the 106 erosion sites, 101 were included in the economic analysis.

Figure 3 displays all of the economic impact areas.

Table 1: Economic Impact Areas, Associated Waterways, and Number of Erosion Sites

Economic Impact Area (Number from Comprehensive Study)	Associated Waterways with Erosion Sites[1]	Number of Erosion Sites Identified
Butte Basin (5)	Sacramento River	4
Grimes (10)	Sacramento River	6
South Sutter (11/34)	Sacramento River	10
Knights Landing (13/14)	Knights Landing RC; Yolo Bypass; Sac River	8
Yolo (15)	Cache Creek; Knights Landing Ridge Cut	2
Woodland (16)	Yolo Bypass; Willow Slough	5
Davis (17)	Willow Slough	1
Linda (27)	Yuba River	1
Rio Oso (30)	Bear River; Natomas Cross Canal; Feather	4
North Sutter (32)	Sacramento River	6
Elkhorn (35)	Sacramento River	3
Natomas (36)	Sacramento River	1
Arden/Rio Linda (37)	American River	1
West Sacramento (38)	Sacramento River	2
Southport (39)	Sacramento River	2
Sacramento (40)	Sacramento River	3
Clarksburg (42)	Sutter Slough; Deep Water Ship Channel	3
Merritt Island (46)	Sacramento River	3
Sutter Island (49)	Steamboat Slough; Sutter Slough	4
Grand Island (50)	Steamboat Slough; Sacramento River	4
Tyler Island (53)	Georgiana Slough	17
Brannan Andrus Island (54)	Sacramento River	7
Ryer Island (55)	Steamboat Slough; Cache Slough	2
Hastings Tract (61)	Cache Slough	2

[1] Erosion sites on Cherokee Canal, Deer Creek, and Elder Creek were not analyzed due to insufficient data; in addition, these waterways protect impact areas that contain minimal economic consequences in terms of agricultural and urban damages.

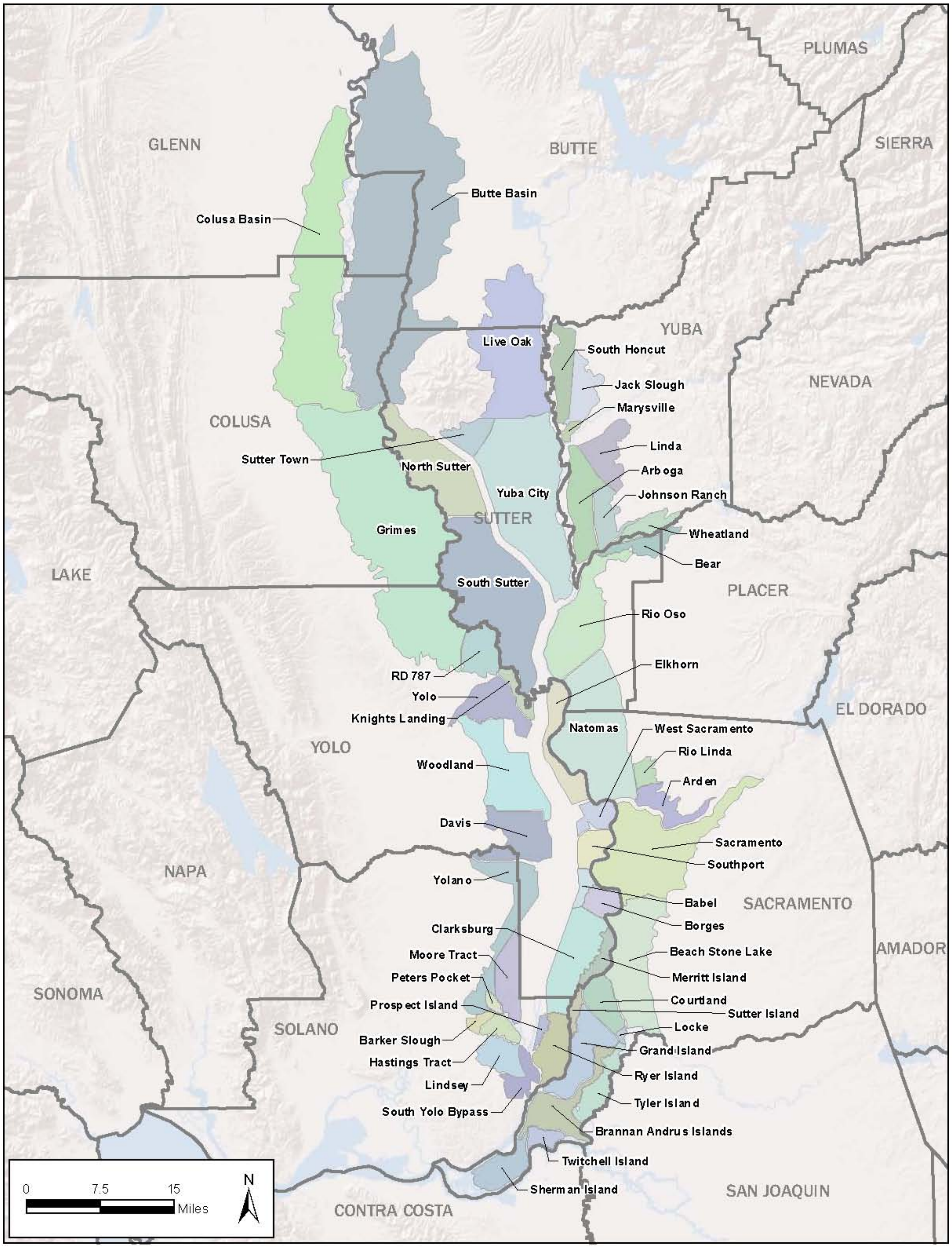

Figure 3: Map of economic impact areas.

9. DATA SOURCES AND DEVELOPMENT

The following sections describe the data sources and development used in the economic analysis.

9.1 Hydrologic, Hydraulic, and Geotechnical Data

For the majority of economic impact areas, the hydrologic/hydraulic/geotechnical HEC-FDA input data (exceedance probability-stage, floodplains, and fragility curves) were developed for the Comprehensive Study and used for the SRBPP analysis. For other impact areas, more current data was obtained from the appropriate Sacramento District studies and used in this analysis. Table 2 below shows the source of the HEC-FDA input data used for each of the 24 economic impact areas. Enclosure 2 to this report includes the HEC-FDA input data (exceedance probability-discharge-stage curves and geotechnical fragility curves) used for each impact area.

Table 2: Sources of Data – Exceedance Probability-Discharge-Stage Curves, Floodplains, and Fragility Curves

Economic Impact Area	Sources of Data					
	Exceedance Probability-Discharge-Stage Curves		Floodplain Depths		Fragility Curves	
	Without-Project	With-Project	Without-Project	With-Project	Without-Project	With-Project
27	2010 Yuba River GRR	2010 Yuba River GRR	2010 Yuba River GRR	2010 Yuba River GRR	Adjusted[2]	2010 Yuba River GRR
36	2010 Natomas PAC	2010 Natomas PAC	2010 Natomas PAC	2010 Natomas PAC	Adjusted[2]	2010 Natomas PAC
37	2008 ARCF GRR[1]	2008 ARCF GRR[1]	2002 Comp Study	2002 Comp Study	Adjusted[2]	2008 ARCF GRR[1]
38	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	Adjusted[2]	2010 West Sac GRR
39	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	2010 West Sac GRR	Adjusted[2]	2010 West Sac GRR
40	2008 ARCF GRR[1]	2008 ARCF GRR[1]	2002 Comp Study	2002 Comp Study	Adjusted[2]	2008 ARCF GRR[1]
All others	2002 Comp Study	2002 Comp Study	2002 Comp Study	2002 Comp Study	Adjusted[2]	2002 Comp Study

[1]American River Common Features General Reevaluation Report (F3 Milestone)
[2]Without-project fragility curves were derived by adjusting the with-project fragility curves to target the appropriate contractor-developed AEP for Condition A as presented in Enclosure 1 of this report.

9.2 AEP Information for the Without-Project Condition

The AEP information for each erosion site and for various conditions was developed by consultants (URS). As mentioned previously, the AEP information for Condition A was used in this analysis to represent the without-project (no erosion stabilization work) condition for each site. Table 3 below displays the without-project AEP for each erosion site. More details regarding the development of the AEP information can be found in the contractor-developed report provided as Enclosure 1.

It also must be emphasized that the geotechnical engineering information (i.e., the without-project annual exceedance probability, or AEP, information) used in this economic analysis was developed specifically for the purpose of estimating damages and benefits of the programmatic SRBPP and to determine benefit-to-cost ratios for the USACE's annual economic analyses; the AEP information was not intended to provide an authoritative, detailed geotechnical engineering analysis of the conditions of the project levees.

Table 3: AEP Information for Condition A by Erosion Site

Annual Exceedance Probability (AEP) in %	Erosion Site
.5	Deep Water Ship Channel LM 5.0L, 5.01L; Sacramento River RM 35.3R
1	Knights Landing Ridge Cut (KLRC) LM 0.2R; Lower American River RM 7.3R; Sacramento River RM 35.4L, 78.3L; Willow Slough LM 2.2L, 0.6L; Yuba River LM 2.3L
2	Cherokee Canal LM 14.0L; KLRC LM 5.3L; Sacramento River RM 60.1L, 63.0R; Sutter Slough RM 24.7R; Yolo Bypass LM 2.0R
4	Cache Slough RM 15.9L, 22.8R; Cherokee Canal LM 21.9L; Deer Creek LM 2.4L; Elder Creek LM 3.0R, 4.1L; Feather River RM 0.6L, 5.0L; Georgiana Slough RM 2.5L, 3.6L, 4.0L, 4.3L, 4.5L, 4.6L, 6.1L, 6.4L, 6.6L, 6.8L, 8.3L; KLRC LM 3.0L, 3.1L, 4.2L; Natomas Cross Canal LM 3.0R; Sacramento River RM 21.5L, 22.5L, 22.7L, 23.2L, 23.3L, 24.8L, 25.2L, 31.6R, 38.5R, 56.5R, 56.6L, 56.7R, 58.4L, 62.9R, 74.4R, 75.3R, 77.7R, 86.3L, 86.5R, 86.9R, 92.8L, 95.8L, 96.2L, 101.3R, 103.4L, 104.0L, 104.5L, 116.0L, 116.5L, 122.0R, 122.3R, 123.3L, 123.7R, 127.9R, 131.8L, 132.9R, 133.0L, 133.8L, 136.6L, 138.1L, 163.0L, 168.3L, 172.0; Steamboat Slough RM 23.2L, 23.9R, 25.0L, 25.8R, 26.0L; Sutter Slough 26.5L; Willow Slough LM 6.9R; Yolo Bypass LM 0.1R, 2.5R, 2.6R, 3.8R
10	Georgiana Slough RM 0.3L, 1.7L, 9.3L; Steamboat Slough RM 18.8R
20	Bear River RM 0.8L; Elder Creek LM1.4L; Georgiana Slough RM 3.7a/b, 5.3L
50	Cache Creek LM 3.9L; Cache Slough RM 23.6R; Sacramento River RM 99.0L, 152.8L; Steamboat Slough 24.7R

9.3 Economic Inventory: Collection of Base Data and Valuations (Structures and Contents)

For each economic impact area, base geographic information system (GIS) inventories with parcel attribute data was obtained from Michael Baker consultants; this data is based on county assessor data. Building attribute data were used to determine land use and valuation of structure and contents. In those areas where existing data did not exist, field visits were taken to collect the base inventory data using standard USACE practices; for several impact areas, current inventories and valuations were taken from other on-going District studies and no fieldwork was required. The following section describes the data collection process in more detail.

Fieldwork was used to verify and collect land use and structure characteristics pertinent to the economic analysis. Field sheets containing the base inventory data were taken to the field along with aerial maps for identification. Characteristics observed in the field were recorded on the field sheets, including:

- The number of stories/floors in the building.
- The foundation height of a building, which was estimated by taking the difference the average ground elevation and the first floor of the structure.
- The specific building use (residential and non-residential occupancy types), including those shown in Table 4 below.
- The building class (a: primary characteristic- steel reinforced frame, b: reinforced concrete frame, c: masonry, d: wood frame, s: pre-fabricated metal frame), which corresponds to the classifications listed in the Marshall and Swift (M&S) Valuation Service handbook. Each of the five classifications corresponds to a grade of construction for use in the structure valuation.
- The construction type (e.g., excellent, very good, good, average, fair, low cost), which addresses the quality of construction and which also used as input into the structure valuation.
- The structure condition (e.g., new, excellent, very good, good, fair, poor), which is a subjective measure of the remaining life of the structure. (This is not a measure of the actual age as many older structures may have been restored and may have had improvements made to extend its remaining life.) The estimated percentage of remaining value (percent good factor) was recorded to account for depreciation, which is also an input into the structure valuation. Table 5 below lists descriptions of the conditions used and the associated percent good factors used in the structure valuations.

Table 4: Occupancy Types

Occupancy Type	Description
Single-family residential (SFR)	Detached SFR, half-plexes, duplexes, townhomes
Multi-family residential (MFR)	Apartments, townhomes, attached multiple units
Mobile homes (MH)	Mobile homes and parks
Commercial office buildings	Office buildings
Retail	Typical retail stores
Food	Retail stores that sell perishable food items
Restaurants	Restaurants and fast food establishments
Medical	Medical, dental, hospitals, care facilities, veterinary
Shopping centers	Large shopping centers, box stores, shopping malls
Service	Auto repair, service, and maintenance shops
Warehouses	Warehouses, storage, transportation centers
Light industrial	Small tool shops, light manufacturing
Heavy industrial	Heavy manufacturing, large plants
Government	Gov't buildings, county-, city-, state- and federally- owned offices
Schools	Elem., middle, and high schools; colleges; day care/pre-school fac.
Churches	Churches
Recreation	Recreation assembly, clubs, theaters
Farm	Non-res outbuildings, sheds; family farm res.; lt. production fac.

Table 5: Condition Classes and Percent Good Factors

Condition	Percent Good Factor
New	100%
Excellent	95%
Very Good	90% to 95%
Good	80% to 90%
Fair	70% to 80%
Poor	50% to 70%
Other (abandoned, condemned)	0%

Table 6 below lists the number of structures by impact area and broken down by major damage category (residential, commercial, industrial, public, and farm).

Table 6: Number of Structures by Economic Impact Area and Damage Category

Economic Impact Area	Number of Structures				
	COM	**IND**	**RES**	**PUB**	**TOTAL**
Butte Basin (5)	--	--	131	--	131
Grimes (10)	--	--	49	--	49
South Sutter (11/34)	--	--	17	--	17
Knights Landing (13/14)	11	4	271	5	291
Yolo (15)	--	--	1	--	1
Woodland (16)	2	6	--	--	8
Davis (17)	3	2	88	1	94
Linda (27)	4	5	1,056	6	1,071
Rio Oso (30)	--	--	64	--	64
North Sutter (32)	--	--	131	--	131
Elkhorn (35)	--	--	--	--	--
Natomas (36)	303	156	22,265	85	22,809
Arden/Rio Linda (37)	737	216	15,247	141	16,341
West Sacramento (38) Southport (39)	485	484	17,419	99	18,487
Sacramento (40)	3,510	1,206	128,015	918	133,649
Clarksburg (42)	10	7	114	6	137
Merritt Island (46)	45	9	145	8	207
Sutter Island (49)	--	1	5	--	6
Grand Island (50)	--	--	--	--	--
Tyler Island (53)	--	--	2	--	2
Brannan Andrus (54)	80	11	3	80	174
Ryer Island (55)	--	1	3	--	4
Hastings Tract (61)	--	--	--	--	--
TOTAL	**5,190**	**2,108**	**185,026**	**1,349**	**193,673**

The total value of damageable property (structures and contents) for the 24 impact areas included in this analysis is approximately $100 billion. Table 7 below displays the total value of damageable property, also by impact area, and broken out by structure value and content value.

Table 7: Total Value of Damageable Property – Structures & Contents (October 2012 Price Level, in $1,000s)

Economic Impact Area	Value of Damageable Property		
	Structures	Contents	Total
Butte Basin (5)	12,210	6,104	18,314
Grimes (10)	4,948	2,475	7,423
South Sutter (11/34)	3,749	1,875	5,624
Knights Landing (13/14)	44,923	28,825	73,748
Yolo (15)	19	9	28
Woodland (16)	53,970	47,211	101,181
Davis (17)	50,983	26,522	77,505
Linda (27)	114,585	120,044	234,629
Rio Oso (30)	6,210	3,105	9,315
North Sutter (32)	12,209	6,104	18,313
Elkhorn (35)	0	0	0
Natomas (36)	5,876,118	2,996,706	8,872,824
Arden/Rio Linda (37)	10,083,891	5,114,688	15,198,579
West Sacramento (38) Southport (39)	2,945,844	2,034,480	4,980,324
Sacramento (40)	47,083,117	22,589,068	69,672,185
Clarksburg (42)	21,584	5,151	26,735
Merritt Island (46)	25,310	18,522	43,832
Sutter Island (49)	708	404	1,112
Grand Island (50)	0	0	0
Tyler Island (53)	255	128	383
Brannan Andrus Is. (54)	38,987	33,340	72,327
Ryer Island (55)	443	269	712
Hastings Tract (61)	0	0	0
TOTAL	**66,380,063**	**33,035,030**	**99,415,093**

All structures were valued based upon a function of square footage, estimated cost per square foot (from the Marshall & Swift Valuation Handbook), and an estimated percent good factor. Values per square foot were based on occupancy type, building class, and construction type as outlined in Marshall and Swift Valuation Service handbook. Structure values are based on the concept of depreciated replacement value, rather than market value or assessed value. Generally speaking, flooding causes damages primarily to physical improvements to the land, such as structures and contents, and does not necessarily cause damage to the land. Replacement cost of the structure and its contents less depreciation, therefore, is used to determine structure/content values, which then serves as the basis for the NED damage/benefit analysis. Median square footage information and median depreciated replacement values can be found in Enclosure 3.

Non-residential content values were based on the results of an expert elicitation that was conducted for the American River Common Features General Reevaluation Report (GRR). An expert elicitation was performed to develop content values and content depth-percent damage curves for specific occupancy types. The results of that expert elicitation were used for the 2009 American River GRR as well as for this study. In total, there were 22 different occupancy types with values ranging from $22 to $235 per square foot with uncertainty.

For SFR structures, depth-percent damage curves developed by the USACE Institute for Water Resources (IWR) and presented in Economic Guidance Memorandum (EGM) 04-01, were used. Since the percentage damages in these generic depth-percent damage curves were developed as a function of structure value, it was unnecessary to explicitly derive content values for input into the HEC-FDA model; the model computes content damages by applying the percentages in the content-percent damage curves to structure values. For reporting purposes and to estimate content value for residential structures, a content-to-structure value ratio of 50% was used, which is consistent with the ratio used in other District studies.

9.4 Depth-Percent Damage Curves

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Damages to structures and contents were determined based on depth of flooding relative to the structure's first floor elevation. To compute these damages, depth damage curves were used. These curves assign loss as a percentage of value for each structure. The deeper the relative depth, the greater the percentage of value damaged. The sources of the functions were different depending on land use. Depth-percent damage functions were used in the HEC-FDA model to estimate the percent of value lost for the various occupancy types listed in Table 4 above.

Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures,* for use on both single-family and multi-family residential structures. Structures were identified as 1-story, 2-story, or split-level. Mobile home curves were taken from the May 1997 Final Report, *Depth Damage Relationships in Support of Morganza to the Gulf, Louisiana Feasibility Study*. Non-residential curves (structures) were based on the same 1997 Morganza study (USACE New Orleans District) and were used for this analysis.

Depth-percent damage functions for automobiles were based on averages from curves developed by the Institute for Water Resources (IWR) and provided in EGM 09-04, *Generic Depth-Damage Relationships for Vehicles*.

In 2007, non-residential content depth-percent damage curves were developed based on the previously-mentioned expert elicitation for various occupancy types; these curves were developed specifically for building types in the Sacramento Metropolitan area and were applied to this analysis.

The complete set of depth- percent damage functions with their corresponding uncertainties can be found in Enclosure 3.

9.5 Agricultural Crop Acreages

Agricultural acreages for each economic impact area were obtained from the Sacramento District's Geographic Information Systems (GIS) Section. Agricultural crop acreages formed the basis for the agricultural damage analysis. Table 8 below displays the number of agricultural acres in each economic impact area. Table 9 below displays by impact area the single-event agricultural damages for five annual chance events (ACE): 10-, 50-, 100-, 200-, and 500-year. These ACE damages were directly entered into the HEC-FDA model as stage-damage curves in order to compute expected agricultural damages and benefits.

Table 8: Total Number of Agricultural Acres by Economic Impact Area

Economic Impact Area	Acreage Per Annual Chance Event (ACE)				
	10-Year	50-Year	100-Year	200-Year	500-Year
Butte Basin (5)	108,117	116,667	118,013	121,562	126,904
Grimes (10)	0	84,194	88,128	98,696	111,613
South Sutter (11/34)	0	54,397	54,658	55,263	63,742
K. Landing (13/14)	0	3,348	3,348	3,348	3,348
Yolo (15)	0	5,432	5,433	5,434	5,916
Woodland (16)	0	3,423	5,075	5,760	10,777
Davis (17)	0	0	0	0	0
Linda (27)	0	0	6,757	7,527	9,020
Rio Oso (30)	0	0	0	26,638	27,020
North Sutter (32)	0	0	31,421	31,445	31,507
Elkhorn (35)	0	11,881	11,923	11,923	11,923
Natomas (36)	0	0	0	39,417	41,014
Arden/Rio Linda (37)	0	0	0	0	0
West Sac (38)	0	0	0	456	564
Southport (39)	0	0	0	2,851	3,267
Sacramento (40)	0	0	0	1,947	2,425
Clarksburg (42)	0	12,028	20,465	20,476	22,375
Merritt Island (46)	0	4,577	4,595	4,638	4,639
Sutter Island (49)	0	2,241	2,241	2,241	2,241
Grand Island (50)	0	15,681	15,681	15,681	15,681
Tyler Island (53)	0	8,680	8,685	8,690	8,695
Brannan Andrus (54)	0	13,346	13,348	13,348	13,354
Ryer Island (55)	0	10,974	11,278	11,278	11,278
Hastings Tract (61)	0	3,411	3,414	3,414	3,419
TOTAL	**108,117**	**350,280**	**404,463**	**492,033**	**530,722**

Table 9: Agricultural Damages by Event and Economic Impact Area (October 2012 Price Level, in $1,000s)

Economic Impact Area	Damage Consequences Per Annual Chance Event (ACE)				
	10-Year	50-Year	100-Year	200-Year	500-Year
Butte Basin (5)	99,814	129,399	131,721	152,254	180,381
Grimes (10)	0	65,734	70,324	84,184	94,144
South Sutter (11/34)	0	62,135	62,546	63,153	77,481
K. Landing (13/14)	0	5,851	5,851	5,851	5,851
Yolo (15)	0	4,224	4,224	4,508	4,909
Woodland (16)	0	1,876	2,753	3,118	5,429
Davis (17)	0	0	0	0	0
Linda (27)	0	0	8,353	8,748	9,576
Rio Oso (30)	0	0	0	48,300	49,114
North Sutter (32)	0	0	52,511	52,558	52,606
Elkhorn (35)	0	39,495	39,674	39,674	39,674
Natomas (36)	0	0	0	17,964	19,231
Arden/Rio Linda (37)	0	0	0	0	0
West Sac (38)	0	0	0	65	78
Southport (39)	0	0	0	1,289	1,520
Sacramento (40)	0	0	0	451	513
Clarksburg (42)	0	6,638	10,911	1,097	11,886
Merritt Island (46)	0	1,641	5,581	5,616	5,616
Sutter Island (49)	0	11,578	11,578	11,578	11,578
Grand Island (50)	0	28,609	28,609	28,609	28,639
Tyler Island (53)	0	7,245	7,245	7,248	7,248
Brannan Andrus (54)	0	12,440	12,440	12,440	12,460
Ryer Island (55)	0	11,060	11,100	11,100	11,100
Hastings Tract (61)	0	1,938	1,938	1,938	1,939
TOTAL	**99,814**	**389,861**	**467,358**	**571,606**	**630,971**

Note: The damages displayed in the table represent damages from a specific annual chance event (e.g., 10% ACE, 25% ACE, 50% ACE, etc.) and floodplain should that flood event/floodplain occur. These damages/frequencies do not reflect the chance of levee failure.

9.6 Economic Uncertainties

Uncertainties in key economic variables were considered. Key economic variables, or those which may have a significant impact on expected damages and benefits, include structure/content values, foundation heights/first floor elevations, and percent damages at specific depths of flooding.

Table 10 below lists the uncertainty used for structure and content values. These were taken from other District studies, including the *Natomas Post-Authorization Change Interim Reevaluation Report* (October 2010) and the *Folsom Dam Modification and Folsom Dam Raise Projects, Economic Reevaluation Report* (Feb 2008).

Table 10: Uncertainty in Structure and Content Values

OCCUPANCTY TYPE	UNCERTAINTY IN VALUE (INPUT TO HEC-FDA)	
	Structures (SD/Mean in Percent)	Contents (SD/Mean in Percent)
Residential (SFR & MFR)	17	--
Mobile Homes	14	--
Office 2-Story	15	14
Office 1-Story	15	16
Retail	13	18
Retail-Furniture	13	20
Auto Dealerships	12	16
Hotel	11	3
Food Stores	11	27
Restaurants	15	3
Restaurants-Fast Food	12	13
Medical	12	46
Shopping Centers	10	23
Large Grocery Stores	11	4
Service (Auto)	15	4
Warehouse	15	31
Light Ind.	16	19
Heavy Ind.	13	31
Government	14	16
Schools	12	33
Religious	12	40
Recreation	13	13
Automobiles	15	N/A

Uncertainty in first floor elevation was assumed to be 0.5 foot; uncertainty in percent damages at specific depths of flooding is presented in Enclosure 3, *Depth-Percent Damage Curves*.

9.7 Project Costs

Project costs for recommended measures/plans at each erosion site were developed by the Sacramento District's Cost Engineering Section. Interest during construction (IDC) was calculated by the District's Economics & Risk Analysis Section. Costs were compiled by basin and used in the economic net benefit and benefit-to-cost analyses. Tables 11 and 12 display the total project costs, the costs of interest during construction (IDC), total investment costs, and average annual costs by impact area (basin) and by groups of basins delineated by predominant land use – urban, agricultural, and mixed. A breakdown of the cost estimates by impact area can be found in Enclosure 4 to this report.

Table 11: Total Project Costs, Interest During Construction, Total Investment Costs, & Average Annual Costs (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area (Basin)	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Butte Basin (5)	9,797	100	9,897	441
Grimes (10)	12,856	291	13,147	586
South Sutter (11/34)	61,696	1,507	63,203	2,818
Knights Landing (13/14)	10,131	480	10,611	473
Yolo (15)	2,266	39	2,305	103
Woodland (16)	5,067	54	5,121	229
Davis (17)	522	7	529	23
Linda (27)	3,034	40	3,074	137
Rio Oso (30)	6,991	69	7,060	314
North Sutter (32)	14,395	146	14,541	649
Elkhorn (35)	7,765	79	7,844	349
Natomas (36)	2,660	27	2,687	120
Arden/Rio Linda (37)	N/A	N/A	N/A	N/A
West Sacramento (38)	1,567	65	1,632	73
Southport (39)	9,821	95	9,916	443
Sacramento (40)	7,429	75	7,504	335
Clarksburg (42)	10,287	107	10,394	463
Merritt Island (46)	8,291	226	8,517	380
Sutter Island (49)	13,360	400	13,760	613
Grand Island (50)	12,166	124	12,290	548
Tyler Island (53)	127,705	6,083	133,788	5,963
Brannan Andrus Island (54)	21,471	222	21,693	967
Ryer Island (55)	7,754	84	7,838	349
Hastings Tract (61)	3,599	38	3,637	163
TOTAL	**360,630**	**10,358**	**370,988**	**16,539**

Table 12: Total Project Costs, IDC, Total Investment Costs, & Average Annual Costs by Analysis Group (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Analysis Group Based on Predominant Land Use	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Agricultural	297,256	9,117	306,373	13,657
Urban	40,231	843	41,074	1,833
Mixed[1]	23,143	398	23,541	1,049
Total	**360,630**	**10,358**	**370,988**	**16,539**

[1]Mixed refers to those areas that cannot be characterized as either predominantly urban or agricultural.

10. ECONOMIC MODEL AND ANALYTICAL APPROACHES/TECHNIQUES

The following sections describe the economic model, analytical approaches, and data application techniques used to perform the economic analysis.

10.1 Economic Model: HEC-FDA

The economic model used to perform this economic analysis/update is the Hydrologic Engineering Center Flood Damage Analysis (HEC-FDA) model developed by the USACE Hydrologic Engineering Center (HEC) in Davis, California. This model was used to compute economic stage-damage curves with uncertainty as well as expected annual damages (EAD) and benefits (EAB) by integrating hydrologic, hydraulic, geotechnical, and economic data. HEC-FDA v1.2.4 and v1.3, which is a version modified specifically for the District for the 2008 Folsom Dam Modification and Folsom Dam Raise economic analysis in order to use the inflow-outflow functionality within the software. (The newer versions of HEC-FDA currently have this functionality.) The economic analysis completed in 2011 for budget purposes relied heavily on existing data and models; these same models were carried forward to this PACR.

10.2 Index Point Locations

This economic analysis was performed using the HEC-FDA model, which requires the input of engineering data at index point locations along a levee reach and tied to a particular economic impact area. These index points are used to aggregate damages and benefits within an impact area in HEC-FDA. For most impact areas delineated for the SRBPP, representative index point locations (and corresponding data) were taken from the Comprehensive Study analysis; for other areas, representative index point locations (and corresponding data) were taken from more current District studies. Table 13 below displays the index point locations used for this economic analysis.

Table 13: Index Point Locations by Impact Area

Economic Impact Area	Index Point Location Used in HEC-FDA Analysis
Butte Basin (5)	Sacramento River RM 183.50; TOL/TOB[1] = 112.86
Grimes (10)	Sacramento River RM 119.75; TOL/TOB = 55.51
South Sutter (11/34)	Sacramento River RM 92.00; TOL/TOB = 42.76
Knights Landing (13/14)	Sacramento River RM 90.00; TOL/TOB = 44.43
Yolo (15)	KLRC LM 3.02; TOL/TOB = 38.86
Woodland (16)	Yolo Bypass LM 48.84; TOL/TOB = 32.78
Davis (17)	Putah Creek; TOL/TOB = 46.23
Linda (27)	Yuba River LM 5.7; TOL/TOB = 94.2
Rio Oso (30)	Feather River RM 7.17; TOL/TOB = 52.5
North Sutter (32)	Sutter Bypass LM 88.60; TOL/TOB = 58.6
Elkhorn (35)	Sacramento River RM 76.75; TOL/TOB = 40.12
Natomas (36)	Sacramento River RM 79.0; TOL/TOB = 44.40
Arden/Rio Linda (37)	American River RM 11.33; TOL/TOB = 58.60
West Sacramento (38)	Sacramento River RM 59.99; TOL/TOP = 40.00
Southport (39)	Sacramento River RM 52.75; TOL/TOB = 39.00
Sacramento (40)	Sacramento River RM 51.00; TOL/TOB = 31.50
Clarksburg (42)	Sutter Slough RM 25.23; TOL/TOB = 22.86
Merritt Island (46)	Sacramento River RM 41.00; TOL/TOB = 26.21
Sutter Island (49)	Sutter Slough RM 23.73; TOL/TOB = 25.2
Grand Island (50)	Sacramento River RM 14.75; TOL/TOB = 22.85
Tyler Island (53)	Georgiana Slough RM 0.25; TOL/TOB = 10.53
Brannan Andrus Is. (54)	Georgiana Slough RM 0.75; TOL/TOB = 10.89
Ryer Island (55)	Sutter Slough RM 22.23; TOL/TOB = 25.35
Hastings Tract (61)	Cache Slough RM 21.0; TOL/TOB = 17.7

[1]TOL/TOB is "top of levee/top of bank."

10.3 Application of Hydrologic, Hydraulic and Geotechnical Engineering Data in HEC-FDA

The HEC-FDA engineering input data was developed by the District's Hydrologic, Hydraulic, and Geotechnical engineers for the 2002 Comprehensive Study and, for most of the impact areas, used in this analysis. In most impact areas, graphical exceedance probability-stage curves were entered into HEC-FDA along with an equivalent record length, which is used in HEC-FDA to estimate uncertainty in in-channel stage. Geotechnical fragility curves (without-project) for each impact area, which were also developed specifically for the Comprehensive Study, were used to represent the with-project condition – or the condition that is trying to be re-attained through the erosion stabilization work. Hydraulic floodplains were also developed for the Comprehensive Study and applied to this analysis (for most of the impact areas); floodplains were developed for the 10%, 2%, 1%, .5%, and .2% annual chance events.

10.4 Application of Floodplain Data within HEC-FDA Model

Comprehensive Study floodplains for the 10%, 2%, 1%, .5%, and .2% annual chance events (ACE) were provided by the District's GIS section as a GIS database of flood depths at each parcel/structure for each event. Flood depths were provided for the entire study area. The District's Economics and Risk Analysis Section then formatted the flood depth data in order to be able to import the data into HEC-FDA, which requires a specific format (HEC-RAS – River Analysis System profile format).

Instead of using river station numbers like in a typical HEC-RAS water surface profile (WSP), assignment of water surface elevations by ACE event were completed using grid cell numbers; the grid cell assignments represent actual floodplain water surface elevations by ACE event rather than in-channel water surface elevations. Once the formatted flood plain data were imported into HEC-FDA, a row was inserted at the top of the WSP which included the in-channel stages associated with the index point (for a particular impact area). This step allowed for the linkage between the 2-dimensional floodplain data and the in-channel stages within HEC-FDA. Importing formatted floodplain data and assigning water surface elevations to grid cells eliminated the need for creating interior-exterior relationships, which is another way to link exterior (river) stages to interior (floodplain) stages within HEC-FDA.

10.5 Computing Economic Stage-Damage Curves in HEC-FDA

Since structures and depths of flooding (water surface elevations) in the WSPs are linked by grid cell number, this technique allowed for the computation of stage-damage curves within HEC-FDA and eliminated the need to use other models (e.g., @Risk) to compute stage-damage curves. Once computed, stages in the stage-damage curves are scaled by HEC-FDA using the in-channel (exterior) stages at the index point (first row of data inserted into WSP). The index point, then, links the floodplain data (via stage-damage curves) to the channel hydrologic, hydraulic, and geotechnical engineering data in the HEC-FDA model.

10.6 Target AEPs to Compute Without-Project Damages and With-Project Residual Damages

This economic analysis requires the establishment of a without-project condition and a target with-project condition in order to be able to estimate "pre-project" damages and "post-project" residual damages, and therefore be able to measure outputs (benefits) of a project. The AEP information from the Comprehensive Study was used to establish the target with-project condition for most of the impact areas; the AEP information from the URS report was used to establish the without-project (pre-erosion repair) condition for all of the impact areas. For those impact areas where there is an on-going District study with more current data, AEP information from these studies were used in place of the Comprehensive Study information.

It should be emphasized that the intent of the contractor-developed AEP information was to provide information as input into this economic analysis, and not to provide a detailed assessment of the project levee conditions. (The contractor-developed AEP information is not meant to be an authoritative analysis of the current geotechnical conditions of the project levees. More detailed geotechnical analyses may be performed in the future.) The intent of this economic analysis is to reasonably estimate benefits of the SRBPP using the available data and information.

10.7 Target AEPs and Erosion Sites

"More critical" and "less critical" erosion sites within an impact area were identified based on information provided in the URS report. The AEPs associated with the erosion sites within an impact area were compared to one another. In all cases, an erosion site(s) within an impact area could be identified as having a higher AEP value than the remainder of the erosion sites (for that impact area); these sites were considered the "more critical" sites within the impact area and the AEPs associated with these sites represented the without-project condition (see next section). The "less critical" erosion sites were the remaining sites having a lower AEP value than the "more critical" sites. Initially, the AEP values associated with these sites were used to represent a first with-project condition; ultimately, however, these intermediate with-project conditions were not used in the economic analysis. Instead, the maximum attainable AEP for a particular impact area was represented by the AEP from either the Comprehensive Study analysis or from a District study having a more current analysis. This methodology reflects that even though erosion sites can be repaired to high level of performance, the risk to the impact area may be limited by the performance for other potential failure modes, (e.g.) under seepage, through seepage, instability). The AEP from the Comprehensive Study analysis (or from a District study having done current analysis includes consideration of those other potential failure modes, and thus represents the maximum attainable AEP for the impact area.

It should be noted that the terms "more critical" and "less critical" are not intended to imply site prioritization or an order of fixes. These terms were used within the context of the economic analysis to compare the magnitude of AEP values of sites within an impact area and to point out that the severity of erosion sites within an impact area, in terms of AEP, are not equal.

10.8 Adjusting Geotechnical Fragility Curves to Achieve Target AEPs and Estimate Benefits

The target without-project AEPs (Condition A from the URS report) were achieved by adjusting the "with-project" geotechnical fragility curves, which were actually represented by the without-project fragility curves from either the Comprehensive Study or another more current District Study. The fragility curves were adjusted in a methodical manner by first taking the same stages used in the "with-project" fragility curves, changing the probabilities of failure (starting from the lower stages), and then computing AEP in HEC-FDA. Although this adjustment technique was methodical, the process is one that can be characterized as inherently trial and error as each step of the adjustment process was repeated until the target without-project AEP (and first with-project condition AEP) was achieved in HEC-FDA. Enclosure 2 shows the geotechnical fragility curves (per impact area) used to represent the two states:

- Without-project condition: no erosion sites are fixed; this is the highest AEP identified in the URS report (Condition A) for an erosion site(s) of all the erosion sites (per impact area); this is the condition that exists due to some flow event causing an erosion issue.

- With-project condition: assumes the AEP using the information from either the Comprehensive Study or another more current District study; it is assumed that this condition represents the maximum attainable performance level for a particular impact area; this with-project condition is the state that exists prior to any erosion issue and to which an erosion repair is trying to re-attain; benefits are capped by this AEP value.

Table 14 below shows the target AEP values for each condition and by impact area.

It is important to note that for many reaches, the assumption regarding the maximum attainable AEP value as listed in Table 14 is greater (lower performing) than the without-project AEP estimate from the aforementioned URS report (Section 10.7), which appears to imply that the levee performance in these areas gets worse with repairs to the erosions site. This is not the case, however. For these reaches these values reflect that there are worse performance conditions for other potential failure modes, and that the AEP for the impact area is not governed by the erosion performance. This is unrealistic and not expected to occur, but is mainly an effect of using data from different sources that were developed using different methods. That is, whether or not the erosion is repaired, the AEP remains as characterized by the Comprehensive Study analysis (or more current District study analyses). In impact areas where this occurred, no benefits were claimed for that particular basin/impact area. However, in future studies when more current data/information becomes available which would allow for a more accurate measurement of pre-repair and post-repair performance, the estimate of benefits for these impact areas will be revised. In other words, the risk assessment methodology will be revised for the Sacramento River Bank Protection Project GRR and applied to future SRBPP updates, with a focus on revised geotechnical fragility curves.

Table 14: Annual Exceedance Probability (AEP) Values by Impact Area and State (Condition)

Economic Impact Area	AEP Value: Without-Project Condition[1]	AEP Value: Maximum Attainable Based on Available AEP Information[2]
Butte Basin (5)	0.500	0.280
Grimes (10)	0.040	0.533
South Sutter (11/34)	0.500	0.255
K. Landing (13/14)	0.040	0.070
Yolo (15)	0.500	0.074
Woodland (16)	0.040	0.090
Davis (17)	0.040	0.040
Linda (27)	0.010	0.008
Rio Oso (30)	0.200	0.086
North Sutter (32)	0.040	0.050
Elkhorn (35)	0.040	0.500
Natomas (36)	0.010	0.007
Arden/Rio Linda (37)	0.010	0.010
West Sac (38)	0.040	0.009
Southport (39)	0.040	0.011
Sacramento (40)	0.040	0.008
Clarksburg (42)	0.020	0.131
Merritt Island (46)	0.040	0.156
Sutter Island (49)	0.500	0.103
Grand Island (50)	0.040	0.108
Tyler Island (53)	0.200	0.805
Brannan Andrus (54)	0.040	0.552
Ryer Island (55)	0.100	0.124
Hastings Tract (61)	0.500	0.329

[1]AEP information associated with Condition A from URS Report
[2]AEP information taken from the Comprehensive Study, or when available, from a more current District study

10.9 Economic Impact Area Groupings for Net Benefit and Benefit-to-Cost Analyses

For purposes of this report, the net benefit and benefit-to-cost analyses were performed by individual impact area/basin and by groups of impact areas based on the consequences of flooding within a particular impact area. The consequences of flooding criteria used to group the impact areas include the type and amount of damages and the population at risk. Table 15 lists the consequences of flooding, in terms of agricultural and urban damages and population at risk, from a 1% exceedance probability event. It should be noted that Table 15 shows the damage values from a 1% exceedance probability event and is computed with engineering uncertainty as well as using a geotechnical levee fragility curves while the tables contained in Enclosure 6 show ACE damages, which are computed without engineering uncertainty and without using a geotechnical levee fragility curve.

Table 15: Consequences of Flooding from a 1% Exceedance Probability Flood Event (October 2012 Price Level, in $1,000s)

<table>
<tr><th rowspan="2">Economic Impact Area</th><th colspan="3">CONSEQUENCES</th></tr>
<tr><th>Agricultural Damages (in $1,000s)</th><th>Urban Damages (in $1,000s)</th><th>Population at Risk (Number of People)</th></tr>
<tr><td>Butte Basin (5)</td><td>135,443</td><td>0</td><td>380</td></tr>
<tr><td>Grimes (10)</td><td>43,675</td><td>3</td><td>142</td></tr>
<tr><td>South Sutter (11/34)</td><td>62,759</td><td>3,105</td><td>49</td></tr>
<tr><td>K. Landing (13/14)</td><td>5,851</td><td>30,537</td><td>786</td></tr>
<tr><td>Yolo (15)</td><td>4,300</td><td>0</td><td>3</td></tr>
<tr><td>Woodland (16)</td><td>1,881</td><td>0</td><td>--</td></tr>
<tr><td>Davis (17)</td><td>29</td><td>3,263</td><td>255</td></tr>
<tr><td>Linda (27)</td><td>2,286</td><td>4,559</td><td>4,100</td></tr>
<tr><td>Rio Oso (30)</td><td>633</td><td>7,298</td><td>186</td></tr>
<tr><td>North Sutter (32)</td><td>47,686</td><td>3,894</td><td>380</td></tr>
<tr><td>Elkhorn (35)</td><td>39,674</td><td>0</td><td>--</td></tr>
<tr><td>Natomas (36)</td><td>0</td><td>0</td><td>100,000</td></tr>
<tr><td>Arden/Rio Linda (37)</td><td>0</td><td>0</td><td>44,216</td></tr>
<tr><td>West Sac (38)</td><td>58</td><td>1,613,730</td><td rowspan="2">50,515</td></tr>
<tr><td>Southport (39)</td><td>244</td><td>1,262,875</td></tr>
<tr><td>Sacramento (40)</td><td>54</td><td>3,946,021</td><td>371,244</td></tr>
<tr><td>Clarksburg (42)</td><td>5,686</td><td>0</td><td>331</td></tr>
<tr><td>Merritt Island (46)</td><td>5,556</td><td>8,908</td><td>421</td></tr>
<tr><td>Sutter Island (49)</td><td>11,578</td><td>777</td><td>15</td></tr>
<tr><td>Grand Island (50)</td><td>28,471</td><td>0</td><td>--</td></tr>
<tr><td>Tyler Island (53)</td><td>7,246</td><td>0</td><td>6</td></tr>
<tr><td>Brannan Andrus (54)</td><td>15</td><td>0</td><td>9</td></tr>
<tr><td>Ryer Island (55)</td><td>11,100</td><td>88</td><td>9</td></tr>
<tr><td>Hastings Tract (61)</td><td>1,939</td><td>0</td><td>--</td></tr>
<tr><td>TOTAL</td><td>416,163</td><td>6,885,058</td><td>573,047</td></tr>
</table>

The first group of impact areas includes those impact areas that contain predominantly agricultural land uses; the second group includes those impact areas that contain predominantly urban land uses; the third group includes those impact areas that cannot be characterized as predominantly agricultural or urban and could be considered “mixed” use; the fourth group is comprised of all impact areas. Table 16 below lists the groups of impact areas by predominant land use.

Table 16: Groups of Impact Areas by Predominant Land Use

Predominant Land Use	Economic Impact Area/Sub-Basin
Predominantly Agricultural	Butte Basin (5); South Sutter (11/34); Yolo (15); Rio Oso (30); North Sutter (32); Elkhorn (35); Merritt Island (46); Sutter Island (49); Grand Island (50); Tyler Island (53); Brannan Andrus Island (54); Ryer Island (55); Hastings Tract (61)
Predominantly Urban	Knights Landing (13/14); Woodland (16); Davis (17); Linda (27); Natomas (36); Arden (37); West Sacramento (38); Southport (39); Sacramento (40)
Mixed Use	Grimes (10); Clarksburg (42)

11. RESULTS: NET BENEFIT AND BENEFIT-TO-COST ANALYSES

The following sub-sections describe the results of the net benefit and benefit-to-cost analyses. The first section presents the results from a Sacramento Basin and land-use perspective by combining sub-basins within the Sacramento Basin by major land use. The second section presents the results from a sub-basin perspective, presenting net benefits and benefit-to-cost ratios by individual impact area.

11.1 Net Benefit and Benefit-to-Cost Analyses by Analysis Group and Sacramento Valley System

Table 17 below displays the without-project expected annual damages (EAD) for each analysis group.

Table 17: Without-Project Expected Annual Damages (EAD) by Analysis Group (October 2012 Price Level, in $1,000s)

Analysis Group	Damage Consequences							Total
	AUTO	COM	IND	RES	PUB	FARM	CROPS	
Agricultural	240	143	184	962	261	0	43,224	**45,014**
Urban	16,477	56,474	52,092	223,537	29,330	117	444	**378,473**
Mixed	1	2	1	9	3	0	1,983	**1,999**
Total	**16,718**	**56,619**	**52,277**	**224,508**	**29,594**	**117**	**45,651**	**425,486**

Table 18 below displays the without-project EAD, with-project residual EAD, and average annual benefits for each group evaluated.

Table 18: Without-Project EAD, With-Project Residual EAD, & Average Annual Benefits by Analysis Group (October 2012 Price Level, 50-Year Period of Analysis, in $1,000s)

Analysis Group	Without-Project EAD	With-Project Residual EAD	Expected Average Annual Benefits
Agricultural	45,014	37,232	**7,782**
Urban	378,473	206,781	**171,692**
Mixed	1,999	1,999	**0**
Total	**425,486**	**246,441**	**179,474**

Table 19 shows the distribution of benefits – the chance benefits exceed an indicated value – for each analysis group. The range of benefits, to an extent, can indicate the amount of uncertainty associated with the benefit values. The range in benefits for the urban analysis group is large, which may indicate a high uncertainty with the average annual benefit value for this group. In light of this, the benefit values (for all groups) having a 75% chance of being exceeded were used in the benefit-to-cost ratio calculations (Table 21 below).

Table 19: Probability Benefits Exceed Indicated Value by Analysis Group (October 2012 Price Level, in $1,000s)

Analysis Group	Without-Project EAD	With-Project Residual EAD	Expected Average Annual Benefits	Probability Benefits Exceeds Indicated Value		
				.75	.50	.25
Agricultural	45,014	37,232	7,782	7,434	7,729	8,167
Urban	378,473	206,781	171,692	63,607	134,187	270,566
Mixed	1,999	1,999	0	0	0	0
Total	425,486	246,012	179,474	71,041	141,916	278,733

For reference purposes, Table 12 is presented again as Table 20 below, which shows the average annual costs by analysis group used in the net benefit and benefit-to-cost analyses.

Table 20: Total Project Costs, IDC, Total Investment Costs, & Average Annual Costs (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Analysis Group Based on Predominant Land Use	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Agricultural	297,256	9,117	306,373	13,657
Urban	40,231	843	41,074	1,833
Mixed[1]	23,143	398	23,541	1,049
Total	**360,630**	**10,358**	**370,988**	**16,539**

[1]Mixed refers to those areas that cannot be characterized as either predominantly urban or agricultural.

Table 21 below displays the average annual benefits (from Table 18 above) by analysis group, average annual costs by analysis group (from Table 20 above), net benefits (average annual benefits minus average annual costs), and benefit-to-cost ratios (average annual benefits divided by average annual costs) for each analysis group.

Table 21: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios by Analysis Group (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Analysis Group	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Agricultural	7,434	13,657	(6,223)	0.5
Urban	63,607	1,833	61,774	35.0
Mixed	0	1,049	(1,049)	0.0
Total	**71,041**	**16,539**	**54,502**	**4.0**

Note: Annual benefits (column 2) used in this table were taken from Table 18 and represent the benefit values having a 75% chance of being exceeded; these lower values were used in the benefit-to-cost ratio calculations in recognition of the uncertainty in both the data inputs and process used to estimate benefits.

11.2 Net Benefit and Benefit-to-Cost Analyses by Sub-Basin (Impact Area)

While analyzing the Sacramento Basin as a whole produces positive net benefits and a benefit-to-cost ratio above unity, the results are different when an incremental analysis is performed by individual impact area/sub-basin. Table 22 displays the expected benefits by impact area; Table 23 displays a range of benefits by impact area/basin. A summary of the net benefits and benefit-to-cost ratios for these impact areas is provided in Table 24 below.

Table 22: Without-Project EAD, With-Project Residual EAD, & Expected Benefits by Impact Area/Sub-Basin

Impact Area/Sub-Basin	Without-Project Damages	With-Project Residual Damages	Expected Annual Benefits
Butte Basin (5)	28,516	24,086	4,430
Grimes (10)	1,859	1,859	0
South Sutter (11/34)	6,661	4,977	1,684
K. Landing (13/14)	1,077	1,077	0
Yolo (15)	845	274	571
Woodland (16)	74	74	0
Davis (17)	197	197	0
Linda (27)	277	234	43
Rio Oso (30)	1,163	749	414
North Sutter (32)	618	618	0
Elkhorn (35)	1,379	1,379	0
Natomas (36)	72,190	51,823	20,367
Arden/Rio Linda (37)	37,698	37,698	0
West Sac (38)	77,034	31,849	45,185
Southport (39)	66,991	19,051	47,940
Sacramento (40)	123,367	65,203	58,164
Clarksburg (42)	141	141	0
Merritt Island (46)	310	310	0
Sutter Island (49)	1,579	912	667
Grand Island (50)	1,014	1,014	0
Tyler Island (53)	1,310	1,310	0
Brannan Andrus (54)	580	580	0
Ryer Island (55)	707	707	0
Hastings Tract (61)	331	316	15
TOTAL	**425,486**	**246,012**	**179,474**

Table 23: Probability Benefits Exceed Indicated Value by Impact Area/Sub-Basin (October 2012 Price Level, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Without-Project EAD	With-Project Residual EAD	Expected Average Annual Benefits	Probability Benefits Exceeds Indicated Value		
				.75	.50	.25
Butte Basin (5)	28,516	24,086	4,430	4,331	4,466	4,521
Grimes (10)	1,859	1,859	0	0	0	0
South Sutter (11/34)	6,661	4,977	1,684	1,562	1,576	1,851
K. Landing (13/14)	1,077	1,077	0	0	0	0
Yolo (15)	845	274	571	535	576	611
Woodland (16)	74	74	0	0	0	0
Davis (17)	197	197	0	0	0	0
Linda (27)	277	234	43	9	64	66
Rio Oso (30)	1,163	749	414	362	413	465
North Sutter (32)	618	618	0	0	0	0
Elkhorn (35)	1,379	1,379	0	0	0	0
Natomas (36)	72,190	51,823	20,367	17,282	20,685	23,515
Arden/Rio Linda (37)	37,698	37,698	0	0	0	0
West Sac (38)	77,034	31,849	45,185	13,809	44,814	78,042
Southport (39)	66,991	19,051	47,940	13,161	28,167	70,289
Sacramento (40)	123,367	65,203	58,164	18,321	37,685	93,020
Clarksburg (42)	141	141	0	0	0	0
Merritt Island (46)	310	310	0	0	0	0
Sutter Island (49)	1,579	912	667	630	683	703
Grand Island (50)	1,014	1,014	0	0	0	0
Tyler Island (53)	1,310	1,310	0	0	0	0
Brannan Andrus (54)	580	580	0	0	0	0
Ryer Island (55)	707	707	0	0	0	0
Hastings Tract (61)	331	316	15	14	15	16

Table 24: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios by Impact Area/Sub-Basin (October 2012 Price Level, 3.75% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	4,331	441	3,890	10
Grimes (10)	0	586	0	N/A
South Sutter (11/34)	1,562	2,818	(1,256)	0.60
K. Landing (13/14)	0	473	0	N/A
Yolo (15)	535	103	432	5.2
Woodland (16)	0	229	0	N/A
Davis (17)	0	23	0	N/A
Linda (27)	9	137	(128)	0.10
Rio Oso (30)	362	314	48	1.2
North Sutter (32)	0	649	0	N/A
Elkhorn (35)	0	349	0	N/A
Natomas (36)	17,282	120	17,162	144
Arden/Rio Linda (37)	0	N/A	0	N/A
West Sac (38)	13,809	73	13,736	189
Southport (39)	13,161	443	12,718	30
Sacramento (40)	18,321	335	17,986	55
Clarksburg (42)	0	463	0	N/A
Merritt Island (46)	0	380	0	N/A
Sutter Island (49)	630	613	17	1.0
Grand Island (50)	0	548	0	N/A
Tyler Island (53)	0	5,963	0	N/A
Brannan Andrus (54)	0	967	0	N/A
Ryer Island (55)	0	349	0	N/A
Hastings Tract (61)	14	163	(149)	0.10

12. ENGINEERING PERFORMANCE STATISTICS FOR ECONOMICALLY JUSTIFIED BASINS

The engineering performance statistics for those areas that are economically justified are presented in Table 25 below. It must be emphasized that the “without-project” AEP values were attained using available data and through non-standard techniques using the HEC-FDA software; Section 10.8 explains how these “without-project” target AEP values were achieved. This non-standard approach was used in the absence of more standard engineering data (e.g., without-project levee fragility curves) and was believed to be viable approach to measure economic outputs associated with erosion repairs (and only erosion repairs) to the levees within each sub-basin. In addition to the AEP values, Table 25 also displays the long-term risk and assurance results for those sub-basins that have a positive BCR. Long-term risk describes the chance of flooding over a specific time period, for example 30 years; assurance describes the chance of passing a specific exceedance probability event, for example the 1% exceedance probability event, without sustaining significant flooding.

It must be reiterated that the analysis for this PACR brings forward the analysis performed for a previous economic analysis. In doing so, the analysis focused mainly on benefit estimation using available data as well as non-standard techniques in HEC-FDA. In light of this, the engineering performance statistics may not be completely representative of a particular sub-basin/erosion site, especially in cases where the "without-project" AEP is actually greater than the "with-project" AEP. The AEP values used in the analysis are a compilation of existing data, taken from multiple sources, developed using different methods, and used primarily to measure the difference between a "without-project" condition and a "with-project" condition in order to estimate the benefits of a sub-basin.

In order to resolve those cases where the "with-project" AEP is greater than the "without-project" AEP, more current data/information needs to be provided and a more standard economic risk analysis would have to be performed.

Table 25: Engineering Performance Statistics for Sub-Basins with a Positive BCR

Without-Project Condition Performance Statistics										
		Long-Term Risk			Assurance					
EIA	AEP	10	30	50	10%	4%	2%	1%	.4%	.2%
Butte Basin	0.500	99%	99%	99%	0%	0%	0%	0%	0%	0%
Yolo	0.500	99%	99%	99%	4%	2%	2%	1%	0%	0%
Rio Oso	0.200	90%	99%	99%	25%	16%	10%	8%	0%	0%
Natomas	0.010	10%	23%	40%	97%	95%	94%	90%	69%	54%
West Sac	0.040	34%	64%	88%	91%	60%	53%	33%	13%	10%
Southport	0.040	34%	65%	87%	87%	74%	72%	68%	65%	65%
Sacramento	0.040	34%	71%	87%	98%	51%	37%	26%	18%	10%
Sutter Is.	0.500	99%	99%	99%	13%	1%	0%	0%	0%	0%
With-Project Condition Performance Statistics										
		Long-Term Risk			Assurance					
EIA	AEP	10	30	50	10%	4%	2%	1%	.4%	.2%
Butte Basin	0.280	96%	99%	99%	0%	0%	0%	0%	0%	0%
Yolo	0.074	54%	85%	98%	67%	36%	28%	14%	0%	0%
Rio Oso	0.086	59%	93%	99%	67%	48%	37%	33%	0%	0%
Natomas	0.007	7%	17%	31%	99%	95%	94%	90%	69%	53%
West Sac	0.009	9%	21%	37%	99%	93%	91%	80%	52%	45%
Southport	0.011	11%	25%	44%	96%	92%	92%	90%	89%	89%
Sacramento	0.008	8%	21%	33%	99%	95%	88%	78%	66%	50%
Sutter Is.	0.103	66%	96%	99%	55%	3%	1%	0%	0%	0%

13. Average Annual Damages, Benefits, Costs, Net Benefits, and BCRs for Eight Sub-Basins

The current update focuses on the eight sub-basins that were determined to be economically feasible; the assumptions, data, and methodologies used to make this determination were explained in the sections above. For the eight economically feasible sub-basins, the information presented in the previous sections was used to update the benefits for price level (October 2012 to October 2013). In addition, the District's Cost Engineering Section performed a complete revision of the costs associated with fixing the erosion sites.

Agricultural damages and benefits for four of the eight impact areas/sub-basins that are comprised predominantly of farmland were also reevaluated using the most current version of the agricultural model (SCARCE). SCARCE has recently gone through model review via the Planning Center of Expertise (PCX) in San Francisco and is awaiting official approval for use from Headquarters. The four impact areas that were reevaluated include Butte Basin, Yolo, Rio Oso, and Sutter Island.

Table 27 below summarizes the updated damages benefits; Tables 28 and 29 summarize the revised costs at 3.50% and 7.00% discount rates, respectively; and Tables 30 and 31 show the net benefit and benefit-to-cost ratio analyses at 3.50% and 7.00% discount rates, respectively .

Table 26: Updated Damages and Benefits for Eight Sub-Basins – Agricultural and Urban (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	WO EAD - Urban	WO EAD - Urban Residual	Expected Benefits - Urban	Annual Benefits (75% Confidence Level)	WO EAD – Agricult.	WO EAD – Agricult. Residual	Expected Benefits – Agricult.	Annual Benefits – Agricult. (75% Confidence Level)	Total Avg. Ann. Benefits
Butte Basin (5)	--	--	--	--	6,595	5,550	1,045	1,028	1,028
Yolo (15)	--	--	--	--	940	139	801	770	770
Rio Oso (30)	857	452	405	353	968	470	498	443	796
Natomas (36)	73,201	52,549	20,652	17,524	--	--	--	--	17,524
West Sac (38)	78,112	32,295	45,817	13,995	--	--	--	--	13,995
Southport (39)	67,929	19,318	48,611	13,345	--	--	--	--	13,345
Sacramento (40)	125,094	66,116	58,978	18,577	--	--	--	--	18,577
Sutter Island (49)	53	50	3	2	441	89	351	347	349
Total	**345,246**	**170,780**	**174,466**	**63,796**	**8,944**	**6,248**	**2,695**	**3,553**	**66,384**

Table 27: Costs of Fixing Erosions Sites in Eight Sub-Basins (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area (Basin)	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Butte Basin (5)	12,658	202	12,860	548
Yolo (15)	5,637	90	5,727	244
Rio Oso (30)	7,713	123	7,836	334
Natomas (36)	2,788	44	2,832	121
West Sacramento (38)	2,186	35	2,221	95
Southport (39)	10,345	165	10,510	448
Sacramento (40)	1,299	21	1,320	56
Sutter Island (49)	11,353	181	11,534	492
TOTAL	**53,979**	**861**	**54,840**	**2,338**

Table 28: Costs of Fixing Erosions Sites in Eight Sub-Basins (October 2013 Price Level, 7.00% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area (Basin)	Total Project Costs	Interest During Construction (IDC)	Total Investment Costs	Average Annual Costs
Butte Basin (5)	12,658	401	13,059	946
Yolo (15)	5,637	179	5,816	421
Rio Oso (30)	7,713	244	7,957	577
Natomas (36)	2,788	88	2,876	208
West Sacramento (38)	2,186	69	2,255	163
Southport (39)	10,345	328	10,673	773
Sacramento (40)	1,299	41	1,340	97
Sutter Island (49)	11,353	360	11,713	849
TOTAL	**53,979**	**1,710**	**55,689**	**4,035**

Table 29: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	548	480	1.9 to 1
Yolo (15)	770	244	526	3.2 to 1
Rio Oso (30)	796	334	462	2.4 to 1
Natomas (36)	17,524	121	17,403	145 to 1
West Sac (38)	13,995	95	13,900	147 to 1
Southport (39)	13,345	448	12,897	30 to 1
Sacramento (40)	18,577	56	18,521	332 to 1
Sutter Island (49)	349	492	(143)	0.7 to 1
TOTAL	**66,384**	**2,338**	**64,046**	**28 to 1**

Table 30: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 7.00% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	946	82	1.1 to 1
Yolo (15)	770	421	349	1.8 to 1
Rio Oso (30)	796	577	219	1.4 to 1
Natomas (36)	17,524	208	17,316	84 to 1
West Sac (38)	13,995	163	13,832	86 to 1
Southport (39)	13,345	773	12,572	17 to 1
Sacramento (40)	18,577	97	18,480	191 to 1
Sutter Island (49)	349	849	(500)	0.4 to 1
TOTAL	**66,384**	**4,035**	**62,349**	**16 to 1**

14. CONCLUSIONS

Without-project damages are based on the contractor-developed AEP information for Condition A (without-project target AEPs). As was mentioned previously, this information is not based on a traditional geotechnical engineering analysis for purposes of characterizing, in detail, the conditions of the levees at the erosion sites, but instead was developed specifically for purposes of providing information for input into this economic analysis. In light of this, it is recognized that there is uncertainty regarding the AEP information used in this analysis, which in turn introduces uncertainty in the project benefits reported here.

It is also recognized that the process to achieve the contractor-developed without-project AEP values entails adjusting the probabilities of failure on the geotechnical fragility curves by trial and error in order to produce the target AEP results. As a result of this trial and error process, there is the possibility that there is more than one way (i.e., different ways to adjust the fragility curves) to get to the target AEPs. This introduces additional uncertainty associated with the project benefits.

In recognition of both the uncertainty in the contractor-developed target AEP values and the uncertainty in the process of achieving these values in HEC-FDA using adjusted fragility curves, a distribution (or range) of benefits was reported. It is important to note that for this report, the benefit values having a 75% chance of being exceeded were used in the net benefit and benefit-to-cost calculations for each evaluation group and for each impact area/sub-basin.

Residual risk in terms of damage consequences and population at risk remains high even after the erosion stabilization work. For this analysis, only failure due to erosion was considered; other mechanisms of levee failure, such as under seepage, through seepage, and stability issues, were not considered. This constraint is directly reflected in the amount of benefits being realized for those sub-basins where improvements to specific erosion sites do not necessarily result in a reduction in residual risk.

In certain impact areas, without-project target AEP values are lower than or equal to the “with-project” AEP values pulled from either the Comprehensive Study analysis or another District Study. For these areas, based solely on the "pre-project" and "post-project" AEP values assumed for this analysis, benefits were not claimed, which is reflected in the benefit-to-cost ratios by evaluation group and by impact area/sub-basin. As was mentioned previously, many of the AEP values assumed for this analysis were those currently available from the 2002 Comprehensive Study, which may in itself have a certain amount of uncertainty attached to it due to its lack of currency. From this perspective, then, benefits may well be higher than which are reported here and which were used to calculate net benefits and benefit-to-cost ratios.

In factoring in all of the uncertainty with the data used in the analysis and the uncertainty inherent to the analytical approach used to estimate benefits, the analysis indicates that there are seven sub-basins with positive net benefits and benefit-to-cost ratios above unity. These are listed in Table 31 below and include the Butte Basin, Yolo, Rio Oso, Natomas, West Sacramento, Southport, and Sacramento sub-basins/impact areas. It should be noted that Sutter Island, which was determined to be economically feasible during the last update, is now determined to be economically infeasible. Table 31 displays the net benefit and BCR analyses for the economically feasible sub-basins/impact areas.

Table 31: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 3.50% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	548	480	1.9 to 1
Yolo (15)	770	244	526	3.2 to 1
Rio Oso (30)	796	334	462	2.4 to 1
Natomas (36)	17,524	121	17,403	145 to 1
West Sac (38)	13,995	95	13,900	147 to 1
Southport (39)	13,345	448	12,897	30 to 1
Sacramento (40)	18,577	56	18,521	332 to 1
TOTAL	**66,035**	**1,846**	**64,189**	**36 to 1**

Table 32: Annual Benefits, Average Annual Costs, Net Benefits, & Benefit-to-Cost Ratios for Economically Feasible Impact Areas/Sub-Basins (October 2013 Price Level, 7.00% Discount Rate, 50-Year Period of Analysis, in $1,000s)

Impact Area/Sub-Basin	Annual Benefits (75% Confidence Level)	Average Annual Costs	Net Benefits	Benefit-to-Cost Ratio (BCR)
Butte Basin (5)	1,028	946	82	1.1 to 1
Yolo (15)	770	421	349	1.8 to 1
Rio Oso (30)	796	577	219	1.4 to 1
Natomas (36)	17,524	208	17,316	84 to 1
West Sac (38)	13,995	163	13,832	86 to 1
Southport (39)	13,345	773	12,572	17 to 1
Sacramento (40)	18,577	97	18,480	191 to 1
TOTAL	**66,035**	**3,185**	**62,850**	**21 to 1**

ENCLOSURE 1

Annual Probability of Failure and Sensitivity Analysis Due to Bank Erosion

URS Corporation (Feb 2011)

DRAFT

Annual Probability of Failure and Sensitivity Analysis Due to Bank Erosion

Sacramento River Bank Protection Project, Phase II Evaluation Report, Sacramento, CA: Economic Studies

Prepared by

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Contract W91238-09-D-0029
Delivery Order No. 0003

Prepared for

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February 2011

STATEMENT OF COMPLETION OF INDEPENDENT TECHNICAL REVIEW

The A-E Contractor, Brown and Caldwell- URS Corporation (URS) Joint Venture, has estimated Annual Exceedance Probability (AEP) and performed Sensitivity Analysis for 107 erosion sites identified by the USACE annual field reconnaissance review within 40 economic impact areas.

Notice is hereby given that an independent technical review (ITR) appropriate to the standard of care was conducted as defined in the Project Plan. The ITR also complied with established URS policy, principles and procedures as required for review of a project of this nature.

The ITR included reviewing data review methods, field inspection methods, field data collection methods, AEP estimating methods, and the sensitivity analysis methodology and results as per USACE requirements.

ITR comments were reviewed, discussed and finalized before they were incorporated into this report.

Loren A. Murray
Independent Technical Reviewer

2/7/2011
Date

Project Manager, A-E Contractor

2/7/2011
Date

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Acronyms and Abbreviations

AEP	annual exceedance probability
DWR	California Department of Water Resources
EIS/EIR	Environmental Impact Statement/Environmental Impact Report
JV	Brown and Caldwell-URS Joint Venture
ID	Identification
LiDAR	Light Detection and Ranging
PAC	Post Authorization Change
SRBPP	Sacramento River Bank Protection Project
ULE	Urban Levee Geotechnical Evaluations Program
USACE	U.S. Army Corps of Engineers
$P_{(fE)}$	Formula Symbol for Annual Exceedance Probability for Levee Failure due to Erosion
V_h	Formula Symbol for River Velocity
V_{EFS}	Formula Symbol for Velocity In Erosion Function Apparatus Test
R_E	Erosion Rate
S	Formula Symbol for Site Factor
W_R	Formula Symbol for Erosion Width
W_E	Formula Symbol for Effective Levee Width

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1.0 INTRODUCTION

1.1 Purpose

This paper provides estimates of annual exceedance probability (AEP) for levee failure due to erosion. Erosion may lead to structural degradation of the levee, increasing the risk failure, flood inundation and damages interior of a levee. The U.S. Army Corps of Engineers' (USACE's) Sacramento District requested AEP estimates for four specified conditions:

- Condition A: Without project existing condition without flood in 2010
- Condition B: Without project existing condition with flood in 2010
- Condition C: Without project future condition with flood in 2025
- Condition D: With project condition

USACE is developing a Phase II Post Authorization Change (PAC) Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and supporting documents for levee repairs to be performed under the Sacramento River Bank Protection Program (SRBPP). SRBPP will address changes to land use, economic conditions, environmental conditions, and updated information about levee failure mechanisms associated with remedial treatment of project levees.

This paper provides a quantitative AEP associated with levee failures caused by bank erosion in 40 economic impact areas (at 107 selected erosion sites) under consideration for repair.

These AEPs were prepared under the assumption that they will be used for prioritizing, screening, and developing net benefits for selecting project sites for the SRBPP *Phase II Evaluation Report*, Sacramento, California: Economic Studies.

1.2 Authorization

This evaluation project is conducted by the Brown and Caldwell-URS Joint Venture (JV) for USACE's Sacramento District under contract W91238-09-D-0029's Delivery Order No. 0003.

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2.0 BACKGROUND

The Sacramento River Flood Control Project is a system of levees, weirs, pumping plants, and bypasses designed to safely convey Sacramento River and tributary flood flows. The project provides protection to about 2.1 million acres of highly productive agricultural land, as well as protection to the cities of Sacramento, West Sacramento, Yuba City, Marysville, Colusa, Gridley, and other communities. There are approximately 1,300 miles of project levees in this system.

The SRBPP is a federal program that inspects the Sacramento River Flood Control Project levees and associated natural banks and berms, identifying and ranking erosion problems, and providing remedial repairs. The SRBPP is a continuing construction project authorized by Section 203 of the Flood Control Act of 1960. The California Department of Water Resources' (DWR's) Central Valley Flood Protection Board is the SRBPP's non-federal sponsor.

To date, SRBPP work has occurred in two phases, during which a total of about 840,000 feet of river levee have been stabilized. SRBPP's Phase I consisted of inspection and repairs to 430,000 feet of levee; Phase II's original authorization included inspecting and repairing 390,000 feet of levee.

Current SRBPP inspection and repair work is being conducted under Phase II of its existing federal authorization, with approximately 15,646 feet remaining. An additional 80,000 feet of bank protection was authorized by the Water Resources Development Act of 2007. These additional feet were added to the SRBPP's Phase II work, increasing Phase II's authorization to 485,000 feet of levee. The USACE and the Central Valley Flood Protection Board are in the process of preparing an EIS/EIR for this supplemental authorization.

The SRBPP recently began planning and developing Phase III; Phase III will ensure that any project levees seriously threatened by erosion will continue to receive corrective measures to prevent levee failure, catastrophic damage or possible loss of life.

As part of the SRBPP, USACE's Sacramento District and DWR conduct an annual field reconnaissance review and maintain an inventory of erosion sites in the Sacramento River basin and northern Delta. The USACE has currently identified 107 erosion sites for evaluation of their probability of failure due to erosion or other failure mechanisms. This evaluation is being carried out under the SRBPP's Phase II. Evaluation results will be used to prioritize, screen, and develop net benefits for selected projects.

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3.0 TECHNICAL APPROACH

This evaluation study entailed three major efforts:

- Field observations and evaluations at each of the 107 erosion sites.

  Each of the 107 sites was visited in the field. Field observations documented 13 characteristics (bank and levee slope, soil type in bank and within the waterside slope, waterside berm width, water velocity, animal activity, and vegetation cover, etc.). Based on these observations, a weighted site characterization score for each site was calculated.
- Estimating the probability of failure due to bank erosion and a sensitivity analysis of key elements that promote erosion process.

  The AEPs of each site were estimated based on the nine-step process described in Appendix A. A sensitivity analysis for 10 of the 107 sites was completed. This paper summarizes these activities and gives the results of the field observation and erosion AEP estimation efforts.
- Estimating the probability of failure due to other failure modes.

  Following this paper, an *Evaluation of Other Probability Failure Scenarios and Economic Impact Area Report* will evaluate the probability of failure associated with other failure mechanisms (stability issues, through seepage, and underseepage). Erosion can contribute to some of the other failure mechanisms that will be evaluated. The *Evaluation of Other Probability Failure Scenarios and Economic Impact Area Report* will use the erosion effects estimated in this report to determine the contribution of erosion to a probability of failure through these other mechanisms.

3.1 Evaluating Procedure

This report focuses on estimating bank erosion and the AEP of levee failure due to bank erosion. The following approach was used to assess AEP for levee failure due to erosion:

1. Conduct a literature search using existing USACE and DWR data sources for information about the selected erosion sites.
2. Perform field observations and describe field conditions at the 107 erosion sites:
   - Describe the physical and geotechnical characteristics of the levee, levee foundation, and adjacent area
   - Numerically weigh and score erosion characteristics using 13 criteria on a field observation checklist (Appendix B contains field observation checklists)
   - Develop a judgment-based AEP for levee failure due to erosion observed in the field
3. Evaluate erosion severity (after field observations) using an nine-step method that considers the levee's geometry, the standard design levee prism, and the erosion rate of the levee's material. Erosion severity is expressed as a ratio of erosion width and effective levee width; it projects the AEP of levee failure due to erosion. This nine-step evaluation method is detailed in Appendix A.

4. Develop AEPs corresponding to the seven recurrence events pre-defined by USACE for the purposes of this project (i.e., annual event probabilities of 50%, 20%, 10%, 4%, 2%, 1% and 0.5%).

5. Estimate AEPs under the following four specified conditions:

   - Condition A: Without project existing conditions with no flood during 2010. This condition estimates AEP for levee failure based on current erosion severity against a standard levee design prism under a low flow condition.
   - Condition B: Without project existing conditions with a flood during 2010. This condition estimates the AEP for levee failure based on the conditions above, but adds projected erosion under an assumed flood condition during 2010.
   - Condition C: Without project future conditions with flood in 2025. This condition estimates AEP for levee failure based on a site's progressive erodibility from 2010 to 2025 based on initial field observations, and then adds projected erosion under an assumed design flood condition happening in 2025.
   - Condition D: With project conditions based on the probability of failure when a proposed erosion site is repaired to USACE standards.

3.2 Summary of USACE Identified Erosion Sites

The USACE annual field reconnaissance review has currently identified 107 erosion sites along the Sacramento River and tributaries. Table 1 provides detail information of number of sites located along Sacramento River and tributaries.

Table 1. Summary of Erosion Sites

Stream	No of Sites
Bear River	1
Cache Creek	1
Cache Slough	3
Cherokee Canal	2
Deep Water Ship Channel	2
Deer Creek	1
Elder Creek	3
Feather River	2
Georgiana Slough	17
Knight's Landing Ridge Cut	5
Lower American River	1
Natomas Cross Canal	1
Sacramento River	50
Steamboat Slough	7
Sutter Slough	2
Willow Slough	3
Yolo Bypass	5
Yuba River	1

3.3 Exceptions

Some exceptions to the evaluating procedure, discussed in section 3.1, were considered at the following sites due to their unique characteristics.

3.3.1 Erosion Sites DEC_2-4_L, ELC_1-4_L, ELC_3-0_R and ELC_4-1_L

For sites along Deer Creek and Elder Creek, levee crests were estimated to be 12 to 15 feet wide with a short freeboard. Erosion calculations were performed by placing the levee's prism at the crest of the levee using a standard levee width of 20 feet (see Appendix A for cross sections).

3.3.2 Erosion Sites Located Along Georgiana Slough

There are 17 erosion sites along the left bank of the Georgiana Slough. For most of these sites, the levee's bench is approximately 30 to 60% eroded. Trees along the edge of these benches have slumped to the base of the slope. Slumping and erosion have resulted in scalloped shorelines, with erosion scarps that are about 3 to 10 feet high. The potential for bank failure due to erosion and collapse of burrows extends to the toe of the waterside slope. At some locations, riprap is present locally along the river bank, as previous erosion repairs extend into the levee prism. Old brush boxes are present locally at eroded embankments. For erosion calculations, the most critical section of each site was considered.

During field observations, the water level was high and the levee waterside toe was not visible. Erosion below the water level was approximated for erosion calculations (see Appendix B for cross sections).

3.3.3 Erosion Sites SAC_163-0_L and SAC_168-3_L

Due to heavy vegetation on waterside berm, the waterside levee bank was not accessible at erosion sites on the right bank of the Sacramento River at SAC_163-0_L and SAC_168-3_L. Erosion estimates was calculated using USACE 2010 survey data (USACE, 2010).

3.4 AEP Considerations

Use of a consistent levee prism provides a uniform basis of comparison for all erosion sites; it establishes a minimum levee geometry requirement for evaluation of erosion impacts. The methodology used to estimate the AEP for levee failure due to erosion is described in Appendix A. In general, erosion sites with thick levees, wide berms and erosion-resistant soil material provide a higher factor of safety; they would be assigned low AEPs related to erosion. If erosion is observed well outside of the levee prism, then it is also assigned a low AEP. However, sites with deep erosion into the levee prism have a lower factor of safety and are therefore assigned high AEPs. Within the 107 erosion sites, many high and low AEP sites fall at both ends of erosion failure probability spectrum.

Erosion sites in the middle of the erosion failure probability spectrum rely more heavily on engineering judgment to establish an AEP. For example, a site with severe erosion near the water slope, but have extended bench on the waterside of the standard levee prism. Because of an extended bench and a higher factor of safety, a low AEP would be assigned. In this report, the distance of erosion from or into the levee prism is used to estimate the potential for levee failure. These distances are expressed as a ratio of "erosion width" (W_R) to "effective levee width" (W_E). Each erosion ratio was assigned an AEP value based on engineering judgment. For this evaluation, the breakdown of erosion ratios and assigned AEPs are shown in Table 2 and Table 3.

If erosion is completely outside the levee prism's waterside slope surface, use Table 2 is used to determine the AEP.

Table 2. Erosion Outside of Levee Prism and Annual Exceedance Probability.

Ratio of W_R/W_E	AEP
< 1%	0.5% (or 0.005)
1% to 5%	1% (or 0.01)
5% to 10%	2% (or 0.02)
> 10%	4% (or 0.04)

If erosion is partially or completely inside the levee prism's waterside slope surface, Table 3 is used to determine the AEP.

Table 3. Erosion Within Levee Prism and Annual Exceedance Probability.

Ratio of W_R/W_E	AEP
1% to 15%	4% (or 0.04)
15% to 20%	10% (or 0.1)
20% to 25%	20% (or 0.2)
> 25%	50% (or 0.5)

3.5 Reconciling Field Results with Calculations

When assigning a final AEP for levee failure due to erosion, an evaluation was performed to reconcile field observations and erosion severity calculations. Some AEPs made in the field observations were adjusted after erosion severity calculations were performed. For example, when a large portion of a levee bank was observed to be eroded, the field judgment-based AEP was assigned a high probability. After severity calculations were performed, it became apparent that some erosion sites were in wide levees. A portion of eroded bank in a wide levee has a lower probability of failure than a similar depth of erosion in a narrower levee. Accordingly, field judgment-based AEPs were adjusted to a lower probability, matching the severity calculation result.

Conversely, when the nine-step estimating method revealed erosion had cut into a large portion of a levee prism, some erosion sites with low-probability, judgment-based AEPs were adjusted to a higher probability.

Field observations indicated certain degrees of projected erosion based on the erosion characteristics of a site, such as flow velocity, levee soil material, vegetation density, geomorphology and other erosion-related aspects. This degree of projected erosion was reflected in the field-assigned AEP for Condition C. For Condition D, AEPs based on field observations were considered when estimating erosion potential in 2025.

Section 4.0 presents the AEP values from the reconciliation evaluation.

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4.0 RESULTS

Field observations were conducted between July 15 and August 13, 2010. The completed field observation checklists for all 107 sites are presented in Appendix B.

4.1 Conditions A, B and C

The AEP for specified Conditions A, B and C were assessed using the nine-step method described in Section 3.0 and detailed in Appendix A. Conditions A, B and C are defined in Step 5 of the technical approach detailed in Section 3.0. Derived estimates are presented below in Table 4. Cross section assessment and erosion severity calculations that were part of the nine-step method are included in Appendix B.

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
1	BER_0-8_L	Bear River RM 0.8L	20	20	20
2	CHC_3-9_L	Cache Creek LM 3.9L	50	50	50
3	CHS_15-9_L	Cache Slough RM 15.9L	4	4	10
4	CHS_22-8_R	Cache Slough RM 22.8R	4	4	4
5	CHS_23-6_R	Cache Slough RM 23.6R	50	50	50
6	CKC_14_0_L	Cherokee Canal LM 14.0L	2	4	4
7	CKC_21-9_L	Cherokee Canal LM 21.9L	4	50	50
8	DWS_5-0_L	Deep Water Ship Channel LM 5.0L	0.5	0.5	0.5
9	DWS_5-01_L	Deep Water Ship Channel LM 5.01L	0.5	0.5	0.5
10	DEC_2-4_L	Deer Creek LM 2.4L	4	4	4
11	ELC_1-4_L	Elder Creek LM 1.4L	20	50	50
12	ELC_3-0_R	Elder Creek LM 3.0R	4	4	10
13	ELC_4-1_L	Elder Creek LM 4.1L	4	4	4
14	FHR_0-6_L	Feather River RM 0.6L	4	4	4
15	FHR_5-0_L	Feather River RM 5.0L	4	4	4
16	GEO_0-3_L	Georgiana Slough RM 0.3L	10	20	20
17	GEO_1-7_L	Georgiana Slough RM 1.7L	10	10	20
18	GEO_2-5_L	Georgiana Slough RM 2.5L	4	10	20
19	GEO_3-6_L	Georgiana Slough RM 3.6L	4	4	10
20	GEO_3-7_L	Georgiana Slough RM 3.7a/b	20	50	50
21	GEO_3-71_L	Georgiana Slough RM 3.7a/b	20	50	50

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
22	GEO_4-0_L	Georgiana Slough RM 4.0L	4	4	10
23	GEO_4-3_L	Georgiana Slough RM 4.3L	4	4	4
24	GEO_4-5_L	Georgiana Slough RM 4.5L	4	4	4
25	GEO_4-6_L	Georgiana Slough RM 4.6L	4	4	10
26	GEO_5-3_L	Georgiana Slough RM 5.3L	20	50	50
27	GEO_6-1_L	Georgiana Slough RM 6.1L	4	4	10
28	GEO_6-4_L	Georgiana Slough RM 6.4L	4	4	10
29	GEO_6-6_L	Georgiana Slough RM 6.6L	4	4	10
30	GEO_6-8_L	Georgiana Slough RM 6.8L	4	4	10
31	GEO_8-3_L	Georgiana Slough RM 8.3L	4	4	10
32	GEO_9-3_L	Georgiana Slough RM 9.3L	10	10	20
33	KLR_0-2_R	Knights Landing Ridge Cut LM 0.2R	1	1	1
34	KLR_3-0_L	Knights Landing Ridge Cut LM 3.0L	4	4	4
35	KLR_3-1_L	Knights Landing Ridge Cut LM 3.1L	4	4	4
36	KLR_4-2_L	Knights Landing Ridge Cut LM 4.2L	4	10	10
37	KLR_5-3_L	Knights Landing Ridge Cut LM 5.3L	2	2	2
38	LAR_7-3_R	Lower American River, RM7.3R	1	4	4
39	NCC_3-0_R	Natomas Cross Canal LM 3.0R	4	4	4
40	SAC_21-5_L	Sacramento River RM 21.5L	4	4	4
41	SAC_22-5_L	Sacramento River RM 22.5L	4	4	4
42	SAC_22-7_L	Sacramento River RM 22.7L	4	4	10
43	SAC_23-2_L	Sacramento River RM 23.2L	4	4	10
44	SAC_23-3_L	Sacramento River RM 23.3L	4	4	4
45	SAC_24-8_L	Sacramento River RM 24.8L	4	10	20
46	SAC_25-2_L	Sacramento River RM 25.2L	4	4	10
47	SAC_31-6_R	Sacramento River RM 31.6R	4	4	10
48	SAC_35-3_R	Sacramento River RM 35.3R	0.5	0.5	0.5

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
49	SAC_35-4_L	Sacramento River RM 35.4L	1	4	4
50	SAC_38-5_R	Sacramento River RM 38.5R	4	4	10
51	SAC_56-5_R	Sacramento River RM 56.5R	4	4	10
52	SAC_56-6_L	Sacramento River RM 56.6L	4	4	4
53	SAC_56-7_R	Sacramento River RM 56.7R	4	4	4
54	SAC_58-4_L	Sacramento River RM 58.4L	4	10	20
55	SAC_60-1_L	Sacramento River RM 60.1L	2	4	4
56	SAC_62-9_R	Sacramento River RM 62.9R	4	4	4
57	SAC_63-0_R	Sacramento River RM 63.0R	2	2	2
58	SAC_74-4_R	Sacramento River RM 74.4R	4	4	4
59	SAC_75-3_R	Sacramento River RM 75.3R	4	4	4
60	SAC_77-7_R	Sacramento River RM 77.7R	4	4	10
61	SAC_78-3_L	Sacramento River RM 78.3L	1	1	1
62	SAC_86-3_L	Sacramento River RM 86.3L	4	4	4
63	SAC_86-5_R	Sacramento River RM 86.5R	4	4	4
64	SAC_86-9_R	Sacramento River RM 86.9R	4	4	4
65	SAC_92-8_L	Sacramento River RM 92.8L	4	4	4
66	SAC_95-8_L	Sacramento River RM 95.8L	4	4	4
67	SAC_96-2_L	Sacramento River RM 96.2L	4	4	4
68	SAC_99-0_L	Sacramento River RM 99.0L	50	50	50
69	SAC_101-3_R	Sacramento River RM 101.3R	4	4	4
70	SAC_103-4_L	Sacramento River RM 103.4L	4	4	4
71	SAC_104-0_L	Sacramento River RM 104.0L	4	4	4
72	SAC_104-5_L	Sacramento River RM 104.5L	4	4	4
73	SAC_116-0_L	Sacramento River RM 116.0L	4	4	4
74	SAC_116-5_L	Sacramento River RM 116.5L	4	4	4
75	SAC_122-0_R	Sacramento River RM 122.0R	4	4	4

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
76	SAC_122-3_R	Sacramento River RM 122.3R	4	4	4
77	SAC_123-3_L	Sacramento River RM 123.3L	4	4	4
78	SAC_123-7_R	Sacramento River RM 123.7R	4	4	4
79	SAC_127-9_R	Sacramento River RM 127.9R	4	4	4
80	SAC_131-8_L	Sacramento River RM 131.8L	4	4	4
81	SAC_132-9_R	Sacramento River RM 132.9R	4	4	4
82	SAC_133-0_L	Sacramento River RM 133.0L	4	4	4
83	SAC_133-8_L	Sacramento River RM 133.8L	4	4	4
84	SAC_136-6_L	Sacramento River RM 136.6L	4	20	20
85	SAC_138-1_L	Sacramento River RM 138.1L	4	4	4
86	SAC_152-8_L	Sacramento River RM 152.8L	50	50	50
87	SAC_163-0_L	Sacramento River RM 163.0L	4	4	4
88	SAC_168-3_L	Sacramento River RM 168.3L	4	50	50
89	SAC_172-0_L	Sacramento River RM 172.0	4	4	10
90	STM_18-8_R	Steamboat Slough RM 18.8R	10	20	20
91	STM_23-2_L	Steamboat Slough RM 23.2L	4	4	10
92	STM_23-9_R	Steamboat Slough RM 23.9R	4	4	10
93	STM_24-7_R	Steamboat Slough RM 24.7R	50	50	50
94	STM_25-0_L	Steamboat Slough RM 25.0L	4	4	10
95	STM_25-8_R	Steamboat Slough RM 25.8R	4	4	10
96	STM_26-0_L	Steamboat Slough RM 26.0L	4	4	10
97	STR_24-7_R	Sutter Slough RM 24.7R	2	4	4
98	STR_26-5_L	Sutter Slough RM 26.5L	4	4	10

Table 4. Summary of AEPs Due to Erosion.

Reference No	Site ID	Erosion Site Location	AEP (Percent)		
			Condition A	Condition B	Condition C
99	WSB_0-2_L	Willow Slough LM 2.2L (Location from GIS)	1	1	2
100	WSB_0-7_L	Willow Slough LM 0.6L (Location from GIS)	1	1	2
101	WSB_6-9_R	Willow Slough LM 6.9R	4	4	4
102	YOL_0-1_R	Yolo Bypass LM 0.1R	4	4	4
103	YOL_2-0_R	Yolo Bypass LM 2.0R	2	4	4
104	YOL_2-5_R	Yolo Bypass LM 2.5R	4	4	4
105	YOL_2-6_R	Yolo Bypass LM 2.6R	4	4	4
106	YOL_3-8_R	Yolo Bypass LM 3.8R	4	4	4
107	YUB_2-3_L	Yuba River LM 2.3L	1	1	1

4.2 Condition D

Condition D, as stated in Section 3.0, is "With project conditions based on the probability of failure when a proposed erosion site was repaired to USACE standards." A proposed erosion site is assumed to be repaired to USACE design and construction standards. It is also assumed that the risk of failure due to post-repair erosion will be minimized by the repair. For Condition D, the AEP is close to 0%. However, to remain consistent with the pre-selected probability values, the AEP for Condition D at any proposed site was assigned a value of 0.5%.

4.3 Uncertainty of Estimated AEP

As listed above, the estimated AEP for each condition is the mode, or the most likely occurrence, value. The maximum estimate of an AEP for levee failure due to erosion is approximated at 20% over the mode value. The minimum estimate of AEP due to erosion is 20% below the mode value. These uncertainty estimates were based on engineering judgment by assessing the erosion site data. For example: if the estimated AEP mode value is 50%, the maximum and minimum AEP estimates are 60% and 40%. Or, in another case, if the estimated AEP mode value is 2%, the maximum and minimum estimates are 2.4% and 1.6%.

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5.0 CONCLUSION

5.1 Condition A

Among the 107 selected erosion sites, 77 sites were estimated to have AEPs for levee failure at 4% under Condition A (i.e., "Without project existing conditions without flood during 2010."), there are five sites (Sites. CHC_3-9_L, CHS_23-6_R, SAC_99-0_L, SAC_152-8_L and STM_24-7_R) estimated to have AEPs for levee failure at 50%.

5.2 Condition B

For Condition B (i.e., "Without project existing conditions with flood during 2010."), the number of sites with an AEP for levee failure at 50 increases by six (Sites CKC_21-9_L, ELC_1-4_L, GEO_3-7_L, GEO_3-71_L, GEO_5-3_L and SAC_168-3_L), for a total of 11. There are six sites (Sites GEO_1-7_L, GEO_2-5_L, GEO_9-3_L, KLR_4-2_L, SAC_24-8_L and SAC_58-4_L) with an AEP of levee failure at 10%.

5.3 Condition C

For Condition C (i.e., "Without project future conditions with flood in 2025."), the number of sites with an AEP for levee failure at 50% remains unchanged. The number of sites with an AEP of levee failure at 10% increases by 19, up from six sites at Condition B, to a total of 25. The number of sites with an AEP of levee failure at 20% increase by five, up from four sites at Condition B, at a total of nine sites.

5.4 Condition D

The AEP estimate for "With Project Condition" is 0.5% for all 107 selected erosion sites. Table 5 summarizes the number of erosion sites with their AEPs at each of the three specified conditions.

Table 5. Numbers of Sites in Each AEP Choice Under Conditions A, B and C.

AEP (Percent)	Condition A	Condition B	Condition C
0.5	4	3	3
1	6	5	3
2	6	2	4
4	77	76	52
10	4	6	25
20	5	4	9
50	5	11	11

Figure 1 illustrates the number of erosion sites and their AEPs under each of the three specified conditions.

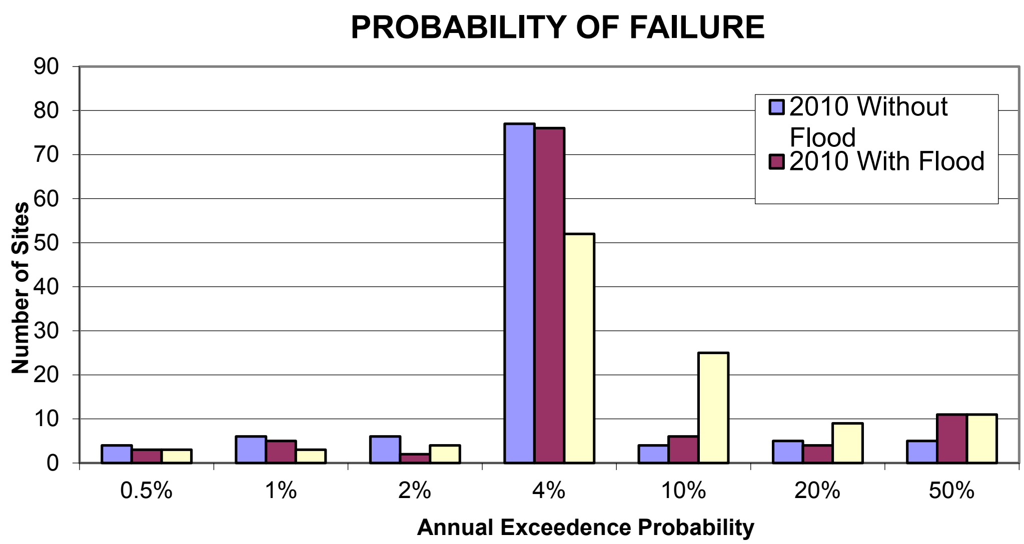

Figure 1. Number of Sites with AEPs Under Conditions A, B and C.

6.0 SENSITIVITY ANALYSIS

To perform a sensitivity analysis, 10 sites were selected to represent the general characteristics of the channel, such as tidal influence, bed material and channel geometry (slope, width, flow depth). Eight of the 10 sites were selected within the reach locations specified by USACE. Two sites (Sites GEO_9-3_L and BER_0.8_L) were selected to represent the Georgiana Slough and the Bear Creek. Table 6 lists the 10 selected sites.

Effects of particular input parameters on the AEP were identified through a sensitivity analysis. The following four input parameters were selected for sensitivity analysis:

- The hydrograph
- Placement of standard levee prism
- Erosion rate versus velocity
- Relationship between erosion width and probability of failure

For each selected representative site, the input parameter was increased and decreased by 25% and the AEPs for each site were calculated under each of the four conditions. These AEPs were compared to the originally-calculated AEPs. Appendix C contains the sensitivity analysis calculations.

Table 6. Sites selected for Sensitivity Analysis.

Reference No	Site ID	Site Selection Criteria
1	BER_0-8_L	Located on Bear Creek
11	ELC_1-4_L	Located on one of the smaller channels, such as Elder Creek or Dear Creek
14	FHR_0-6_L	Located on the Feather River
32	GEO_9-3_L	Located on Georgiana Slough
38	LAR_7-3_R	Located on the American River
43	SAC_23-2_L	In the Sacramento River Delta downstream of Courtland, California (downstream of River Mile[1] 34.0)
57	SAC_63-0_R	In the Sacramento River between Verona and Courtland, California (between River Miles[1] 80.0 to 34.0)
84	SAC_136-6_L	In the Sacramento River between Colusa and Verona, California (between River Miles[1] 140.0 to 80.0)
86	SAC_152-8_L	In the meander section of the Sacramento River North of Colusa, California (upstream of UNET River Mile[1] 140.0)
104	YOL_2-5_R	Located in one of the large project bypasses such as the Sutter or Yolo bypasses

Note:
[1]River miles specified in site selection criteria column refer to the Historic United States Geological Survey (USGS) River Miles.

6.1 The Hydrograph

When the hydrograph was selected as the input parameter to be varied for sensitivity analysis, velocity and duration were decreased and increased by 25 % without changing other parameters. As an example, Table 7 below shows the results for Reference Site 57. Results are also illustrated graphically in Figure 2.

Table 7. Hydrograph Sensitivity Analysis.

Base Values		25% Decrease		25% Increase	
Velocity (ft/s)	Time (Hours)	Velocity (ft/s)	Time (Hours)	Velocity (ft/s)	Time (Hours)
0.00	200	0.00	150	0.00	250.00
0.65	200	0.49	150	0.81	250.00
0.65	50	0.49	37.5	0.81	62.50
1.30	50	0.97	37.5	1.62	62.50

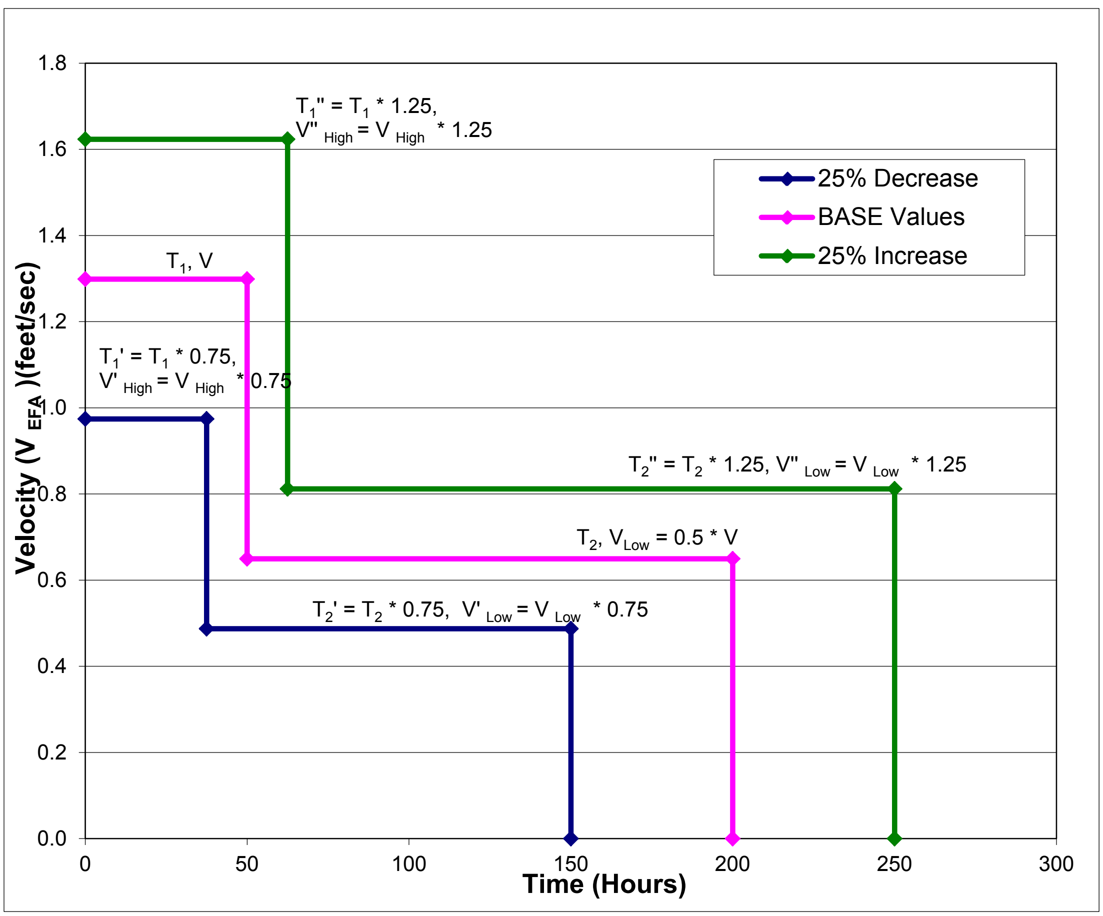

Figure 2. The Hydrograph Sensitivity Analysis.

Results of the hydrograph sensitivity analysis indicate no change in AEP for eight out of the ten selected sites when the velocity and duration were decreased by 25%. Sites, which had changes in AEP, resulted in 2% and 16% decreases in AEP. Similarly, there was no change in AEP for eight out of the ten selected sites when the velocity and duration were increased by 25%. Two sites which had changes in AEP exhibited a 30% increase in AEP.

Table 8 and Table 9 present the base AEP and the change in AEP when the velocity and duration were decreased and increased by 25% respectively for the 10 selected sites.

Table 8. Hydrograph Sensitivity Analysis Results for 25 Percent Decrease.

Reference No	Site ID	Base Value AEP in 2010 with Flood (Percent)	25 Percent Decrease AEP in 2010 with Flood (Percent)	AEP (Percent Change)
1	BER_0-8_L	20	20	0
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	**LAR_7-3_R**	**4**	**2**	**-2**
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**20**	**4**	**-16**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

Table 9. Hydrograph Sensitivity Analysis Results for 25 Percent Increase.

Reference No	Site ID	Base Value AEP in 2010 with Flood (Percent)	25 Percent Increase AEP in 2010 with Flood (Percent)	AEP (Percent Change)
1	**BER_0-8_L**	**20**	**50**	**+ 30**
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	LAR_7-3_R	4	4	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**20**	**50**	**+30**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

6.2 Placement of the Standard Levee Prism

Sensitivity analysis was also performed by varying the placement of the standard levee prism. Due to physical characteristics of the placement of levee prism, The project team determined that the placement would be aligned with a physical levee point, rather than a placement relative to numerically increased or decreased amount.

The base condition AEP is estimated by placing the standard levee prism landside hinge point to be aligned with the levee landside slope. There are two viable directions for moving the standard levee prism toward the levee's waterside, or toward landside for sensitivity analysis:

- Waterside shift. The waterside hinge point is aligned with the levee waterside slope. Due to the impractical nature of this placement (as it would likely "over predict" vulnerability to erosion), sensitivity analysis with this placement was not performed. Instead, the center of the levee prism was aligned with the center of the levee crown.
- Landside shift. Landside shift of the prism is not practical; sensitivity of landside shift was not analyzed.

Figure 3 shows the levee prism at the center of levee, landside levee slope, and waterside levee slope.

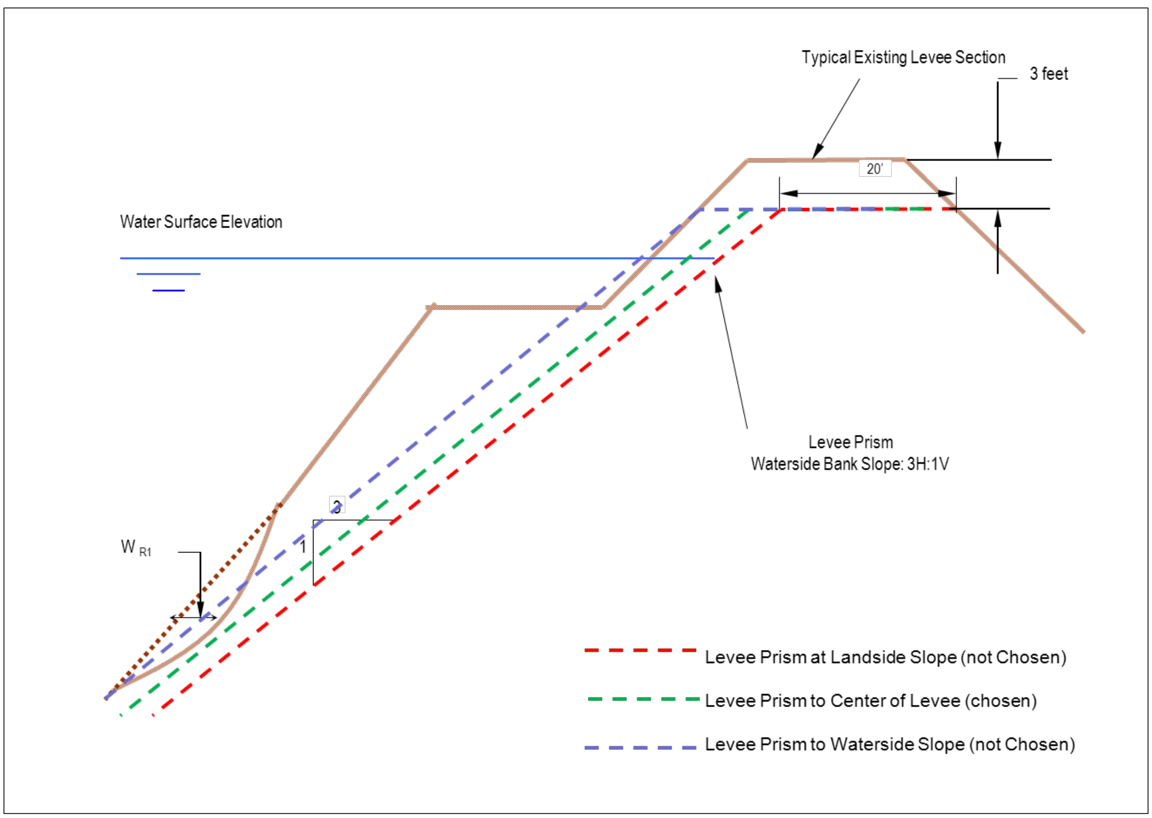

Figure 3. Placement of Standard Levee Prism Sensitive Analysis.

6.2.1 Waterside Shift Levee Prism to the Center of the Levee

This analysis was performed under 2010 project conditions both without and with a flood.

There was no change in AEP for seven of the 10 selected sites when the levee prism was placed at the center of the levee under 2010 project conditions without flood. Three sites had a change in AEP, resulting in an average 40% increase in AEP.

Similarly, there was no change in AEP for six out of the 10 selected sites when the levee prism was placed at the center of the levee under 2010 project conditions with flood. However, three out of the four sites had an average 30% increase in AEP while the remaining site had a nominal increase of 6%.

Table 10 and Table 11 present the AEP and the change in AEP when the levee prism is placed at the center of the levee under 2010 project conditions both without and with flood for the 10 selected sites.

Table 10. Placement of Standard Levee Prism, Parameter Sensitivity Analysis at Center of Levee Without Flood Results.

Reference No	Site ID	Base Values (Percent)	At Center of Levee (Percent)	AEP (Percent Change)
		AEP in 2010 without Flood	AEP in 2010 without Flood	
1	**BER_0-8_L**	**20**	**50**	**+30**
11	ELC_1-4_L	20	20	0
14	FHR_0-6_L	4	4	0
32	**GEO_9-3_L**	**10**	**50**	**+40**
38	LAR_7-3_R	1	1	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**4**	**50**	**+46**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

Table 11. Placement of the Standard Levee Prism, Parameter Sensitivity Analysis At Center Of Levee With Flood Results.

Reference No	Site ID	Base Values (Percent)	At Center of Levee (Percent)	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
1	**BER_0-8_L**	**20**	**50**	**+30**
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	**GEO_9-3_L**	**10**	**50**	**+40**

Table 11. Placement of the Standard Levee Prism, Parameter Sensitivity Analysis At Center Of Levee With Flood Results.

Reference No	Site ID	Base Values (Percent)	At Center of Levee (Percent)	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
38	LAR_7-3_R	4	4	0
43	**SAC_23-2_L**	**4**	**10**	**+6**
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**20**	**50**	**+30**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

6.3 Erosion Rate Versus Velocity

Sensitivity analysis was performed by increasing and decreasing the erosion rate (R_E) input parameter by 25% while the velocity remained unchanged. The erosion rate was based on the erosion screening process developed using ULE Program data in the Central Valley. Table 12 presents the R_E for a 25% decrease and increase in erosion rates.

Table 12. Erosion Rate Versus Velocity Parameter Sensitivity Analysis.

Velocity (V_{EFA}) (ft/s)	Erosion Rate (feet/hour)								
	25 Percent Decrease			Base Values			25 Percent Increase		
	Silt	Sand	Clay	Silt	Sand	Clay	Silt	Sand	Clay
0.5	0.00225	0.00165	0.001125	0.003	0.0022	0.0015	0.0038	0.0028	0.0019
1	0.015	0.00675	0.00375	0.02	0.009	0.005	0.0250	0.0113	0.0063
1.5	0.04425	0.01575	0.00675	0.059	0.021	0.009	0.0738	0.0263	0.0113
2	0.096	0.02775	0.0105	0.128	0.037	0.014	0.1600	0.0463	0.0175
2.5	0.1755	0.04425	0.015	0.234	0.059	0.02	0.2925	0.0738	0.0250
3	0.2865	0.06375	0.0195	0.382	0.085	0.026	0.4775	0.1063	0.0325
3.5	0.435	0.08775	0.0255	0.58	0.117	0.034	0.7250	0.1463	0.0425
4	0.62475	0.11475	0.0315	0.833	0.153	0.042	1.0413	0.1913	0.0525
4.5	0.85875	0.14625	0.03825	1.145	0.195	0.051	1.4313	0.2438	0.0638
5	1.1415	0.1815	0.045	1.522	0.242	0.06	1.9025	0.3025	0.0750
5.5	1.4775	0.2205	0.0525	1.97	0.294	0.07	2.4625	0.3675	0.0875
6	1.86975	0.264	0.06075	2.493	0.352	0.081	3.1163	0.4400	0.1013

Table 12. Erosion Rate Versus Velocity Parameter Sensitivity Analysis.									
Velocity (V_{EFA}) (ft/s)	Erosion Rate (feet/hour)								
	25 Percent Decrease			Base Values			25 Percent Increase		
	Silt	Sand	Clay	Silt	Sand	Clay	Silt	Sand	Clay
7	2.8365	0.3615	0.07725	3.782	0.482	0.103	4.7275	0.6025	0.1288
8	4.07025	0.4755	0.096	5.427	0.634	0.128	6.7838	0.7925	0.1600
9	5.59725	0.6045	0.11625	7.463	0.806	0.155	9.3288	1.0075	0.1938
10	7.44225	0.75	0.138	9.923	1	0.184	12.4038	1.2500	0.2300
11	9.63075	0.91125	0.1605	12.841	1.215	0.214	16.0513	1.5188	0.2675
12	12.186	1.089	0.1845	16.248	1.452	0.246	20.3100	1.8150	0.3075

The results of erosion rate verses velocity sensitivity analysis indicated that, there was no change in AEP for 9 of the 10 selected sites when the erosion rate was decreased by 25%. Similarly, when the erosion rate was increased by 25% none of the 10 selected sites had a change in AEP.

Table 13 and Table 14 present the AEP and change in AEP when the erosion rate was decreased and increased by 25% at the 10 selected sites.

Table 13. Erosion Rate Versus Velocity Sensitivity Analysis Results for 25 Percent Decrease.				
Reference No	Site ID	25 Percent Decrease	Base Values (Percent)	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
1	BER_0-8_L	20	20	0
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	LAR_7-3_R	4	4	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	**SAC_136-6_L**	**10**	**20**	**-10**
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

Table 14. Erosion Rate Versus Velocity Sensitivity Analysis Results for 25 Percent Increase.

Reference No	Site ID	Base Values (Percent)	25 Percent Increase	AEP (Percent Change)
		AEP in 2010 with Flood	AEP in 2010 with Flood	
1	BER_0-8_L	20	20	0
11	ELC_1-4_L	50	50	0
14	FHR_0-6_L	4	4	0
32	GEO_9-3_L	10	10	0
38	LAR_7-3_R	4	4	0
43	SAC_23-2_L	4	4	0
57	SAC_63-0_R	2	2	0
84	SAC_136-6_L	20	20	0
86	SAC_152-8_L	50	50	0
104	YOL_2-5_R	4	4	0

6.4 Relationship Between Erosion Width and Probability of Failure

Sensitivity analysis was then performed by increasing and decreasing the ratio of erosion width (W_R) over effective levee width (W_E) by 25% without changing the estimated probability ranking. This analysis was performed under 2010 project conditions both without and with flood. Table 15 and Table 16 below show estimated probability for a 25% decrease and increase in ratio of W_R over effective W_E. (Table 2 and Table 3, provided earlier in this report, show the estimated probability for a ratio of erosion width over effective levee width during AEP.)

Table 15. Sensitivity Analysis, Relationship Between Erosion Width and Probability of Failure by 25 Percent Decrease.

Ratio of W_R/W_E	AEP
Erosion Outside of Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
< 0.75%	0.005, or 0.5%
0.75% to 3.75%	0.01, or 1%
3.75% to 7.5%	0.02, or 2%
> 7.5%	0.04, or 4%
Erosion Within Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
0.75% to 11.25%	0.04, or 4%
11.25% to 15.0%	0.1, or 10%
15.0% to 18.75%	0.2, or 20%
> 18.75%	0.5, or 50%

Table 16. Sensitivity Analysis, Relationship Between Erosion Width and Probability of Failure by 25 Percent Increase.	
Erosion Outside of Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
< 1.25%	0.005, or 0.5%
1.25% to 6.25%	0.01, or 1%
6.25% to 12.5%	0.02, or 2%
> 12.5%	0.04, or 4%
Erosion Within Levee Prism and AEP	
Ratio of W_R/W_E	**AEP**
1.25% to 18.75%	0.04, or 4%
18.75% to 25%	0.1, or 10%
25% to 31.25%	0.2, or 20%
> 31.25%	0.5, or 50%

6.4.1 Decreasing W_R/W_E by 25%

There was no change in AEP for 7 out of the 10 selected sites when the ratio of W_R/W_E was decreased by 25% under 2010 project conditions without a flood. Two out of the three sites had a change in AEP, resulting in a 10% decrease in AEP while the remaining site had a 6% decrease in AEP.

Similarly, there was no change in AEP for six out of the 10 selected sites when the ratio of W_R/W_E was decreased by 25% under 2010 project conditions with flood. Two out of the four sites had a change in AEP, resulting in a 10% decrease in AEP while the remaining two sites had decreases of 30% and 6%.

Table 17 presents the AEP and change in AEP when the ratio of W_R over effective W_E was decreased by 25% under 2010 project conditions both without and with flood for the 10 selected sites.

6.4.2 Increasing W_R/W_E by 25%

There was no change in AEP for 7 of the 10 selected sites when the ratio of W_R/W_E was increased by 25% under 2010 project conditions without flood. Two of the three sites had a change in AEP, resulting in a 30% increase in AEP while the remaining site had a 10% increase in AEP.

Similarly, there was no change in AEP for 6 of the 10 selected sites when the ratio of W_R/W_E was increased by 25% under 2010 project conditions with flood. Two of the four sites had a change in AEP, resulting in a 30% increase in AEP while the remaining two sites had increases of 10% and 2%.

Table 17. Erosion Width over Effective Levee Width, Sensitivity Analysis Results for 25 Percent Decrease.

Reference No	Site ID	25 Percent Decrease		Base Values (Percent)		AEP Percent Change	
		AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood
1	**BER_0-8_L**	**10**	**10**	**20**	**20**	**-10**	**-10**
11	**ELC_1-4_L**	**10**	**20**	**20**	**50**	**-10**	**-30**
14	FHR_0-6_L	4	4	4	4	0	0
32	**GEO_9-3_L**	**4**	**4**	**10**	**10**	**-6**	**-6**
38	LAR_7-3_R	0.5	4	1	4	0	0
43	SAC_23-2_L	4	4	4	4	0	0
57	SAC_63-0_R	2	2	2	2	0	0
84	**SAC_136-6_L**	**4**	**10**	**4**	**20**	**0**	**-10**
86	SAC_152-8_L	50	50	50	50	0	0
104	YOL_2-5_R	4	4	4	4	0	0

Table 18 presents the AEP and change in AEP when the ratio of W_R over effective W_E was increased by 25% under 2010 project conditions both without and with a flood at the 10 selected sites.

Table 18. Erosion Width over Effective Levee Width Sensitivity Analysis Results for 25 Percent Increase.

Reference No	Site ID	Base Values (Percent)		25 Percent Increase		AEP Percent Change	
		AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood	AEP in 2010 without Flood	AEP in 2010 with Flood
1	**BER_0-8_L**	**20**	**20**	**50**	**50**	**+30**	**+30**
11	**ELC_1-4_L**	**20**	**50**	**50**	**50**	**+30**	**0**
14	FHR_0-6_L	4	4	4	4	0	0
32	**GEO_9-3_L**	**10**	**10**	**20**	**20**	**+10**	**+10**
38	LAR_7-3_R	1	4	0.5	4	0	0
43	SAC_23-2_L	4	4	4	4	0	0
57	SAC_63-0_R	2	2	2	4	0	**2**
84	**SAC_136-6_L**	**4**	**20**	**4**	**50**	**0**	**+30**
86	SAC_152-8_L	50	50	50	50	0	0
104	YOL_2-5_R	4	4	4	4		0

7.0 UNCERTAINTY AND LIMITATIONS

7.1 Uncertainty

This report is based upon the JV's interpretation of available information and certain key assumptions. Evaluation results are conditioned upon these assumptions, and are defined below.

Topographic data used in this evaluation was based on the light detection and ranging (LiDAR) data and bathymetry data collected from DWR's Urban Levee Geotechnical Evaluations (ULE) Program. These topographic data were collected per ULE Program specifications. Bathymetry data were not available for all sites within the project reaches. Whenever a discrepancy was found in data provided by others, the cross section of each erosion site was updated in accordance with the site conditions observed during the field visits. Data presented in this report are the best available information and are time-sensitive, in that they apply only to locations and conditions existing at the time of LiDAR survey and preparation of this report. These topographic data should not be applied to any other projects in or near the area of study; nor should they be applied under future conditions without appropriate verification. Topographic data should not to be used as the basis for design and construction.

Where bathymetry is not available, bank and channel geometry were estimated below the water surface using the best available information. This information includes the available hydraulic model cross sections (such as a UNET model), an approximated depth of water and an approximated channel slope.

Placement of the standard levee prism was based on conservatism and engineering judgment. Prism placement on landside slopes allows erosion assessment for the entire levee width. Prism placement 3 feet below crest is based on a typical levee cross section and design freeboard along the Sacramento River. Some exceptions were considered for the sites at Deer Creek, Elder Creek and Georgiana Slough (see Section 3.3) due to their unique circumstances.

Riverine hydrologic and hydraulic data were obtained from other available studies. At most sites, velocities were obtained from the 2007 Ayres and Associates' *Field Reconnaissance Report* (Ayres, 2007). This report presented mean channel velocities were using a USACE UNET hydraulic model based on the 100-year discharge, where available. For this report, channel velocities at some erosion sites were adjusted based on conditions observed in the field. These velocities cannot be used as the basis for design or construction.

Field observation and assessment are engineering judgments based on a combination of an individual's observations and available information. Site conditions varied during field observation and could change after field observation.

The erosion rates of silt, sand and clay levee material were developed from the ULE Program dataset for California's Central Valley. Soil sample and lab testing information, although limited, are the best available information.

To provide a consistent impact evaluation, a high-flood event was assumed. The velocity and duration of this high-flood event are based on hydrographs of past flood events in the Central Valley. These typical velocities and durations do not represent any specific flood event.

7.2 Limitation

This report was prepared by the JV in a manner consistent with the level of care and skill ordinarily exercised by professional engineers in the geographic area of study, based upon the information available at the time of the project. The JV provides no other warranties, express or implied, concerning the contents of this paper, which was prepared under the technical direction of a registered professional engineer.

This evaluation is not design-level, but of a more general nature, and similar to estimates found in a PL94-99-type *Project Information Report* analysis or a pre-feasibility phase analysis. AEP estimates are general in nature, and in this case are further confined to the seven pre-defined choices made by USACE.

Evaluation data presents the best estimated probability of erosion damage in any given year. Evaluations provide a numerical value (in general classes) and document the rationale for these decisions.

8.0 REFERENCES

Ayres Associates. 2007. *Field Reconnaissance Report of Bank Erosion Sites and Site Priority Ranking.* Sacramento River Flood Control Levees, Tributaries and Distributaries, Sacramento River Bank Protection Project. Prepared for USACE.

USACE. 2002. Sacramento and San Joaquin River Basins Comprehensive Study, Sacramento River Basin UNET Model. April.

USACE. 2010. Levee Survey data Collected during 2010 annual erosion inventory in June-July 2010.

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ENCLOSURE 2

Supporting Data

Impact Area Number (From Comp Study)	Name/Location of Impact Area	Index Point Location Used for Economic Analysis	Top of Levee (TOL) Elevation	Adjusted Without-Project Fragility Curve (AEP Level of More Critical Erosion Sites)		Adjusted Without-Project Fragility Curve (AEP Level of Less Critical Erosion Sites)		With-Project Fragility Curve (AEP Level from Comprehensive Study WO Analysis/Other Current Study Analysis)	
				Elevation	P(f)	Elevation	P(f)	Elevation	P(f)
15	Yolo	Knights Landing Ridge Cut LM 3.02R	38.86	26.41	0.90	30.90	0.01	30.90	0.15
				30.90	0.95	32.40	0.02	32.40	0.50
				32.40	0.97	34.90	0.10	34.90	0.85
				34.90	0.99	38.70	0.15		
				AEP = .500		AEP = .010		AEP = .074	
55	Ryer Island	Sutter Slough RM 22.23R	25.35	10.40	0.05	10.40	0.05	10.40	0.15
				10.90	0.10	10.90	0.15	10.90	0.50
				11.10	0.55	11.40	0.25	11.40	0.85
						25.30	0.40		
				AEP = .100		AEP = .040		AEP = .124	
61	Hastings Tract	Cache Slough RM 21R	17.70	6.35	0.70	None		8.20	0.15
				8.20	0.75			8.70	0.50
				8.70	0.80			9.20	0.85
				9.20	0.99				
				AEP = .500				AEP = .329	
42	Clarksburg	Sutter Slough RM 25.23R	22.86	10.90	0.02	10.90	0.00	10.90	0.15
				13.90	0.06	13.90	0.02	13.90	0.50
				16.90	0.20	16.90	0.03	16.90	0.85
						21.80	0.10		
				AEP = .020		AEP = .005		AEP = .131	
53	Tyler Island	Georgiana Slough RM .25L	10.53	6.50	0.05	6.50	0.02	6.50	0.50
				6.90	0.17	6.90	0.03	6.90	0.85
				7.10	0.35	10.40	0.08		
				AEP = .200		AEP = .040		AEP = .805	
13 and 14	Knights Landing	Sacramento River RM 90R	44.43	35.50	0.05	35.50	0.02	35.50	0.15
				38.00	0.25	38.00	0.03	38.00	0.50
				40.50	0.40	40.50	0.07	40.50	0.85
				AEP = .040		AEP = .020		AEP = .070	
50	Grand Island	Sacramento River RM 14.75R	22.85	7.30	0.05	7.30	0.05	7.30	0.15
				7.80	0.10	7.80	0.10	7.80	0.50
				8.30	0.20	8.30	0.20	8.30	0.85
				22.70	0.60	22.70	0.60		
				AEP = .040		AEP = .040		AEP = .108	
49	Sutter Island	Sutter Slough RM 23.73L	25.20	9.05	0.75	11.80	0.02	11.80	0.15
				11.80	0.80	12.30	0.05	12.30	0.50
				12.30	0.85	12.80	0.15	12.80	0.85
				12.80	0.99	25.20	0.75		
				AEP = .500		AEP = .040		AEP = .103	
16	Woodland	Yolo Bypass LM 48.84R	32.78	24.80	0.01	24.80	0.01	24.80	0.15
				30.30	0.25	30.30	0.03	30.30	0.50
				32.70	0.50	32.70	0.08	32.70	0.85
				AEP = .040		AEP = .010		AEP = .090	
17	Davis	Putah Creek	46.23	42.80	0.15	42.80	0.15	42.80	0.15
				43.80	0.50	43.80	0.50	43.80	0.50
				45.30	0.85	45.30	0.85	45.30	0.85
				AEP = .040		AEP = .040		AEP = .040	

37	Arden	American River RM 11.33R	58.60	52.60	0.25	52.60	0.25	52.60	0.05
				54.60	0.35	54.60	0.35	54.60	0.11
				56.60	0.43	56.60	0.43	56.60	0.43
				58.60	0.93	58.60	0.93	58.60	0.93
				AEP = .010		AEP = .010		AEP = .010	
30	Rio Oso	Feather River RM 7.17R	52.40	42.30	0.50	43.10	0.05	43.10	0.15
				43.10	0.65	46.00	0.20	46.00	0.50
				46.00	0.85	49.50	0.50	49.50	0.85
				49.50	0.99				
				AEP = .200		AEP = .040		AEP = .086	
54	Brannan Andrus	Georgiana Slough RM .75R	10.89	6.70	0.02	6.70	0.02	6.20	0.15
				7.20	0.05	7.20	0.05	6.70	0.50
				10.80	0.65	10.80	0.65	7.20	0.85
				AEP = .040		AEP = .040		AEP = .671	
46	Merritt Island	Sacramento River RM 41R	26.21	17.30	0.05	N/A		17.30	0.15
				19.80	0.10			19.80	0.50
				22.30	0.15			22.30	0.85
				26.20	0.35				
				AEP = .040		AEP = .005		AEP = .156	
39	Southport	Sacramento River RM 52.75R	39.00	26.45	0.20	26.45	0.20	26.45	0.04
				27.00	0.30	27.00	0.30	27.00	0.04
				35.00	0.40	35.00	0.40	35.00	0.17
				37.00	0.45	37.00	0.45	37.00	0.27
				39.00	0.75	39.00	0.75	39.00	0.43
				AEP = .040		AEP = .040		AEP = .011	
40	Sacramento	Sacramento River RM 51L	31.50	24.00	0.30	24.00	0.15	25.40	0.10
				25.40	0.65	25.40	0.25	27.40	0.23
				27.40	0.85	27.40	0.50	29.40	0.49
				29.40	0.90	29.40	0.75	31.40	0.73
				31.40	0.99	31.40	0.85		
				AEP = .040		AEP = .020		AEP = .008	
38	West Sacramento	Sacramento River RM 59.99R	40.00	32.00	0.65	32.00	0.25	32.00	0.02
				34.00	0.85	34.00	0.40	34.00	0.09
				36.00	0.90	36.00	0.50	36.00	0.37
				38.00	0.95	38.00	0.75	38.00	0.81
				40.00	0.99	40.00	0.99	40.00	0.99
				AEP = .040		AEP = .020		AEP = .009	
35	Elkhorn	Sacramento River RM 76.75R	40.12	31.20	0.01	31.20	0.01	28.20	0.15
				34.20	0.02	34.20	0.02	31.20	0.50
				40.10	0.04	40.10	0.04	34.20	0.85
				AEP = .040		AEP = .040		AEP = .500	
36	Natomas	Sacramento River RM 79.00L	44.40	36.40	0.02	36.40	0.02	36.40	0.01
				39.40	0.04	39.40	0.04	39.40	0.01
				41.40	0.05	41.40	0.05	41.40	0.05
				44.39	0.12	44.39	0.12	44.39	0.12
				AEP = .010		AEP = .010		AEP = .007	
11 and 34	South Sutter	Sacramento River RM 86.50L	42.59	33.80	0.60	33.80	0.02	33.80	0.15
				36.30	0.95	36.30	0.05	36.30	0.50
				38.80	0.99	38.80	0.15	38.80	0.85
						42.70	0.35		
				AEP = .500		AEP = .040		AEP = .254	
				45.00	0.02	45.00	0.02	45.00	0.33

10	Grimes	Sacramento River RM 119.75R	55.51	46.50	0.03	46.50	0.03	46.50	0.50
				49.50	0.05	49.50	0.05	49.50	0.85
				55.40	0.35	55.40	0.35		
				AEP = .040		AEP = .040		AEP = .533	
32	North Sutter	Sutter Bypass LM 88.60	58.60	50.60	0.10	50.60	0.10	50.60	0.15
				56.10	0.40	56.10	0.40	56.10	0.50
				58.50	0.85	58.50	0.85	58.50	0.85
				AEP = .040		AEP = .040		AEP = .050	
27	Linda	Yuba River LM 5.7L	94.10	88.00	0.08	88.00	0.08	88.00	0.04
				90.00	0.30	90.00	0.30	90.00	0.24
				92.00	0.87	92.00	0.87	92.00	0.78
				94.00	1.00	94.00	1.00	94.00	1.00
				AEP = .010		AEP = .010		AEP = .008	
5	Butte Basin	Sacramento River RM 183.50L	112.86	111.00	0.02	N/A		None	
				111.63	0.05				
				AEP = .500				AEP = .281	

ENCLOSURE 3

Depth-Percent Damage Curves

ENCLOSURE 2

Depth-Percent Damage Curves – Structures and Contents

Table 1

C-RET1		
Commercial Retail 1-story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	42.71
1	21.73	79.83
1.5	26	94.79
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 2

C-RET2		
Commercial Retail 2-story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	20.49
1	15.26	38.31
1.5	17.1	49.61
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 3

C-DEAL1		
Full Service Auto Dealership 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	5.75
-0.5	3.5	5.81
0	7	5.81
0.5	14.4	41.07
1	21.73	80.26
1.5	26	97.18
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 4

C-DEAL2		
Full Service Auto Dealership 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	2.76
-0.5	2.5	2.79
0	5	2.79
0.5	10.1	19.71
1	15.26	38.52
1.5	17.1	50.86
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 5

C-FURN1		
Furniture Store 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	89.48
1	21.73	98.2
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 6

C-FURN2		
Furniture Store 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.94
1	15.26	47.13
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 7

C-HOS1		
Hospital 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	75.49
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 8

C-HOS2		
Hospital 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	36.23
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 9

C-AUTO1		
Commercial Auto Sales 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 10

C-AUTO2		
Commercial Auto Sales 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.89
1	15.26	46.44
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 11

C-HOTEL1		
Hotel 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.36
1	21.73	91.34
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 12

C-HOTEL2		
Hotel 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.73
1	15.26	43.83
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 13

C-FOOD1		
Commercial Food-Retail 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0.5
0.5	14.4	56.98
1	21.73	78.33
1.5	26	94.47
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 14

C-FOOD2		
Commercial Food-Retail 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0.24
0.5	10.1	27.35
1	15.26	37.59
1.5	17.1	49.44
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 15

C-RESTFF1		
Commercial Fast Food Rest 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	45.1
1	21.73	87.8
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 16

C-RESTFF2		
Commercial Fast Food Rest 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	21.64
1	15.26	42.14
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 17

C-GROC1		
Commercial Grocery Store 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	61.04
1	21.73	87.33
1.5	26	94.38
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 18

C-GROC2		
Commercial Grocery Store 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	29.29
1	15.26	41.91
1.5	17.1	49.39
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 19

C-MED1		
Commercial Medical 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	75.49
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 20

C-MED2		
Commercial Medical 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	36.23
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 21

C-OFF1		
Commercial Office 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 22

C-OFF2		
Commercial Office 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	42.89
1	15.26	46.44
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 23

C-SHOP1		
Commercial Shopping Center 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	76.45
1	21.73	95.92
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 24

C-SHOP2		
Commercial Shopping Center 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	36.69
1	15.26	46.03
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 25

C-REST1		
Commercial Restaurant 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.36
1	21.73	91.34
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 26

C-REST2		
Commercial Restaurant 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.73
1	15.26	43.83
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 27

C-SERV1		
Commercial Service-Auto 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	9.91
-0.5	3.5	10
0	7	10
0.5	14.4	38.69
1	21.73	73.51
1.5	26	97.44
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 28

C-SERV1		
Commercial Service-Auto 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	4.75
-0.5	2.5	4.8
0	5	4.8
0.5	10.1	18.57
1	15.26	35.28
1.5	17.1	50.99
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 29

I-LT1		
Industrial Light 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0.19
0.5	14.4	45.36
1	21.73	87.64
1.5	26	92.79
2	30.19	96.39
3	31.22	98.97
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 30

I-LT2		
Industrial Light 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0.19
0.5	10.1	21.77
1	15.26	42.06
1.5	17.1	48.56
2	18.88	53.95
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 31

I-HV1		
Industrial Heavy Manufacture 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	12.18
1	21.73	32.69
1.5	26	53.81
2	30.19	69.95
3	31.22	77.48
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 32

I-HV2		
Industrial Heavy Manufacture 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	5.85
1	15.26	15.69
1.5	17.1	28.16
2	18.88	39.15
3	21.48	43.37
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 33

I-WH1		
Industrial Warehouse 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	41.32
1	21.73	84.19
1.5	26	94.42
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 34

I-WH2		
Industrial Warehouse 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	19.83
1	15.26	40.4
1.5	17.1	49.41
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 35

P-CH1		
Public Church 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	47.33
1	21.73	73.35
1.5	26	83.86
2	30.19	98.82
3	31.22	98.82
4	32.44	98.82
5	32.44	98.82
6	39.82	98.82
7	42.76	98.82
8	51.72	98.82
9	53.1	98.82
10	54.09	98.82
11	61.78	98.82
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 36

P-CH2		
Public Church 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	22.71
1	15.26	35.2
1.5	17.1	43.88
2	18.88	55.31
3	21.48	55.31
4	22.8	55.31
5	22.8	55.31
6	24.05	55.31
7	26.1	55.31
8	40.4	66.08
9	43.25	66.08
10	46.2	66.08
11	46.2	68.47
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 37

P-GOV1		
Public Government Building 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	48.39
1	21.73	96.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 38

P-GOV2		
Public Government Building 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	40.87
1	15.26	45.43
1.5	17.1	51.23
2	18.88	55.88
3	21.48	55.88
4	22.8	55.88
5	22.8	55.88
6	24.05	55.88
7	26.1	55.88
8	40.4	68.08
9	43.25	68.08
10	46.2	68.08
11	46.2	69.4
12	49.05	100
13	49.05	100
14	55.16	100
15	80.05	100

Table 39

P-REC1		
Public Recreation/Assembly 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	97.95
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 40

P-REC2		
Public Recreation/Assembly 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	47.01
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 41

P-SCH1		
Public and Private Schools 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	50
1	21.73	87.78
1.5	26	100
2	30.19	100
3	31.22	100
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 42

P-SCH2		
Public and Private Schools 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	2.5	0
0	5	0
0.5	10.1	24
1	15.26	42.12
1.5	17.1	52.33
2	18.88	55.97
3	21.48	55.97
4	22.8	55.97
5	22.8	55.97
6	24.05	55.97
7	26.1	55.97
8	40.4	66.87
9	43.25	66.87
10	46.2	66.87
11	46.2	69.29
12	49.05	96.33
13	49.05	100
14	55.16	100
15	80.05	100

Table 43

FARM		
Farm Buildings Including Primary RES		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	3.5	0
0	7	0
0.5	14.4	29.67
1	21.73	56.23
1.5	26	69.84
2	30.19	93.46
3	31.22	99.58
4	32.44	100
5	32.44	100
6	39.82	100
7	42.76	100
8	51.72	100
9	53.1	100
10	54.09	100
11	61.78	100
12	64.77	100
13	64.77	100
14	65.49	100
15	86.06	100

Table 44

SFRB1		
Single Family Residential 1-story W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	5.2	5.7
-3	9	8
-2	13.8	10.5
-1	19.4	13.2
-0.5	22.5	14.6
0	25.5	16
0.5	28.8	17.5
1	32	18.9
1.5	35.4	20.4
2	38.7	21.8
3	45.5	24.7
4	52.2	27.4
5	58.6	30
6	64.5	32.4
7	69.8	34.5
8	74.2	36.3
9	77.7	37.7
10	80.1	38.6
11	81.1	39.1
12	81.1	39.1
13	81.1	39.1
14	81.1	39.1
15	81.1	39.1

Table 45

SFRB2		
Single Family Residential 2-story W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	4.7	5.2
-3	7.2	6.8
-2	10.2	8.4
-1	13.9	10.1
-0.5	15.9	11
0	17.9	11.9
0.5	20.1	12.9
1	22.3	13.8
1.5	24.7	14.8
2	27	15.7
3	31.9	17.7
4	36.9	19.8
5	41.9	22
6	46.9	24.3
7	51.8	26.7
8	56.4	29.1
9	60.8	31.7
10	64.8	34.4
11	68.4	37.2
12	71.4	40
13	73.7	43
14	75.4	46.1
15	76.4	49.3

Table 46

SFRBS		
Single Family Residential Split-Level W/Basement		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	4.7	3.8
-3	7.2	5.4
-2	10.4	7.3
-1	14.2	9.4
-0.5	16.4	10.5
0	18.5	11.6
0.5	20.9	12.7
1	23.2	13.8
1.5	25.7	15
2	28.2	16.1
3	33.4	18.2
4	38.6	20.2
5	43.8	22.1
6	48.8	23.6
7	53.5	24.9
8	57.8	25.8
9	61.6	26.3
10	64.8	26.3
11	67.2	26.3
12	68.8	26.3
13	69.3	26.3
14	69.3	26.3
15	69.3	26.3

Table 47

SFR1		
Single Family Residential 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	2.5	2.4
-0.5	8	5.3
0	13.4	8.1
0.5	18.4	10.7
1	23.3	13.3
1.5	27.7	15.6
2	32.1	17.9
3	40.1	22
4	47.1	25.7
5	53.2	28.8
6	58.6	31.5
7	63.2	33.8
8	67.2	35.7
9	70.5	37.2
10	73.2	38.4
11	75.4	39.2
12	77.2	39.7
13	78.5	40
14	79.5	40
15	80.2	40

Table 48

SFR2		
Single Family Residential 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	3	1
-0.5	6.2	3
0	9.3	5
0.5	12.3	6.9
1	15.2	8.7
1.5	18.1	10.5
2	20.9	12.2
3	26.3	15.5
4	31.4	18.5
5	36.2	21.3
6	40.7	23.9
7	44.9	26.3
8	48.8	28.4
9	52.4	30.3
10	55.7	32
11	58.7	33.4
12	61.4	34.7
13	63.8	35.6
14	65.9	36.4
15	67.7	36.9

Table 49

SFRS		
Single Family Residential Split-Level		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6.4	2.2
-0.5	6.8	2.6
0	7.2	2.9
0.5	8.3	3.8
1	9.4	4.7
1.5	11.2	6.1
2	12.9	7.5
3	17.4	11.1
4	22.8	15.3
5	28.9	20.1
6	35.5	25.2
7	42.3	30.5
8	49.2	35.7
9	56.1	40.9
10	62.6	45.8
11	68.6	50.2
12	73.9	54.1
13	78.4	57.2
14	81.7	59.4
15	83.8	60.5

Table 50

MFR1		
Multi-Family Residential 1-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	2.5	2.4
-0.5	8	5.3
0	13.4	8.1
0.5	18.4	10.7
1	23.3	13.3
1.5	27.7	15.6
2	32.1	17.9
3	40.1	22
4	47.1	25.7
5	53.2	28.8
6	58.6	31.5
7	63.2	33.8
8	67.2	35.7
9	70.5	37.2
10	73.2	38.4
11	75.4	39.2
12	77.2	39.7
13	78.5	40
14	79.5	40
15	80.2	40

Table 51

MFR2		
Multi-Family Residential 2-Story		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	3	1
-0.5	6.2	3
0	9.3	5
0.5	12.3	6.9
1	15.2	8.7
1.5	18.1	10.5
2	20.9	12.2
3	26.3	15.5
4	31.4	18.5
5	36.2	21.3
6	40.7	23.9
7	44.9	26.3
8	48.8	28.4
9	52.4	30.3
10	55.7	32
11	58.7	33.4
12	61.4	34.7
13	63.8	35.6
14	65.9	36.4
15	67.7	36.9

Table 52

MH		
Mobile Home Single/Double		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6.4	0
-0.5	7.3	0
0	9.9	0
0.5	43.4	85
1	44.7	85
1.5	45	90
2	45.7	95
3	96.5	99
4	96.5	99
5	96.5	99
6	96.5	99
7	96.5	99
8	96.5	99
9	96.5	99
10	96.5	99
11	96.5	99
12	96.5	99
13	96.5	99
14	96.5	99
15	96.5	99

Table 53

AUTO		
Automobiles		
Stage	Structure	Content
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	0	0
-0.5	0	0
0	0	0
0.5	2.8	0
1	21.8	0
1.5	31.15	0
2	40.5	0
3	56.9	0
4	71.1	0
5	83.2	0
6	91.9	0
7	96.1	0
8	99.2	0
9	100	0
10	100	0
11	100	0
12	100	0
13	100	0
14	100	0
15	100	0

Sacramento River Bank Protection Project (SRBPP)
Median Square Footage and Median Structure Value Information
October 2010 Price Level

Impact Area	Median Sq Ft	Median Value
Butte Basin (5)	n/a	n/a
Grimes (10)	1,604	$89,736
Knight's Landing (13/14)	1,875	$122.730
Yolo (15)	n/a	n/a
Woodland (16)	n/a	n/a
Davis (17)	3,171	$510,277
Linda Yuba East (27)	1,287	$68,270
Rio Oso (30)	1,359	$83,621
North Sutter (32)	1,240	74,955
South Sutter (34)	3,205	$223,991
Elkhorn (35)	n/a	n/a
Natomas (36)	1,759	$141,167
Arden Rio Linda (37)	1,353	$103,900
West Sac (38)	1,489	$95,251
SouthPort (39)	2,192	$54,520
Sacramento 4of 4 (40)	1,474	$118,400
Clarksburg (42)	1,494	$100,102
Merritt island (46)	1,186	$76,967
Sutter Island (49)	1,690	$118,111
Grand Island (50)	n/a	n/a
Tyler Island (53)	1,818	$122,903
Brannan Andrus Isalnd (54)	1,592	$88,583
Ryer Island (55)	1,455	$94,424
Hastings Tract (61)	n/a	n/a

ENCLOSURE 4

Project Costs

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
PROJECT NO: P2 105606
LOCATION: Sacramento Valley - Various locations

DISTRICT: SPD South Pacific Division PREPARED: 6/16/2014
POC: CHIEF, COST ENGINEERING, xxx

This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2016									
						Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2013** ($K)	**TOTAL FIRST COST** ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***				***M***	***N***	***O***
02	RELOCATIONS	$679	$149	22%	$828	3.5%	$702	$155	$857	$0	$857	7.1%	$753	$166	$918
06	FISH & WILDLIFE FACILITIES	$2,017	$444	22%	$2,461	3.5%	$2,087	$459	$2,546	$0	$2,546	6.6%	$2,225	$489	$2,714
11	LEVEES & FLOODWALLS	$4,182	$920	22%	$5,102	3.5%	$4,327	$952	$5,278	$0	$5,278	7.1%	$4,636	$1,020	$5,656
16	BANK STABILIZATION	$19,579	$4,307	22%	$23,886	3.5%	$20,256	$4,456	$24,712	$0	$24,712	5.8%	$21,436	$4,716	$26,152
	CONSTRUCTION ESTIMATE TOTALS:	$26,457	$5,821		$32,278	3.5%	$27,371	$6,022	$33,393	$0	$33,393	6.1%	$29,050	$6,391	$35,440
01	LANDS AND DAMAGES	$6,014	$2,815	47%	$8,829	3.5%	$6,222	$2,912	$9,134	$0	$9,134	4.1%	$6,478	$3,032	$9,510
30	PLANNING, ENGINEERING & DESIGN	$6,086	$1,339	22%	$7,425	5.7%	$6,431	$1,415	$7,846	$0	$7,846	9.0%	$7,008	$1,542	$8,550
31	CONSTRUCTION MANAGEMENT	$3,837	$844	22%	$4,681	5.7%	$4,054	$892	$4,946	$0	$4,946	12.3%	$4,553	$1,002	$5,555
18	CULTURAL RESOURCE PRESERVATION	$489	$0	0%	$489	0.0%	$489		$489	$0	$489	0.0%	$489	$0	$489
	PROJECT COST TOTALS:	$42,883	$10,818	25%	$53,701		$44,567	$11,240	**$55,808**	$0	**$55,319**	6.7%	$47,578	$11,966	$59,544

Mandatory by Regulation CHIEF, COST ENGINEERING, xxx

Mandatory by Regulation PROJECT MANAGER, xxx

Mandatory by Regulation CHIEF, REAL ESTATE, xxx

CHIEF, PLANNING,xxx

CHIEF, ENGINEERING, xxx

CHIEF, OPERATIONS, xxx

CHIEF, CONSTRUCTION, xxx

CHIEF, CONTRACTING,xxx

CHIEF, PM-PB, xxxx

CHIEF, DPM, xxx

ESTIMATED FEDERAL COST:	**65%**	**$38,704**
ESTIMATED NON-FEDERAL COST:	**35%**	**$20,840**
ESTIMATED TOTAL PROJECT COST:		**$59,544**

**** CONTRACT COST SUMMARY ****

PROJECT: Sacramento River Bank Protection Project - Economically Justified
LOCATION: Sacramento Valley - Various locations
This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

DISTRICT: SPD South Pacific Division PREPARED: 6/16/2014
POC: CHIEF, COST ENGINEERING, xxx

Civil Works Work Breakdown Structure		ESTIMATED COST	PROJECT FIRST COST (Constant Dollar Basis)	TOTAL PROJECT COST (FULLY FUNDED)

****** TOTAL PROJECT COST SUMMARY ******

WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
			Estimate Prepared: 6/2/2014				Program Year (Budget EC): 2016								
			Effective Price Level: 10/1/2013				Effective Price Level Date: 1 OCT 15								
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 1														
16	BANK STABILIZATION	Butte Basin, Cherokee Canal 21.9 L	$1,106	$243	22%	$1,349	3.5%	$1,144	$252	$1,396	2017Q3	3.0%	$1,178	$259	$1,438
16	BANK STABILIZATION	Butte Basin, Sacramento River 152.8 L	$951	$209	22%	$1,160	3.5%	$984	$216	$1,200	2017Q3	3.0%	$1,013	$223	$1,236
16	BANK STABILIZATION	Butte Basin, Sacramento River 163 L	$1,495	$329	22%	$1,824	3.5%	$1,547	$340	$1,887	2017Q3	3.0%	$1,593	$350	$1,943
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 152.8 L	$55	$12	22%	$67	3.5%	$57	$13	$69	2017Q3	3.0%	$59	$13	$71
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 163 L	$179	$39	22%	$218	3.5%	$185	$41	$226	2017Q3	3.0%	$191	$42	$233
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$3,786	$833	22%	**$4,619**		$3,917	$862	$4,779			$4,034	$887	$4,921
01	LANDS AND DAMAGES	Butte Basin, Cherokee Canal 21.9 L	$152	$71	47%	$223	3.5%	$157	$74	$231	2016Q3	1.0%	$159	$74	$233
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 152.8 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2016Q3	1.0%	$148	$69	$218
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 163 L	$568	$266	47%	$834	3.5%	$588	$275	$863	2016Q3	1.0%	$593	$278	$871
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$95	$21	22%	$116	5.7%	$100	$22	$122	2016Q3	1.9%	$102	$23	$125
2.0%	Planning & Environmental Compliance		$76	$17	22%	$93	5.7%	$80	$18	$98	2016Q3	1.9%	$82	$18	$100
8.5%	Engineering & Design		$322	$71	22%	$393	5.7%	$340	$75	$415	2016Q3	1.9%	$347	$76	$423
0.5%	Reviews, ATRs, IEPRs, VE		$19	$4	22%	$23	5.7%	$20	$4	$24	2016Q3	1.9%	$20	$5	$25
0.5%	schedule, risks)		$19	$4	22%	$23	5.7%	$20	$4	$24	2016Q3	1.9%	$20	$5	$25
2.0%	Contracting & Reprographics		$76	$17	22%	$93	5.7%	$80	$18	$98	2016Q3	1.9%	$82	$18	$100
3.0%	Engineering During Construction		$114	$25	22%	$139	5.7%	$120	$27	$147	2017Q3	5.9%	$128	$28	$156
2.0%	Planning During Construction		$76	$17	22%	$93	5.7%	$80	$18	$98	2017Q3	5.9%	$85	$19	$104
2.0%	Project Operations		$76	$17	22%	$93	5.7%	$80	$18	$98	2016Q3	1.9%	$82	$18	$100
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$379	$83	22%	$462	5.7%	$400	$88	$489	2017Q3	5.9%	$424	$93	$517
2.0%	Project Operation:		$76	$17	22%	$93	5.7%	$80	$18	$98	2017Q3	5.9%	$85	$19	$104
2.5%	Project Management		$95	$21	22%	$116	5.7%	$100	$22	$122	2017Q3	5.9%	$106	$23	$130
18	CULTURAL RESOURCE PRESERVATION		$70			$70		$70		$70			$70		$70
	CONTRACT COST TOTALS:		$6,141	$1,549		**$7,690**		$6,382	$1,610	$7,992			$6,568	$1,653	**$8,220**

****** CONTRACT COST SUMMARY ******

PROJECT: Sacramento River Bank Protection Project - Economically Justified
LOCATION: Sacramento Valley - Various locations
This Estimate reflects the scope and schedule in report; Project X Major Rehabilitation Report June 2014

DISTRICT: SPD South Pacific Division
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 6/16/2014

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 6/2/2014				Program Year (Budget EC): 2016								
			Effective Price Level: 10/1/2013				Effective Price Level Date: 1 OCT 15								
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 2														
16	BANK STABILIZATION	Butte Basin, Sacramento River 168.3 L	$1,290	$284	22%	$1,574	3.5%	$1,335	$294	$1,628	2018Q3	5.0%	$1,402	$308	$1,710
16	BANK STABILIZATION	Butte Basin, Sacramento River 172.0 L	$715	$157	22%	$872	3.5%	$740	$163	$902	2018Q3	5.0%	$777	$171	$948
16	BANK STABILIZATION	Natomas, Sacramento River 78.3 L	$1,304	$287	22%	$1,591	3.5%	$1,349	$297	$1,646	2018Q3	5.0%	$1,417	$312	$1,729

16	BANK STABILIZATION	Sacramento, Sacramento River 56.6 L	$386	$85	22%	$471	3.5%	$399	$88	$487	2018Q3	5.0%	$420	$92	$512
16	BANK STABILIZATION	Southport, Sacramento River 56.5 R	$1,487	$327	22%	$1,814	3.5%	$1,538	$338	$1,877	2018Q3	5.0%	$1,616	$356	$1,972
16	BANK STABILIZATION	Southport, Sacramento River 56.7 R	$3,824	$841	22%	$4,665	3.5%	$3,956	$870	$4,827	2018Q3	5.0%	$4,156	$914	$5,070
06	FISH & WILDLIFE FACILITIES	Natomas, Sacramento River 78.3 L	$205	$45	22%	$250	3.5%	$212	$47	$259	2018Q3	5.0%	$223	$49	$272
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 168.3 L	$117	$26	22%	$143	3.5%	$121	$27	$148	2018Q3	5.0%	$127	$28	$155
06	FISH & WILDLIFE FACILITIES	Butte Basin, Sacramento River 172.0 L	$25	$6	22%	$31	3.5%	$26	$6	$32	2018Q3	5.0%	$27	$6	$33
06	FISH & WILDLIFE FACILITIES	Sacramento, Sacramento River 56.6 L	$8	$2	22%	$10	3.5%	$8	$2	$10	2018Q3	5.0%	$9	$2	$11
06	FISH & WILDLIFE FACILITIES	Southport, Sacramento River 56.5 R	$37	$8	22%	$45	3.5%	$38	$8	$47	2018Q3	5.0%	$40	$9	$49
06	FISH & WILDLIFE FACILITIES	Southport, Sacramento River 56.7 R	$95	$21	22%	$116	3.5%	$98	$22	$120	2018Q3	5.0%	$103	$23	$126
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$9,493	$2,088	22%	**$11,581**		$9,821	$2,161	$11,982			$10,317	$2,270	$12,587
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 168.3 L	$284	$133	47%	$417	3.5%	$294	$138	$431	2017Q3	3.0%	$303	$142	$444
01	LANDS AND DAMAGES	Butte Basin, Sacramento River 172.0 L	$568	$266	47%	$834	3.5%	$588	$275	$863	2017Q3	3.0%	$605	$283	$888
01	LANDS AND DAMAGES	Natomas, Sacramento River 78.3 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2017Q3	3.0%	$151	$71	$222
01	LANDS AND DAMAGES	Sacramento, Sacramento River 56.6 L	$426	$199	47%	$625	3.5%	$441	$206	$647	2017Q3	3.0%	$454	$212	$666
01	LANDS AND DAMAGES	Southport, Sacramento River 56.5 R	$426	$199	47%	$625	3.5%	$441	$206	$647	2017Q3	3.0%	$454	$212	$666
01	LANDS AND DAMAGES	Southport, Sacramento River 56.7 R	$284	$133	47%	$417	3.5%	$294	$138	$431	2017Q3	3.0%	$303	$142	$444
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$237	$52	22%	$289	5.7%	$250	$55	$306	2017Q3	5.9%	$265	$58	$324
2.0%	Planning & Environmental Compliance		$190	$42	22%	$232	5.7%	$201	$44	$245	2017Q3	5.9%	$213	$47	$259
8.5%	Engineering & Design		$807	$178	22%	$985	5.7%	$853	$188	$1,040	2017Q3	5.9%	$903	$199	$1,102
0.5%	Reviews, ATRs, IEPRs, VE		$47	$10	22%	$57	5.7%	$50	$11	$61	2017Q3	5.9%	$53	$12	$64
0.5%	schedule, risks)		$47	$10	22%	$57	5.7%	$50	$11	$61	2017Q3	5.9%	$53	$12	$64
2.0%	Contracting & Reprographics		$190	$42	22%	$232	5.7%	$201	$44	$245	2017Q3	5.9%	$213	$47	$259
3.0%	Engineering During Construction		$285	$63	22%	$348	5.7%	$301	$66	$367	2018Q3	10.0%	$331	$73	$404
2.0%	Planning During Construction		$190	$42	22%	$232	5.7%	$201	$44	$245	2018Q3	10.0%	$221	$49	$270
2.0%	Project Operations		$190	$42	22%	$232	5.7%	$201	$44	$245	2017Q3	5.9%	$213	$47	$259
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$949	$209	22%	$1,158	5.7%	$1,003	$221	$1,223	2018Q3	10.0%	$1,103	$243	$1,346
2.0%	Project Operation:		$190	$42	22%	$232	5.7%	$201	$44	$245	2018Q3	10.0%	$221	$49	$270
2.5%	Project Management		$237	$52	22%	$289	5.7%	$250	$55	$306	2018Q3	10.0%	$276	$61	$336
18	CULTURAL RESOURCE PRESERVATION		$173			$173		$173		$173			$173		$173
	CONTRACT COST TOTALS:		$15,355	$3,868		**$19,224**		$15,959	$4,019	$19,978			$16,823	$4,226	**$21,049**

**** CONTRACT COST SUMMARY ****

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DISTRICT: SPD South Pacific Division
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 6/16/2014

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			**6/2/2014**	Program Year (Budget EC):			2016					
			Effective Price Level:			10/1/2013	Effective Price Level Date:			1 OCT 15					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***		***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	CONTRACT 3														
02	RELOCATIONS	Sutter Island, Steamboat Slough 24.7 R	$203	$45	22%	$248	3.5%	$210	$46	$256	2019Q3	7.1%	$225	$50	$275
02	RELOCATIONS	Sutter Island, Steamboat Slough 25.8 R	$82	$18	22%	$100	3.5%	$85	$19	$103	2019Q3	7.1%	$91	$20	$111
02	RELOCATIONS	Sutter Island, Steamboat Slough 23.9 R	$87	$19	22%	$106	3.5%	$90	$20	$110	2019Q3	7.1%	$96	$21	$118
02	RELOCATIONS	Yolo, Cache Creek 3.9 L	$307	$68	22%	$375	3.5%	$318	$70	$387	2019Q3	7.1%	$340	$75	$415
06	FISH & WILDLIFE FACILITIES	West Sacramento, Sacramento River 62.9 R	$13	$3	22%	$16	3.5%	$13	$3	$16	2019Q3	7.1%	$14	$3	$18

06	FISH & WILDLIFE FACILITIES	West Sacramento, Sacramento River 63.0 R	$6	$1	22%	$7	3.5%	$6	$1	$8	2019Q3	7.1%	$7	$1	$8
06	FISH & WILDLIFE FACILITIES	Sutter Island, Sutter Slough 26.5 L	$22	$5	22%	$27	3.5%	$23	$5	$28	2019Q3	7.1%	$24	$5	$30
06	FISH & WILDLIFE FACILITIES	Sutter Island, Steamboat Slough 23.9 R	$229	$50	22%	$279	3.5%	$237	$52	$289	2019Q3	7.1%	$254	$56	$310
06	FISH & WILDLIFE FACILITIES	Sutter Island, Steamboat Slough 25.8 R	$229	$50	22%	$279	3.5%	$237	$52	$289	2019Q3	7.1%	$254	$56	$310
06	FISH & WILDLIFE FACILITIES	Sutter Island, Steamboat Slough 24.7 R	$377	$83	22%	$460	3.5%	$390	$86	$476	2019Q3	7.1%	$418	$92	$510
11	LEVEES & FLOODWALLS	Sutter Island, Steamboat Slough 25.8 R	$494	$109	22%	$603	3.5%	$511	$112	$624	2019Q3	7.1%	$548	$120	$668
11	LEVEES & FLOODWALLS	Sutter Island, Steamboat Slough 24.7 R	$1,025	$226	22%	$1,251	3.5%	$1,060	$233	$1,294	2019Q3	7.1%	$1,136	$250	$1,386
11	LEVEES & FLOODWALLS	Sutter Island, Steamboat Slough 23.9 R	$558	$123	22%	$681	3.5%	$577	$127	$704	2019Q3	7.1%	$619	$136	$755
11	LEVEES & FLOODWALLS	Yolo, Cache Creek 3.9 L	$2,105	$463	22%	$2,568	3.5%	$2,178	$479	$2,657	2019Q3	7.1%	$2,333	$513	$2,847
16	BANK STABILIZATION	Sutter Island, Sutter Slough 26.5 L	$2,590	$570	22%	$3,160	3.5%	$2,680	$589	$3,269	2019Q3	7.2%	$2,871	$632	$3,503
16	BANK STABILIZATION	West Sacramento, Sacramento River 63.0 R	$323	$71	22%	$394	3.5%	$334	$74	$408	2019Q3	7.2%	$358	$79	$437
16	BANK STABILIZATION	West Sacramento, Sacramento River 62.9 R	$448	$99	22%	$547	3.5%	$463	$102	$565	2019Q3	7.2%	$497	$109	$606
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$9,098	$2,002	22%	**$11,100**		$9,412	$2,071	$11,483			$10,085	$2,219	$12,304
01	LANDS AND DAMAGES	Sutter Island, Steamboat Slough 24.7 R	$390	$183	47%	$573	3.5%	$403	$189	$592	2018Q3	5.0%	$424	$198	$622
01	LANDS AND DAMAGES	Sutter Island, Steamboat Slough 25.8 R	$195	$91	47%	$286	3.5%	$202	$94	$296	2018Q3	5.0%	$212	$99	$311
01	LANDS AND DAMAGES	Sutter Island, Steamboat Slough 23.9 R	$195	$91	47%	$286	3.5%	$202	$94	$296	2018Q3	5.0%	$212	$99	$311
01	LANDS AND DAMAGES	Sutter Island, Sutter Slough 26.5 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2018Q3	5.0%	$154	$72	$227
01	LANDS AND DAMAGES	West Sacramento, Sacramento River 62.9 R	$284	$133	47%	$417	3.5%	$294	$138	$431	2018Q3	5.0%	$309	$144	$453
01	LANDS AND DAMAGES	West Sacramento, Sacramento River 63.0 R	$284	$133	47%	$417	3.5%	$294	$138	$431	2018Q3	5.0%	$309	$144	$453
01	LANDS AND DAMAGES	Yolo, Cache Creek 3.9 L	$426	$199	47%	$625	3.5%	$441	$206	$647	2018Q3	5.0%	$463	$217	$680
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$227	$50	22%	$277	5.7%	$240	$53	$293	2018Q3	10.0%	$264	$58	$322
2.0%	Planning & Environmental Compliance		$182	$40	22%	$222	5.7%	$192	$42	$235	2018Q3	10.0%	$212	$47	$258
8.5%	Engineering & Design		$773	$170	22%	$943	5.7%	$817	$180	$997	2018Q3	10.0%	$899	$198	$1,096
0.5%	Reviews, ATRs, IEPRs, VE		$45	$10	22%	$55	5.7%	$48	$10	$58	2018Q3	10.0%	$52	$12	$64
0.5%	schedule, risks)		$45	$10	22%	$55	5.7%	$48	$10	$58	2018Q3	10.0%	$52	$12	$64
2.0%	Contracting & Reprographics		$182	$40	22%	$222	5.7%	$192	$42	$235	2018Q3	10.0%	$212	$47	$258
3.0%	Engineering During Construction		$273	$60	22%	$333	5.7%	$288	$63	$352	2019Q3	14.4%	$330	$73	$403
2.0%	Planning During Construction		$182	$40	22%	$222	5.7%	$192	$42	$235	2019Q3	14.4%	$220	$48	$268
2.0%	Project Operations		$182	$40	22%	$222	5.7%	$192	$42	$235	2018Q3	10.0%	$212	$47	$258
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$910	$200	22%	$1,110	5.7%	$962	$212	$1,173	2019Q3	14.4%	$1,100	$242	$1,342
2.0%	Project Operation:		$182	$40	22%	$222	5.7%	$192	$42	$235	2019Q3	14.4%	$220	$48	$268
2.5%	Project Management		$227	$50	22%	$277	5.7%	$240	$53	$293	2019Q3	14.4%	$274	$60	$335
18	CULTURAL RESOURCE PRESERVATION		$168			$168		$168		$168			$168		$168
	CONTRACT COST TOTALS:		$14,592	$3,648		**$18,240**		$15,166	$3,791	$18,957			$16,382	$4,083	**$20,465**

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DISTRICT: SPD South Pacific Division
POC: CHIEF, COST ENGINEERING, xxx
PREPARED: 6/16/2014

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 6/2/2014 Effective Price Level: 10/1/2013				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15				FULLY FUNDED PROJECT ESTIMATE				
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	CONTRACT 4														
16	BANK STABILIZATION	Yolo, Knights Landing Ridge Cut 0.2 R	$178	$39	22%	$217	3.5%	$184	$41	$225	2020Q3	9.3%	$201	$44	$246
16	BANK STABILIZATION	Rio Oso, Bear River 0.8 L	$539	$119	22%	$658	3.5%	$558	$123	$680	2020Q3	9.3%	$609	$134	$744
16	BANK STABILIZATION	Rio Oso, Feather River 0.6 L	$871	$192	22%	$1,063	3.5%	$901	$198	$1,099	2020Q3	9.3%	$985	$217	$1,202

16	BANK STABILIZATION	Rio Oso, Feather River 5.0 L	$2,072	$456	22%	$2,528	3.5%	$2,144	$472	$2,615	2020Q3	9.3%	$2,343	$515	$2,858
06	FISH & WILDLIFE FACILITIES	Rio Oso, Feather River 0.6 L	$109	$24	22%	$133	3.5%	$113	$25	$138	2020Q3	9.3%	$123	$27	$150
06	FISH & WILDLIFE FACILITIES	Rio Oso, Feather River 5.0 L	$311	$68	22%	$379	3.5%	$322	$71	$393	2020Q3	9.3%	$352	$77	$429
								$0							
	CONSTRUCTION ESTIMATE TOTALS:		$4,080	$898	22%	**$4,978**		$4,221	$929	$5,150			$4,613	$1,015	$5,628
01	LANDS AND DAMAGES	Yolo, Knights Landing Ridge Cut 0.2 R	$396	$185	47%	$581	3.5%	$410	$192	$601	2019Q3	7.2%	$439	$205	$644
01	LANDS AND DAMAGES	Rio Oso, Bear River 0.8 L	$142	$66	47%	$208	3.5%	$147	$69	$216	2019Q3	7.2%	$157	$74	$231
01	LANDS AND DAMAGES	Rio Oso, Feather River 0.6 L	$284	$133	47%	$417	3.5%	$294	$138	$431	2019Q3	7.2%	$315	$147	$462
01	LANDS AND DAMAGES	Rio Oso, Feather River 5.0 L	$284	$133	47%	$417	3.5%	$294	$138	$431	2019Q3	7.2%	$315	$147	$462
30	PLANNING, ENGINEERING & DESIGN														
2.5%	Project Management		$102	$22	22%	$124	5.7%	$108	$24	$131	2019Q3	14.4%	$123	$27	$150
2.0%	Planning & Environmental Compliance		$82	$18	22%	$100	5.7%	$87	$19	$106	2019Q3	14.4%	$99	$22	$121
8.5%	Engineering & Design		$347	$76	22%	$423	5.7%	$367	$81	$447	2019Q3	14.4%	$419	$92	$512
0.5%	Reviews, ATRs, IEPRs, VE		$20	$4	22%	$24	5.7%	$21	$5	$26	2019Q3	14.4%	$24	$5	$29
0.5%	schedule, risks)		$20	$4	22%	$24	5.7%	$21	$5	$26	2019Q3	14.4%	$24	$5	$29
2.0%	Contracting & Reprographics		$82	$18	22%	$100	5.7%	$87	$19	$106	2019Q3	14.4%	$99	$22	$121
3.0%	Engineering During Construction		$122	$27	22%	$149	5.7%	$129	$28	$157	2020Q3	18.9%	$153	$34	$187
2.0%	Planning During Construction		$82	$18	22%	$100	5.7%	$87	$19	$106	2020Q3	18.9%	$103	$23	$126
2.0%	Project Operations		$82	$18	22%	$100	5.7%	$87	$19	$106	2019Q3	14.4%	$99	$22	$121
31	CONSTRUCTION MANAGEMENT														
10.0%	Construction Management		$408	$90	22%	$498	5.7%	$431	$95	$526	2020Q3	18.9%	$513	$113	$625
2.0%	Project Operation:		$82	$18	22%	$100	5.7%	$87	$19	$106	2020Q3	18.9%	$103	$23	$126
2.5%	Project Management		$102	$22	22%	$124	5.7%	$108	$24	$131	2020Q3	18.9%	$128	$28	$156
18	CULTURAL RESOURCE PRESERVATION		$78			$78		$78		$78			$78		$78
	CONTRACT COST TOTALS:		$6,795	$1,752		**$8,547**		$7,061	$1,820	$8,881			$7,806	$2,004	**$9,810**

ENCLOSURE 5

Agricultural Damage Analysis

Agricultural Flood Damages

The Planning Guidance Notebook of the USACE (ER 1105-2-100) and the IWR Report 87-R-10 provide guidance and rules on the treatment of agricultural crops. These documents serve as the basis for the agricultural analyses. Further, damages expressed as annual values are calculated utilizing the FY13 discount rate of 3.75 percent with an analysis period of 50 years. All benefits and costs are expressed at an October 2012 price level. The base operational year is 2014.

ER 1105-2-100, Appendix E, beginning on page E-113 includes specific guidance for studies where the primary damages occur to agricultural crops. These damages are directly related, and evaluated with special consideration for the expected time of seasonal flooding as well as the variability associated with crop prices and yields. The identified hydrologic/hydraulic variables, discharge associated with exceedence frequency and conveyance roughness and cross-section geometry, also apply to agricultural studies. The crop damage is directly related to the duration of flooding, and is evaluated accordingly. Procedurally, the damage assessment is coordinated with the residential and non-residential structural analysis conducted in typical USACE fashion employing the HEC-FDA damage assessment model.

Farm Budget and Crop Data

The preponderance of the study area lies within or adjacent to two Counties with the Sacramento River Valley. Accordingly, evaluation of each analytical area is analyzed based on the yields and seasonal variations related to the County which is closest in proximity. Agricultural crop acreage was developed by Sacramento District COE on a GIS basis with the assistance of the Agricultural Commissioner's office in Sacramento and Sutter Counties. GIS mapping of agriculture allows for the overlaying of Flo2D flood plain mapping thereby identifying flooded acreage by crop type. Various crop budgets were obtained from the University of California at Davis' Agricultural & Resource Economics web site. Historical crop yields and values for various flood plain crops were obtained from the U.S. Department of Agriculture, National Agricultural Statistics Service web site of the Sacramento and Sutter County's Agricultural Commissioner's Annual Crop Report. Agricultural land restoration costs are based on previous USACE studies and farm budget reports. Monthly flood probabilities were derived based on the percentage of historical annual peak discharges occurring in each month as documented by the Water Management Section, Sacramento District COE.

Agricultural Economic Damages Related to Flooding in Sutter Study Area, California

The analysis below outlines the general concepts and procedures used in the computation of the agricultural damages incurred by assumed flood events within the study area.

Procedures used in the Estimation of Agricultural Damages

The discussion below indicates considerations used in the computation of agricultural damages within the Sacramento River Basin Study Area.

The current land use for the Study Area was secured from the County Assessor data identified as the agricultural land area for each flood event.

The land/crop uses were categorized into six general categories for analytical and reporting purposes. The five general categories of land/crop use are:

1. Truck and Specialty Crops – including processing tomatoes
2. Field Crops – including row crops like corn and wheat
3. Orchard – including crops like Walnuts and Almonds
4. Alfalfa and Irrigated Pasture
5. Rice
6. Other – including lands irrigated and native pasture and lands that are idle, semi-agricultural, and native vegetation

Agricultural damages due to flooding for each acre are computed by adding four elements:

1) The cumulative direct production or annual variable costs incurred prior to flooding
2) The net value of the crop affected by the flood event
3) Depreciated value of perennial crops lost as a direct result of flooding
4) The land clean-up and rehabilitation resulting from flooding

Direct Production Costs

Cultural costs are incurred periodically throughout the crop year. Examples of these direct production costs include: seedbed preparation, chemical and fertilizer application, hired labor, seed, planting, and weed and pest control. These individual crop costs for the five crops are computed on a monthly basis to determine the amount of expended cultural costs at the time of the flood event. An example of the monthly production costs is included in Table 2 for the production of processing tomatoes in the study area.

Net Value of Crop

The second component represents the net income of the crop plus return to fixed items of production such as land, labor and management, real estate taxes, and fixed costs associated with pre-harvest and harvest activities. The net value of the crop is the amount of revenue that the producer may not get if a significant flood event were to occur of his property.

Seasonality

Computationally, the season of the year that the flood occurs greatly impacts amount of flood damage to the agricultural crop. If flooding occurs early within the year, the producer may be able to re-prepare the seedbed, plant and realize a return on his efforts. Conversely, a flood of substantial proportion occurring at harvest time will most certainly result in complete loss for the entire year.

The probability of a storm occurrence, and accompanying flood damage, in any particular month was provided by the District Hydrologist for the Study area vicinity and displays the likelihood of a storm occurring for each month throughout the year.

Farm budgets were obtained from the University of California at Davis. The monthly probability of flood occurrence was derived from peak annual flow data secured from the Water Management Section, USACE, Sacramento District. Due to year-to-year variability flood occurrences may be as much as 4 weeks early or later than the flood occurrence midpoint. These flood occurrence probabilities for the Sacramento River Basin Study area (Sacramento and Sutter Counties) are displayed below showing the flood event probabilities with uncertainty associated with each month:

Table 1 - Monthly Flood Occurrence Probabilities

Month	Sacramento County Probability		
	Scenario Midpoint	Scenario Beginning	Scenario Ending
January	0.210	0.170	0.310
February	0.310	0.210	0.170
March	0.170	0.310	0.080
April	0.080	0.170	0.010
May	0.010	0.090	0.000
June	0.000	0.010	0.000
July	0.000	0.000	0.000
August	0.000	0.000	0.000
September	0.000	0.000	0.010
October	0.010	0.000	0.040
November	0.040	0.010	0.170
December	0.170	0.040	0.210

Month	Sutter County Probability		
	Scenario Midpoint	Scenario Beginning	Scenario Ending
January	0.220	0.160	0.310
February	0.310	0.220	0.150
March	0.150	0.310	0.100
April	0.100	0.150	0.010
May	0.010	0.100	0.000
June	0.000	0.010	0.000
July	0.000	0.000	0.000
August	0.000	0.000	0.000
September	0.000	0.000	0.010
October	0.010	0.000	0.040
November	0.040	0.010	0.160
December	0.160	0.040	0.220

Multiplying the direct production costs and the value of crop at risk for each month times the monthly probability provides the probable damages expected if a flood event occurred in any particular month. Uncertainty parameters were used in the overall computation of both direct production losses and the net incomes for each crop impacted.

Value of Perennial Crops

Damage caused by long-term duration flooding may result in permanent loss of perennial crops. The damage to perennials susceptible to flooding is computed based upon the assumption that the crop stands are at various ages, ranging from year 1 throughout their economic useful life. Accordingly, damage caused by long-term duration flooding is computed based upon a stand that is at the mid-point of its economic useful life.

Clean-up and Rehabilitation

Erosion and deposition of debris and sediment may be caused by floods of any duration or time of year. Additionally, drainage and irrigation ditches may become clogged with silt and debris. Interviews with cooperative extension agents and local farmers have been conducted over the past several years. Clean-up and rehabilitation of farm acreage is a genuine flood loss and is accordingly accounted for in the computation of agricultural flood damages.

Restoration of Field Cropland after Flooding

The requirement to restore agricultural land after having been inundated by flood will require the removal of trash and debris that may have accumulated, dealing with sediment deposition, and reworking of fields to incorporate the sediment and re-level the irrigated cropland. The restoration costs are based on estimates of cultural procedures from the University of California, Davis and range, for this type of flooding, from a cost of $0 to $92 for open cropland. This level of restoration requirement is consistent with the post-flood demands identified in other USACE studies. The estimated cost for agricultural land restoration requiring the largest amount of clean-up and restoration effort on a per acre basis is:

Table 2 – Per Acre Field Cropland Restoration Costs

Operation	$ Cost/per Acre
Debris/Trash Removal	16.00
Chisel Plow (2X)	22.00
Disc and Roll (2X)	16.00
Triplane (2X)	22.00
Repair/Replace Irrigation System	16.00
Total (50% of acres)	92.00

The average cleanup and restoration costs over the entire floodplain are estimated occur on approximately one-half of the affected acres or $46 per acre. It is noted that the restoration costs include only those costs that re-establish the land to a condition prior to the incurrence of any of the expected annual production costs. Accordingly, restoration costs do not provide for fertilizing, applying herbicide, or any pre-planting activities that are expected to occur during the normal growing season.

Pollutants

In an article in the Los Angeles Times dated March 22, 2010 writer John Flesher discussed the possible environmental hazards associated with flooding in the Fargo North Dakota area. These factors are similar to what could be expected in the Sacramento River Bank Study Area and are provided for informational purposes and, to the extent possible, are included in this economic analysis.

> *Floodwaters can be noxious brews of pesticides, sewage, garbage and animal carcasses that foul drinking water, spread disease and damage fish habitat. Although the Red River didn't do nearly as much damage this year as during record-breaking floods in 2009, authorities say danger could persist.*
>
> *"Fuels, chemicals, all kinds of things find their way into the water system and it's a huge environmental risk," said Keith Berndt, engineer for Cass County, which includes Fargo and West Fargo.*
>
> *"We don't want people to use used sand for old sand bags in their kids' sand boxes or anywhere else they could come in direct contact with it," said Myron Bergland, environmental health manager for Fargo-Cass Public Health.*

Last year's disaster (2009) swept pollutants into the Red and its tributaries, although the sheer volume of water and accelerated flow rate weakened the effect, said David Glatt, environmental chief for the North Dakota Department of Health. Even as officials were ready to declare victory in this year's flood fight, Glatt emphasized the importance of safeguarding drinking water supplies, particularly in rural areas where private wells may have been submerged.

No large-scale water-quality testing was conducted in 2009, but officials monitored hospital emergency rooms and found no upswing in visits that would have indicated an outbreak of flood-related sickness, Glatt said. Officials credited experience and public education with preventing serious environmental health problems.

"We've had a little familiarity with floods in recent history," Glatt said. "People have had an opportunity to prepare and minimize the harm."

Cities in the region have reduced their exposure to contaminated water over the years by elevating wellheads or surrounding them with dikes to keep floodwaters out. But numerous wastewater treatment systems were overwhelmed during last year's flooding, forcing officials to dump raw sewage into the rivers. A few have requested permission to do likewise this year if necessary.

Private well users are particularly vulnerable. State and local agencies have provided information about protecting residential wells and stand ready to help disinfect contaminated ones. Fargo-Cass Public Health last week warned owners of submerged wells not to use the water for drinking or cooking until it can be tested. Agencies also urged people to secure household and farm chemicals, fuel tanks and other potential sources of pollution.

Dead livestock is a particular threat in Great Plains ranch country. Some 90,000 head of cattle were lost during last year's calamity. They're a potential source of pathogens that can pollute wells and surface waters.

"Even a typically normal, healthy cow has E. coli bacteria in its gut," Bergland said. "You need to properly dispose of the bodies before they drift away in the water."

State agencies, including the North Dakota National Guard, helped retrieve bloated carcasses and advised ranchers how to deal with them. It's not as simple as it sounds. If buried, the bodies must be placed above the water table under at least 4 feet of loamy, clay soils. If burned, only organic fuels such as wood can be used and a state permit is required.

Once immediate flood dangers have passed, ecological aftereffects can persist for months or years.

Phosphorus fertilizers that wash into rivers and lakes can stimulate growth of algae blooms that reduce oxygen levels and kill fish. Heavy soil erosion along riverbanks degrades fish habitat and spawning areas, particularly in streams that feed larger rivers such as the Red.

"Think of trying to breathe in a dust storm," said Henry Van Offelen, a scientist with the Minnesota Center for Environmental Advocacy. "That's what a big sediment plume in water is for fish."

But the environmental setbacks are not always a total loss. Some of the leftover bag sand can be used in landfills to prevent liquid pollution from seeping into groundwater.

Special Consideration for Specialty, Truck Crops, and Selected Field Crops

Vegetable crops raised for direct human consumption are vulnerable to passing on the E.Coli bacteria to humans through contamination from animals. In 2006 an E. coli outbreak traced to bagged spinach was blamed for the deaths of three people and for sickening hundreds more across the U.S. Authorities ultimately identified a central California cattle ranch next to a spinach field as being the source of the bacteria. In 2007 salad mix packaged by a major food processor tested positive for E.coli and triggered a recall in at least nine states. The ultimate cost to the processor and the producers are unknown but is determined to be of significant proportions and is deemed to be life threatening.

Between 1999 and 2006, there were 12 outbreaks of E. Coli traced to California leafy greens resulting in 539 reported illnesses. Of those 12 outbreaks, 10 were on fresh-cut leafy greens and those 10 outbreaks involved 531 of the illnesses. In addition to E. Coli, a recent announcement from the Centers for Disease Control and Prevention on June 11 of 2008 confirms that a salmonella outbreak has struck at least 167 people in 17 states. The Food and Drug Administration estimates that an average of 2 to 4 million cases of salmonellosis occur annually in the U.S. This particular outbreak is linked with raw tomatoes infected by microscopic bacteria that live in the intestinal tracks of people and animals. The infection is spread by the ingestion of raw or undercooked food and water that is contaminated with feces carrying the bacteria. Contaminated goods usually stem from animal origin but are not limited to and often include vegetation and water. Already, restaurants and supermarkets have either stopped selling tomatoes altogether or only carry tomatoes deemed safe by the FDA.

Even slight flooding of fields has the associated probability of carrying animal waste in the floodwater, and accordingly, may carry the E.coli and salmonella bacteria. In an article titled *Transmission of Escherichia coli 0157:H7 from Contaminated Manure and Irrigation Water to Lettuce Plant tissue and Its Subsequent Internalization,*[1] the authors stated: " *Application of E.coli 0517:H7-contaiminated manure to the production field or irrigation with E.coli 0157:H7-contaminated water may result in contamination of the crop in the field. Studies have indicated the E.coli can survive for extended periods in manure and water. We have demonstrated that lettuce grown in soil containing contaminated manure, or irrigated with contaminated water, results in contamination of the edible portion of the lettuce plant. Moreover, the results suggest that edible portions of a plant can become contaminated without direct exposure to a pathogen, but rather through transport of the pathogen into the plant by the root system.*"

In a November 4, 2005, FDA "Letter to California Firms that Grow, Pack, Process, or Ship Fresh and Fresh-cut Lettuce[12]," the Agency stated as follows:

FDA considers ready to eat crops (such as lettuce) that have been in contact with flood waters to be adulterated due to potential exposure to sewage, animal waste, heavy metals, pathogenic microorganisms, or other contaminants. FDA is not aware of any method of reconditioning these crops that will provide a reasonable assurance of safety for human food use or otherwise bring them into compliance with the law. Therefore, FDA recommends that such crops be excluded from the human food supply and disposed of in a manner that ensures they do not contaminate unaffected crops during harvesting, storage or distribution. Adulterated food may be subject to seizure under the Federal Food, Drug, and Cosmetic Act, and those responsible for its introduction or delivery for introduction into interstate commerce may be enjoined from continuing to do so or prosecuted for having done so . . . [F]ood produced under unsanitary conditions whereby it may be rendered injurious to health is adulterated under section 402(a)(4) of the Act (21 U.S.C. 342(a)(4)).
Situations related to flooding can be separated into three groups: (1) a product that has come into contact with flood water, (2) a product that is in proximity to a flooded area but has not come in contact with flood water, and (3) a production field which was partially or completely flooded in the past before a crop was planted. The recommendations for each situation are provided below.
For a product that has come into contact with flood water, FDA recommends:

- Excluding such crops from the human food supply and disposing of them in a manner that ensures they do not contaminate unaffected crops during harvesting, storage or distribution.

For a product that is in proximity to a flooded area but has not come in contact with flood water, FDA recommends:

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[1] Subject article written by Ethan B. Solomon, Sima Yaron, and Karl R. Matthews, Department of Food Science, Rutgers University, New Brunswick, New Jersey, appeared in "Applied and Environmental Microbiology," January 2002, p. 397-400, Vol 68, No. 108901.

- Preventing cross contamination between flooded and non-flooded areas (e.g., cleaning equipment, eliminating contact of any farming or harvesting equipment or personnel with the flooded area during production and harvest of crop in non-flooded areas).

For formerly flooded production ground, FDA recommends:

- Assessing field history and crop selection.
- Determining the time interval between the flooding event, crop planting, and crop harvest.
- Determining the source of flood waters (e.g., drainage canal, river, or irrigation canal) and whether there are significant upstream potential contributors of human pathogens.
- Allowing soils to dry sufficiently and be reworked prior to subsequently planting crops on formerly flooded production ground.
- Sampling previously flooded soil for the presence of microorganisms of significant public health concern or appropriate indicator microorganisms. Note: Microbial soil sampling can provide valuable information regarding relative risks, but sampling by itself does not guarantee that all raw agricultural commodities grown within the formerly flooded production area are free of the presence of human pathogens.

The National Organic Producer regulation provides guidelines on the use of manure that is applied to the croplands. There are several conditions of manure being either composted, worked into the soil, or when it comes into contact with the edible portion of the crop.

> *The producer must manage plant and animal materials to maintain or improve soil organic matter content in a manner that does not contribute to contamination of crops, soil, or water by plant nutrients, pathogenic organisms, heavy metals, or residues of prohibited substances. Animal and plant materials include:*
>
> *(1) Raw animal manure, which must be composted unless it is:*
>
> *(i) Applied to land used for a crop not intended for human consumption;*
>
> *(ii) Incorporated into the soil not less than 120 days prior to the harvest of a product whose edible portion has direct contact with the soil surface or soil particles; or*
>
> *(iii) Incorporated into the soil not less than 90 days prior to the harvest of a product whose edible portion does not have direct contact with the*

soil surface or soil particles;

For purposes of this analysis, any flooding of truck crop acreage will result in the assumption that the vegetables are not fit for human consumption and valued as a total loss. It is deemed to be inappropriate to assume any salvage of vegetable matter for human consumption considering the risks associated with these deadly bacteria.

Planting of lands that have previously been flooded are not expected to be adversely affected since the organic materials are assumed to be incorporated into the soil well in advance of the time constraints currently provided by national guidelines.

Agricultural Acreage and Yields - No Failure due to Levee Erosion

The alternative discussed in the following several pages is based on an assumed scenario where no erosion damage is present. Two other alternatives are discussed and compared near the end of this report. This alternative is discussed at length to provide the reader with an understanding of the methodology that has gone in to the alternative evaluations.

The study area contains approximately 530,000 acres of agricultural lands that are subject to flooding. About 41,000 acres of the affected floodplain is devoted to high value orchard and grape production with about 60,000 acres planted annually to crops including truck crops such as processing tomatoes. Rice comprises about 186,000 acres and the remaining acreage is primarily devoted to field crops, pasture, and alfalfa hay. These agricultural products have been consolidated into 6 different farm budget analyses. In addition to the damages revealed through farm budget analysis, damages for cropland and associated restoration have been included in the analysis.

Table 3. Acreage Inundated by Flood Event- Study Area

	Flood Frequency						
	5	10	20	50	100	200	500
FRUITS AND NUTS	0	7,827	0	22,842	27,557	33,324	35,992
FIELD CROPS	0	17,796	0	115,208	136,091	160,490	170,622
PASTURE & ALFALFA	0	4,894	0	21,854	24,829	31,005	33,406
RICE	0	66,469	0	122,139	135,307	171,958	185,532
TRUCK CROPS	0	2,331	0	44,570	52,437	55,360	59,574
VINE CROPS	0	0	0	3,895	5,014	5,038	5,370
OTHER	0	8,800	0	19,772	23,228	34,859	40,232
TOTAL	0	108,117	0	350,280	404,463	492,034	530,728

Procedurally the damages are calculated for each flood event within each area of analysis. Tables 4 and 5 below display the areas of analysis and the acreage that were evaluated for each flood event.

Table 4. Acreage Inundated by Flood Event-
Sacramento County Associated Impact Areas

	------------------ Flood Frequency --------------------				
	10	50	100	200	500
Tyler Island	0	8,680	8,685	8,690	8,695
Clarksburg	0	12,028	20,465	20,476	22,375
Hastings Tract	0	3,411	3,414	3,414	3,419
Ryer Island	0	10,974	11,278	11,278	11,278
Yolo	0	5,432	5,433	5,434	5,916
Grand Island	0	15,681	15,681	15,681	15,687
Sutter Island	0	2,241	2,241	2,241	2,241
Woodland	0	3,423	5,075	5,760	10,777
Natomas	0	0	0	39,417	41,014
Elkhorn	0	11,881	11,923	11,923	11,923
West Sacramento	0	0	0	456	564
Sacramento	0	0	0	1,947	2,425
Southport	0	0	0	2,851	3,267
Merrit Island	0	4,577	4,595	4,639	4,639
Brannan Andrus	0	13,346	13,348	13,348	13,354

Table 5. Acreage Inundated by Flood Event-
Sutter County Associated Impact Areas

------------------ Flood Frequency --------------------

	10	50	100	200	500
Butte Basin	108,117	116,667	118,013	121,562	126,904
North Sutter	0	0	31,421	31,445	31,507
Linda	0	0	6,757	7,527	9,020
Grimes	0	84,194	88,128	98,696	111,613
South Sutter	0	54,397	54,658	55,263	63,742
Rio Oso	0	0	0	26,638	27,020
Knights Landing	0	3,348	3,348	3,348	3,348

Typical Farm Budget Example

A typical farm budget analysis employed for this analysis is shown in Table 6 below as is provided to illustrate the cultural practices and cost considerations that are in the typical farm budget analysis process.

Table 6 – Winter Wheat Farm Budget Analysis

	U.C. COOPERATIVE EXTENSION												
	MONTHLY COSTS PER ACRE TO PRODUCE WINTER WHEAT												
	SACRAMENTO – 2009												
	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	TOTAL**
Cultural:													
Land Prep – Disc 2X	13		12								5		30
Preplant - Incorporate Fertilizer			55										55
Land Prep – Border Disk, List Beds			12										12
Plant Wheat,& Apply P2O5 -25% acres				35									35
Weed Control							10						10
Fertilize Top Dress N -50%acres							45						45
Disease Control – Strip Rust -25% acres									5				5
Open /Close Ditch									4				4
Irrigate									30				30
Pickup Truck /ATV – (wheat business)	1	1	1	1	1	1	1	1	1				9
TOTAL CULTURAL COSTS	**14**	**1**	**80**	**36**	**1**	**1**	**56**	**1**	**40**		**5**		**235**
Harvest:											22		22
Bank Out Grain:											6		6
Haul Grain to Storage											80		80
TOTAL HARVEST COSTS											**108**		**108**
Interest on Operating Capital @ 5.75%				1	1	1	1	1	1	1	1		8
TOTAL OPERATING COSTS/ACRE:	**14**	**1**	**80**	**37**	**2**	**2**	**57**	**2**	**41**	**1**	**114**		**351**
OVERHEAD:													
Office Expense	1	1	1	1	2	1	2	1	2	1	2	1	16
Supervisor’s Salary	1	2	1	2	1	2	1	2	1	2	1	1	17
Land Rent	6	7	7	7	7	6	7	7	7	7	7	7	82
Field Sanitation						1						1	2
Property Taxes/Insurance						4						3	7
Investment Repairs						1	1	1	1				4
TOTAL OVERHEAD COSTS	8	10	9	10	10	15	11	11	11	10	10	13	128
TOTAL COSTS/ACRE	**22**	**11**	**89**	**47**	**12**	**17**	**68**	**13**	**52**	**11**	**124**	**13**	**479**

** Totals do not necessarily add due to rounding of monthly data.

Through farm budget analysis the per-acre damage has been determined at the following values for the analyzed crops of the study area.

A Palisades software program @Risk was used for evaluation of gross receipts. @RISK allowed for the modeling of uncertainties associated with crop yield and price. Table 7 below reflects the statistics related to selected crops evaluated in this analysis.

Table 7
Statistical Evaluation of Selected Crops using @Risk
Based on Five Year Gross Income
Sacramento County

Selected Crop Type	Minimum	Maximum	Mean	Standard Deviation
Alfalfa Hay	$519	$1,142	$816	132
Almonds*	$895	$2750	$1,899	394
Corn Grain	$475	$827	$656	82
Rice	$980	$2,049	$1,481	230
Tomatoes	$1,647	$2,892	$2,247	283
Small Grain – Wheat	$188	$454	$324	61
Walnuts*	$2,318	$3,297	$2,799	235
Wine Grapes*	$2,805	$3,824	$3,304	220

Statistical Evaluation of Selected Crops using @Risk
Based on Three Year Gross Income
Sutter County

Selected Crop Type	Minimum	Maximum	Mean	Standard Deviation
Alfalfa Hay	$916	$1,392	$1,137	104
Almonds*	$895	$2750	$1,899	394
Corn Grain	$817	$935	$885	27
Rice	$1,237	$2,217	$1,737	220
Tomatoes	$2,470	$2,891	$2,696	94
Small Grain – Wheat	$439	$508	$479	16
Walnuts*	$2,318	$3,297	$2,799	235
Wine Grapes*	$2,805	$3,824	$3,304	220

*Due to lack of information data for in Sutter County Almond and Walnut yields and prices was used for Sacramento County analysis. Wine Grape data reported in Sacramento County was used for Sutter County.

Table 8 illustrates the estimated per acre crop loss by respective county. The results are based on multiplying the direct production costs and the value of crop at risk for each month times the monthly probability provides the probable damages expected if a flood event occurred in any particular month. Uncertainty parameters were used in the overall computation of both direct production losses and the net incomes for each crop impacted.

Table 8
Statistical Losses of Selected Crops using @Risk
Based on Direct Production Costs, Net Income at Risk and Probability of Flooding
Sacramento County

	Three Day Duration Period			Forty Five Day Duration Period		
Crop	Expected Value	Mean Value	Standard Deviation	Expected Value	Mean Value	Standard Deviation
Alfalfa Hay	$291	$299	38	$664	$671	43
Almonds*	$804	$887	117	$7,900	$7,977	126
Corn Grain	$272	$280	37	$272	$279	38
Rice	$320	$311	56	$395	$383	93
Tomatoes	$1,003	$1,033	259	$1,351	$1,328	285
Small Grain – Wheat	$393	$389	47	$393	$389	48
Walnuts*	$714	$780	106	$7,810	$7,882	109
Wine Grapes*	$2,026	$2,044	370	$8,593	$8,634	303

Statistical Losses of Selected Crops using @Risk
Based on Direct Production Costs, Net Income at Risk and Probability of Flooding
Sutter County

	Three Day Duration Period			Forty Five Day Duration Period		
Crop	Expected Value	Mean Value	Standard Deviation	Expected Value	Mean Value	Standard Deviation
Alfalfa Hay	$357	$369	57	$775	$790	100
Almonds*	$815	$823	132	$7,900	$7,978	128
Corn Grain	$262	$287	33	$262	$285	37
Rice	$382	$420	69	$519	$574	120
Tomatoes	$1,090	$1,220	264	$1,387	$1,594	289
Small Grain – Wheat	$364	$393	44	$364	$394	48
Walnuts*	$747	$815	134	$7,870	$7,912	187
Wine Grapes*	$2,054	$2,144	412	$8,632	$8,687	382

Table 9 provides a summary of the total damages by flood event for the assumed non-eroded levee's that would typify the "with project" condition of the Sacramento River Bank Protection Project. These numbers will be incorporated into the HEC-FDA model for computation of the annualized flood damages which are used in deriving the benefits associated with repair of erosion sites within the project overall methodology.

Table 9
Agricultural Damages by Flood Event
With No Levee Erosion Damage

Total Estimated Dollars of Damages by Event*

	---------------------- Flood Frequency -------------------------					
TOTAL FOR STUDY AREA						
CROP LOSS	5	10	50	100	200	500
FRUITS AND NUTS	0	34,242,743	130,854,945	163,851,850	210,573,661	237,732,014
FIELD CROPS	0	6,127,676	38,337,679	45,566,161	53,827,819	57,326,553
PASTURE & ALFALFA	0	2,836,073	13,241,504	15,066,674	19,808,067	21,704,736
RICE	0	33,035,093	63,127,396	70,519,708	88,532,509	96,772,059
TRUCK CROPS	0	3,279,717	65,516,449	77,942,366	82,974,186	89,463,638
VINE CROPS	0	0	0	0	0	0
OTHER	0	330,014	810,272	939,552	1,569,280	1,777,104
TOTAL	0	79,851,316	311,888,244	373,886,311	457,285,522	504,776,104

ENCLOSURE 6

Frequency-Damage Curves: Urban

Sacramento River Bank Protection Project
Frequency-Damage Curves (Urban) by Economic Impact Area
October 2012 Price Level
In $1,000s

Economic Impact Area	Damages by Frequency Event						
	2-Year	10-Year	25-Year	50-Year	100-Year	200-Year	500-Year
Butte Basin (5)	0	0	0	0	0	0	0
Grimes (10)	0	0	0	64	67	360	725
South Sutter (11/34)	0	0	0	2,856	3,078	3,142	3,557
Knight's Landing (13/14)	0	0	0	29,066	29,848	31,174	38,540
Yolo (15)	0	0	0	0	0	0	0
Woodland (16)	0	0	0	0	0	0	0
Davis (17)	0	0	0	0	3,746	5,963	17,281
Linda (27)	0	0	0	1,927	2,619	5,227	7,340
Rio Oso (30)	0	0	0	7,265	7,302	7,419	7,855
North Sutter (32)	0	0	0	0	6,341	7,044	7,432
Elkhorn (35)	0	0	0	0	0	0	0
Natomas (36)	3,766,252	4,342,314	4,439,523	4,569,310	4,620,389	4,669,933	4,690,256
Arden (37)	0	0	0	0	0	4,243,267	4,761,432
West Sac (38)	1,166,333	2,245,241	2,595,729	2,814,315	3,419,238	3,574,309	3,661,753
SouthPort (39)	921,685	1,343,451	2,170,619	2,683,658	3,270,179	3,400,424	3,462,783
Sacramento (40)	27,106	27,106	27,106	55,473	58,984	9,279,294	13,745,279
Clarksburg (42)	0	0	0	0	0	0	2,922
Merritt island (46)	0	0	0	7,092	8,791	12,118	14,793
Sutter Island (49)	0	0	0	757	762	762	777
Grand Island (50)	0	0	0	0	0	0	0
Tyler Island (53)	306	306	306	306	306	306	306
Brannan Andrus Island (54)	0	0	0	25,987	26,127	26,418	27,732
Ryer Island (55)	0	0	0	74	74	74	90
Hastings Tract (61)	0	0	0	0	0	0	0