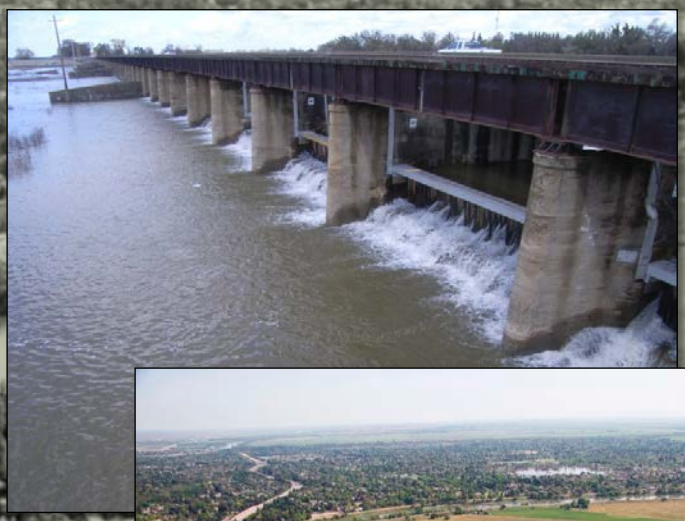
American River Watershed

Common Features
General Reevaluation Report



Appendix A
Plan Formulation

October 2015

SAFCA
Sacramento Area Flood Control Agency

Central Valley Flood Protection Board
Public Safety · With Flood Protection · State of California

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Sacramento District

Cover Photos courtesy of the Sacramento District:

Sacramento Weir during operation

Sacramento River facing south near the Pocket and Little Pocket neighborhoods

High flows on the American River at the Highway 160 overcrossing

Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Appendix A

Plan Formulation

U.S. Army Corps of Engineers
Sacramento District

October 2015

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AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

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Attachment 1:
American River Common Features
and West Sacramento General Reevaluation Reports Bridging Document

1.0 BACKGROUND

Document Purpose

The purpose of this document is to demonstrate that formulation and identification of the National Economic Development (NED) plans for the American River Common Features (ARCF) and West Sacramento (WS) projects is not affected by investigating the two areas separately. The U.S. Army Corps of Engineers (USACE) is completing General Reevaluation Reports (GRRs) for the ARCF and WS projects. This bridging document accompanies each GRR to explain how the two projects function both independently and together by summarizing the following:

- Existing flood risk management system in the greater Sacramento area
- Flood history of the greater Sacramento urban area
- Future without project conditions for the study area
- Potential system-wide flood risk management alternatives considered
- NED Plan for the ARCF GRR
- NED Plan for the WS GRR
- Effects of Re-evaluating ARCF and WS Projects Separately
- Conclusions

Existing Flood Risk Management System in the Greater Sacramento Area

The city of Sacramento sits along the east bank of the Sacramento River at the confluence with the American River. Immediately across the Sacramento River lies the city of West Sacramento. The cities of Sacramento and West Sacramento are collectively referred to as the greater Sacramento urban area.

Sacramento sits within three distinct basins each protected by a system of levees. The American River South (ARS) basin is protected by 25 miles of levee including the south levee of the American River and the east levee of the Sacramento River. The American River North (ARN) basin is protected by 25 miles of levee including the north levee of the American River, the east levee of the Natomas East Main Drainage Canal (NEMDC), the north and south levee of Arcade Creek, the north and south levee of Dry/Robla Creeks, and the west levee of the Magpie Creek Diversion Channel. The Natomas (NAT) basin is not included in the ARCF GRR.

West Sacramento sits within one distinct basin protected by a system of levees. This basin is split in two by a navigation project. This basin is protected by 50 miles of levee including the west levee of the Sacramento River, the south levee of the Sacramento Bypass, the east levee of the Yolo Bypass, and a canal embankment levee on the south. Refer to Plate 1 for a map of the greater Sacramento urban area.

The Sacramento River comes from the far north portion of California and passes between the cities of Sacramento and West Sacramento. Upstream of the greater Sacramento urban area, major tributaries to the Sacramento River includes the Feather River, the Colusa Basin Drain, and Butte Creek. Within the urban study area, the major tributary is the American River. Up until the flood of 1909, engineers attempted to keep all flow within the Sacramento River. The 1909 flood, along with other floods previously, caused levee failures. After the 1909 flood, the State of California and the Federal government decided to build a bypass system. Over the next 20 years, the bypass system was constructed.

The Sacramento River's bypass system starts approximately 100 miles above the Natomas basin where flow spills out of the Sacramento River to the east upstream of the project levees and into the Butte Basin. Flow in the Butte Basin feeds into the Sutter Bypass. The Sutter Bypass then flows into and across the Sacramento River and is then called the Yolo Bypass. The Fremont Weir sits at the very upper limit of the Yolo Bypass and controls when flow starts to spill into the Yolo Bypass. Continuing downstream, the Yolo Bypass passes just to the west of the city of West Sacramento.

Further down the Sacramento River in the city of Sacramento, the American River comes into the Sacramento River from the east. The Sacramento Weir and Bypass is located approximately three miles upstream of the American River. The primary purpose of the Sacramento Weir and Bypass is to take high flows from the American River over to the Yolo Bypass.

Below the greater Sacramento urban area, the Yolo Bypass and the Sacramento River come back together near the town of Rio Vista. Combined flow then continues out to San Francisco Bay and the Pacific Ocean. Refer to Plate 2 for a map of the Sacramento River Flood Control System.

History of Flooding in the Greater Sacramento Area

The city of Sacramento last flooded in 1909. Folsom Dam and the north levee of the American River, as well as the rest of the Sacramento River Flood Control Project, were all completed by the mid-1950s. 1955 marked a flood of record in the Sacramento Valley. 1964 was also a somewhat significant flood event on the American River. 1986 was a significant flood event that replaced the flood of record. And 1997 was a flood event that was almost as significant as the 1986 event. The 1955, 1964, 1986, and 1997 flood events caused much distress to the levees protecting the greater Sacramento urban area. The main causes of distress included seepage, stability, and erosion. Figure 1 below shows seepage and stability distress on the Sacramento River during the 1986 event that required flood fighting to prevent a full levee breach. Figure 2 below shows erosion distress on the American River that occurred during the 1986 event but was not known about until after flow receded.

For the 1986 flood event, potential levee overtopping became a significant threat on the American River because of Folsom Dam releases having to be ramped up above the objective release of 115,000 cfs and up to 134,000 cfs, which caused flow to be within one foot of the top of levee in certain locations along the American River. Some of these deficiencies have been addressed by seepage and stability improvements authorized in WRDA 1996, WRDA 1999, EWDAA 2004, and WRRDA 2014 for the city of Sacramento as part of the ARCF project, seepage and stability improvements authorized in WRDA 1992 for the city of West Sacramento as part of the WS project, and storage and release improvements

for Folsom Dam authorized in WRDA 1999 and EWDAA 2004. Many deficiencies remain which are the subject of the ARCF and WS GRRs.

Figure 1. Seepage and stability distress in Natomas during the 1986 flood event

Figure 2. Erosion distress on the American River after the 1986 flood event

2.0 FUTURE WITHOUT PROJECT CONDITIONS2.1 Legacy of Historic Levee Construction Techniques

The Sacramento River Flood Control Project, including the portion within the greater Sacramento urban area, was constructed using either a clamshell dredge or a suction dredge retrieving material from the adjacent river and piling it up along the levee alignment. Figures 3 and 4 show typical levee construction by both clamshell dredge and suction dredge methodology.

Figure 3. Typical clamshell dredge levee construction on the Sacramento River system

Figure 4. Typical suction dredge levee construction on the Sacramento River system

The material dredged from the adjacent river was predominately sand with very little silt that tends to be non-cohesive. Additionally, the land on which the levees were constructed tended to be materials similar to the material dredged from the adjacent river. These materials are very poor for levee safety. Water is able to freely move through and under the levee causing severe seepage

problems. Water seeping through the levee tends to carry levee material with it, weakening the levee. Additionally, in much of the study area, the levees have narrower crown widths and steeper side slopes than current engineering standards. In some locations, the waterside slope is steeper than 2 to 1 and the landside slope approaches 1 to 1, which coupled with the nature of the levee fill material, causes a significant stability issue as well.

In addition to the inherent seepage and stability issues of the levees and levee foundations, the potential for an erosion induced levee failure is significant. In many cases, the levees were built somewhat set back from the main channel of the adjacent river. Over the course of about a hundred years, much of the waterside berm left during initial construction has eroded away. This occurred because flow was confined between the levees to much higher stages and velocities than would have occurred prior to the levee construction. In some locations, 100 feet of berm has eroded away making it necessary to armor the waterside levee slope to stop additional erosion into the levee foundation and undermining of the levee. The Sacramento River Bank Protection Project constructs rock riprap bank protection at damaged sites. The problem with this approach is it reacts to erosion after it happens. Erosion has led to partial levee failures at very frequent events.

2.2 Legacy of Historic Levee System Configuration

Reclamation of the Sacramento Valley began around 1850. Up until the flood of 1909, all reclamation activities focused on forcing all flow to be confined to the main rivers. This was a trial and error period with frequent levee failures, including failures in the 1909 event. After this event, the State of California and the Federal Government decided on the need for the bypass system. The State approved the bypass system and the overall Sacramento River Flood Control Project in 1911 and the Federal Government authorized it in 1917. The bypass system and overflow weirs were then constructed over the next 15 years.

The flood of 1909 and a flood that occurred in 1907 were the only significant flood events for which detailed streamflow gage data is available. Initial design of the State and Federally authorized flood control system was developed around the floods of 1907 and 1909. In 1927, a new flood of record occurred for a portion of the Sacramento River system. The larger magnitude flow on these reaches was incorporated into the overall design of the entire flood control system. The entire Sacramento River Flood Control Project was completed in the mid 1950s.

In 1955, a new flood of record occurred for the entire Sacramento River system. This flood event caused a levee failure that inundated Yuba City, as well as a few other levee failures into relatively rural areas. Another flood event occurred in 1964 that was more substantial than every other event that occurred prior to the 1955 event. In 1986, again a new flood of record occurred for the entire Sacramento River system. This flood event caused a levee failure that flooded smaller communities around the City of Marysville, as well as a few other levee failures into relatively rural areas. In 1997, a flood event occurred that was nearly as significant as the 1986 event. This flood event caused a levee failure that nearly flooded the small community of Meridian, as well as a few other levee failures into relatively rural areas.

With the increasing size and frequency of storms since the mid 1950s, the levee system has been stressed by conveying more flow than it was intended to convey. This has partially been mitigated by the construction of various reservoirs around the Sacramento Valley. However, there are numerous

unregulated tributaries that contribute flow to the Sacramento River system. Therefore, the effect the reservoirs have on attenuation of flow in the Sacramento River system is minimal.

2.3 Prior Decisions on Folsom Dam

The 1986 flood event nearly caused the inundation of the cities of Sacramento and West Sacramento. After this event, the Corps was directed to complete a feasibility study to identify Federal interest in flood risk reduction measures. For American River, studies were completed in 1991 and 1996, with each identifying a new dam to be constructed on the north fork of the American River near the town of Auburn, plus levee improvements in the greater Sacramento area, as the NED plan. For various reasons, Congress chose not to authorize Auburn Dam and instead authorized modifications to Folsom Dam.

The Folsom Dam Modifications and Raise Projects are intended to control a 200-year flood event with a peak release of 160,000 cfs. The current objective release from Folsom Dam is 115,000 cfs. The original intent was to modify the existing Folsom Dam to be able to accomplish this higher objective release, however, due to technical complexities, it was decided to build an auxiliary spillway and control structure to accomplish this. This project is also combined with a USBR dam safety project and is therefore referred to as the Folsom Dam Joint Federal Project (JFP).

Prior authorizations in WRDA 1996, WRDA 1999, and EWDAA 2004 for the ARCF project were intended to improve the conveyance capacity of the levee system in the greater Sacramento area to safely convey the new release of 160,000 cfs. The 1997 flood event along with subsequent investigation combined with Hurricane Katrina, the inundation of New Orleans, and subsequent investigation have all illustrated that much more work needs to occur to the levee system protecting the greater Sacramento urban area.

2.4 General Problem Identification for the Greater Sacramento Urban Area

There are four main problems with the levee system for the greater Sacramento urban area: seepage, stability, erosion, and height. In general, three of these problems are a result of levee construction techniques (seepage, stability, and erosion). The other problem (height) is a result of the design conveyance capacity of the overall Sacramento River system based primarily on the 1907, 1909, and 1927 flood events.

<u>Levee Construction Technique Problems</u>

<u>Seepage:</u> Water traveling through and/or under a levee carries soil particles with it, greatly weakening the entire structure. If this condition is not corrected, it will likely lead to a levee failure. Even with flood fighting efforts, this condition occasionally leads to a levee failure. Figure 5 below shows a general seepage condition on the Sacramento River system.

<u>Stability:</u> Because the levees are built out of relatively non-cohesive materials (sand), and are in general built to a poor geometry, stability problems cause much distress in flood conditions. Like seepage, if this condition is not corrected, it will likely lead to a levee failure. Figure 6 below shows sloughing of a levee as a result of stability problems.

Figure 5. General seepage condition on the Sacramento River system

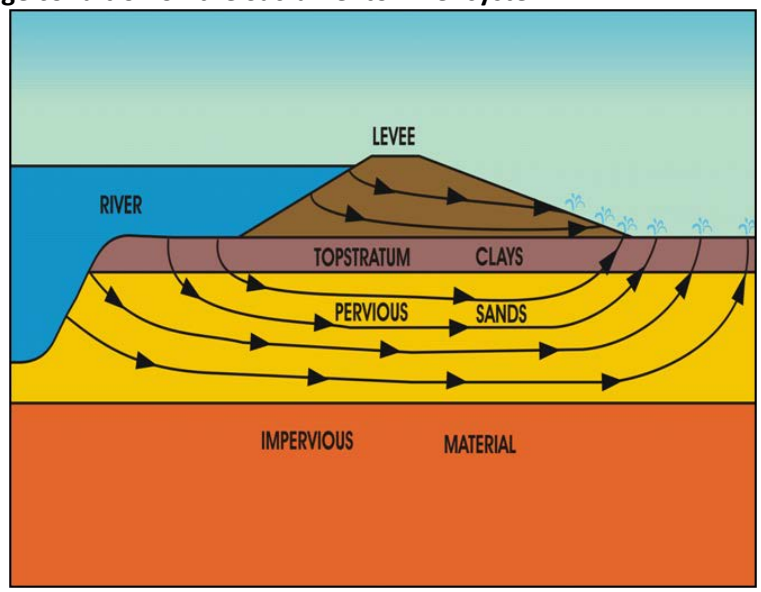


Figure 6. Sloughing of levee slope as a result of stability problem

Erosion: Because the levees are built out of relatively non-cohesive materials (sand), and are subjected to very severe (12 feet per second) river currents in some cases, erosion of the berm and levee slope is an ongoing concern. When erosion is occurring during a flood event, it is not evident and does not become evident until a full levee failure is in progress. Figure 7 below shows erosion on the Sacramento River at a site in the city of Sacramento.

Levee System Configuration Problem

The Sacramento River and Yolo Bypass combined were designed to convey 469,000 cfs, based primarily on the floods of 1907, 1909, and 1927. In 1986, that flow was exceeded by over 100,000 cfs. The American River was designed to convey 115,000 cfs. This amount was based on the hydrology used to design Folsom Dam and the north levee of the American River in the late 1940s. In 1986, there was

nearly 20,000 cfs more than that amount in the American River. The 1986 flood event was approximately an 80-year event.

The 1986 and 1997 flood events each stressed the levee system for the greater Sacramento urban area beyond what it was intended to convey. With the urbanization of the greater Sacramento urban area, the design conveyance capacity past the cities is insufficient to minimize the risk of catastrophic flood damages.

Figure 7. Erosion of the levee slope on the Sacramento River.

2.5 General Probability of Levee Failures into the Cities of Sacramento and West Sacramento

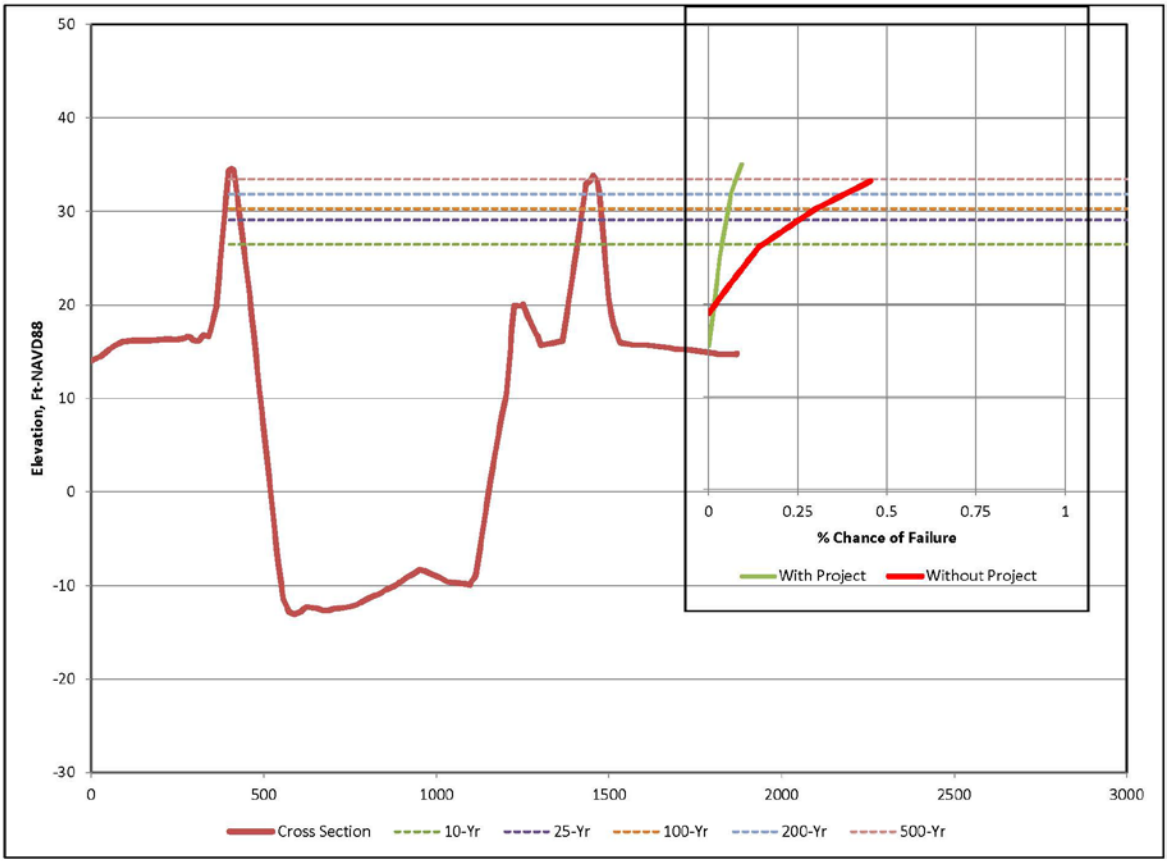
The GRRs for both ARCF and WS have been developed using consistent methodology and tools. For hydrology, both studies are using the updated Sacramento/San Joaquin Rivers Comprehensive Study hydrology. For hydraulics, both studies are using a HEC-RAS model of the entire Sacramento River Flood Control Project. For geotechnical, both studies are using accepted seepage and stability model software with inputs based on site specific geotechnical explorations. For risk analysis and economics, both studies are using the HEC-FDA software. For cultural resources, environmental, real estate, and civil design, methodologies are the same between the two studies.

The analysis for both studies has calculated water surface elevations for various frequency events along all levees adjacent to the greater Sacramento urban area. The analysis for both studies has also developed levee performance curves for typical reaches within each city.

Figure 8 below shows a cross section of the Sacramento River in the Pocket Area of Sacramento, along with the levee performance curve for that location. In the cross section, Sacramento is to the left side of the left levee and channel and West Sacramento is to the right side of the right levee and channel. Also shown on the cross section is the calculated water surface elevation for a 10-, 25-, 100-,

200-, and 500-year event. Elevations on the levee performance curve are at the same level as the cross section so that the water surface elevations in the channel can be compared to the levee performance curve.

Figure 8. Cross Section of the Sacramento River in the Pocket Area Along With the Levee Performance Curve for that Location



Based on this graphic, it can be seen that the 10-year water surface elevation has approximately a 15% chance of causing a levee failure into Sacramento. For the 25-, 100-, 200-, and 500-year events, the chances of have a levee failure into the city is 25%, 30%, 40%, and 45% respectively.

The without project condition levee performance curve is a composite curve that includes a component for through and under seepage, stability, and judgment. At this particular location, through seepage is not a concern because a shallow seepage cutoff wall was constructed there in the early 1990s. Additionally, stability in general is not a concern because of the presence of this same wall. Therefore, the drivers for the levee performance curve at this particular location are underseepage and judgment. Between the two, approximately 60% of the risk is driven by judgment and 40% is driven by underseepage. Judgment is a composite curve representing risk from vegetation, encroachments, rodent activity, access, and erosion. The risk from each of these components is significant but the single largest driver of the judgment curve is erosion.

The levee performance curve shown above is for the Sacramento side of the Sacramento River. The levee performance curve for the West Sacramento side of the river is very similar. Therefore, relative risk of levee failure is similar for West Sacramento as it is for Sacramento.

3.0 SYSTEM-WIDE IMPROVEMENT ALTERNATIVES

System-wide flood risk management alternatives for the Sacramento River were evaluated to determine if they would provide a cost-efficient solution without levee improvements for individual basins in the greater Sacramento urban area. Following is a brief description of each of the system-wide alternatives considered, the flood risk reduction effects of each alternative, and the reason each alternative was excluded from further consideration.

American River Upstream Storage

Studies completed in 1991 and 1996 identified Auburn Dam as the NED Plan to address flooding on the American River. Auburn Dam would be able to control a much larger flood event than Folsom Dam alone and would provide a higher level of flood risk reduction to the greater Sacramento urban area.

For Auburn Dam to be effective, the combined objective release from Auburn and Folsom Dams would need to be maintained at 115,000 cfs to leave storage available for the flood peak in each reservoir. With an objective release of 115,000 cfs, almost all of the levee improvements included in the NED Plans for both the ARCF and WS GRRs would still be necessary because the existing levee system is unreliable even at relatively low flow stages above the levee toe.

Specific levee improvements that would be required in conjunction with Auburn Dam include all seepage and stability improvements, all of the levee raising, probably the Sacramento Weir and Bypass widening, and almost all of the erosion protection improvements included in the ARCF and WS TSPs. Additionally, levee raising along the Sacramento River and Yolo Bypass would be required to protect against upstream Sacramento River driven floods of similar magnitude as Auburn Dam would be designed to control (approximately 400-year level of performance as identified in the 1996 report). This levee raising, possibly coupled with widening the Sacramento Weir and Bypass would be beyond the level needed for the two NED Plans because it would need to convey a 400-year flood event from the Sacramento River as opposed to an approximately 200-year event, which is the level of the NED Plans.

This alternative was excluded from further consideration in the GRRs because it would require almost all (if not all) of the features of both NED Plans. The levee improvements in the greater Sacramento urban area and the conveyance improvements of widening the Sacramento Weir and Bypass are required components of a comprehensive flood risk reduction alternative involving upstream storage on the American River and are therefore “no regrets” features. The currently proposed levee and conveyance improvements would be necessary and would provide benefits whether or not additional upstream storage is constructed in the American River watershed.

Transitory Storage In Rural Basins Upstream of the Greater Sacramento Urban Area

A possible way to improve flood risk for the greater Sacramento urban area is to temporarily store flood volume in some of the rural area adjacent to the Sacramento River, the Feather River, the Yolo Bypass, and/or the Sutter Bypass.

This temporary or transitory storage has the effect of reducing water surface elevations at the northwest corner of Natomas for various frequency events by between 2 and 3 feet. Further down the Sacramento River and Yolo Bypass, this decrease in stage reduces to zero, essentially giving no benefit to most of the greater Sacramento urban area. There are two primary reasons why this is the case. First, there is a tremendous volume of water coming down the Sacramento Valley towards the greater Sacramento urban area and when a basin is used for temporary storage, the volume of water taken out of conveyance in the river channels and put into storage is relatively small and insignificant. Second, the contribution of the Folsom Dam flood releases being conveyed down the American River eliminates any small decrease in stages that might have been experienced by transitory storage.

Therefore, with transitory storage, all of the levee improvements included in both NED Plans for ARCF and WS are still necessary, with transitory storage not providing nearly enough economic benefit to justify the very large cost. Therefore, transitory storage was excluded from further consideration.

Yolo Bypass Widening and Conveyance Capacity Improvements

Another possible way to reduce flood risk for the greater Sacramento urban area is to improve the amount of conveyance and the reliability of conveyance of the Yolo Bypass. This alternative would likely include widening the Yolo Bypass by setting back the east levee from Fremont Weir down to the Sacramento Bypass, widening the Fremont Weir, removal of embankment within the bypass at the Yolo Shortline Railroad, the Union Pacific Railroad, and Interstate Highway 80, construction of a diversion structure from the Yolo Bypass into the Sacramento River Deep Water Ship Channel (DWSC), construction of a closure structure on the DWSC, and construction of seepage and stability improvements of all of the existing levees along the bypass.

Yolo Bypass conveyance improvements have the effect of reducing water surface elevations at the northwest corner of Natomas for various frequency events by up to 3 feet. Further down the Sacramento River and Yolo Bypass, this decrease in stage reduces to nearly zero, essentially giving no benefit to most of the greater Sacramento urban area. The primary reasons why there is not more of a stage reduction is the same as for the transitory storage alternative.

Therefore, with Yolo Bypass conveyance improvements, all of the levee improvements included in both TSPs for ARCF and WS are still necessary, with Yolo Bypass conveyance improvements not nearly providing enough economic benefit to justify the very large cost. Therefore, for purposes of these two studies, it was screened out. It is important to note that the Yolo Bypass widening does potentially provide benefits elsewhere and is being looked at by the State of California as part of the Central Valley Flood Protection Plan (CVFPP), and this feature is still being analyzed by others but would not affect (strand)levee improvement in the greater Sacramento urban area.

Reoperation of Upstream Reservoirs

Another possible way to reduce flood risk for the greater Sacramento urban area is to reoperate upstream reservoirs to provide more flood flow attenuation within existing reservoirs. There are three

main reservoirs upstream of Folsom Dam that are intended for hydropower, including Union Valley, French Meadows, and Hell Hole, that could be reoperated for flood flow attenuation. Surrounding the Sacramento Valley to the north of the greater Sacramento urban area, Shasta, Oroville, Bullards Bar, Englebright, and Black Butte are all reservoirs that have some flood flow attenuation but also have a water supply and hydropower component; some of the water supply and hydropower storage space could be converted to flood flow attenuation at these reservoirs as well.

On the American River, the three hydropower reservoirs are relatively small compared to Folsom Dam. Therefore, unless significant storage space was to be converted to flood control, very little benefit is provided by reoperation of these reservoirs.

On the Sacramento River to the north, as pointed out in a previous section, there are many tributaries to the Sacramento Valley that are unregulated. Therefore the effect of reoperation of the existing reservoirs is quickly made irrelevant as the non-regulated streams and rivers contribute flow to the Sacramento Valley.

Therefore, with reoperation of upstream reservoirs, all of the levee improvements included in both NED Plans for ARCF and WS are still necessary, with reoperation of these reservoirs not providing nearly enough economic benefit to justify the very large cost. Therefore, the reoperation of upstream reservoirs was excluded from further consideration.

Overall Conclusions of System-Wide Improvement Alternatives

Every system-wide improvement alternative has minimal to no impact on stage reduction in the greater Sacramento urban area and requires almost all (if not all) of the levee improvements included in each of the NED Plans in order to significantly reduce the flood risk for the greater Sacramento urban area. Consequently, levee improvements in the greater Sacramento urban area are a first increment to any system-wide improvement plan. The State of California is formulating the "Central Valley Flood Protection Plan" (CVFPP) which is considering some or all of these system-wide plans. For purposes of their plan formulation efforts, they consider the levee improvements in these two GRRs to be "early implementation projects" and necessary integral increments to the overall CVFPP.

In Figure 8 above, if the water surface elevations were dropped by a half of foot on the stage reduction (which is an upper limit at this location as a result of the system-wide alternatives considered), very little risk reduction is provided to the greater Sacramento urban area. Therefore, the conclusions from evaluation of the system-wide alternatives are: 1) There is not a system-wide alternative that alone significantly reduces the flood risk to the greater Sacramento urban area; 2) Any system-wide plan still requires levees to be improved so that they can more reliably convey even moderate flows; and 3) Almost all of the levee improvements proposed in the ARCF and WS GRRs are integral to any system-wide plan that may be implemented in the future.

4.0 AMERICAN RIVER COMMON FEATURES NED PLAN AND LPP PLAN

After the system-wide plans were determined to alone not significantly reduce flood risk for the Sacramento urban area, levee improvements within the urban area were determined to be required for significant flood risk reduction. The NED Plan and a Locally Preferred Plan (LPP) were identified with the most substantial difference between the two being inclusion of a widened Sacramento Weir and Bypass

in the LPP but not the NED Plan. Following are details of the NED Plan for the ARCF GRR, identified by basin.

American River South (ARS) Basin

- Sacramento River: Approximately 9 miles of seepage cutoff walls, 2.5 miles of geotextile stabilized slope, 2 miles of slope flattening, 10 miles of rock riprap protection, and 9 miles of levee raising will be constructed.
- American River: Approximately 7 miles of rock riprap protection will be constructed.

American River North (ARN) Basin

- American River: Approximately 4 miles of rock riprap protection will be constructed.
- Natomas East Main Drainage Canal (NEMDC): Approximately 1 mile of seepage cutoff walls will be constructed.
- Arcade Creek: Approximately 4 miles of seepage cutoff walls, 4 miles of geotextile stabilized slope, and 4 miles of existing floodwall will be raised.
- Magpie Creek Diversion Channel: Approximately 0.5 miles of the Magpie Creek Diversion Channel west levee will be raised and the levee will be extended approximately 1,000 feet upstream.

For the NED plan, specific locations for the seepage, stability, erosion, and overtopping improvements for both basins are shown on Figure 9 below. Figure 8 above shows the with-project levee performance curve, and by comparing to the without project condition curve, the relative risk reduction provided by the plan features can be seen.

Following are details of the LPP for the ARCF GRR, identified by basin.

- Sacramento River: Construction of about 9 miles of slurry cutoff walls and about 10 miles of rock bank protection along the Sacramento River east levee, as well as about 2.5 miles of geotextile stabilized slope, 2 miles of slope flattening, and less than 1 mile of levee raise.
- Eastside Tributaries: Construction of about 4 miles of slurry cutoff walls and 4 miles of levee raises along the NEMDC and Arcade Creek levees.
- American River: Construction of rock bank protection and launchable rock trenches along 4 miles of the north bank and 7 miles of the south bank of the American River.
- Sacramento Bypass: Widen the Sacramento Weir and Bypass by 1,500 feet.

For the LPP, specific locations for the seepage, stability, erosion and overtopping improvements for both basins along with the widening of the Sacramento Weir and Bypass are shown on Figure 10 below.

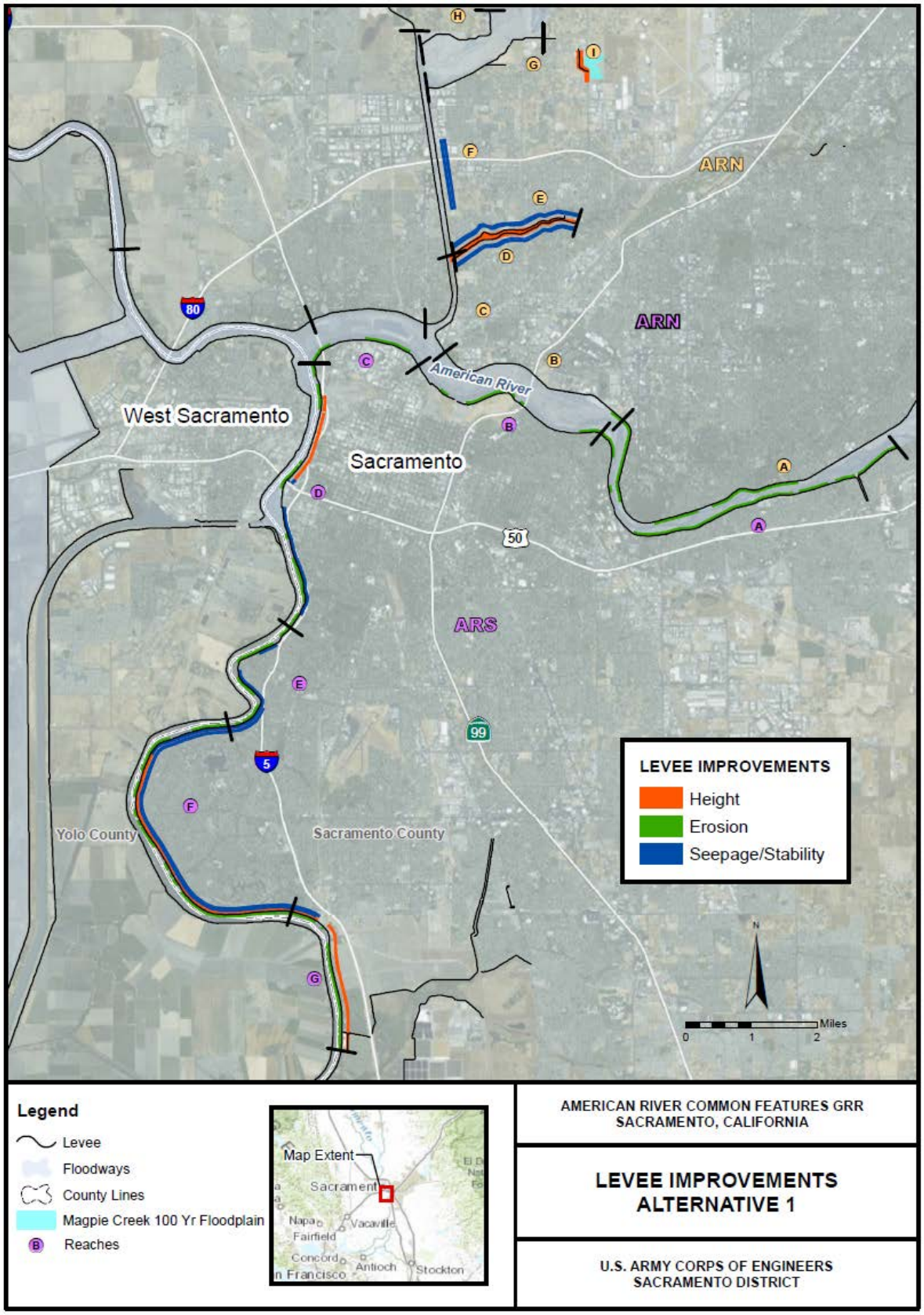


Figure 9. NED Plan Features for the American River Common Features GRR

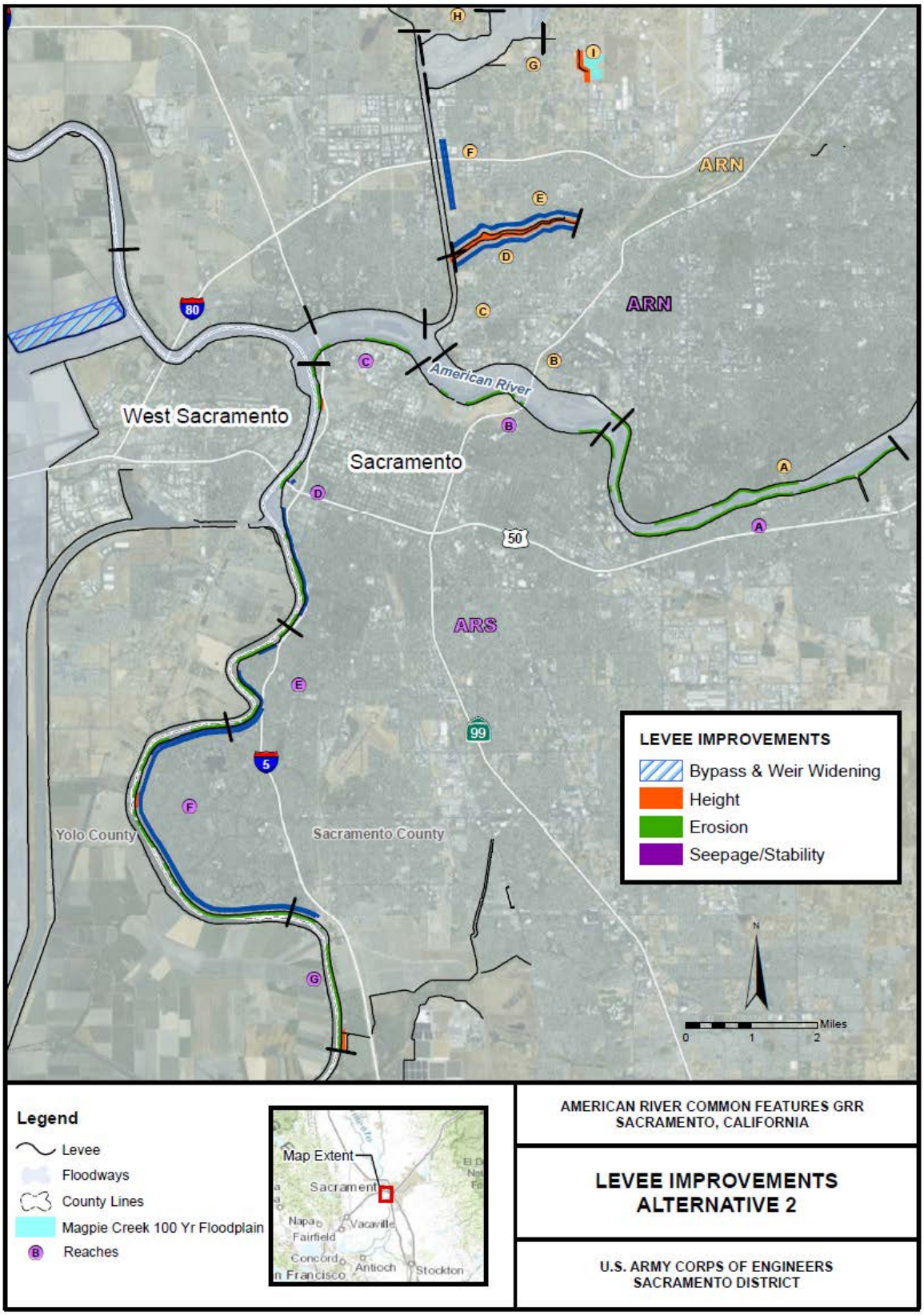


Figure 10. LPP Plan Features for the American River Common Features GRR

5.0 WEST SACRAMENTO NED PLAN

After the system-wide plans were determined to alone not significantly reduce flood risk for West Sacramento, levee improvements within the city were determined to be required for significant flood risk reduction. Alternatives for West Sacramento included improvement of the existing levees, construction of setback levees, construction of a widened Sacramento Bypass and Weir, construction of a diversion structure from the Yolo Bypass into the Deep Water Ship Channel, and construction of a Deep Water Ship Channel Closure Structure. Following are details of the NED Plan for the WS GRR, identified by basin. For West Sacramento, the NED Plan is also the TSP.

West Sacramento North Basin

- Sacramento River: Approximately 6 miles of rock riprap protection will be constructed.
- Yolo Bypass: Approximately 1 mile of seepage cutoff walls will be constructed.
- Port of Sacramento: The obsolete navigation lock from the DWSC to the Sacramento River will be removed and the Sacramento River west levee between the north and the south basins will be made continuous.
- Sacramento Bypass: Approximately 3,000 feet of rock riprap protection will be constructed.

West Sacramento South Basin

- Sacramento River: Approximately 6 miles of setback levee with seepage cutoff walls will be constructed.
- Port of Sacramento: Approximately 1,000 feet of seepage cutoff walls will be constructed. Also, the obsolete navigation lock from the DWSC to the Sacramento River will be removed and the Sacramento River west levee between the north and the south basins will be made continuous.
- Sacramento River DWSC: Approximately 1 mile of seepage cutoff walls will be constructed.
- Yolo Bypass: Approximately 5 miles of seepage cutoff walls and 19 miles of rock riprap protection will be constructed.
- South Cross Levee: Approximately 1 mile of relief wells and 0.2 miles of stability berm will be constructed.

Specific locations for the seepage, stability, and erosion improvements for both basins are shown on Figure 11 below.

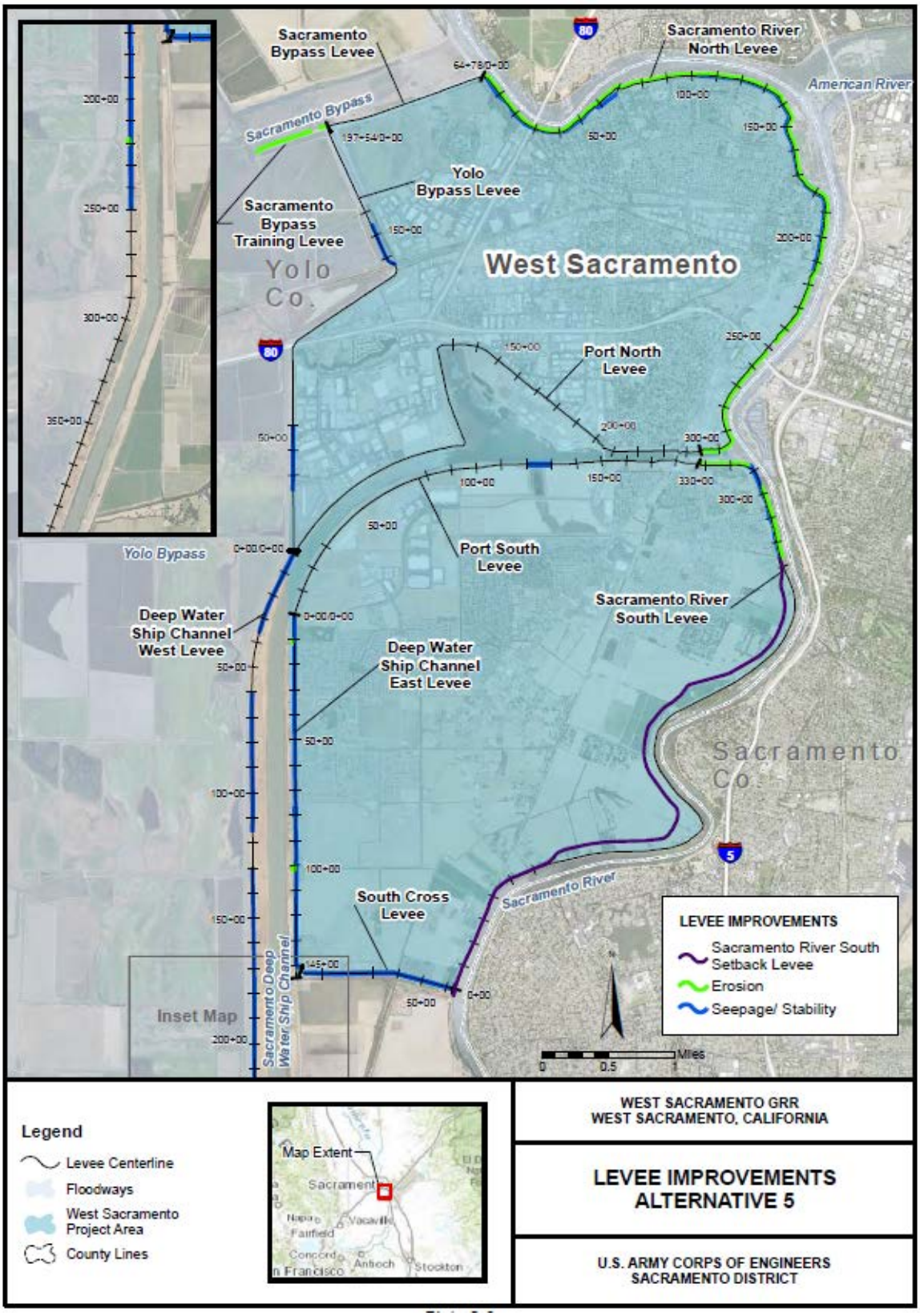


Figure 11. TSP Recommended Features for the West Sacramento GRR

6.0 EFFECTS OF RE-EVALUATING ARCF AND WS PROJECTS SEPARATELY

To determine the effects of improving levees in various basins, hydraulic analysis of the ARCF and WS study areas was performed as follows: (1) without project conditions for Sacramento and West Sacramento; (2) system-wide plans were developed and screened because they did not significantly reduce the flood risk of the two cities; (3) the ARCF TSP was considered in place but not the WS TSP; (4) the WS TSP was considered in place but not the ARCF TSP; and (5) the two TSPs were evaluated together. Details of this hydraulic analysis can be found in the Hydraulic Attachment to the Engineering Appendix for each of the two GRRs.

Step (1) in the above process confirmed the existing flood risk of the two cities as described in the background presented previously in this document. Step (2) established that there is no system-wide plan that has a significant effect on flood risk reduction in Sacramento and West Sacramento; therefore, system-wide plans were screened out. Plan formulation then proceeded to evaluate flood risk reduction measures within both cities. In carrying out steps (3), (4), and (5), it became clear that it does not matter whether the two cities are evaluated separately or together, the identification of the NED Plan would be the same

USACE engineering and economics models were used to evaluate without- and with-project conditions for each of the four hydraulic basins in the ARCF and WS study areas. Due to the practical limitations of models, the use of simplifying methods is necessary in representing the complexities of the real world. One of those methods is to evaluate each hydraulic basin separately from other basins whether those other basins are part of the same study or not. In the evaluation of each basin, it is assumed that there are no failures of levees in other basins under both without- and with-project conditions. Consequently, the proposed strengthening of an existing levee in any basin is assumed to have no effect on the probability of a levee failure in any other hydraulic basin, whether the other basin is part of the same study or not.

There is both empirical and analytical support for the assumption that there are no levee failures in other hydraulic basins. Since completion of the Sacramento River Flood Control Project in the mid 1950s, levee failures have occurred during the 1955,1983, 1986, and 1997 flood events. Detailed streamflow data necessary to determine the effect of the levee failure on stage reduction in the greater Sacramento urban area is only available for the 1997 event. An analysis was performed on the 1997 event to determine effect of the levee failures. This analysis showed that the levee failures on the Sutter Bypass and the Feather River reduced the highest stage recorded at the very upper limit of the Natomas Basin by 0.4 feet, and that reduction tapered down to zero further south within the cities of Sacramento and West Sacramento. The limited reduction in stage was due in part to the levee failures occurring near the peak of the flood. Also, the American River flows overwhelmed any minimal reduction in the Sacramento River stage that might have otherwise reached the Sacramento urban area. The levee failures that occurred during 1955, 1983, and 1986 all occurred around the peak of the flood and therefore would have resulted in similar minimal reductions in stage in the Sacramento urban area.

Analysis was performed to estimate the potential risk reduction on one side of the Sacramento River if the levee failed on the other side of the river. The specific analysis considered a levee failure into the city of Sacramento and what the stage reduction would be affecting West Sacramento. The analysis estimated that there is a 0.4 foot of stage reduction. The analysis assumed that the failure started to occur slightly before the peak of the hydrograph and developed rapidly. Actual levee failures

have happened very near the peak or somewhat after the peak and have taken considerable time to develop to their full width. Therefore, the estimate of 0.4 foot is likely an upper limit.

If the worst case scenario occurred with a breach sufficiently before the peak to lead to a 0.4 foot stage reduction, the probability of a levee failure on the West Sacramento side of the river would be reduced from 23% to 18%. Because there is only a 39% chance of levee failure on the Sacramento side during a 1 in 200 (0.5%) AEP event under without-project conditions, strengthening the levee on only the Sacramento side would have an insignificant effect on expected flood damages on the West Sacramento side. For smaller, more frequent flood events, the effect of a levee failure on flood stages, and consequently on the probability of a levee failure on the opposite bank, would be even less. If the period of time before the West Sacramento levee was also strengthened was relatively short (e.g., 10 years or less), the chance of a significant flood event occurring during that period would be minimized, and the already insignificant increase in expected flood damages in West Sacramento would be even further reduced. In the reverse scenario, a single levee failure on the West Sacramento side during a 1 in 200 ACE event under without-project conditions (which has a probability of only 23%) would cause a stage reduction of about 0.4 foot, and the probability of a levee failure on the Sacramento side of the river would then be reduced from 39% to 37%. Because three low probability events are involved, strengthening the levee on only the West Sacramento side would have an insignificant effect on the expected flood damages on the Sacramento side, particularly over a relatively short period of time.

To determine the effect of re-evaluating the ARCF and WS projects separately, hydraulic analysis of the two project areas was performed in three ways: (1) without-project conditions; (2) the two TSPs were evaluated separately; and (3) the two TSPs were evaluated together. Comparison of those three scenarios indicated that combining the two projects would not result in the selection of different plans (Tech Memo, Common Features GRR and West Sacramento GRR TSP Comparison, 16 October 2014).

Table 1: Tentative Regional Construction Sequence for ARCF and West Sacramento.

REGIONAL PRIORITY	WATERWAY	REACH	YEAR OF PROJECT CONSTRUCTION										
			1	2	3	4	5	6	7	8	9	10	11-17
1	JFP/Dam Raise												
2	ARCF Sacramento River	ARS F											
3	ARCF Sacramento River	ARS E											
4	ARCF American River	ARS A											
5	WS Yolo Bypass Levee												
6	ARCF Sacramento River	ARS G											
7	ARCF Sacramento River	ARS D											
8	ARCF American River	ARS B											
9	ARCF American River	ARN A											
10	ARCF American River	ARS C											
11	ARCF American River	ARN B											
12	ARCF Sac Weir & Bypass	--											
13	WS Sacramento River North												
14	WS Port North Levee												
15	WS Sac Bypass Training Levee												
16	WS Sacramento River South												
17	WS Port South Levee												
18	ARCF Arcade Creek	ARN D											
19	ARCF NEMDC	ARN F											
20	ARCF Arcade Creek	ARN E											
21	ARCF NEMDC	ARN C											
22	ARCF Magpie Creek	ARN I											
23	WS Deep Water Ship Ch. East												
24	South Cross Levee												
25	WS Deep Water Ship Ch. West												

7.0 CONCLUSIONS

There is no system-wide flood risk management alternative that would avoid the need for levee improvements in the ARCF and WS project areas. The effect of levee improvements in one of the four hydraulic basins in the ARCF and WS project areas on any other basin is insignificant relative to plan formulation or implementation. Consequently, combining all four hydraulic basins into a single evaluation rather than two evaluations would not change the plan formulation process or identification of the NED plan for either project.

Attachment 2: DEVELOPMENT OF COSTS AND BENEFITS FOR THE FOCUSED ARRAY OF ALTERNATIVES

COST BASIS FOR FOCUSED ARRAY OF ALTERNATIVES

This document describes the basis for the costs estimates for the alternatives identified in Table 3-14 of the GRR.

The alternatives included in the focused array are effectively building blocks that start with fixing levees. It was determined that to reduce the flood risk for the City of Sacramento, fixing the levees is the first increment.

Alternative 0.5: Alternative 0.5 included improvements to the levees protecting Sacramento to address seepage, stability, and erosion. Levee raising or other conveyance improvements were not included in this alternative. This alternative provides somewhere around a 1/100 ACE performance before overtopping would occur. The cost estimate for this alternative is the Alternative 1 cost estimate from the 2013 time frame (2012 price levels) with the quantities and cost for levee raising removed. The total cost for this alternative at this level of analysis was $1,262,915,000. The cost for Alternative 1 is shown in the following Table 1. The reduction of Alternative 1 costs as a result of removing the levee raising on the Sacramento River and the Natomas Basin is shown on Table 2. The costs as shown on Table 2 included with the total cost of the additional levee improvement construction is shown on Table 3. Table 3 also includes supporting economic information (interest during construction and average annual costs).

Alternative 1: Alternative 1 adds levee raising to the previous alternative and got to approximately a 1/200 ACE level of performance. There is a spreadsheet estimate for this alternative in 2012 price levels that is the basis of the cost estimate in Table 3-14. That estimate is included in the following Table 1. The total cost for this alternative at this level of analysis was $1,426,055,000.

Alternative 2: Alternative 2, includes the levee improvements described in Alternative 1 and adds widening of the Sacramento Weir and Bypass which negates the need to include most of the levee raising in Alternative 1. It accomplishes this by rerouting flow that would have gone down the Sacramento River instead to the widened Sacramento Weir and Bypass. A spreadsheet estimate for this alternative in 2012 price levels is the basis for the cost estimate in Table 3-14 and is also included in the following Table 4. The total cost for this alternative at this level of analysis was $1,567,746,000. Supporting economic information (interest during construction and average annual costs) are shown on Table 5.

Alternative 3: Alternative 3 includes the levee work and widening of the Sacramento Weir and Bypass described in Alternative 2, and then adds the I Street Diversion Structure which negates the need to do all levee raising work on the Sacramento River, plus most of the erosion, seepage, and stability work downstream of the Diversion Structure. Diverting this much flow from the Sacramento River into the Sacramento Weir/Bypass and into the Yolo Bypass had very severe impacts. The hydraulic impacts to the Yolo Bypass were large and it was obvious that many features would need to be added to mitigate for the effects. The cost includes the cost of Alternative 2 with all of the work for ARS Reaches D-G removed, , plus the cost of Yolo Bypass mitigation features, approximately estimated at $1,131,880,900

(shown on Table 8), and the cost of the I-Street Diversion structure itself at $122,161,763 (shown on Table 9). The total cost for the alternative is $2,122,000 and is shown in Table 6. This alternative did not have the support of the environmental community or the local partners and stakeholders. Once it was shown that Alternative 3 was not on the rising limb of the net benefits curve, no further effort on this alternative was performed.

Alternative 4: Alternative 4 added Auburn Dam to the levee improvements proposed in Alternative 1. This feature did not negate the need to do any of the levee improvements in Alternative 1. The cost estimate developed for Auburn Dam in 1996 was inflated to 2014 dollars, and added to the cost of Alternative 1. The benefit provided by including Auburn Dam would be that instead of the overall project providing approximately a 1/200 ACE-year level of performance, it would provide approximately a 1/400 ACE-year level of performance. The cost of Auburn Dam, inflated from 1996 to 2014 is approximately $1,800,000,000. It does provide additional benefits beyond Alternative 1, however not enough to keep it on the rising limb of the net benefits curve. Moving forward with the TSP does not preclude the possible future justification of Auburn Dam; the features of the TSP are no-regrets actions with regards to the possibility of Auburn Dam ever being built. Once it was shown that Auburn Dam was not on the rising limb of the net benefits curve, no further effort on this alternative was performed. The total cost for Alternative 4 is shown on Table 10.

Alternative 5: This alternative was developed to show a maximum level of flood risk reduction for the City of Sacramento. It basically includes all building block steps including levee improvements from Alternative 1, the Sacramento Weir and Bypass widening of Alternative 2, the I Street Diversion Structure from Alternative 3 (including the Yolo Bypass mitigation work), and the Auburn Dam from Alternative 4. Taking the cost of all of these features and adding them together is the background for the cost of this alternative. The total cost for Alternative 5 is shown on Table 11.

Alternative 6: This alternative is non-structural and therefore there is no significant cost, but also no significant flood risk reduction.

The analysis conducted on the Focused Array of Alternatives displayed that Alternatives 1 and 2 would be the most efficient alternatives and would be carried forward for further analysis. This further analysis is shown in the GRR in the tables following Table 3-14. Additionally, the costs for these alternatives were updated to reflect 2015 price levels.

Cost and associated economic information is shown on Table 12.

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

OCT 30 2014

CECW-SPD

MEMORANDUM FOR THE ASSISTANT SECRETARY OF THE ARMY (CIVIL WORKS)

SUBJECT: American River Common Features (ARCF) Project, California, Deviation from the National Economic Development (NED) Plan

1. PURPOSE: To request that you grant an exception to the requirement to recommend the NED plan. The exception would allow the U.S. Army Corps of Engineers (USACE) to recommend the Locally Preferred Plan (LPP) for flood risk management for the American River Common Features General Reevaluation Study.

2. BACKGROUND: The Sacramento District and South Pacific Division have completed the Tentatively Selected Plan milestone. The district has resolved legal, policy and technical issues raised by the District Support Team and Office of Water Project Review. HQUSACE policy and legal review of the LPP Exemption Request is complete and we support the request to allow a recommendation that deviates from the NED plan.

3. DISCUSSION - General:

This report was prepared as a general reevaluation study of the American River Common Features Project, which was authorized by Section 101(a) (1) of the Water Resources Development Act (WRDA) 1996 (P. L. No. 104-303) and amended by Section 366 of WRDA 1999 (P. L. No. 106-53).

a. The effects of the 1986 storms raised concerns over the adequacy of the existing flood management system. These concerns led to a series of study authorizations and investigations into the need for additional reduction of flood risk for the Sacramento area. These investigations have resulted in the recommendation and subsequent authorization of the Folsom Dam Modification Project (now known as the Joint Federal Project or JFP), the Folsom Dam Raise Project, and incremental improvements to the network of levees along the American and Sacramento Rivers surrounding the city of Sacramento authorized in WRDA 1996 and WRDA 1999. Recommendations for levee improvements in the Natomas Basin are the subject of a Chief's Report signed in 2010 and are included in the Water Resources Reform and Development Act of 2014. The American River Common Features General Reevaluation Report (GRR) identifies the remaining flood risk to the city of Sacramento and the surrounding areas and alternatives to reduce this flood risk.

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b. The identified NED plan involves the construction of levee improvement measures to address seepage, slope stability, erosion, and overtopping concerns identified for the Sacramento River levees, Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks. It includes erosion protection measures for the American River levees. American River seepage, stability, and overtopping issues were addressed in the WRDA 1996 and 1999 construction projects. Due to environmental, real estate, and hydraulic constraints within the American River North and South basins, the plan proposes to improve the levees within the existing footprint to the extent practical. The purpose of this would be to improve the flood risk management system to safely convey flows to a level that maximizes net benefits.

c. The LPP includes all the levee improvements contained in the NED Plan, except for 8 miles of flood walls or levee raises along the Sacramento River. The Sacramento Weir and Bypass would be widened to divert more flows into the Yolo Bypass. This would reduce the amount of levee raising required on the Sacramento River levees to address Hydraulic and Hydrologic uncertainty and meet the state's criteria for levee performance that would equal or exceed the 200 year water surface elevation plus 3 feet. As previously described under the NED, the levees along the American River, NEMDC, Arcade, Dry/Robla, and Magpie Creeks, would be improved to address identified seepage, stability, erosion, and height concerns. The levees along the Sacramento River would be improved to address identified seepage, stability, and erosion concerns as described under the NED. Due to environmental, real estate, and hydraulic constraints within the American River North and South basins, the majority of the levees would be fixed in place.

Widening of the Sacramento Weir and Bypass, and enhancing the flood system capacity, are key features of the system-wide improvements identified in the state of California's 2012 Central Valley Flood Protection Plan. Widening of the Sacramento Weir and Bypass reduces the river stage downstream of the American River confluence in the Sacramento and West Sacramento urban areas by diverting more water into the rural Yolo Bypass. The downstream stage reduction also decreases the risk to life safety and reduces flood damages to the rural communities located downstream of Sacramento. These communities include Clarksburg, Hood, Courtland, Walnut Grove, Ryde, and Isleton. Preliminary information from the Delta Islands Feasibility Study indicates existing expected annual damages for these communities to be around $10 million, and stage reductions would be expected to reduce damages by approximately 10% -30%.

The Central Valley Flood Protection Board and the Sacramento Area Flood Control Agency are the non-federal sponsors. They agree to pay the full incremental cost of the LPP above the NED Plan cost. The LPP is supported by the non-federal sponsors and the state of California because it allows the city of Sacramento and the surrounding

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SUBJECT: American River Common Features Project, California – Deviation from the National Economic Development (NED) Plan

areas to meet the requirements of Senate Bill 5 which stipulates that urban and urbanizing areas (with a population of 10,000 or greater) must achieve 1/200 Annual Chance Exceedence level of flood risk management in order to qualify for state funding of flood management projects.

4. DISCUSSION – NED vs. LPP:

The total costs, annual costs, annual benefits, net benefits and benefit to cost ratios for the NED and LPP are presented below.

	NED	LPP
Investment Costs:		
Flood Risk Management First Costs	$1,387,928,000	$1,547,833,000
Interest During Construction	361,375,000	489,447,000
Total	**1,749,303,000**	**2,037,280,000**
Annual Cost		
Interest and Amortization	74,573,000	86,849,000
OMRR&R	300,000	500,000
Total	**74,873,000**	**87,349,000**
Annual Benefits	414,553,000	410,928,000
Net Annual Flood Risk Management Benefits	339,680,000	323,579,000
Benefit to Cost Ratio	5.5	4.7

The LPP total first cost is about $160 million greater than the NED. The total federal cost contribution to the LPP will be limited to the federal share of the identified NED plan. The non-federal sponsor will be responsible for all operation, maintenance, repair, replacement and rehabilitation costs of the LPP.

5. RECOMMENDATION:

The LPP is recommended to further reduce the probability of catastrophic levee failure. The LPP achieves this by enhancing levee performance based on its ability to reduce the water surface elevation in the river adjacent to two urban areas, increase the regional flexibility of the flood management system, provide benefits to downstream communities in the form of reduced water surface elevations in the Sacramento River, and improve natural floodplain values by increasing the areas exposed to overbank flooding in the expanded bypass area. The LPP is a critical initial component of a larger regional plan under development by the state and local interests. The reduction in water surface elevation against these levees would reduce the probability of levee

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SUBJECT: American River Common Features Project, California – Deviation from the National Economic Development (NED) Plan

failure in the urban areas. The results of such a levee failure would be catastrophic due to the minimal warning time for evacuation and deep flooding that would occur. The LPP reduces those consequences in alignment with the state of California Central Valley urban flood risk standards and long term flood risk management strategy. I request that you grant an exception to the requirement to recommend the NED plan to allow USACE to recommend the LPP for flood risk management for the American River Common Features General Reevaluation Report.

6. If you have any questions, please contact my action officer, Mrs. Pauline Acosta, Civil Engineer for the South Pacific Division Regional Integration Team, at (202) 761-4085.

STEVEN L. STOCKTON, P.E.
Director of Civil Works

Encls
1. SPD EndorsementLletter
2. SPK Exception Request
3. Non-federal Sponsor Letter Request
4. TSP Milestone MFR

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

MAR -9 2015

MEMORANDUM FOR DEPUTY COMMANDING GENERAL FOR CIVIL AND EMERGENCY OPERATIONS

SUBJECT: American River Common Features - Policy Waiver – Request to Deviate from the National Economic Development (NED) Plan

I am responding to a request from the Director of Civil Works that I grant an exception to the requirement to recommend the national economic development (NED) plan and instead allow the U.S. Army Corps of Engineers (Corps) to recommend Federal participation in the locally preferred plan (LPP) for the American River Common Features, California project.

My staff has reviewed the memorandum, the background information and the supporting documentation. The primary difference between the NED plan and the LPP is that the LPP includes all the levee improvements contained in the NED Plan, except for 8 miles of flood walls or levee raises along the Sacramento River. In place of those levee raises, the Sacramento Weir and Bypass would be widened to divert more flows into the Yolo Bypass. The LPP provides outputs and benefits similar to the NED plan within the study area but the LPP would result in lower water surface elevations against existing levees both within and beyond the study area.

The benefits provided by the 2 alternatives within the study area are very close. The costs and benefits of Alternatives 1 and 2 are still preliminary and will continue to be refined as the study progresses and the plan with the greatest average net annual benefits is re-affirmed. However, Alternative 1 has consistently achieved greater net benefits and, therefore, has been identified as the NED plan. The non-Federal sponsor supports the LPP and agrees to pay 100 percent of the LPP costs in excess of the NED plan. Therefore, I approve the requested policy exception to recommend the LPP provided that the sponsor shall have the sole responsibility for all additional costs above the NED plan.

If there are any questions, your staff may contact Mr. Henri Langlois, Project Planning and Review at (202) 761-0038.

jo-ellen darcy

Jo Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

CF: CECW-P

Table 1

****** TOTAL PROJECT COST SUMMARY ****** 3/4/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, NED PLAN
PROJECT: ARCF GRR - Alt 1 — **U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT**
LOCATION: CALIFORNIA — **P.O.C.: JEREMIAH FROST, CHIEF, COST ENGINEERING SECTION**

Current MCACES Estimate Prepared: 1-Mar-2012 Effective Price Level (EPL): 1-Oct-2012					PROGRAM YEAR(BUDGET EC) 2014 EFF. PRICE LEVEL DATE:1-Oct-2013				TOTAL PROJECT COST (FULLY FUNDED) SPENT THRU:			
		ESTIMATED COST				PROJECT FIRST COST			1-Oct-2012			FULLY
WB NO.	Civil Works Feature\Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	COST ($K)	CNTG ($K)	FUNDED ($K)
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2012			
	FEDERAL COSTS												
6	FISH & WILDLIFE FACILITIES	22,466	5,282		27,748		22,823	5,364	28,187	0	0	0	0
	ARN - Reaches D-I	660	150		810		672	150	822	0	0	0	0
	ARN - Reaches A-C	9,660	2,273		11,933		9,813	2,309	12,122	0	0	0	0
	ARS - Reaches A-C	10,886	2,561		13,447		11,059	2,600	13,659	0	0	0	0
	ARS - Reaches D-G	1,260	298		1,558		1,279	305	1,584	0	0	0	0
11	LEVEES & FLOODWALLS	723,798	164,143		887,941		734,817	166,739	901,556	26,215	0	0	0
	Natomas - Reaches B-H	71,017	10,542		81,559		71,724	10,709	82,433	26,215	0	0	0
	ARN - Reaches D-I	57,104	13,438		70,542		58,006	13,651	71,657	0	0	0	0
	ARN - Reaches A-C	82,837	19,492		102,329		84,145	19,800	103,945	0	0	0	0
	ARS - Reaches A-C	141,943	33,401		175,344		144,186	33,929	178,115	0	0	0	0
	ARS - Reaches D-G	370,897	87,270		458,167		376,756	88,650	465,406	0	0	0	0
18	CULT. RESRC PRESERV. (1	7,410	1,747		9,157		7,541	1,775	9,316	0	0	0	0
	Natomas - Reaches B-H	764	105		869		774	107	881	0	0	0	0
	ARN - Reaches D-I	687	134		821		700	136	836	0	0	0	0
	ARN - Reaches A-C	794	164		958		809	166	975	0	0	0	0
	ARS - Reaches A-C	1,253	256		1,509		1,276	260	1,536	0	0	0	0
	ARS - Reaches D-G	3,912	1,088		5,000		3,982	1,106	5,088	0	0	0	0
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	753,674	171,172		924,846		765,181	173,878	939,059	26,215	0	0	0
1	LANDS & DAMAGES, Admin (2	9,325	469		9,794		9,597	485	10,082	0	0	0	0
	ARN - Reaches D-I	2,575	130		2,705		2,649	135	2,784	0	0	0	0
	ARN - Reaches A-C	525	27		552		540	29	569	0	0	0	0
	ARS - Reaches A-C	350	17		367		361	17	378	0	0	0	0
	ARS - Reaches D-G	5,875	295		6,170		6,047	304	6,351	0	0	0	0
30	PLAN/ENGINEERING/DESIGN	107,973	7,557		115,530		111,138	7,779	118,917	0	0	0	0
	Natomas - Reaches B-H	6,721	470		7,191		6,919	482	7,401	0	0	0	0
	ARN - Reaches D-I	8,631	604		9,235		8,884	622	9,506	0	0	0	0
	ARN - Reaches A-C	13,874	972		14,846		14,280	1,001	15,281	0	0	0	0
	ARS - Reaches A-C	22,924	1,604		24,528		23,596	1,652	25,248	0	0	0	0
	ARS - Reaches D-G	55,823	3,907		59,730		57,459	4,022	61,481	0	0	0	0
31	CONSTRUCTION MANAGE'MT	61,188	4,285		65,473		62,980	4,412	67,392	0	0	0	0
	Natomas - Reaches B-H	3,808	267		4,075		3,919	276	4,195	0	0	0	0
	ARN - Reaches D-I	4,891	344		5,235		5,035	353	5,388	0	0	0	0
	ARN - Reaches A-C	7,862	551		8,413		8,092	568	8,660	0	0	0	0
	ARS - Reaches A-C	12,992	909		13,901		13,373	935	14,308	0	0	0	0
	ARS - Reaches D-G	31,635	2,214		33,849		32,561	2,280	34,841	0	0	0	0
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	932,160	183,483		1,115,643		948,896	186,554	1,135,450	26,215	0	0	0
	NON-FEDERAL CONTRIBUTION (-)	191,077	8,879		199,956		194,804	9,075	203,879	5,398	0	0	0
	TOTAL FEDERAL COSTS	**$741,083**	**$174,604**		**$915,687**		**$754,092**	**$177,479**	**$931,571**	**$20,817**	**$0**	**$0**	**$0**
	NON-FEDERAL COSTS												
1	LANDS AND DAMAGES	123,551	76,215		199,766		125,504	77,417	202,921	0	0	0	0
	ARN - Reaches D-I	13,888	8,237		22,125		14,108	8,366	22,474	0	0	0	0
	ARN - Reaches A-C	3,204	1,040		4,244		3,255	1,056	4,311	0	0	0	0
	ARS - Reaches A-C	1,730	467		2,197		1,757	475	2,232	0	0	0	0
	ARS - Reaches D-G	104,729	66,471		171,200		106,384	67,520	173,904	0	0	0	0
2	RELOCATIONS	75,589	16,393		91,982		76,690	16,654	93,344	5,811	0	0	0
	Natomas - Reaches B-H	30,108	5,692		35,800		30,491	5,783	36,274	5,811	0	0	0
	ARN - Reaches D-I	22,592	5,315		27,907		22,948	5,400	28,348	0	0	0	0
	ARN - Reaches A-C	2,385	561		2,946		2,423	570	2,993	0	0	0	0
	ARS - Reaches D-G	20,504	4,825		25,329		20,828	4,901	25,729	0	0	0	0
30	PLAN/ENGINEERING/DESIGN	10,466	733		11,199		10,632	746	11,378	0	0	0	0
	Natomas - Reaches B-H	3,645	254		3,899		3,702	259	3,961	0	0	0	0
	ARN - Reaches D-I	3,387	238		3,625		3,441	242	3,683	0	0	0	0
	ARN - Reaches A-C	358	25		383		364	25	389	0	0	0	0
	ARS - Reaches D-G	3,076	216		3,292		3,125	220	3,345	0	0	0	0
31	CONSTRUCTION MANAGE'MT	6,978	487		7,465		7,090	494	7,584	0	0	0	0
	Natomas - Reaches B-H	2,429	171		2,600		2,468	173	2,641	0	0	0	0
	ARN - Reaches D-I	2,260	156		2,416		2,296	159	2,455	0	0	0	0
	ARN - Reaches A-C	238	17		255		242	17	259	0	0	0	0
	ARS - Reaches D-G	2,051	143		2,194		2,084	145	2,229	0	0	0	0
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)	216,584	93,828		310,412		219,916	95,311	315,227	5,811	0	0	0
	NON-FEDERAL CONTRIBUTION (+)	191,077	8,879		199,956		194,804	9,075	203,879	5,398	0	0	0
	Natomas - Reaches B-H	5,886	870		6,756		5,961	884	6,845	5,398	0	0	0
	ARN - Reaches D-I	5,799	1,431		7,230		5,902	1,454	7,356	0	0	0	0
	ARN - Reaches A-C	36,145	7,092		43,237		36,820	7,213	44,033	0	0	0	0
	ARS - Reaches A-C	65,059	13,168		78,227		66,259	13,388	79,647	0	0	0	0
	ARS - Reaches D-G	78,188	(13,682)		64,506		79,862	(13,864)	65,998	0	0	0	0
	TOTAL NON-FEDERAL COSTS	**$407,661**	**$102,707**		**$510,368**		**$414,720**	**$104,386**	**$519,106**	**$11,209**	**$0**	**$0**	**$0**
	TOTAL FEDERAL & NON-FEDERAL COSTS	**$1,148,744**	**$277,311**		**$1,426,055**		**$1,168,812**	**$281,865**	**$1,450,677**	**$32,026**	**$0**	**$0**	**$0**

**** TOTAL PROJECT COST SUMMARY(CONT'ED) ****

Current MCACES Estimate Prepared: 1-Mar-2012 Effective Price Level (EPL): 1-Oct-2012						PROGRAM YEAR(BUDGET EC) 2014 EFF. PRICE LEVEL DATE:1-Oct-2013				TOTAL PROJECT COST (FULLY FUNDED) SPENT THRU:			
		ESTIMATED COST				PROJECT FIRST COST				1-Oct-2012			FULLY
WB NO.	Civil Works Feature\Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	COST ($K)	CNTG ($K)	FUNDED ($K)
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2012			

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 01 Account for Land and Damages cost are from Real Estates.

Table 2

ARCF GRR
ARS Reaches D-G
Subset of Costs for Alternative 0.5 (without levee raising)

Feature	Alternative 1 Cost ($1,000s)			Alternative 0.5 Cost ($1,000s)	
	Seepage, Stability, Erosion	Levee Raising 1/	Total	Seepage, Stability, Erosion	Total
6 Fed - Fish & Wildlife Facilities	1,503	55	1,558	1,503	1,503
11 Fed - Levees & Floodwalls	441,940	16,227	458,167	441,940	441,940
18 Fed - Cultural Resource Preservation	4,823	177	5,000	4,823	4,823
1 Fed - Lands & Damages	5,951	219	6,170	5,951	5,951
30 Fed - PED	57,615	2,115	59,730	57,615	57,615
31 Fed - CM	32,650	1,199	33,849	32,650	32,650
1 NF - Lands & Damages	165,137	6,063	171,200	165,137	165,137
2 NF - Relocations	24,432	897	25,329	24,432	24,432
30 NF - PED	3,175	117	3,292	3,175	3,175
31 NF - CM	2,116	78	2,194	2,116	2,116
	739,342	27,147	766,489	739,342	739,342

1/ Costs for levee raising based on quantities and construction cost equating to 3.67% of total construction cost and this percentage being used for all other accounts.

Table 3

Alternative 0.5 – Costs

BASIN	ALTERNATIVE 0.5: FIX IN PLACE-NO LEVEE RAISE (IN $1,000s, OCTOBER 2012 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.75% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS	IDC	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	231,293	86,646	317,939	14,171	TBD	14,171
	Sacramento	739,342	234,786	974,128	43,417	TBD	43,417
	Total Basin	**970,635**	**321,432**	**1,292,067**	**57,588**	**0**	**57,588**
ARN	American	146,859	23,405	170,264	7,589	TBD	7,589
	Tributaries[2]	145,421	17,309	162,730	7,253	TBD	7,253
	Total Basin	**292,280**	**40,714**	**332,994**	**14,842**	**TBD**	**14,842**
GRAND TOTAL	**All Basins**	**1,262,915**	**362,146**	**1,625,061**	**72,430**	TBD	**72,430**

Alternative 1 – Costs

BASIN	ALTERNATIVE 1: FIX IN PLACE (IN $1,000s, OCTOBER 2012 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.75% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS	IDC	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	231,293	86,646	317,939	14,171	TBD	14,171
	Sacramento	739,342	234,786	974,128	43,417	TBD	43,417
	Sac Raises	27,147	7,572	34,719	1,547	TBD	1,547
	Total Basin	**997,782**	**329,004**	**1,326,786**	**59,135**	**TBD**	**59,135**
ARN	American	146,859	23,405	170,264	7,589	TBD	7,589
	Tributaries[2]	145,421	17,309	162,730	7,253	TBD	7,253
	Total Basin	**292,280**	**40,714**	**332,994**	**14,842**	**TBD**	**14,842**
NATOMAS	All sources[3]	135,993	8,391	144,384	6,435	TBD	6,435
	Total Basin	**135,993**	**8,391**	**144,384**	**6,435**	**TBD**	**6,435**
GRAND TOTAL	**All Basins**	**1,426,055**	**378,109**	**1,804,164**	**80,412**	TBD	**80,412**

Table 4

****** TOTAL PROJECT COST SUMMARY ****** 3/4/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, NED PLAN
PROJECT: ARCF GRR - Alt 2 — U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT
LOCATION: CALIFORNIA — P.O.C.: JEREMIAH FROST, CHIEF, COST ENGINEERING SECTION

Current MCACES Estimate Prepared: 1-Mar-2013
Effective Price Level (EPL): 1-Oct-2012

PROGRAM YEAR(BUDGET EC) 2014
EFF. PRICE LEVEL DATE:1-Oct-2013

TOTAL PROJECT COST (FULLY FUNDED)
SPENT THRU: 1-Oct-2012

WB NO.	Civil Works Feature\Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	PROJECT FIRST COST COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2012			
	FEDERAL COSTS												
6	FISH & WILDLIFE FACILITIES	22,466	5,506		27,972		22,823	5,591	28,414	0	0	0	0
	ARN - Reaches D-I	660	156		816		672	156	828	0	0	0	0
	ARN - Reaches A-C	9,660	2,369		12,029		9,813	2,406	12,219	0	0	0	0
	ARS - Reaches A-C	10,886	2,670		13,556		11,059	2,711	13,770	0	0	0	0
	ARS - Reaches D-G	1,260	311		1,571		1,279	318	1,597	0	0	0	0
11	LEVEES & FLOODWALLS	744,342	176,233		920,575		755,687	179,020	934,707	26,215	0	0	0
	Natomas - Reaches B-H	71,017	10,995		82,012		71,724	11,169	82,893	26,215	0	0	0
	ARN - Reaches D-I	57,104	14,015		71,119		58,006	14,237	72,243	0	0	0	0
	ARN - Reaches A-C	82,837	20,329		103,166		84,145	20,652	104,797	0	0	0	0
	ARS - Reaches A-C	141,943	34,834		176,777		144,186	35,385	179,571	0	0	0	0
	ARS - Reaches D-G	346,429	85,014		431,443		351,903	86,356	438,259	0	0	0	0
	Sac Bypass Widening	45,012	11,046		56,058		45,723	11,221	56,944	0	0	0	0
15	FLDWAY CONTRL & DIV STRUCTURE	54,713	13,427		68,140		55,577	13,640	69,217	0	0	0	0
	Sac Bypass Widening	54,713	13,427		68,140		55,577	13,640	69,217	0	0	0	0
18	CULT. RESRC PRESERV. (1	8,127	1,954		10,081		8,270	1,986	10,256	0	0	0	0
	Natomas - Reaches B-H	764	110		874		774	111	885	0	0	0	0
	ARN - Reaches D-I	687	140		827		700	142	842	0	0	0	0
	ARN - Reaches A-C	794	170		964		809	173	982	0	0	0	0
	ARS - Reaches A-C	1,253	266		1,519		1,276	270	1,546	0	0	0	0
	ARS - Reaches D-G	3,714	1,071		4,785		3,780	1,089	4,869	0	0	0	0
	Sac Bypass Widening	915	197		1,112		931	201	1,132	0	0	0	0
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	829,648	197,120		1,026,768		842,357	200,237	1,042,594	26,215	0	0	0
1	LANDS & DAMAGES, Admin (2	9,575	482		10,057		9,854	499	10,353	0	0	0	0
	ARN - Reaches D-I	2,575	130		2,705		2,649	135	2,784	0	0	0	0
	ARN - Reaches A-C	525	27		552		540	29	569	0	0	0	0
	ARS - Reaches A-C	350	17		367		361	17	378	0	0	0	0
	ARS - Reaches D-G	5,875	295		6,170		6,047	304	6,351	0	0	0	0
	Sac Bypass Widening	250	13		263		257	14	271	0	0	0	0
30	PLAN/ENGINEERING/DESIGN	119,262	8,348		127,610		122,757	8,593	131,350	0	0	0	0
	Natomas - Reaches B-H	6,721	470		7,191		6,919	482	7,401	0	0	0	0
	ARN - Reaches D-I	8,631	604		9,235		8,884	622	9,506	0	0	0	0
	ARN - Reaches A-C	13,874	972		14,846		14,280	1,001	15,281	0	0	0	0
	ARS - Reaches A-C	22,924	1,604		24,528		23,596	1,652	25,248	0	0	0	0
	ARS - Reaches D-G	52,153	3,651		55,804		53,681	3,758	57,439	0	0	0	0
	Sac Bypass Widening	14,959	1,047		16,006		15,397	1,078	16,475	0	0	0	0
31	CONSTRUCTION MANAGE'MT	67,585	4,733		72,318		69,565	4,872	74,437	0	0	0	0
	Natomas - Reaches B-H	3,808	267		4,075		3,919	276	4,195	0	0	0	0
	ARN - Reaches D-I	4,891	344		5,235		5,035	353	5,388	0	0	0	0
	ARN - Reaches A-C	7,862	551		8,413		8,092	568	8,660	0	0	0	0
	ARS - Reaches A-C	12,992	909		13,901		13,373	935	14,308	0	0	0	0
	ARS - Reaches D-G	29,555	2,069		31,624		30,421	2,129	32,550	0	0	0	0
	Sac Bypass Widening	8,477	593		9,070		8,725	611	9,336	0	0	0	0
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	1,026,070	210,683		1,236,753		1,044,533	214,201	1,258,734	26,215	0	0	0
	NON-FEDERAL CONTRIBUTION (-)	213,346	15,319		228,665		217,511	15,621	233,132	5,398	0	0	0
	TOTAL FEDERAL COSTS	**$812,724**	**$195,364**		**$1,008,088**		**$827,022**	**$198,580**	**$1,025,602**	**$20,817**	**$0**	**$0**	**$0**
	NON-FEDERAL COSTS												
1	LANDS AND DAMAGES	126,573	77,459		204,032		128,574	78,680	207,254	0	0	0	0
	ARN - Reaches D-I	13,888	8,237		22,125		14,108	8,366	22,474	0	0	0	0
	ARN - Reaches A-C	3,204	1,040		4,244		3,255	1,056	4,311	0	0	0	0
	ARS - Reaches A-C	1,730	467		2,197		1,757	475	2,232	0	0	0	0
	ARS - Reaches D-G	104,729	66,471		171,200		106,384	67,520	173,904	0	0	0	0
	Sac Bypass Widening	3,022	1,244		4,266		3,070	1,263	4,333	0	0	0	0
2	RELOCATIONS	85,907	19,630		105,537		87,171	19,942	107,113	5,811	0	0	0
	Natomas - Reaches B-H	30,108	5,936		36,044		30,491	6,031	36,522	5,811	0	0	0
	ARN - Reaches D-I	22,592	5,544		28,136		22,948	5,633	28,581	0	0	0	0
	ARN - Reaches A-C	2,385	585		2,970		2,423	594	3,017	0	0	0	0
	ARS - Reaches D-G	20,504	5,033		25,537		20,828	5,112	25,940	0	0	0	0
	Sac Bypass Widening	10,318	2,532		12,850		10,481	2,572	13,053	0	0	0	0
30	PLAN/ENGINEERING/DESIGN	12,014	841		12,855		12,204	856	13,060	0	0	0	0
	Natomas - Reaches B-H	3,645	254		3,899		3,702	259	3,961	0	0	0	0
	ARN - Reaches D-I	3,387	238		3,625		3,441	242	3,683	0	0	0	0
	ARN - Reaches A-C	358	25		383		364	25	389	0	0	0	0
	ARS - Reaches D-G	3,076	216		3,292		3,125	220	3,345	0	0	0	0
	Sac Bypass Widening	1,548	108		1,656		1,572	110	1,682	0	0	0	0
31	CONSTRUCTION MANAGE'MT	8,010	559		8,569		8,138	567	8,705	0	0	0	0
	Natomas - Reaches B-H	2,429	171		2,600		2,468	173	2,641	0	0	0	0
	ARN - Reaches D-I	2,260	156		2,416		2,296	159	2,455	0	0	0	0
	ARN - Reaches A-C	238	17		255		242	17	259	0	0	0	0
	ARS - Reaches D-G	2,051	143		2,194		2,084	145	2,229	0	0	0	0
	Sac Bypass Widening	1,032	72		1,104		1,048	73	1,121	0	0	0	0
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)	232,504	98,489		330,993		236,087	100,045	336,132	5,811	0	0	0

**** TOTAL PROJECT COST SUMMARY(CONT'ED) ****

Current MCACES Estimate Prepared: 1-Mar-2013
Effective Price Level (EPL): 1-Oct-2012

PROGRAM YEAR(BUDGET EC) 2014
EFF. PRICE LEVEL DATE:1-Oct-2013

TOTAL PROJECT COST (FULLY FUNDED)
SPENT THRU: 1-Oct-2012

WB NO.	Civil Works Feature\Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	PROJECT FIRST COST COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2012			
	NON-FEDERAL CONTRIBUTION (+)	213,346	15,319		228,665		217,511	15,621	233,132	5,398	0	0	0
	Natomas - Reaches B-H	5,886	905		6,791		5,961	920	6,881	5,398	0	0	0
	ARN - Reaches D-I	5,799	1,472		7,271		5,902	1,495	7,397	0	0	0	0
	ARN - Reaches A-C	36,145	7,403		43,548		36,820	7,530	44,350	0	0	0	0
	ARS - Reaches A-C	65,059	13,708		78,767		66,259	13,936	80,195	0	0	0	0
	ARS - Reaches D-G	67,611	(14,742)		52,869		69,092	(14,945)	54,147	0	0	0	0
	Sac Bypass Widening	32,846	6,573		39,419		33,477	6,685	40,162	0	0	0	0
	TOTAL NON-FEDERAL COSTS	**$445,850**	**$113,808**		**$559,658**		**$453,598**	**$115,666**	**$569,264**	**$11,209**	**$0**	**$0**	**$0**
	TOTAL FEDERAL & NON-FEDERAL COSTS	**$1,258,574**	**$309,172**		**$1,567,746**		**$1,280,620**	**$314,246**	**$1,594,866**	**$32,026**	**$0**	**$0**	**$0**

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 01 Account for Land and Damages cost are from Real Estates.

Table 5

Alternative 2

BASIN	LPP : SACRAMENTO BYPASS WIDENING (IN $1,000s, OCTOBER 2012 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.75% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS	IDC	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	232,845	110,958	343,803	15,323	TBD	15,323
	Sacramento	733,620	308,925	1,042,545	46,466	TBD	46,466
	Sac Bypass	170,525	30,895	201,420	8,977	TBD	8,977
	Total Basin	**1,136,990**	**450,778**	**1,587,768**	**70,767**	**TBD**	**70,767**
ARN	American	147,822	32,421	180,243	8,033	TBD	8,033
	Tributaries	146,239	17,406	163,645	7,294	TBD	7,294
	Total Basin	**294,061**	**49,827**	**343,888**	**15,327**	**TBD**	**15,327**
NATOMAS	All sources	136,695	8,431	145,126	6,468	TBD	6,468
	Total Basin	**136,695**	**8,431**	**145,126**	**6,468**	**TBD**	**6,468**
GRAND TOTAL	**All Basins**	**1,567,746**	**509,036**	**2,076,782**	**92,562**	TBD	**92,562**

Table 6

ARCF GRR
Costs for Alternative 3

Civil Works Feature Description	ESTIMATED COST		
	COST ($K)	CNTG ($K)	TOTAL ($K)
ARN - Reaches A-C	114,000	20,000	134,000
ARN - Reaches D-I	112,000	26,000	138,000
ARS - Reaches A-C	185,000	33,000	218,000
Natomas - Reaches B-H	118,000	15,000	133,000
Sac Bypass Widening	157,000	28,000	185,000
Sac River Diversion Structure	122,000	61,000	183,000
Yolo Bypass, I-80 Railroad Relocation	277,000	55,000	332,000
Yolo Bypass, I-80 Causeway Improvement	475,000	95,000	570,000
Yolo Bypass, DWSC Overflow Weir	42,000	8,000	50,000
Yolo Bypass, DWSC Control Structure	144,000	29,000	173,000
Yolo Bypass, Pump Stations	5,000	1,000	6,000
	1,751,000	371,000	2,122,000

Table 7

****** TOTAL PROJECT COST SUMMARY ****** 2/1/2013

THIS ESTIMATE IS BASED ON THE SCOPE CONTAINED IN THE DRAFT FEASIBILITY REPORT, NED PLAN
PROJECT: ARCF GRR - Alt 3 — **U. S. ARMY CORPS OF ENGINEER, SACRAMENTO DISTRICT**
LOCATION: CALIFORNIA — **P.O.C.: JEREMIAH FROST, P.E., CHIEF, COST ENGINEERING SECTION**

Current MCACES Estimate Prepared: 17-Sep-2012 — **PROGRAM YEAR(BUDGET EC) 2013** — **TOTAL PROJECT COST (FULLY FUNDED)**
Effective Price Level (EPL): 1-Oct-2012 — **EFF. PRICE LEVEL DATE:1-Oct-2012** — **SPENT THRU: 1-Oct-2011**

WB NO.	Civil Works Feature\Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	PROJECT FIRST COST COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2011			
	FEDERAL COSTS												
6	FISH & WILDLIFE FACILITIES	51,911	4,227		56,138		51,911	4,227	56,138	0	0	0	0
	ARN - Reaches D-I	660	126		786		660	126	786	0	0	0	0
	ARN - Reaches A-C	9,660	1,928		11,588		9,660	1,928	11,588	0	0	0	0
	ARS - Reaches A-C	10,886	2,173		13,059		10,886	2,173	13,059	0	0	0	0
	Yolo Bypass Improvements	30,705	0		30,705		30,705	0	30,705	0	0	0	0
11	LEVEES & FLOODWALLS	453,196	101,821		555,017		453,196	101,821	555,017	26,215	0	0	0
	Natomas - Reaches B-H	71,017	8,945		79,962		71,017	8,945	79,962	26,215	0	0	0
	ARN - Reaches D-I	55,357	11,056		66,413		55,357	11,056	66,413	0	0	0	0
	ARN - Reaches A-C	76,723	15,322		92,045		76,723	15,322	92,045	0	0	0	0
	ARS - Reaches A-C	136,705	27,300		164,005		136,705	27,300	164,005	0	0	0	0
	Sac Bypass Widening	58,273	11,637		69,910		58,273	11,637	69,910	0	0	0	0
	Yolo Bypass Improvements	55,121	27,561		82,682		55,121	27,561	82,682	0	0	0	0
15	FLDWAY CONTRL & DIV STRUCTURE	251,161	50,156		301,317		251,161	50,156	301,317	0	0	0	0
	Sac River Diversion Structure	196,448	39,230		235,678		196,448	39,230	235,678	0	0	0	0
	Sac Bypass Widening	54,713	10,926		65,639		54,713	10,926	65,639	0	0	0	0
18	CULT. RESRC PRESERV. (1	8,043	1,261		9,304		8,043	1,261	9,304	0	0	0	0
	Natomas - Reaches B-H	764	90		854		764	90	854	0	0	0	0
	ARN - Reaches D-I	668	111		779		668	111	779	0	0	0	0
	ARN - Reaches A-C	742	132		874		742	132	874	0	0	0	0
	ARS - Reaches A-C	1,210	213		1,423		1,210	213	1,423	0	0	0	0
	Sac River Diversion Structure	1,596	280		1,876		1,596	280	1,876	0	0	0	0
	Sac Bypass Widening	1,022	184		1,206		1,022	184	1,206	0	0	0	0
	Yolo Bypass Improvements	2,041	251		2,292		2,041	251	2,292	0	0	0	0
	SUBTOTAL FEDERAL & NON-FEDERAL CONSTRUCTION COSTS	764,311	157,465		921,776		764,311	157,465	921,776	26,215	0	0	0
1	LANDS & DAMAGES, Admin (2	3,775	191		3,966		3,775	191	3,966	0	0	0	0
	ARN - Reaches D-I	2,575	130		2,705		2,575	130	2,705	0	0	0	0
	ARN - Reaches A-C	525	27		552		525	27	552	0	0	0	0
	ARS - Reaches A-C	350	17		367		350	17	367	0	0	0	0
	Sac River Diversion Structure	75	4		79		75	4	79	0	0	0	0
	Sac Bypass Widening	250	13		263		250	13	263	0	0	0	0
30	PLAN/ENGINEERING/DESIGN	122,348	19,635		141,983		122,348	19,635	141,983	0	0	0	0
	Natomas - Reaches B-H	6,721	470		7,191		6,721	470	7,191	0	0	0	0
	ARN - Reaches D-I	8,369	585		8,954		8,369	585	8,954	0	0	0	0
	ARN - Reaches A-C	12,957	908		13,865		12,957	908	13,865	0	0	0	0
	ARS - Reaches A-C	22,138	1,550		23,688		22,138	1,550	23,688	0	0	0	0
	Sac River Diversion Structure	29,467	2,063		31,530		29,467	2,063	31,530	0	0	0	0
	Sac Bypass Widening	16,948	1,186		18,134		16,948	1,186	18,134	0	0	0	0
	Yolo Bypass Improvements	25,748	12,873		38,621		25,748	12,873	38,621	0	0	0	0
31	CONSTRUCTION MANAGE'MT	63,325	8,122		71,447		63,325	8,122	71,447	0	0	0	0
	Natomas - Reaches B-H	3,808	267		4,075		3,808	267	4,075	0	0	0	0
	ARN - Reaches D-I	4,743	331		5,074		4,743	331	5,074	0	0	0	0
	ARN - Reaches A-C	7,343	514		7,857		7,343	514	7,857	0	0	0	0
	ARS - Reaches A-C	12,545	879		13,424		12,545	879	13,424	0	0	0	0
	Sac River Diversion Structure	16,699	1,168		17,867		16,699	1,168	17,867	0	0	0	0
	Sac Bypass Widening	9,604	672		10,276		9,604	672	10,276	0	0	0	0
	Yolo Bypass Improvements	8,583	4,291		12,874		8,583	4,291	12,874	0	0	0	0
	SUBTOTAL FEDERAL & NON-FEDERAL CONTRIBUTION	953,759	185,413		1,139,172		953,759	185,413	1,139,172	26,215	0	0	0
	NON-FEDERAL CONTRIBUTION (-)	251,510	42,029		293,539		251,510	42,029	293,539	5,398	0	0	0
	TOTAL FEDERAL COSTS	**$702,249**	**$143,384**		**$845,633**		**$702,249**	**$143,384**	**$845,633**	**$20,817**	**$0**	**$0**	**$0**
	NON-FEDERAL COSTS												
1	LANDS AND DAMAGES	32,357	11,091		43,448		32,357	11,091	43,448	0	0	0	0
	ARN - Reaches D-I	13,888	8,237		22,125		13,888	8,237	22,125	0	0	0	0
	ARN - Reaches A-C	3,204	1,040		4,244		3,204	1,040	4,244	0	0	0	0
	ARS - Reaches A-C	1,730	467		2,197		1,730	467	2,197	0	0	0	0
	Sac River Diversion Structure	423	103		526		423	103	526	0	0	0	0
	Sac Bypass Widening	3,022	1,244		4,266		3,022	1,244	4,266	0	0	0	0
	Yolo Bypass Improvements	10,090	0		10,090		10,090	0	10,090	0	0	0	0
2	RELOCATIONS	266,178	11,756		277,934		266,178	11,756	277,934	5,811	0	0	0
	Natomas - Reaches B-H	30,108	4,831		34,939		30,108	4,831	34,939	5,811	0	0	0
	ARN - Reaches D-I	20,802	4,461		25,263		20,802	4,461	25,263	0	0	0	0
	ARN - Reaches A-C	2,024	404		2,428		2,024	404	2,428	0	0	0	0
	Sac Bypass Widening	10,318	2,060		12,378		10,318	2,060	12,378	0	0	0	0
	Yolo Bypass Improvements	202,926	0		202,926		202,926	0	202,926	0	0	0	0
30	PLAN/ENGINEERING/DESIGN	59,348	4,154		63,502		59,348	4,154	63,502	0	0	0	0
	Natomas - Reaches B-H	3,645	254		3,899		3,645	254	3,899	0	0	0	0
	ARN - Reaches D-I	3,119	220		3,339		3,119	220	3,339	0	0	0	0
	ARN - Reaches A-C	304	21		325		304	21	325	0	0	0	0
	Sac Bypass Widening	1,548	108		1,656		1,548	108	1,656	0	0	0	0
	Yolo Bypass Improvements	50,732	3,551		54,283		50,732	3,551	54,283	0	0	0	0
31	CONSTRUCTION MANAGE'MT	26,036	1,823		27,859		26,036	1,823	27,859	0	0	0	0
	Natomas - Reaches B-H	2,429	171		2,600		2,429	171	2,600	0	0	0	0
	ARN - Reaches D-I	2,080	145		2,225		2,080	145	2,225	0	0	0	0
	ARN - Reaches A-C	202	15		217		202	15	217	0	0	0	0

**** TOTAL PROJECT COST SUMMARY(CONT'ED) ****

Current MCACES Estimate Prepared: 17-Sep-2012
Effective Price Level (EPL): 1-Oct-2012

WB NO.	Civil Works Feature\Sub-Feature Description	ESTIMATED COST COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	OMB (%)	PROGRAM YEAR(BUDGET EC) 2013 EFF. PRICE LEVEL DATE:1-Oct-2012 PROJECT FIRST COST COST ($K)	CNTG ($K)	TOTAL ($K)	TOTAL PROJECT COST (FULLY FUNDED) SPENT THRU: 1-Oct-2011 COST ($K)	COST ($K)	CNTG ($K)	FULLY FUNDED ($K)
		Contingency Applied To Remaining Cost Only								Sunk Cost Price Level (EPL): 1-Oct-2011			
	Sac Bypass Widening	1,032	72		1,104		1,032	72	1,104	0	0	0	0
	Yolo Bypass Improvements	20,293	1,420		21,713		20,293	1,420	21,713	0	0	0	0
	SUBTOTAL NON-FEDERAL (INCLUDES FED IRRIGATION SHARE)	383,919	28,824		412,743		383,919	28,824	412,743	5,811	0	0	0
	NON-FEDERAL CONTRIBUTION (+)	251,510	42,029		293,539		251,510	42,029	293,539	5,398	0	0	0
	Natomas - Reaches B-H	5,886	747		6,633		5,886	747	6,633	5,398	0	0	0
	ARN - Reaches D-I	5,580	1,264		6,844		5,580	1,264	6,844	0	0	0	0
	ARN - Reaches A-C	33,796	5,582		39,378		33,796	5,582	39,378	0	0	0	0
	ARS - Reaches A-C	62,794	10,868		73,662		62,794	10,868	73,662	0	0	0	0
	Sac River Diversion Structure	84,666	14,796		99,462		84,666	14,796	99,462	0	0	0	0
	Sac Bypass Widening	38,578	6,287		44,865		38,578	6,287	44,865	0	0	0	0
	Yolo Bypass Improvements	20,210	2,485		22,695		20,210	2,485	22,695	0	0	0	0
	TOTAL NON-FEDERAL COSTS	**$635,429**	**$70,853**		**$706,282**		**$635,429**	**$70,853**	**$706,282**	**$11,209**	**$0**	**$0**	**$0**
	TOTAL FEDERAL & NON-FEDERAL COSTS	**$1,337,678**	**$214,237**		**$1,551,915**		**$1,337,678**	**$214,237**	**$1,551,915**	**$32,026**	**$0**	**$0**	**$0**

GENERAL NOTES

(1 Cultural Resources Preservation costs associated with mitigation and/or data recovery up to one percent of the total Federal cost are not subject to cost sharing.
(2 Federal administrative costs for non-Federal land acquisition.
(3 01 Account for Land and Damages cost are from Real Estates.

Table 8

Combined w/New and Edited Features

Description	Construction	Right-of-Way	Environmental Mitigation	Project Development	Additional Compensation	All Features Total Cost	Needed for I-Street Diversion Mitigation	Costs for Mitigation
Fremont Weir Extension (Alternative B)	$27,831,600	$3,861,000	$3,608,000	$11,133,000	$0	$46,433,600	No	$ -
Upper Elkhorn Setback Levee	$149,741,900	$24,325,000	$10,947,000	$59,896,000	$0	$244,909,900	No	$ -
Lower Elkhorn Setback Levee	$129,346,100	$10,970,000	$11,733,000	$ -	$0	$152,049,100	No	$ -
Little Holland Tract - Liberty Island	$1,989,200	$1,050,000	$3,170,000	$795,000	$0	$7,004,200	No	$ -
Lower Egbert Tract	$74,209,500	$8,265,000	$25,537,100	$29,684,000	$0	$137,695,600	No	$ -
Sac R Bypass Setback Levee	$80,099,100	$3,260,000	$3,231,000	$32,040,000	$0	$118,630,100	No	$ -
Sac R Bypass Weir Extension	$156,790,830	$660,000	$1,748,000	$62,717,000	$0	$221,915,830	No	$ -
Shortline Railroad Relocation	$41,250,000	$3,660,000	$11,393,000	$16,501,000	$0	$72,804,000	No	$ -
Yolo Bypass West Levee	$555,434,500	$29,610,000	$83,477,000	$221,493,000	$0	$890,014,500	No	$ -
Sac River West Levee	$56,048,400	$3,507,000	$12,197,500	$22,419,500	$0	$94,172,400	No	$ -
I-80 Railroad Relocation	$243,536,600	$135,800	$3,527,800	$85,237,900	$0	$332,438,100	Yes	$ 332,438,100
I-80 Causeway Improvement	$418,655,300	$121,100	$5,271,300	$146,529,400	$0	$570,577,100	Yes	$ 570,577,100
DWSC Overflow Weir	$35,199,600	$235,000	$892,000	$14,080,000	$0	$50,406,600	Yes	$ 50,406,600
DWSC Control Structure	$120,044,100	$50,000	$1,740,000	$48,018,000	$3,000,000	$172,852,100	Yes	$ 172,852,100
Yolo East Pump Stations	$3,766,500	$403,500	$118,500	$1,318,500	$0	$5,607,000	Yes	$ 5,607,000
Yolo Bypass East Levee Improvements & DWSC Erosion Protection	$843,437,400	$40,020,000	$155,374,400	$337,375,200	$0	$1,376,207,000	No	$ -
						$4,493,717,200		$ 1,131,880,900

Table 9

Description	UOM	Quantity	ProjectCost
Summary			**122,161,762.85**
15 Floodway Control and Diversion Structures	**LS**	**1.0000**	**122,161,762.85**
15 01 Mob & Demob	**LS**	**1.0000**	**4,418,243.29**
15 02 Excavation	**LS**	**1.0000**	**5,834,078.51**
02 Channel/Bypass Channel Excavation	**CY**	**164,351.0000**	*35.4977* **5,834,078.51**
15 03 Phase 1 Internaly Braced Cofferdam	**LS**	**1.0000**	**5,952,570.42**
01 Sheet Piling PZ-35	**SF**	**64,000.0000**	*48.4618* **3,101,554.93**
02 Strut, Wales & Bracing	**LB**	**388,852.0000**	*5.0705* **1,971,679.57**
03 Tremie Slab	**CY**	**1,348.0000**	*200.7697* **270,637.62**
04 Dewatering System	**LS**	**1.0000**	**286,195.90**
05 Timber Guidewall (Temp Bypass)	**LF**	**216.0000**	*1,213.2413* **262,060.12**
06 7 Pile Dolphin Cluster (Temp Bypass)	**EA**	**2.0000**	*30,221.1409* **60,442.28**
15 04 Phase 2 Internaly Braced Cofferdam	**LS**	**1.0000**	**5,199,433.00**
01 Sheet Piling PZ-35	**SF**	**60,800.0000**	*48.4614* **2,946,454.39**
02 Strut, Wales & Bracing	**LB**	**338,802.0000**	*5.1201* **1,734,692.88**
03 Tremie Slab	**CY**	**1,156.0000**	*200.7697* **232,089.82**
04 Dewatering System	**LS**	**1.0000**	**286,195.90**
15 05 Phase 3 Internaly Braced Cofferdam	**LS**	**1.0000**	**4,003,368.77**
01 Sheet Piling PZ-35	**SF**	**48,000.0000**	*48.4614* **2,326,148.20**
02 Strut, Wales & Bracing	**LB**	**243,322.0000**	*5.0567* **1,230,408.87**
03 Tremie Slab	**CY**	**800.0000**	*200.7697* **160,615.80**
04 Dewatering System	**LS**	**1.0000**	**286,195.90**

Description	UOM	Quantity	ProjectCost
15 06 Civil	**EA**	**1.0000**	*3,777,062.0294* **3,777,062.03**
01 Granular Fill	**CY**	**11,629.0000**	*23.5198* **273,512.05**
02 Embankment	**CY**	**24,822.0000**	*40.7770* **1,012,167.17**
03 Separator Geotextile	**SY**	**16,165.0000**	*12.0399* **194,624.46**
04 Bedding	**CY**	**5,389.0000**	*43.3912* **233,834.92**
05 36" Riprap	**TON**	**24,247.0000**	*81.4000* **1,973,705.22**
06 Fertilizing and Seeding	**ACR**	**5.0000**	*2,008.3923* **10,041.96**
07 9" Unreinforced Slope Paving	**SY**	**800.0000**	*98.9703* **79,176.24**
15 07 Foundation	**EA**	**1.0000**	*30,050,135.1954* **30,050,135.20**
U-Frame Structure	**EA**	**1.0000**	*6,540,565.6796* **6,540,565.68**
Tainter Gate	**EA**	**1.0000**	*15,487,857.6422* **15,487,857.64**
Tie-in Walls	**EA**	**1.0000**	*8,021,711.8736* **8,021,711.87**
15 08 Structure Concrete	**LS**	**1.0000**	**30,897,660.17**
U-Frame Structure	**LS**	**1.0000**	**6,531,399.43**
Tainter Gate	**LS**	**1.0000**	**22,184,844.37**
Tie-in Walls	**LS**	**1.0000**	**2,181,416.38**
15 09 Structural Steel	**LS**	**1.0000**	**11,175,409.54**
01 Tainter Gate	**LB**	**1,480,000.0000**	*7.5510* **11,175,409.54**
15 10 Mechanical	**LS**	**1.0000**	**2,621,000.10**
01 Tainter Gate Machinery	**LS**	**1.0000**	**2,621,000.10**
15 11 Electrical	**LS**	**1.0000**	**2,469,788.55**

Description	UOM	Quantity	ProjectCost
			1,213.2413
15 12 Timber Wall Guides	**LF**	**312.0000**	**378,531.28**
			29,105.3674
15 13 Timber Pile Clusters (7 Pile)	**EA**	**3.0000**	**87,316.10**
			15,297,165.8973
15 14 Ground Improvement	**EA**	**1.0000**	**15,297,165.90**

Table 10

ARCF GRR
Costs for Alternative 4

Auburn Dam Cost Update

Item		Cost, $1,000s
Auburn Dam cost 1995		948,700
CCI 1994	422.71	
CCI 2014	767.89	
CCI	1.8166	
Auburn Dam cost 2014		1,723,397
Note, will round up to nearest hundred million dollars		1,800,000

Notes
CCI information from EM 1110-2-1304.
Auburn Dam cost from the American River Watershed, Supplemental Information Report, 1996.

Alternative 4 Total Cost Estimate

Item	Cost, $1,000s
Auburn Dam	1,800,000
Levee Improvement work from Alternative 1	1,426,055
Total	3,226,055

Table 11

ARCF GRR
Costs for Alternative 5

Item	Cost, $1,000s
Alternative 2 Levee Improvement and Sacramento Bypass Widening Construction	1,567,746
I Street Diversion Structure	183,000
Yolo Bypass Mitigation Work	1,131,000
Auburn Dam	1,800,000
Total	4,681,746

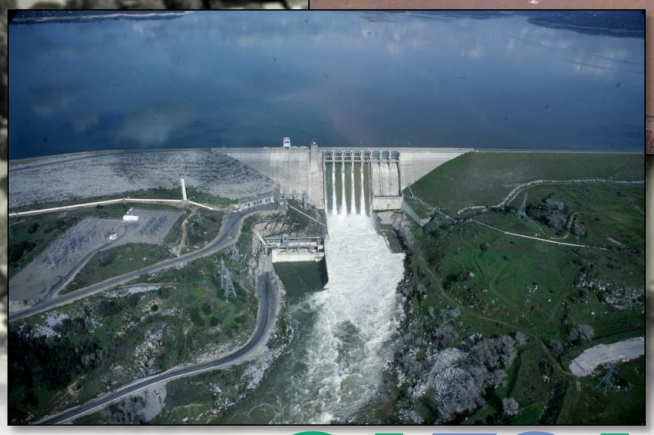
Table 12

ARCF GRR
Table 3-14 Backup

	Alternative						
	0.5 - Fix levees	1 - Fix & raise levees	2 - Fix levees and widen Sac Bypass	3 - I St Diversion	4 - Auburn Dam	5 - Maximum	6 - Non Structural
First Cost	1,262,915	1,426,055	1,567,746	2,122,000	3,226,055	4,681,746	N/A
Annual Costs	71,213	80,412	88,401	119,654	181,909	263,992	N/A
Annual Benefits	384,047	433,581	430,798	428,000	451,600	451,600	N/A
Net Benefits	312,834	353,169	342,397	308,346	269,691	187,608	N/A
B/C	5.4	5.4	4.9	3.6	2.5	1.7	N/A

American River Watershed

Common Features
General Reevaluation Report



Appendix B
Review Documentation

October 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:

Sacramento Weir during operation

Sacramento River facing south near the Pocket and Little Pocket neighborhoods

High flows on the American River at the Highway 160 overcrossing

Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Appendix B

Review Documentation

U.S. Army Corps of Engineers
Sacramento District

October 2015

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AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

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2 – Agency Technical Review (ATR)

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3 – Independent External Peer Review (IEPR)

1. PCX Memo transmitting the Final Comment Response Record
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DISTRICT QUALITY CONTROL CERTIFICATION
AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT, SACRAMENTO COUNTY, CALIFORNIA

COMPLETION OF QUALITY CONTROL ACTIVITIES

The District has completed review of the American River Common Features General Reevaluation Study. Products reviewed include the final report, report synopsis, slide presentation, risk register, decision log and decision management plan. Certification is hereby given that all quality control activities defined in the Project Review Plan appropriate to the level of risk and complexity inherent in the product have been completed. Documentation of the quality control process is enclosed.

GENERAL FINDINGS

Compliance with clearly established principles and procedures, utilizing clearly justified and valid assumptions, has been verified. This includes assumptions, methods, procedures and materials used in analyses; the appropriateness of data used and level of data obtained; and the reasonableness of the results, including whether the product meets the sponsor's needs consistent with law and existing Corps policy. Cost data in the review copy of the document was DQC'd concurrent with ATR; however the District has yet to receive the certified final costs. Any changes resulting from the final cost certification will be reviewed prior to the Civil Works Review Board.

Based on documented policy concerns received during concurrent review, the DQC review included a consistency review between this project's document and the West Sacramento General Reevaluation Report to ensure a consistent response to ATR and policy comments, where applicable. DQC comments were provided based on this additional consistency review.

All appropriate DQC comments have been incorporated into this project.
The undersigned recommends certification of the quality control process for this product.

Jerry Fuentes
Quality Control Reviewer

Date 9/4/15

QUALITY CONTROL CERTIFICATION

As noted above, all issues and concerns resulting from technical review of the product have been resolved. The project is recommended to proceed to policy review by SPD.

Nick Applegate

for Mark E. Cowan
Chief, Water Resources Branch

9/14/15
Date

American River Common Features Draft Final Report
DQC Comments
Reviewer: Jerry Fuentes, RTS

19 August 2015

Comment	Response	Backcheck
Page 1-1, Section 1.2: Citation of Section 130 of EWDAA of 2004 is incorrect. Should be EWDAA of 2008. Also note that this need to be added to Section 2 of the PACR.	Concur. Text corrected and text added to Section 2 of PACR.	Response accepted. Comment closed.
Page 1-13, 2nd complete paragraph: Do we consider 1/3 to 1/5 ACE "high?"	Concur, term "high" removed from sentence.	Response accepted. Comment closed.
Page 1-16: This discussion is less history and more problem statement.	Concur. Wanted to emphasize points-problems as a result of the way the levee was constructed.	Response accepted. Comment closed.
Page 1-18, Added text in 2nd paragraph under Upstream Dams: Make sure this text is also added to W. Sac.	Concur	Response accepted. Comment closed.
Page 1-19, 1st paragraph: see second comment	Concur. But critical to overall storytelling.	Response accepted. Comment closed.
Page 1-23, Table 1-2: 2nd footnote: This information is repeated in text. Delete	Concur. Footnote deleted.	Response accepted. Comment closed.
Page 1-24, Section 1.5 Watershed Planning: Make sure this is consistent with W. Sac.	Concur.	Response accepted. Comment closed.
Page 1-27, Sacramento River Bank Protection Project: Update to note current GRR activities.	Concur. Language added.	Response accepted. Comment closed.
Page 1-28, CVFPP: Update with current information and note that the plan identifies a preferred alternative - SSIA.	Concur. Language added from CVFPP document.	Response accepted. Comment closed.
Page 2-5, General description: This discussion should include discussion of American River contribution as well.	Concur. Language added.	Response accepted. Comment closed.
Page 2-16, Seismic Vulnerability: Rewrite to match tone of report (sounds like cut and paste).	Concur. Paragraph rewritten.	Response accepted. Comment closed.
Page 2-36, Future Without-Project Conditions, 2nd paragraph: Don't feel comfortable with statement in final sentence. Should say that improvements would only be made as part of this project and locals are assuming authorization.	Concur. Statement removed.	Response accepted. Comment closed.
Page 2-38, next to last sentence: Suggest adding "without the LPP" to the end of the sentence.	Concur. Sentence modified to clarify that erosion protection is needed with or without the JFP.	Response accepted. Comment closed.
Page 2-39, Section 2.8.4: Are we assuming, herefore that it is in place for the without-project condition.	Concur. Sentence modified.	Response accepted. Comment closed.
Page 3-1, 1st paragraph: completeness is not a screening metric for measures.	Concur. Deleted.	Response accepted. Comment closed.
Page 3-17, Section 3.9, Table 3-3: Combined objectives should also have	Concur. Modified	Response accepted. Comment closed.

check marks for each shown.		
Page 3-20, Table 3-5: Make sure that if a measure was dropped because it did not preclude levee improvements, it would not be used in an alternative that addressed "worst second situation"	Concur.	Response accepted. Comment closed.
Page 3-25, Table 3-6: How did upstream storage and Max Plan get carried forward?	Concur. Both are not acceptable do to inclusion of the Auburn Dam.	Response accepted. Comment closed.
Page 3-26, Section 3.13.2, Why are we focused on the 1/200 ACE again?	Concur. statement is for comparison purposes only.	Response accepted. Comment closed.
Page 3-26, Section 3.13.2, second paragraph, first sentence: specify what concerns you mean.	Concur.	Response accepted. Comment closed.
Page 3-27, Section 3.13.3, first sentence: This implies that we are optimizing. These should be formulated as a common performance level. Same comment for Alternative 3.	Concur. Deleted reference to increments.	Response accepted. Comment closed.
Page 3-30, Section 3.13.5, 1st paragraph, added text: This is evaluation language, should focus only on description here.	Concur. Moved to evaluation.	Response accepted. Comment closed.
Page 3-31, Section 3.13.6: This description need a better rationale for including this plan since it does not fit into our formulation strategy.	Concur. Formulation strategy expanded to include a strategy to establish an out boundary for costs and benefits.	Response accepted. Comment closed.
Page 3-43, Table 3-16: Totals are incorrect.	Concur. Updated.	Response accepted. Comment closed.
Page 3-47, Table 3-17: Totals are incorrect.	Concur. Updated.	Response accepted. Comment closed.
Page 3-49, Table 3-18, Metrics should be renumbered.	Concur.	Response accepted. Comment closed.
Page 4-1, Chapter name: This is now that Selected Plan.	Concur.	Response accepted. Comment closed.
Page 4-1, Section 4.1, Bullet 4: Include length of new levee.	Concur. About two miles.	Response accepted. Comment closed.
Page 4-5, Launchable rock trench, Citation to figure 4-8 is not cross section graphic.	Concur. Changed to figure 4-9.	Response accepted. Comment closed.
Page 4-14, Magpie Creek Diversion Canal, 4th paragraph: No rationale provided for sizing.	Concur. Deleted.	Response accepted. Comment closed.
Page 4-14, Magpie Creek Diversion Canal, 4th paragraph: Provide additional information regarding when the takings analysis will be completed.	Concur. Coordination with RE is underway to determine schedule.	Response accepted. Comment closed.
Page 4-15, Figure 4-19: Graphic has letter designations but nothing in legend to explain them.	Concur. Will add to legend.	Response accepted. Comment closed.
Page 4-16, Section 4.1.4: Need to include length of new levee.	Concur. Added to text.	Response accepted. Comment closed.
Page 4-21, 1st paragraph: Clarify if there are any general fish and wildlife mitigation.	Concur. Clarification added.	Response accepted. Comment closed.
Page 4-26, Section 4.5.3: Are there any risk	Concur. Yes, will add to RR.	Response accepted.

register items for implementation?		Comment closed.
Page 4-40, Section 4.10: Summary does not address all significant effects beyond ESA.	Concur. Other significant effects added to summary.	Response accepted. Comment closed.
age 4-44, Item #3: Update to eliminate mention of the draft.	Concur.	Response accepted. Comment closed.
Page 4-47, Item #7: Update to eliminate mention of the draft.	Concur.	Response accepted. Comment closed.
Page 4-51, Table 4-11: Cost for levees is roughly $10 K less than W. Sac per mile.	Concur. In depth comparison is being prepared to address.	Response accepted. Comment closed.
Page 4-51, Table 4-11: Cost for bank stabilization is roughly 2x per mile in W. Sac.	Concur. In depth comparison is being prepared to address.	Response accepted. Comment closed.
Page 4-53, Table 4-12: Table is consistent with Table 4-11.	Concur. These are NED costs. Need to compare TSP costs to table 4-11.	Response accepted. Comment closed.
Page 5-5, Table 5-3: See comments on cost differences between W. Sac and yours.	Concur.	Response accepted. Comment closed.
Page 7-1, Recommendations: Costs are inconsistent with Ch. 5.	Concur. Costs have been revised and are now consistent.	Response accepted. Comment closed.
Page 7-3, Item n: Please ensure that the recommended rewrite of this item is also accomplished in W. Sac.	Concur.	Response accepted. Comment closed.

DATE: 13 August 2015

TO: Anne Baker, Environmental Manager, ARCF

FROM: Tanis Toland, Environmental DQC

SUBJECT: ARCF Draft Final EIS/EIR - DQC Backcheck

All of my DQC comments on the draft Final EIS/EIR for the American River Comment Features GRR are closed. Documentation of this review accompanies this memo.

Tanis Toland
13 August 2015

Main document changes and comments

Page 3: Comment [T1] **Tanis Toland** **8/13/2015 4:54:00 PM**

Also DWR?

RESPONSE: SAFCA is our only formal cooperating agency. DWR staff represent the CVFPB for the project, but DWR is not considered a sponsor or cooperating agency.

BACKCHECK: CLOSED

Page 1: Comment [T2] **Tanis Toland** **8/13/2015 4:54:00 PM**

Header needs to refer to the Final EIS/EIR and to the correct date. Note that, under NEPA, we clearly distinguish between the Draft and Final EIS's. Both are distinct documents and are part of the Administrative Record and both are published and widely circulated. It is important for tracking purposes throughout the project life that the distinction be clear, even where chapter or an appendix has been detached from the published final EIS.

RESPONSE: Concur. Change made throughout.

BACKCHECK: CLOSED

Page 14: Comment [T3] **Tanis Toland** **8/13/2015 4:53:00 PM**

Effects to cultural resources and resources significant to Native American tribes is identified in the Areas of Controversy and Unresolved Issues section. Is there specific information that should be included in this summary table?

RESPONSE: The table references potential adverse effects to historic properties by either of the alternatives and mitigation through implementation of agreement documents, such as the programmatic agreement. There is not specific information to include in the table beyond this since specific effects to historic properties will be later determined through execution of the programmatic agreement.

BACKCHECK: CLOSED

Page i: Comment [T4] **Tanis Toland** **8/13/2015 4:53:00 PM**

Need to identify the Environmentally Preferable Alternative in the TOC and within the body of the document.

RESPONSE: Sections ES-10 and 2.4 have been updated to identify Alternative 2 as the Environmentally Preferred Alternative.

BACKCHECK: OPEN – Correct language is "environmentally preferable alternative." See CEQ Regulations, Section 1505.2 and CEQ 40 Questions # 6a &6b. A quick fix would be to explain that, in this document, "environmentally preferred alternative" is the same as the NEPA "environmentally preferable alternative." Perhaps this choice was made to better communicate with the intended audience?

RESPONSE: Updated the sections referenced above to correct terminology.

BACKCHECK: CLOSED

Page iv: Inserted	Tanis Toland	8/13/2015 5:13:00 PM

112

Page viii: Comment [T5]	Tanis Toland	8/13/2015 4:52:00 PM

This is now the "Recommended Plan" and the NEPA "preferred alternative."

RESPONSE: TSP has been updated to Recommended Plan. Updated Sections ES - 10 and 2.4 to reflect NEPA Environmentally Preferred Alternative, CEQA Environmentally Superior Alternative, and LEDPA.

BACKCHECK: CLOSED

Page 1: Comment [T6]	Tanis Toland	8/13/2015 4:52:00 PM

If you are using the largest footprint that would reasonably be expected, wouldn't the site-specific work be expected to result in reduced impacts? If you do not reasonably anticipate additional significant impacts during PED, why flag it here? We are required to consider our project actions throughout the project life to e

RESPONSE: The intent of evaluating the largest footprint was to capture the maximum impact, however, there is the potential for a change in significance during PED. Public and IEPR comments requested that we acknowledge the possibility of supplements, which is why this language is here.

BACKCHECK: CLOSED

Page 10: Comment [T7]	Tanis Toland	8/13/2015 4:51:00 PM

Do you mean "performance"?

RESPONSE: Performance is an appropriate term to use here as well, but this is the language used in the GRR by planning/economics to discuss this issue. For consistency purposes, no change has been made.

BACKCHECK: CLOSED

Page 15: Comment [T8]	Tanis Toland	8/13/2015 4:51:00 PM

Do you mean "could"? NEPA requires discussion of all potential mitigation measures to reduce impacts but does not require that they be included in the project. It, therefore, becomes important to distinguish between those mitigation measures that could reduce impacts and those mitigation measures that are proposed to be implemented.

RESPONSE: Concur, change has been made.

BACKCHECK: CLOSED

Page 15: Comment [T9]	Tanis Toland	8/13/2015 4:50:00 PM

Do you mean "late 2015"?

RESPONSE: Concur, change has been made.

BACKCHECK: CLOSED

Page 15: Comment [T10]	Tanis Toland	8/13/2015 4:50:00 PM

Could you beef this up a bit so that it is very clear to the reader who will use this document for what purposes. The CEQA description seems pretty robust but you may wish to add some additional information to the NEPA description. Who will be making what decisions? Corps will be use the EIS as a basis for signing a ROD. The EIS and ROD, together with the GRR support a Chief's report, which is the Corps recommendation on a project.....which then goes to Congress.

RESPONSE: Section has been updated accordingly.

BACKCHECK: CLOSED

Page 56: Comment [T11]	Tanis Toland	8/13/2015 4:49:00 PM

Can you provide a clear overall significance determination for each alternative?

RESPONSE: Reviewed Chapter 3 and ensured that the determinations were there for each river/alternative/resource.

BACKCHECK: CLOSED; however, the overall significance determination for each alternative under each resource category is somewhat obscured by the by river. Table ES-3 does provide an overall description of significance for each alternative under each resource category.

Page 60: Comment [T12]	Tanis Toland	8/13/2015 4:48:00 PM

Needs content.

RESPONSE: Section updated.

BACKCHECK: CLOSED

Page 61: Comment [T13]	Tanis Toland	8/13/2015 4:48:00 PM

This seems reasonable. It is not consistent with some of the other No Action descriptions (which assume full compliance with the Veg ETL through veg free zones). You may wish to bring the others into alignment with this statement.

RESPONSE: Concur. This language has been consistently added to all No Action sections.

BACKCHECK: CLOSED

Page 62: Comment [T14]	Tanis Toland	8/13/2015 4:48:00 PM

Under NEPA, mitigation includes (in order of how each should be considered in project planning): avoiding, minimizing, rectifying, reducing and compensating.

RESPONSE: Concur. No change has been made.

BACKCHECK: OPEN. Avoidance and minimization are types of mitigation. This phrase (which is used in this title and elsewhere in the text) doesn't make sense. Do you mean "avoidance, minimization, and COMPENSATORY mitigation measures"? Two options I see for handling this: (1) add "compensatory" here and wherever this phrase occurs in the document, or (2) include an explanation in Chapter 1.8 that explains what this phrase means and the relationship to NEPA mitigation language and concepts.

RESPONSE: Changing these headings back to Mitigation Measures.

BACKCHECK: CLOSED

Page 70: Comment [T15] **Tanis Toland** **8/13/2015 4:47:00 PM**

Is the project description incomplete? How can you determine costs and impacts with an incomplete project description? Can you make some assumptions about how many miles of each measure would par t of the alternative?

RESPONSE: These two measures have been developed based on locations where each measure could potentially be implemented. In some cases, like the north bank of the American River, we evaluated impacts based on both measures being implemented – essentially doubling the impacts so that either measure's impacts are covered. However, given the level of uncertainty associated with the time frame of authorization and appropriations, vegetation is likely going to significantly change prior to project implementation, which is why this evaluation needs to occur prior to construction.

BACKCHECK: CLOSED

Page 76: Comment [T16] **Tanis Toland** **8/13/2015 4:46:00 PM**

What vegetation is planned for the bypass? How will it be managed? How will this affect water surface elevation?

RESPONSE: See the vegetation and wildlife analysis below for this discussion. The analysis here (in Land Use) is focused on the agricultural impacts to the Bypass.

BACKCHECK: CLOSED

Page 102: Comment [T17] **Tanis Toland** **8/13/2015 4:46:00 PM**

Can you be more specific? Will this be native grasses and forbs or something else?

RESPONSE: Added that the revegetation in the Sacramento Bypass would be native grasses and trees. Since this is the water quality section, the native grasses is the key issue for this resource to prevent additional erosion during flood flows. This was also previously established in the list of mitigation measures below.

BACKCHECK: CLOSED

Page 112: Comment [T18]	Tanis Toland	8/13/2015 4:45:00 PM

Recommend deleting this sentence. It is not necessary since any changed circumstances that occurs during the project life requires review to determine whether a new NEPA document is required or whether there is a need to reinitiate consultation under ESA, etc. If you want to address all of these kinds of possibilities you could include a paragraph at the beginning of the chapter that describes how NEPA treats uncertainty and changed conditions.

RESPONSE: Public/resource agencies/ATR/IEPR all requested that we include this statement. As a result, no change has been made.

BACKCHECK: CLOSED

Page 113: Comment [T19]	Tanis Toland	8/13/2015 4:45:00 PM

I am not sure how the entire Parkway would be lost. Do you mean that the Parkway would be severely damaged with high value habitat being lost for many years while natural or managed succession takes place?.

RESPONSE: See the American River Erosion Susceptibility Section of the H&H Section above. A key assumption of this project is that the American River erosion risk is significant enough that if we do nothing, it is possible to lose the berms of the parkway in a major flood event. In the case of the No Action, we assume full berm loss causing an eventual levee break. This erosion is part of the existing condition, which is why the project is necessary.

BACKCHECK: CLOSED

Page 113: Comment [T20]	Tanis Toland	8/13/2015 4:44:00 PM

Can't the sponsors use this approach now on both the landside and the waterside of the levees? Would the levee improvements make approval of a SWIF or a variance possible in the action alternative circumstance and unacceptable in the No Action alternative.

RESPONSE: Concur that the sponsors could apply the SWIF to both. However, under this study the Corps proposed to apply for a variance prior to the sponsor issuing a LOI to implement a SWIF. Therefore, the assumption under this project is that the variance is a Federal action by the Corps (and thus not occurring under the No Action) and the SWIF is the non-Federal Action (could occur with or without the project).

BACKCHECK: CLOSED

Page 187: Comment [T21] **Tanis Toland** **8/13/2015 4:43:00 PM**

Are there any applicable state laws or local ordinances?

RESPONSE: CEQA has been referenced below.

BACKCHECK: CLOSED

Page 200: Comment [T22] **Tanis Toland** **8/13/2015 4:25:00 PM**

Monument?

RESPONSE: Concur. Change has been made

BACKCHECK: CLOSED

Page 206: Comment [T23] **Tanis Toland** **8/13/2015 4:26:00 PM**

Southport 408 received a comment on the affect of utility relocations on cultural resources. You may wish to explicitly address this for each of the alternatives.

RESPONSE: For all activities for the project (including utility relocations) there will be inventory, eligibility determinations, and evaluation of effects to potential historic properties. This document does not have site specific information in order to complete an analysis on specific utility relocations.

BACKCHECK: CLOSED

Page 212: Comment [T24] **Tanis Toland** **8/13/2015 4:27:00 PM**

It is not clear what commitment is being made here. Are there historic properties that the project, as currently designed, would adversely affect? Is there an expectation that the project be redesigned during feasibility to avoid impacts on historic properties or is the expectation that the project would or could be redesigned during PED? If the latter, this raises concerns about whether the project has been appropriately identified, evaluated, and costs fully disclosed. Would it be appropriate to refer instead to "design refinements" during PED that may reduce or avoid impacts?

RESPONSE: There are likely historic properties that the project will adversely affect but those specific determinations by historic property have not been made. They will be made through the execution of the programmatic agreement during PED. Redesign during feasibility to avoid historic properties is not expected, but refinement of designs should be considered during PED. The costs for cultural resources were developed with consideration for significant efforts to identify and evaluate cultural resources during PED. Instead of "redesign," changed the references in this paragraph to "design refinements" in order to clarify the level of activity that may occur in PED.

BACKCHECK: CLOSED

Page 252: Inserted	**Tanis Toland**	**8/13/2015 5:13:00 PM**

Table

Page 252: Formatted	**Tanis Toland**	**8/13/2015 5:13:00 PM**

Font: Calibri, Not Bold

Page 331: Comment [T25]	**Tanis Toland**	**8/13/2015 4:42:00 PM**

Need to update.

RESPONSE: Updated.

BACKCHECK: CLOSED

Page 348: Comment [T26]	**Tanis Toland**	**8/13/2015 4:41:00 PM**

Who will request the 401 WQ Cert? When will this occur?

RESPONSE: Concur, this information has been added.

BACKCHECK: CLOSED

Page 349: Comment [T27]	**Tanis Toland**	**8/13/2015 4:41:00 PM**

Did you identify the LEDPA? Is it the preferred alternative/Recommended Plan? Include this information here.

RESPONSE: Concur. Added.

BACKCHECK: CLOSED

Page 350: Comment [T28] **Tanis Toland** **8/13/2015 4:40:00 PM**

Under ESA effect determinations are made for both listed species and designated critical habitat, using one of the following:
No effect
May affect, not likely to adversely affect
May affect, likely to adversely affect.
Please revise the text to specify the correct determination and address whether designated critical habitat is present in the project area and, if present, what your determination is.

RESPONSE: Section revised.

BACKCHECK: CLOSED

Page 350: Comment [T29] **Tanis Toland** **8/13/2015 4:40:00 PM**

Typically we would say something like, "In a letter, dated XXX, USACE requested to initiate Section 7 consultation."

RESPONSE: Concur. Change made as requested.

BACKCHECK: CLOSED

Page 350: Comment [T30] **Tanis Toland** **8/13/2015 4:39:00 PM**

Please include the USFWS' recommendations in this section together with the USACE response to each of those recommendations. This comment was also provided on the draft EIS/EIR (DQC Comment #12).

RESPONSE: Concur. The recommendations and responses have been added to this document as Section 4.7.

BACKCHECK: CLOSED

Page 350: Comment [T31] **Tanis Toland** **8/13/2015 4:39:00 PM**

EFH has not been designated for steelhead.

RESPONSE: Concur.

BACKCHECK: CLOSED

Page 350: Comment [T32]	Tanis Toland	8/13/2015 4:38:00 PM

NMFS' EFH recommendations should be included in the Final EIS.

RESPONSE: Concur. Will be added once received.

BACKCHECK: CLOSED

Page 351: Comment [T33]	Tanis Toland	8/13/2015 5:05:00 PM

Consider including EO 13112, Invasive Species.

RESPONSE: Added below.

BACKCHECK: CLOSED

Page 353: Comment [T34]	Tanis Toland	8/13/2015 4:37:00 PM

Are there any NRCS conservation easements on this land or on any other lands being used for this project?

RESPONSE: The draft EIS/EIR was provided to NRCS for review and no comments were received. Technical research has not resulted in any NRCS conservation easements found within the project area.

BACKCHECK: CLOSED

Page 353: Comment [T35]	Tanis Toland	8/13/2015 4:37:00 PM

Was For DA 1006 completed, provided to NRCS, and returned. Is this document included in the Appendix (doesn't appear to be).

RESPONSE: NRCS form DA 1006 will be included as an appendix to the final EIS/EIR.

BACKCHECK: CLOSED

Page 353: Comment [T36]	Tanis Toland	8/13/2015 4:36:00 PM

What is the relationship of this Act to the proposed project?

RESPONSE: The relationship is simply related to the level of protection in the study area. The NFIP is not a regulatory function over the project, just a relationship. Added the final sentence to the section.

BACKCHECK: CLOSED with the following caveat: Please check with the planner regarding this statement. USACE no longer supports the concept of "x-year level of protection." Perhaps an acception has been made in this case

BACKCHECK: Added because the GRR does identify the level of protection for the project. Specifically, Table 3-19 of the GRR indicates that Alternative 2 would bring the American River South Basin to a 1 in 147 level of protection, and the American River North Basin to a 1 in 256 level of protection. Will update this discussion to be consistent with those numbers, rather than general.'

BACKCHECK: CLOSED

Page 357: Comment [T37]	Tanis Toland	8/13/2015 4:35:00 PM

If you coordinated with the National Park Service, regarding this Act, recommend including this information here.

RESPONSE: Concur. Language has been added below.

BACKCHECK: CLOSED

Page 357: Comment [T38]	Tanis Toland	8/13/2015 4:34:00 PM

Please clarify, would the extraordinary fishery value improve over the baseline or No Action conditions or would the adverse project impacts to fisheries be reduced over time?

RESPONSE: There would be an initial direct effect during construction, but SAM results show that the long-term effects are beneficial/improvement over baseline. Section has been updated accordingly.

BACKCHECK: CLOSED

Page 362: Comment [T39]	Tanis Toland	8/13/2015 4:34:00 PM

Recommend specifying the number of meetings and the dates they were held.

RESPONSE: Concur. Dates and locations have been added.

BACKCHECK: CLOSED

Page 362: Comment [T40]	Tanis Toland	8/13/2015 4:34:00 PM

Discuss how the comments were addressed and helped to frame the scale of the analysis for the EIS.

RESPONSE: Concur, language was added following Table 55.

BACKCHECK: CLOSED

Page 363: Comment [T41]	Tanis Toland	8/13/2015 4:33:00 PM

Please confirm that these were DVDs and not actually CDs?

RESPONSE: They were DVDs.

BACKCHECK: CLOSED

Page 364: Comment [T42]	Tanis Toland	8/13/2015 4:33:00 PM

And comment cards?

RESPONSE: concur

BACKCHECK: CLOSED

Page 364: Comment [T43]	Tanis Toland	8/13/2015 4:32:00 PM

Can you provide some context? How many Federal, state, local agencies, NGOs, businesses, individuals provided substantive comments on the draft EIS?

RESPONSE: 137 people, to include the list above, attended the meetings. Further detail such as this will be included in the Public Response Appendix (Appendix F). This section is a brief summary and more detail will be available there.

BACKCHECK: CLOSED

Page 364: Comment [T44]	Tanis Toland	8/13/2015 4:32:00 PM

This is confusing. Are the comments summarized here the most significant comments? The comments raised by the greatest number of commenters? Reviewers and decision makers are most interested in being alerted to key substantive comments and how they were addressed in alternatives development and evaluation between the draft and the final EIS.

RESPONSE: Added, "The most significant comments"...focused on." Additionally indicated that the full array of comments are included in the appendix.

BACKCHECK: CLOSED

Page 364: Comment [T45] Tanis Toland 8/13/2015 4:32:00 PM

Under NEPA, all interested parties are noticed regarding the availability off the FEIS and those who have submitted substantive comments on the Draft EIS must be provided with a copy of the Final EIS. This can be a CD. See 40 CFR Parts 1500-1508 (1502.19) and ER 1105-2-100, Appendix H, Amendment #1

RESPONSE: Concur. Added language indicating that the distribution would include commenters.

BACKCHECK: CLOSED

Page 364: Comment [T46] Tanis Toland 8/13/2015 4:31:00 PM

Will Congress be taking one action or two separate actions? Be clear.

RESPONSE: Added "following authorization".

BACKCHECK: CLOSED with the following caveat: The modification didn't quite address my original comment. I proposed a revision within the text. "...project construciton is also contingent on congressional authorization OF THE PROJECT and SUBSEQUENT appropriat of funds TO DESIGN AND CONSTRUCT THE PROJECT.".

RESPONSE: Change accepted.

BACKCHECK: CLOSED

Page 365: Comment [T47] Tanis Toland 8/13/2015 4:30:00 PM

This section needs to be beefed up so that it tells a useful story about coordination and consultation with other Federal, state and local agencies. Language included gives the impression that coordination with the state and federal agencies took place early on and leaves a question about whether coordination has continued throughout the project planning and EIS/EIR process. Need to distinguish between general coordination and required consultation.

RESPONSE: Concur, this section was updated as requested.

BACKCHECK: CLOSED

Page 365: Comment [T48]	Tanis Toland	8/13/2015 4:30:00 PM

Recommend that you specify, as appropriate, consultation with USFWS, NMFS and CDFW under FWCA, ESA and Magnuson-Stevens Fishery and Conservation Act. How about coordination or consultation with USEPA, RWQCB, or the air pollution control districts?

RESPONSE: Concur, updated as recommended.

BACKCHECK: CLOSED

Page 366: Comment [T49]	Tanis Toland	8/13/2015 4:29:00 PM

SJAFCA is identified as a Cooperating Agency. Is DWR also a Cooperating Agency?

RESPONSE: See response to cover page. No, DWR is not a coordinating agency.

BACKCHECK: CLOSED

Page 366: Comment [T50]	Tanis Toland	8/13/2015 4:28:00 PM

See comment T11 , above. Also, did this list also receive copies or notice of the release of the Draft EIS/EIR? If so, you may wish to make this clear.

RESPONSE: These individuals all received copies of the document. We typically send DVD copies of the document to all of the agencies and individuals listed here, and letters to residents.

BACKCHECK: CLOSED

Page 368: Comment [T51]	Tanis Toland	8/13/2015 4:29:00 PM

What about Sacramento Municipal Utility District?

RESPONSE: Added.

BACKCHECK: CLOSED

Page 384: Comment [T52]	Tanis Toland	8/13/2015 10:57:00 AM

Include the content providers and key reviewers from the CEQA Lead Agency and the NEPA Cooperating Agencies.

Response: Concur, added below.

BACKCHECK: CLOSED

Header and footer changes

Text Box changes

Header and footer text box changes

Footnote changes

Endnote changes

Draft 404(b)(1) 5March15 - DQC TT cmts 8-11-15 AB rsp 8-27-15, TT bkck 8-28-15 CLEAN.docx

Main document changes and comments

Page 1: Comment [T1]	Tanis Toland	8/28/2015 9:11:00 AM

Need to write NEMDC out since this is the first time it appears in the document.

RESPONSE (VH):Concur. The change has been made as requested.

BACKCHECK (TT): CLOSED

Page 4: Comment [T2]	Tanis Toland	8/28/2015 9:11:00 AM

Need to define "East Side Tributaries" since this is the first time it appears in the document.

RESPONSE (VH): All areas of the East Side Tributaries have been defined.

BACKCHECK (TT): CLOSED

Page 7: Comment [T3]	Tanis Toland	8/28/2015 9:12:00 AM

Would the existing weir be replaced or modernized? This description seems to indicate that structure of the existing weir would not be altered by this project (Alternative 2. Is this correct?

RESPONSE (AB): Clarified the description to reflect that the extension of the Sacramento Weir would be a new structure. The existing weir is not proposed for alteration.

BACKCHECK (TT): CLOSED

Page 19: Comment [T4]	Tanis Toland	8/28/2015 9:12:00 AM

Comment carried in from fist DQC: How thick would the rock berm be? How thick would the silty/sandy layer be? Once this material is washed away, would it be replaced?

RESPONSE (VH): Included rock berm thickness.

BACKCHECK (TT): CLOSED

Page 20: Comment [T5]	Tanis Toland	8/28/2015 9:12:00 AM

Comment carried in from first DQC: What about the riprap, would it migrate, too?

RESPONSE (VH): Addressed possible migration.

BACKCHECK (TT): CLOSED

Page 23: Comment [T6]	Tanis Toland	8/28/2015 9:13:00 AM

Comment carried in from first DQC: What would the increase in water surface elevation be? At one time, an increase of half a foot was considered unacceptable.

RESPONSE (AB): Section has been updated to reflect that the increase in water surface elevation would be 0.10-foot during a 200-year event. Additional edits were madeto reflect that this would only be during large flood events, as the new weir would not be operated until flows from Folsom Dam exceed 115,000 cfs. The existing weir would be operated consistent with current conditions.

BACKCHECK (TT): CLOSED

Page 24: Comment [T7]	Tanis Toland	8/28/2015 9:14:00 AM

Comment carried in from first DQC: Has this been modeled? If freshwater flows leave the river and route to the Delta down the Bypass system, it would seem like this could affect salinity gradients as well as turbidity.

RESPONSE (AB): This has not been modeled, however changes could only occur during a large flood event, when there is already a huge amount of water in the system pushing salinity back down into the Delta/Bay system. The section was revised to more clearly portray the condition.

BACKCHECK (TT): CLOSED

Page 34: Comment [T8]	Tanis Toland	8/28/2015 9:14:00 AM

Mitigation must be evaluated consistent with ER 1105-2-100 (see Appendix C).

RESPONSE (AB): Updated this write up for consistency with the Biological Opinion.

BACKCHECK (TT): CLOSED

Page 37: Comment [T9]	Tanis Toland	8/28/2015 9:14:00 AM

What effect would the cutoff walls have on groundwater and other subsurface flows?

RESPONSE (VH): Concur. Included that there is minimal risk due to a non-permeable layer of soil between the groundwater table and the cutoff wall.

BACKCHECK (TT): CLOSED

Page 38: Comment [T10]	Tanis Toland	8/28/2015 9:15:00 AM

To improve clarity, please be more specific where appropriate throughout the document. In this case, the referenced vegetation s trees and shrubs?

RESPONSE (VH): Added the types of vegetation that would be permitted on site.

BACKCHECK (TT): CLOSED

Page 38: Comment [T11]	Tanis Toland	8/28/2015 9:15:00 AM

Type of vegetation?

RESPONSE (VH): Added the types of vegetation that would be permitted on site.

BACKCHECK (TT): CLOSED

Page 42: Comment [T12]	Tanis Toland	8/28/2015 9:15:00 AM

Temporarily during construction or permanently?

RESPONSE (VH): Added temporarily. Also: Once construction is complete the recreation facilities would be returned to the pre-construction conditions and long term effects would be less than significant.

BACKCHECK (TT): CLOSED

Page 44: Comment [T13]	Tanis Toland	8/28/2015 9:15:00 AM

Can you place this in context with other similar work in the Sacramento Valley/Central Valley? There are X LF/Miles of levee system. This project would place linear feet/miles linear feet of riprap. Riprap placed by other projects includes: X LF/miles of existing riprap, LF/miles of riprap currently being placed, LF/miles of riprap planned?

RESPONSE (AB): Updated to include a summary of cumulative Corps actions in the area.

BACKCHECK (TT): CLOSED

Page 44: Comment [T14]	**Tanis Toland**	**8/28/2015 9:16:00 AM**

Are these areas under an HCP or is one in development? In some cases, for example a SWIF, ESA compliance would be accomplished by the Corps under Section 7.

RESPONSE (AB): This language was from the BA and was specifically referring to non-Federal actions, as required in the ESA consultation handbook. The language has been updated to include Federal and non-Federal actions for the purposes of the 404(b)(1)

BACKCHECK (TT): CLOSED

Page 45: Comment [T15]	**Tanis Toland**	**8/28/2015 9:16:00 AM**

Do mean "placed" or "migrate"?

RESPONSE (VH):Changed to "placed".

BACKCHECK (TT): CLOSED

Page 45: Comment [T16]	**Tanis Toland**	**8/28/2015 9:16:00 AM**

Above ordinary high water?

RESPONSE (VH): Added no-in water work would occur. (AB): Also added that this measure is only implementable on the American River.

BACKCHECK (TT): CLOSED

Page 47: Comment [T17]	**Tanis Toland**	**8/28/2015 9:17:00 AM**

Need to identify the LEDPA. Which alternative is the LEDPA?

RESPONSE (VH): Concur. Identified the LEDPA. (AB): Also added explanation for why it is the LEDPA.

BACKCHECK (TT): CLOSED

Header and footer changes

Text Box changes

Header and footer text box changes

Footnote changes

Endnote changes

Comments and Responses for the
Habitat Mitigation and Monitoring Plan
American River Common Features General Reevaluation Report

*Note: all in-line changes were accepted in the document. All other comments are addressed below.

Number	Location	Comment	Response	Toland Backcheck (9/14/15)
T1	Under Primary Purpose and Goals	Recommend clarifying in this introductory section that most of the compensatory mitigation is directly tied to compliance with the ESA and is intended to off-set effects on listed species.	Concur; added text: "Mitigation for habitat loss is a requirement to compensate for the loss of habitat due to a Federal action. Section 2036(a) of the Water Resources Development Act of 2007 states that project alternatives must support recommendations with a specific plan to mitigate fish and wildlife losses. Additionally, the Endangered Species Act states that the purpose of compensatory mitigation is to offset environmental losses resulting from unavoidable impacts (40 CFR 230.93 (a)(1)."	Comment Closed
T2	On statement "The purpose of this mitigation and monitoring plan is to establish a framework for creation of mitigation sites and evaluating the success of these sites"	This MMP is proposed as a "framework for creation of mitigation sites and the success of these sites." This is inconsistent with the requirements of USACE implementing guidance for Section 2036(a) of WRDA of 2007 (31 August 2009), paragraph 1a, which specifies that: "…any report, submitted to Congress for authorization, shall not select a project alternative unless such report contains (1) a specific recommendation with a specific plan to mitigate fish and wildlife losses or (2) the Secretary determines that the	Although the draft MMP does not specifically call out the exact parameters of the survey protocols that will be established for the individual mitigation sites, it does describe the types and amounts of mitigation that would be required for habitat losses due to the project. Revised text: "This Habitat Mitigation and Monitoring Plan (HMMP) describes the types of habitats that will be impacted, the potential impacts caused by the project, and describes the types and amounts of mitigation that would be established in order to compensate for habitat losses. This plan also establishes a framework for the creation of mitigation sites and methods to evaluate the success of these sites in order to ensure that the goals and requirements of the project's required mitigation are accomplished."	Comment closed

		project will have negligible adverse impacts." At what point will a specific recommendation with a specific plan to mitigate fish and wildlife losses be completed?		
T3	On statement "Due to environmental, real estate, and hydraulic constraints within the study area, the majority of the levees would be fixed in place."	The placement of "environmental" first in this list infers that the environmental concerns are a primary driver for the fix in place option. If this is not the case, recommend reordering this list.	Concur; the text has been revised to "Due to hydraulic,, real estate, and environmental constraints within the study area, the majority of the levees would be fixed in place."	Comment closed
T4	On title "Description of Proposed Protective Measures"	Recommend using "Proposed Flood Risk Management Measures" to distinguish the content of this section from mitigation measures.	Concur; text has been revised to "Proposed Flood Risk Management Measures" as recommended. Table of Contents has been updated.	Comment closed
T5	Under Section 1.6, Potential Project Impacts, first sentence	Who would obtain the variance from whom? This is a USACE document and USACE makes veg variance decisions. Has HQUSACE agreed to grant a veg variance? Do you mean that initial engineering analyses indicate that all/part (what part) of the project would be likely to be determined during PED to be suitable for a veg variance?	The text has been revised to "A vegetation variance is being sought by the Sacramento District to comply with ETL 1110-2-583 on the waterside of the levee. The vegetation variance request requires the Corps to show that the safety, structural integrity, and functionality of the levee would be retained if the vegetation were to remain in place."	Comment closed
T6	On the heading of Table 2	I understand that these headings are being revised to increase clarity.	Added "Western Yellow-billed Cuckoo" to "Riparian" tab.	Comment closed
T7	1.7, Proposed Mitigation Measures	Need to discuss the mitigation objectives before discussing the mitigation measures that will address those objectives (see USACE implementation guidance for Section 2036(a) of WRDA 2007.	Concur. Text assed: "The preparation of mitigation plans, including objectives, plan design, determination of success criteria, and monitoring needs would be coordinated with Federal and State resource agencies to the greatest extent practicable. Mitigation objectives are specific actions to be taken to avoid and minimize adverse affects, such as Best Management Practices,	Comment closed

			compliance with Federal and State regulatory laws, and environmental commitments. Mitigation objectives include the identification of specific amounts of mitigation required to compensate for remaining unavoidable losses."	
T8	Section 1.7 on the phrase "requirements specified in the BOs."	If these are terms and conditions, state this.	Text revised to "requirements, terms and conditions specified"	Comment closed
T9	Under Section 1.7, Proposed Mitigation Measures" first bullet, on "the Corps will obtain an ETL approved vegetation variance"	See previous comment on this subject. Could you say something like: "The Corps anticipates that the project will be found suitable for a variance to the XXX ETL [need the correct number].	Concur; text revised to "A vegetation variance is being sought by the Sacramento District to comply with ETL 1110-2-583 in order to exempting the Sacramento River and East Side Tributaries from vegetation removal in the lower third of the waterside of the levee prior to final construction and design phase."	Comment closed
T10	Section 1.7 on phrase "The mitigation acreages for ARCF GRR were calculated…"	Specify the acreages of what and/ or refer to the appropriate table.	Concur; text added to describe Table 3: "Table 3 describes the types and amounts of habitat that would be potentially impacted by the project, the duration of the impacts, the amount of mitigation in total acreage according to the requirements provided by USFWS and NMFS, and projected costs as estimated according to existing mitigation prices." Additionally, information in Table 3 has been changed from mitigation ratios to total acreage required according to projected impacts.	Comment closed
T11	Under Section 1.8, Location of Mitigation and Compensation Sites, first paragraph	Can you add any specificity? For example, about how much (or what percent-sh) of the project length (ideally by waterway) would be restored to pre-construction conditions?	The only specificity we really have at this design phase is the area associated with on-site restoration. Revised text: "Sites compatible with on-site mitigation such as the 30 acres of upland GGS habitat and 82, 325 linear feet of SRA habitat would be restored in place."	Comment closed
T12	Under Section 1.8, Location of Mitigation and Compensation Sites, third paragraph	You may also wish to include similar language in the first paragraph of the document.	Concur; the language "This mitigation and monitoring plan will accompany the final EIS/EIR, and will be updated throughout the design phase as detailed design efforts allow for finalizing the mitigation plans" has been added after the phrase "This HMMP is a living document and will be modified as part of an adaptive management strategy to allow for the accomplishment of the goals and requirements in a	Comment closed

			constantly changing environment" in the second paragraph of the introduction.	
T13	Section 1.9, Compensation Timing on phrase "The authority to compensate prior to or concurrent with project construction is given under WRDA 1986 (33 United States Code [USC] § 2283)."	ER 1105-2-100, Appendix C, page C-19 provides guidance on the timing of mitigation.	Concur; language added: "Additionally, ER 1105-2-100, Appendix C states that authorized ecological resource mitigation activities and features should occur before construction of the project, concurrent with the acquisition of lands, or concurrent with the physical construction of the project."	Comment closed
T14	Section 2.0, fourth paragraph, on phrase "project objectives"	Do you mean "mitigation objectives"?	Concur; text has been changed to "mitigation objectives."	Comment closed

QUALITY CONTROL CERTIFICATE FOR CIVIL DESIGN PRODUCTS

PROJECT NAME: American River Common Features GRR

PROJECT MANAGER: Dan Tibbitts

ORGANIZATION: Civil Design Section A

TECHNICAL PRODUCTS: The edited engineering summary appendix for the Feasibility Report Milestone (FRM). This review is for edits made as a result of the concurrent review period and refinements to the plan and document.

PREPARER – I have prepared the above products in accordance with the Quality Management Plan. I have incorporated or resolved all review issues in accordance with the Quality Management Plan.

Preparer: _____ Date: 8/17/15
James Elsberry, P.E.

REVIEWERS – I have reviewed the product noted above and find it to be in accordance with the Quality Management Plan meeting project requirements, standards of the profession and Corps of Engineers policies and standards. All comments have been back-checked and closed out to my satisfaction.

QC Reviewer: _____ Date: 8/17/15
Mark Boedtker, P.E.

RESOURCE PROVIDER – I have reviewed and resolved all critical and technical issues. I agree that all project requirements and standards of the profession and Corps of Engineers policies and standards have been met.

Section Chief: _____ Date: 9.9.15
Peter Valentine, PE
Chief, Civil Design Section A

PROJECT: American River Common Features GRR
P2#: 149827
PM: Dan Tibbitts
REVIEW: Engineering Appendix for FRM

DESIGNER: James Elsberry, P.E.
REVIEWER: Mark Boedtker, P.E.
PERIOD OF REVIEW: 8/10/2015 - 8/14/2015

#	TYPE	REFERENCE	NOTES
1	Comment 08/10/2015	Table of Contents, List of Figures	There is no Figure 1 listed. Based on what was deleted prior, it appears it should be "Figure 1 - Study Area Map".
	Response 08/16/2015		Yes that is a good catch. The list of figures has been updated to include "Figure 1 - Study Area Map". Thank you.
	Backcheck 08/17/2015		Comment closed.
2	Comment 08/10/2015	Paragraph 1.3	Change Figure 1-1 to Figure 1.
	Response 08/16/2015		"Figure 1-1" reference has been changed to "Figure 1" and cross link to the figure has been incorporated. Thank you.
	Backcheck 08/17/2015		Comment closed.
3	Comment 08/10/2015	Figure 13	Delete "SEE PLANS" in the figure.
	Response 08/16/2015		Another good catch. The figure was revised with the "see plans" annotations removed. Thank you.
	Backcheck 08/17/2015		Comment closed.

WATER MANAGEMENT SECTION
CERTIFICATION FOR AGENCY TECHNICAL REVIEW

American River Common Features Project General Reevaluation Report
Placer, Sacramento, Sutter Counties, California
Synthetic Hydrology Technical Documentation, Sacramento District
September 2008, Revised January 2009

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 agency 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 American River Common Features Project General Reevaluation.

Laurine L. White — 26 Jan 2009
Laurine L. White
Hydrologist, SPK
Date

James Chieh — 1-26-2009
James Chieh
Independent Technical Reviewer
Date

John M. High — 1-26-2009
John M. High
Chief, Water Management Section, SPK
Date

HYDROLOGY SECTION
CERTIFICATION FOR AGENCY TECHNICAL REVIEW

American River Common Features Project General Reevaluation Report
Appendix B, Dry and Arcade Creeks Flow Frequency Curves
And Synthetic 8-Flood Series Hydrographs
Upstream of Steelhead Creek, Sacramento District
November 2009, Revised January 2010

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 agency 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 American River Common Features Project General Reevaluation.

Laurine L. White — 19 January 2010
Laurine L. White
Hydrologist, SPK
Date

James Chieh — 20 January 2010
James Chieh
Independent Technical Reviewer
Date

John M. High — 19 JANUARY 2010
John M. High
Chief, Hydrology Section, SPK
Date

QUALITY CONTROL CERTIFICATE

Hydraulic Design/Analysis Section, Engineering Division

PROJECT NAME: AMERICAN RIVER COMMON FEATURES (ARCF) GENERAL RE-EVALUATION STUDY
PRODUCT: HYDRAULIC APPENDIX TO SUPPORT FINAL ARRAY OF ALTERNATIVE FOR ACRF STUDY
Actual Completion Date: 9-Sep-15

PROJECT MANAGER: DAN TIBBITTS

Background: [Include project description, technical products, and review methodology]

Additional District Quality Control was performed for the American River Common Features General Re-evaluation Study on the updated portions of the Hydraulic appendix to support the final array of alternatives for the feasibility study. The DQC Certificate from August 13, 2013 still applies as this is an update to that review, not a replacement.

The purpose of this document is to present the summary of hydraulic analyses conducted to support the American River Common Features General Re-evaluation Report (ARCF GRR) Study. This is an executive report of what has been traditionally know as a hydraulic appendix. A collection of technical memorandums (see table below) containing the detailed information typically found in a full version of the hydraulic appendix have been assembled as an office report for reference here at the District. This executive report has been prepared to meet the intention of the new Planning Modernization that USACE has undertaken.

The ARCF study area includes generally the entire Sacramento metropolitan region. The project area being considered for flood damage reduction can be divided up into three basins – Natomas, American River North, and American River South.

Both Flo2D and HECRAS models were used for this effort.

Models and Technical Memorandums Supporting the ARCF Hydraulic Appendix
Hydraulic Models
HECRAS 1-D Hydraulic Model FLO2D 2-D Hydraulic Model
Technical Memorandums
Sacramento Basin HEC-RAS Phase I Model Development Sacramento Basin HEC-RAS Phase II Model Development Sutter Basin HEC-RAS Model Conversion Datum Conversion Downstream Boundary Conditions Gages Hydrologic Inputs (.dss files) Highwater Marks FDA Inputs FLO-2D Floodplain Mapping Documentation Levee Breach Sensitivity Climate Change Systems Risk and Uncertainty Interior Drainage Upstream Alternative Analysis Calibration

HYDRAULIC LEAD

I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved all issues identified during District Quality Control (DQC) review.

Title: Jesse Schlunegger		9-11-2015
Print name	Signature	Date

REVIEWERS

I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer: Peter Blodgett	Title: Regional Technical Specialist, Senior Hydraulic Engineer	
Print name	Signature BLODGETT.PETER.JAMES.1366852340	Date

RESOURCE PROVIDER

I have reviewed and resolved all critical and technical issues. I agree that all project requirements, standards of the profession, and USACE policies and standards have been met.

Section Chief: Jesse Schlunegger		9-11-2015
Print name	Signature	Date

American River Watershed Common Features General Re-evaluation Report Study

SPK HYDRAULIC ANALYSIS SECTION
DISTRICT QUALITY CONTROL REVIEW

HYDRAULIC APPENDIX
DATED FEBRUARY 25, 2013
UPDATED DQC AUGUST 10, 2015

Reviewer: Peter Blodgett, P.E. SPK Hydraulic Analysis Section
Review Date: 12 August 2015
Response Date: xx August 2015
Backcheck Date: xx August 2015

The following describes SPK District Quality Control (DQC) performed for the report noted above.

Responder Comments
Blue – Comment is ready for Backcheck
Dark Blue – 2nd Response to Comment.
Red – Comment needs Discussion or more work to resolve

No.	Date	Notes
1.	Comment	Plate 4 and 5. "ARCF Study Area" should be "project area". The text in the report differentiates between study area and project area and this map is not consistent with that.
	Response	Plates were updated.
	Back-check	Comment addressed and closed.
2.	Comment	Plate 9 and 10. We should avoid the use of the term "repair" because OMRRR is a sponsor responsibility. Need clarification, are these locations of proposed improvements or existing features.
	Response	Plates were updated.
	Back-check	Comment addressed and closed.
3.	Comment	General: Recommend removing all use of recurrence interval from document. Document should use ACE.
	Response	Concur, Recurrence interval has been replaced with ACE.
	Back-check	Report still contains recurrence intervals throughout. However, this is primarily a terminology comment and does not impact the selected plan. Comment closed.
4.	Comment	Section 6.6. This section indicates the stages are based on upstream failures. Is this correct? If so, how was the upstream

		failure scenario determined?
	Response	The stages were not based on upstream failures. The text has been updated. This paragraph was trying to highlight some of the assumptions used for the study.
	Back-check	Comment addressed and closed.
5.	Comment	Figure 6-1. X and Y axis need labels. The x axis appears to be log. However, it should be probability.
	Response	Based on additional comments, this entire section has been removed including this graphic.
	Back-check	Comment addressed and closed.
6.	Comment	Section 7.2. Levee Superiority Suggest including Sanke Gap as a levee superiority reach.
	Response	This section has been rewritten, including bringing in the Sankey Gap as part of the superiority discussion.
	Back-check	Comment addressed and closed.
7.	Comment	Section 7.3. Climate Change.This wording needs to be rephrased. A project would be constructed and maintained to a design flow rate. We should not imply the design is based on maintaining a design frequency. In addition, it appears the LPP is designed to meet the ULOP requirements which are tied to a finding over the ULOP finding period. Was this climate change amount included in the design height of the LPP?
	Response	Text has been updated to reflect this concern. An added increase in height was not included in the Top of Levee Design Height. Much of the top of levee was based on 160,000 cfs coming out of the American regardless of the frequency.
	Back-check	Comment addressed and closed.
8.	Comment	Profile Plates. Text indicates profiles are based on infinite levee height in model. This assumption should probably be included on the profile plates.
	Response	The n-year profiles, Plates 12-24 are for the without project condition and do not include infinitely tall levees in the project area. Plates 31 – 56 show the existing top of levee but include the with-project Alt 1 and Alt 2 water surface profiles that have the project levees raised 20' to account for any levee raise.
	Back-check	Comment addressed and closed.
9.	Comment	Plate 68. Index point title is wrong. This should be ARN E.
	Response	Concur. Plate Updated.
	Back-check	Comment addressed and closed.

10.	Comment	Plate 70 through 72. - All plates should not use return period. - On Plate 70. Page number is wrong. This should be Plate 70 but text says 72. On Plate 72 text says Plate 70. - The title of these plates says existing conditions but should say future without project conditions. - There term "advertised flow" is not standard terminology. Is this the "design flow" as described in the OMRRR manual? - Check location for flow comparison for yolo Bypass upsteam of Sac bypass. The arrow is shown above the sac bypass but I think this is flow below the sac bypass.
	Response	Return Period corrected to ACE, Plate numbers corrected, Title corrected. Advertised flow is from the DWR 1986 graphic which is supposed to represent the 1957 design flows that should match the O&M manual. The flow for the Yolo Bypass upstream was at RM 45 which is a half mile upstream of the Sacramento Bypass.
	Back-check	Comment addressed and closed.
11.	Comment	Erosion Protection. This section needs to more clearly describe the features that were included in the design and cost estimates.
	Response	Text has been updated .
	Back-check	Comment addressed and closed.

DISTRICT QUALITY CONTROL CERTIFICATE for GEOTECHNICAL PRODUCTS

PROJECT AND DOCUMENT INFORMATION

Project Name: ARCF GRR

Document: Geotechnical Appendix and Office Report

Project Manager: Dan Tibbitts

Document Completion Date: January, 2013 Document Author: Michael Kynett, P.E.

Reviewer: Anthony Deus, P.E. Senior Reviewer: Mary Perlea, P.E.

The above reviewer will perform the Quality Control Review in accordance with SOP EDG-02: "Technical Product Review Policy and Procedures" developed for the Engineering Quality System. The senior reviewer will provide a review of major assumptions, analytical approaches, significant calculations, recommendations and conclusions.

REVIEW CERTIFICATION

PREPARER – I have discussed the above document and review requirements with the DQC Reviewer(s) and believe that this review is completed and that the document will meet the requirements of the project.

Preparer's Signature: _____ Date: 12 Feb 2013

REVIEWER – I have reviewed the assigned Item(s)/Section(s) noted for the above document and believe them to be in accordance with the project requirements, standards of the profession, and Corps of Engineers policies and standards.

Reviewer's Signature: _____ Date: 12 Feb 2013

SENIOR REVIEWER – I have reviewed and resolved all critical and technical issues. I agree that the item(s)/Section(s) noted for the above document are in accordance with project requirements, standards of the profession, and Corps of Engineers policies and standards.

Senior Reviewer's Signature: _____ Date: 12 Feb 2013

No.	Page No.	Comment	Response
1	xii	Is part of the Yolo Bypass included only because you have that weir structure on the Sacramento River? Otherwise why do you include Yolo Bypass?	The Yolo Bypass is included because it is a critical component to both the Sacramento Bypass Weir expansion and the I Street Diversion Structure. The study has expanded to look at features outside of the existing flood protection system that may benefit the study area.
2	Xiii	What about the windows? Do you want to discuss them here?	Windows are a component to the WRDA 96/99 project, the with project assumption is that the WRDA 96/99 project is completed. A discussion of the windows sites is a detail associated with the WRDA 96/99 project and not relevant to the ARCF GRR.
3	Xiii	No blanket?	The geology of the MCDC area is not riverine (riverbank formation) but modesto formation associated with the foothills. The subsurface conditions consist of low permeability dense/stiff silty sand and sandy silt. Essentially there are not the typical blanket/aquifer layers associated with riverine geology.
4	xv	I am not sure we want to show what has been constructed as part of NLIP. NLIP is approved for credit after the Natomas NPACR is authorized, we consider the NLIP improvements as non-existent and have them included as preferred plan in our proposal, so I would not say anything regarding the already improvements in place recently done by NLIP. However you can mention that there is additional information available from NLIP studies only.	Correct, the references to NLIP and constructed features associated with NLIP have been removed from the report text. Reference to the implementation of the NPACR as part of the without project conditions for the ARCF GRR remain.
5	xv	Delete this completely, we disregard the NLIP construction at this stage. However you may indicate the levee improvement such as cut-off wall and others was included in NPACR, and the Chiefs report approved,	See response to previous comment.

No.	Page No.	Comment	Response
		but do not say constructed.	
6	Xvi	Are you sure that this is for 200 year flood? The levees are designed for 200 year +3 feet of freeboard, so if 1 foot is lost than the freeboard is only 2 feet.	The seismic criteria came directly from Vlad's draft ETL on seismic analyses of levees, I can only present the criteria as it has been written in the draft ETL.
7	xvi	I would not write this, it is less stringent than the SOP which we actually apply being in the SPK	Agreed that it is less stringent, but in this section of the report I am presenting the various criteria associated with the federal levee section from the national to local level.
8	Xvii	Actually there is a typical cross section that is 1V:3H waterside, 1V:2H landside and 20 feet wide crest. Exceptions may be at ramps, pump stations and other encroachments where the levee varies from the typical cross section, but you cannot say there is no typical cross section,.	There might be some confusion here, the text does not say that there is no typical levee section of the existing levee but that there is variability in the levee section and the critical section was chosen. Further, the typical existing levee section varies for each channel.
9	Xvii	Say something regarding the Datum used (NAVD88) also regarding the horizontal datum.	Reference to datum has been included.
10	Xvii	Do you really need to show all these details on HH? These may confuse only the reviewers. What if you simply said the data was obtained from HH studies, list the years and this is all.	I believe it is warranted, the H&H changed so many times that it was confusing for us to track what version we used on what analyses and it is important to document the process and why.
11	xvii	Usually we extended the model to the centerline of the river, this is a requirements we always used, and was also imposed to the URS models for ULE. The models used bathymetric information from ULE survey	Correct, this is what we did as well. The text has been updated.
12	xviii	Did we not use wedge analyses when a thin clay layer would indicate that this would be appropriate?	No, for feasibility we used circular searches to find the critical failure surface. We acknowledge that a noncircular failure surface maybe critical in some locations but that would not have a significant

No.	Page No.	Comment	Response
			effect to the results and is a PED level refinement.
13	xviii	Seepage or combined berms were not analyzed at all? I believe we had some in Natomas at least.	Berms were not analyzed, berms were screened prior to analyses using maximum sections for cost and real estate analyses. The berms in Natomas were analyzed under NPACR and only levee raise was analyzed in Natomas under the ARCF GRR.
14	xix	Was this included in the acronyms?	Yes.
15	xix	Was this included in the acronyms?	Yes.
16	xx	I suggest spelling it out, you do not write the report in acronyms only.	Text revised.
17	xx	I suggest spelling it out, you do not write the report in acronyms only.	Text revised.
18	xx	Again, I am not sure we want to include NLIP improvements since the ANLIP is not yet credited and the "without project" conditions assumes NLIP not being constructed,	Text revised as per previous comment.
19	xx	What about tributaries such as Arcade Creek, NEMDC, Dry Creek?	Correct, deficiencies remain on those channels. The point I was making was that the majority of deficiencies and the most serious ones remain on the Sacramento River.
20	xx	There are no other deficiencies here? I was sure we have some seepage and slope stability issues also besides freeboard. Am also , generally, may we ask in the official report for 3 feet of freeboard or we need to talk the new language?	Yes, there are other deficiencies remaining. This sentence is just pointing out that there are overtopping deficiencies in addition to geotechnical deficiencies such as seepage, slope stability, and erosion. The text has been updated to be more clear.
21	xxi	Rephrase it, the sentence does not sound right.	Sentence does appear to convey the message of where deficiencies remain in ARN.
22	Xii	It is not clear if these were proposed and constructed already or are not constructed but there is no need for any improvement. I	This paragraph does appear to convey that I have evaluated the recommendations from previous studies as geotechnical acceptable for inclusion in

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		would rather say these were constructed not were proposed.	the ARCF GRR. Some text was revised.
23	xii	Was it not discussed to lower the weir also?	Yes, but it was screened early. This would be covered by H&H.
24	xxiii	Considerations or constrains? I believe there are constrains since it is not recommended.	The considerations were design level recommendations that would need to be implemented during further study if the alternative were recommended as the tsp. They are not constraints that eliminated the alternative as viable.
25	xiii	I suggest spelling out the first time, particularly in the Executive summary –	Text revised.
26	xiii	This entire paragraph is somehow confused. I do not understand why the additional 60,000 cfs discharged in the Yolo Bypass would increase the capacity in the Deep Water Sheep Chanel. Actually what you probable want to say is that the additional discharge in the Yolo Bypass would require additional work on the levees on both sides of the bypass by relocation, setback, raising and improvements such as seepage and slope stability mitigations to preserve the 6 feet of freeboard as required for a Bypass levee and to improve seepage and stability for a higher water elevation. The water will flow through the Bypass not through the DWSC, so practically it has no impact on the DWSC.	At this point the measures used to mitigate for hydraulic impacts associated with the alternative have not been fully defined by planning, civil, and pm. I have chosen to present the list of possible measures and the geotechnical components so that the PDT can choose which ones they need in the future without revisions to the geotech report. The paragraph referenced presents a summary of the requirements to mitigate hydraulic impacts through improvements to the affected levees in the bypass. The previous paragraph grave recommendations for the geotechnical components to increased capacity in the bypass.
27	xxv	There is no discussion on the borrow material below, it is in the main report only, but not in the executive summary.	Correct, it seemed appropriate to only discuss the needs and how we would obtain the material in the summary. Not the material requirements.
28	8	Do you have all these reports in the references?	Yes.

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29	9	Were the improvements only on American River or included some on Sacramento River also? (i.e. improvement on Sac River for the Pump Station 1.	Yes there were some Sacramento River improvements which were discussed with the other Sacramento river improvements.
30	35	Fix the table to fit on the page width (change fonts eventually) (on all tables eventually)	Table formatting revised.
31	38	Don't forget, NLIP has not been constructed , it is not without project conditions. Rephrase it.	Text revised.
32	39	This is NLIP, not yet constructed,	Text revised.
33	51	You may want to discuss that analyses were performed to determine the levee would respect the seepage and stability requirements in case of a vegetation variance will be requested during the PED	Agreed, this is discussed in a separate section of the report.
34	51	This is not clear, you may need additional description. Anyway, I did not understand what you mean.	Text revised.
35	51	A planting berm cannot serve as access road for vehicular access!	Text revised.
36	51	Are the following paragraphs mitigation measures? I don't think so, these are analyzed alternatives. In this paragraph 8 you have mitigation measures only. You may have eventually a separate paragraph regarding studied alternatives.	As presented these are measures. The Sacramento Weir and Bypass widening is a measure to address overtopping of the Sacramento River and on its own is not an alternative. The I Street Diversion Structure is a measure to address seepage, stability, and erosion on the Sacramento River.
37	51	See the comment above. These are not mitigation measures but alternatives.	See previous response.
38	58	Did you not use an anisotropy 1 for poorly graded sands?	No, all the material parameter guidance at the beginning of our analyses provided a range between 4 and 10 for sands. Since then the ULE

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			study has recommended 1 for clean sands. We could not revise our parameters at that late date and maintain schedule. I have performed a sensitivity study of this and the difference is relatively small. The Kh is vastly more important than Kv for sands.
39	65	Check the numbers. This is after 11.4.5.	Text revised.
40	66	This segment does not meet criteria. You do not have with project analyses results	I believe the wrong results were presented here, the figure has been updated.
41	66	Stability does not meet criteria. You do not have any mitigation measure and with project analyses results?	I believe the wrong results were presented here, the figure has been updated.
42	68	You may indicate this is a new levee designed and constructed to meet recent requirements	I would prefer not to state that. The report presents the construction history of the segment in a previous section. It may not be totally accurate to say that it was designed and constructed to modern guidance as it probably wouldn't meet SOP-003 requirements of the requirements of a 408 review conducted today.
43	68	No with project for stability analysis?	No, the levee meets seepage and stability criteria for top of levee and design water surface elevations.
44	72	It looks like with project barely meets criteria. I suggest to add a table showing the gradients and FS with and without project as a summary.	Correct, this is discussed in text. I would prefer not to add a table.
45	85	May you please check the sentence, it does not sound right	That should have been a report reference, the text has been revised.
46	89	You need to discuss the white paper accepted by the HQ and explain the reasons for non-compliance: the fact that we do not do any work on the landside slope and levee so we do not cut trees there. You cannot	Correct, the text was revised. However, the white paper never went anywhere, I referenced meetings held with HQ that were documented with meeting minutes instead.

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		just say not compliant with no explanation why.	
47	89	Actually the construction on the Sac River is from the landside toe to the river but not on the landside entire 15 feet from the toe. I suggest to indicate a 10 foot wide access road will be constructed along the landside toe , the remaining 5 feet for vegetation free zone will be the responsibility of the Sponsor. Leave it there, do not say when and how. Show it also like that on the drawing. Also trace a horizontal line from the landside toe to show the corresponding toe of the levee on the waterside slope, to show that trees are above the toe	As per our conversation, the 15 feet vegetation free zone would be acquired for the project. The exact details of how the vfz versus the access road were not important for geotech. We decided to simply state for the VVR that a 15 foot vegetation free zone would be acquired as part of the project.
48	92	We need to discuss the stability, I am not sure I agree with it. You need to remove a piece of the levee supposed to be gone due to the tree fall and have a steeper slope, than do a stability analysis for rapid drawdown and one for intermediate river level. I do not really agree or understand what you did so far. Seepage analysis and slope stability of the landside slope is not needed since you have a cut-off wall.	It appears that figure 14-3 was obscured for some reason in the document. As shown in that figure and described in text, the analyses did remove the tree fall scour as described in your comment. Landside seepage and stability was performed to confirm that the tree fall scour did not adversely affect the performance of the seepage and stability improvements.
49	92	I think you need a paragraph regarding the O&M corridor for inspection and maintenance, also show the sketch from Sarah. You can relate these two together if you want but need to discuss it for all areas, including American River.	The O&M corridor will be covered in the planning report as per our meeting with April and Virginia. The O&M corridor is not a geotechnical component and is unrelated to the ability to obtain a vegetation variance.
50	93	NLIP is not yet considered as without project conditions.	Text revised.

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51	93	Say something on the O&M corridor	See previous comment.
52	94	Check numbering	Text revised.
53	96	Is it geotextile or Tensar for reinforcement? Need to specify.	Andy Johnson has design/construction experience in New Orleans with geotextile reinforcement and performed this analysis for us. Geotextile was his preference.
54	96	Fig. 15-4 shows a levee with a cut-off wall, I do not see the cross section with the geoptextile or tensar. May you check again please? Also this figure needs wore work. What is the benching width below the dashed line. We need to discuss it a little.	Correct, the wrong figure was included. An updated figure has been included.
55	99	Use SB for traditional open trench method	I am not recommending one over the other, that is PED. WRDA 96/99 used SCB, it is possible we would again.
56	100	The minimum 1:2 slope is not only for stability but for O&M also (walkable, wowing). You need to indicate a special ground cover is recommended that will not require mowing, if the slope is steeper than 1:2/	That is an O&M/Planning issue. Geotechnical, the geotextile allows for maintaining the existing footprint and slope.
57	100	Do you really need to relocate or replace the open ditch with culverts if you have a cut-off wall?	Yes.
58	101	I do not recall any floodwall for levee raise. You need to show a cross section with the adjacent levee that will be raised to 200 year level of protection also.	Raises were not included in the NPACR, the ARCF GRR did a comparison between an embankment raise and a floodwall raise.
59	103	This is also an improvement in place, so is a continuation of the Par. 15.	The Magpie Creek area does include levees but also several other features. The previous section included solely recommendations for levees within the existing flood control system. The Magpie Creek levees and additional features are

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			not part of the existing system and therefore have been included in a separate section.
60	105	Consider this as Alternatives for increasing the level of protection but not for levee improvements. Suggest to consider it as a separate paragraph.	Again, this is a separate measure associated with levees outside the existing system and is therefore a separate section.
61	106	Should be Part 17	Again, this is a separate measure associated with levees outside the existing system and is therefore a separate section.
62	111	Was this coordinated with Vlad? Why is it different than the entire CF GRR study? It has to be the same seismicity, it is within the basin anyway. Who made this paragraph?	The seismic characterization was done in accordance with Vlad's guidance. The analyses is not different that the entire ARCF GRR study performed by George Hu. The diversion structure was deemed by be a significant structure with critical seismic design considerations and therefore a location specific seismic characterization was performed.
63	124	Indicate there is no improvement for this reach, therefore the same curve is with and without project conditions	Text revised.
64	125	Where is the curve for with project conditions? Do you have any improvement here? It looks like it needs improvement for seepage	No with project analyses was performed. First, this section was not utilized for economic analyses. Secondly, the deterministic analyses met criteria. The BTA was very sensitive to the input parameters and slightly more conservative than the FEM analyses. Instead a judgment call was made to recommend cutoff wall extents and depth based on coordination with DWR/AMEC on the ULE results using information that was not available to us at the time of analyses.
65	127	Why is this the same curve as with project condition? It does not look there is a need for an improvement. You indicate that a cut-off wall is recommended, this means	I believe the wrong results were presented here, the figure has been updated.

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		seepage may be an issue.	
66	129	You need somehow to explain why you do not have any improvements for stability particularly that the Prf is above 15% (which requires mitigations. Actually you may indicate that the high Prf is for water at the crest of the levee, for 3 feet below (design level) it is 0.	Agreed, text revised.
67	133	No erosion protection on this reach? If so, add a reduced curve	Apparently there is, the curve has been revised.
68	136	What do you want to say here?	Text revised.
69	139	Check the two sets. The stability without project condition is flat 0 and with project condition you have a risk up to 10%	I believe the wrong results were presented here, the figure has been updated.
70	139	You need to explain the R&U analysis for the Natomas existing conditions was provided in the NPACR. What you have here is strictly the R&U considering the approved NPACR, only for the additional levee raise. Otherwise it is not clear	Text was already included that described this.
71	139	What about reaches A and B	The report was updated with all the Natomas Curves
72	139	Check the pages, it shows Page 137 of 134?	Formatting changed.
73	149	I am not sure we include anymore the list of approved quarries in the specifications, so I believe you do not have to add it in the report either. Actually you do not add this list in the geotechnical report for the design phase either.	True, for consistency I prefer to keep it in. We provided soil borrow locations so rock locations seem appropriate.
74		Consider the NLIP project not being constructed, not part of the “without	Agreed, comment incorporated.

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		project" conditions, but consider NPACR approved for improvements to the exiting level of protection. I tried to chase down all references to the already constructed NLIP but I may miss some of them.	
75		I would recommend calling the probabilistic analyses Risk Base Analysis. It is strange you have it at the end, however it is explicable because you have included the with project curves. Normally it should be following the deterministic analysis, this actually was the reason for improvements.	While the existing/rescinded USACE guidance (EM/ETL) do reference the analyses as "Risk Based" the comments I have received in past ATR reviews have been technically correct that it is not risk based. The geotechnical analyses we perform is technically correct as probabilistic analyses that is used in hazard analyses. Risk analyses is technically not performed.
76		R&U curves: I recommend reducing the horizontal scale for each segment within the top to toe levee height to make the figures more readable.	I understand the figures are a little hard to read but, the R&U spreadsheet I developed has code that auto creates the x and y axis based on a standard scale for all points regardless of the levee height. That way all of the slopes of the lines in the graphs are equal representations. Reformatting would be significant effort and would no longer provide a standard scale for relative comparison between index points.
77		You should discuss the LSAC rating also as part of the Risk Based Analysis. The HQ is interested to have the rating done before the feasibility report. Showing that you have it done and it is already categorized by LSOG it will help the HQ for a better understanding and for an approval with fewer comments. The geotechnical engineering of this report was actually included in the LSAC. You may just summarize it and indicate the rating for each system. Tony may help you a lot, he did a great job for the LSAC.	Agree, comment incorporated. A section has been added at the end of the R&U section.

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78		Include a paragraph on access road along the levee on the landside, it is completely missing. Add as an enclosure the memo we sent to the HQ asking for the American River landside slope, vegetation issue and ROW and discuss why we don't touch American River landside vegetation and access.	This is a planning consideration, not a geotechnical one.
79		Separate the geotechnical fix in place levee improvement as an analyzed alternative (with subchapter for each basin) and the other 2 (widening the Sac Bypass and diversion structure) present them as separate alternatives not as geotechnical mitigation.	HQ has not given approval of the final array of alternatives. Therefore the alternative descriptions may change. I have chosen to describe alternatives and their geotechnical components so that planning can arrange them as necessary and in accordance with my technical recommendations. The widened Sacramento Weir and Bypass are not geotechnical mitigation, they are hydraulic improvements for increased system performance. I provided the geotechnical measures associated with this feature. The Diversion structure is a measure that addresses seepage, stability, erosion, and overtopping and requires its own set of geotechnical recommendations not associated with the existing flood control system.

QUALITY CONTROL CERTIFICATE FOR COST ENGINEERING PRODUCTS

Project Name: AMERICAN RIVER COMMON FEATURES - GRR
Project Manager: Dan Tibbitts

Technical Products: GRR documents
Actual Completion Date: 9/9/2015

PREPARER – I have prepared the above the products in accordance with Quality Management Plan.

Preparer: date:

REVIEWERS – I have reviewed the product noted above and find it to be in accordance with the Quality Management Plan meeting project requirements, standards of the profession and Corps of Engineers policies and standards.

Lead QC Reviewer: date:

Preparer – I have incorporated or resolved all review issues in accordance with the Quality Management Plan.

Preparer: date:

Resource Providers – I have reviewed and resolved all critical and technical issues. I agree that all project requirements and standards of the profession and Corps of Engineers policies and standards have been met.

Section Chief: date:

Branch Chief: date:

ARCF-GRR
Feasibility Study

EXTERNAL REVIEW

Document Under Review: ARCF-GRR MII Feasibility Cost Estimate

Backcheck Document:

ATTN:

	ADMIN USE ONLY	REVIEWER				RESPONDENT								
	COMMENT ID (DO NOT Edit this Column)	REVIEWER CONTACT INFO	LOCATION IN REPORT/DWG	DATE OF ORIGINAL REVIEW COMMENT MM/DD/YY	ORIGINAL REVIEW COMMENT	RESPONDENT CONTACT INFO	DATE OF RESPONSE MM/DD/YY	RESPONSE	CONCUR	NON-CONCUR	FIO	CARRY FORWARD	CLOSED Y / N	DATE OF BACK CHECK MM/DD/YY
	Date of Document under review and Sub info if appropriate (e.g., "BCI - Dated June 8, 2012")													
1	1	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Project Properties	5/21/2015	"General" tab - add phone number to contact information and possibly email address	Robert Vrchoticky (916) 557-7336, Robert.D.Vrchoticky@usace.army.mil	5/29/2015	Not enough characters can be input into the 'General' tab so notes have been added to the general 'Notes' tab, authored as POCs.	X				Y	6/19/2015
2	2	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Project Properties	5/21/2015	"Labor" tab - Please add more specific info on the rates used. DB rates indicate when they were updated.		5/29/2015	Added additional wording to Note - 'Labor Rates are per General Decision Number - CA140009 12/19/2014 CA9 State - California Construction Types - Building, Heavy (Heavy and Dredging), Highway Counties - Multiple (including Sacramento County) '	X			X	Y	6/19/2015
3	3	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Project Properties	5/21/2015	"Equipment" tab - current costbook being used. Prior to final ATR'd estimate, consider updating to most current fuel rates. Currently they look just a little high, however fuel is ver cycical and may be fine over the long run.		6/12/2015	Fuel Costs updated.	X				Y	6/19/2015
4	4	Joe Reynolds, (916) 557-7573,	Project Properties	5/21/2015	"Notes" tab - Scope is included.		5/29/2015	FIO			X		Y	6/19/2015
5	5	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Contractors Tab	5/21/2015	All bonds are below 1%. Consider making at least 1%.		5/29/2015	Bond Table 'Class B' typically appear to be low per DQC reviewer's previous conversation with Bid Agent (1-1.2% is more typical). Increased to 1.2%.	X				Y	6/19/2015
6	6	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Contractors Tab	5/21/2015	Profits generally 8.5% with a few at 10%. Consider getting Profits all up into the 10% range.		5/29/2015	Weights in Profit Weighted Guidelines increased to reflect profit around of just over 10%. Assumed relatively high values due to project size, complexity (confined area, utility crossings), construction duration (10 yr plus), and risk (e.g. unknown utilities).	X				Y	6/19/2015
7	7	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Project Items Tab	5/22/2015	Zero Quantity Check: You may want to put a note describing the use of "NULL ITEM" - ARS-Reach G/ Levees / Jet Grouting / Random Fill => Zero quantity, please verify this to be the case for this item.		5/29/2015	NULL ITEM' was previously used as a 'dummy' in order to express task duration only (not cost). In this case all those items were part of omitted folders. Deleting the omitte folder removed all 'NULL ITEMs' Quantity in Reach G corrected.	X				Y	6/19/2015
8	8	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach A	5/22/2015	Appears that time at CHP scales along HWY 80 have not been accounted for in haul cycle times. There are scales on both East bound and West bound directions. Any time Teichert-Cool Cave is used as a supplier, this will be the case.		5/29/2015	Added 7 minutes as average wait time at the scales for all trips to-from Teichert Cool Cave.	X				Y	6/19/2015
9	9	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach A	5/22/2015	Several staging areas appear that they will requuire removal of existing elements to be able to gain access to them. Along with this, estimate is also missing the repair of staging areas. Highlighted areas on GE indicate that there are areas that will require repair of gates, fences, grass areas.		6/4/2015	Estblishment and repair of staging area is considered to be part of JOOH costs. Locations identified on Google Earth are not per any design (were a rough guess by the Cost Engineer. Civil Designers have only indicated that about 1 acr per levee mile was needed for staging.		X			Y	6/19/2015
10	10	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach A	5/22/2015	In this reach there are numerous asphalt ramps that are between the top and top of levee that may need to be repaired at completion of project.		5/29/2015	Added costs for resurfacing ramps that appear from Google Earth to be asphalt. Also added costs for regrading, compaction, adding AB to AB ramps.	X				Y	6/19/2015
11	11	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach A	5/22/2015	haul assumptions indicate to midpoint of reach, but do not address how the trucks would make there way onto the levee in one location and off the levee in another. What is missing is the time lost in the various subreaches.		6/4/2015	Checked sensitivity. Determined Haul Routes to Access Pts of subreaches for several reaches. Using the average (not rounded down to the nearest 5 MPH) in the calculations. This resulted in an average increase of 0.14% in the construction costs. This is not considered significant.		X			Y	6/19/2015

12	12	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach A	5/22/2015	Project will require bicycle/pedestrian detours. Estimate does not address this hidden cost.		6/4/2015	No design has been done for this at this stage. Establishment of bicycle/pedestrian detours. Added a percentage cost of 0.5% to cover temporary access ramps, bicycle/pedestrian detours, etc. Folder added under Relocations.	X				Y	6/19/2015
13	13	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach B	5/22/2015	See comments 8, 9, 10, 11, 12		6/4/2015	(8) Added 7 minutes as average wait time at the scales for all trips to-from Teichert Cool Cave. (9) Estblishment and repair of staging area is considered to be part of JOOH costs. Locations identified on Google Earth are not per any design (were a rough guess by the Cost Engineer. Civil Designers have only indicated that about 1 acr per levee mile was needed for staging. (10) No ramps that appear to be available from Google Earth appear to be asphalt. Restablishing any gravel ramps should be a minimal cost and is considered at this time to be covered under mob/demob costs. (11) Checked sensitivity. Determined Haul Routes to Access Pts of subreaches for several reaches. Using the average (not rounded down to the nearest 5 MPH) in the calculations. This resulted in an average increase of 0.14% in the construction costs. This is not considered significant. (12) No design has been done for this at this stage. Establishment of bicycle/pedestrian detours. Added a percentage cost of 0.5% to cover temporary access ramps, bicycle/pedestrian detours, etc. Folder added under Relocations.					Y	6/19/2015
14	14	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach C	5/22/2015	See comments 8, 9, 10, 11, 12		6/4/2015	(8) Added 7 minutes as average wait time at the scales for all trips to-from Teichert Cool Cave. (9) Estblishment and repair of staging area is considered to be part of JOOH costs. Locations identified on Google Earth are not per any design (were a rough guess by the Cost Engineer. Civil Designers have only indicated that about 1 acr per levee mile was needed for staging. (10) Added costs for resurfacing ramps that appear from Google Earth to be asphalt. (11) Checked sensitivity. Determined Haul Routes to Access Pts of subreaches for several reaches. Using the average (not rounded down to the nearest 5 MPH) in the calculations. This resulted in an average increase of 0.14% in the construction costs. This is not considered significant. (12) No design has been done for this at this stage. Establishment of bicycle/pedestrian detours. Added a percentage cost of 0.5% to cover temporary access ramps, bicycle/pedestrian detours, etc. Folder added under Relocations.					Y	6/19/2015
15	15	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	See comments 8, 9, 10, 11, 12		6/4/2015	(8) Added 7 minutes as average wait time at the scales for all trips to-from Teichert Cool Cave. (9) Estblishment and repair of staging area is considered to be part of JOOH costs. Locations identified on Google Earth are not per any design (were a rough guess by the Cost Engineer. Civil Designers have only indicated that about 1 acr per levee mile was needed for staging. (10) Added costs for resurfacing ramps that appear from Google Earth to be asphalt. (11) Checked sensitivity. Determined Haul Routes to Access Pts of subreaches for several reaches. Using the average (not rounded down to the nearest 5 MPH) in the calculations. This resulted in an average increase of 0.14% in the construction costs. This is not considered significant. (12) No design has been done for this at this stage. Establishment of bicycle/pedestrian detours. Added a percentage cost of 0.5% to cover temporary access ramps, bicycle/pedestrian detours, etc. Folder added under Relocations.					Y	6/19/2015

16	16	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	You may have to get creative on the access. On the south end, you may need to move K-rail out of the way and restore at the end of every day.		6/4/2015	At the access point cited (existing K-rail along the road, 20 ft sections), there is an area over 100 ft6 wide where bicycles access the levee. There are about 4 small (6"-12" dia) existing trees that either must be removed, or k-rail removed and re-set each day. There are also two sidewalk access paths. Assumption is that the trees will be removed and replanted and sidewalk will be removed and replaced.	X				Y	6/19/2015
17	17	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	GE layer indicates that there are no seepage issues, but MII indicates installation of DSM, Excavator, and Jet grout in estimate. Also indicates degrade. Please verify quantities, and if needed and remove all related un-needed tasks. Looks as though nothing needed in Old Sac but possibly further south these tasks may be needed.		6/4/2015	Per the quantity takeoff provided by Civil Design, about cutoff wall is required south of about STA 125+00 (intersection of Front Street and Miller Park Circle) Jet grouting is required around two large RC Boxes. Note the shaded area from Google Earth relative to Seepage extends to about STA 96+00, but this is not correct. Civil has not provided an updated kmz file, QTO value and station is used. Quantities for cutoff walls and jet grouting remain unchanged.		X			Y	6/19/2015
18	18	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	Bank stabilization is estiamated using water side placement. Consider using waterside placement for sand filter as well.		6/4/2015	The quarry that the stone protection is expected to come from for waterside placement is not a supplier of bedding sand for the riprap. Sand would have to be hauled from the source to someplace along the river where it would be loaded on barge and then transported via barge for placement at the various slope/erosion protection sites.		X			Y	6/19/2015
19	19	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.a	MII - ARS - Reach D (alt 1)	5/22/2015	This reach indicates slurry wall needed and stationing indicated along top of levee where there is a rail line present. Estimate does not indicate R&R of RR Track.		6/3/2015	RR Track R & R added.	X				Y	6/19/2015
20	20	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	CL stationing appears to go into parking lot of hotel. There does not appear to be any tasks associated with removing & replacing asphalt, and any associated concrete repair.		6/4/2015	This appears to be in ARS E (~STA 239+00 to 247+00). This is not an area of Cutoff Wall placement, but WILL be part of the haul route. Haul Route surface repairs are included under Relocations.		X			Y	6/19/2015
21	21	Joe Reynolds, (916) 557-7573,	MII - ARS - Reach D (alt 1)	5/22/2015	Due to bike trail basically being the haul route, consider adding task to repair bike trail		6/4/2015	Similar to Cmt 12. Levee Access Asphalt Repairs have been added as part of relocations.	X				Y	6/19/2015
22	22	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	Does haul route include getting on levee at one point and getting off at another?		6/4/2015	Similar to Cmt 11. Haul Routes were typically determined using the average distance from the upstream/downstream access points and the midpoint of the reach. Checked sensitivity of this using apparent access points for reaches ARSA,B,C,D. Determined Haul Routes to Access Pts of individual subreaches for these reaches. Using the average (not rounded down to the nearest 5 MPH) in the calculations. This resulted in an average increase of 0.14% in the construction costs. This is not considered significant.		X			Y	6/19/2015
23	23	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach D (alt 1)	5/22/2015	Slurry wall is down center of bike trail which is currently paved but no asphalt replacement included in estimate for repair of this path. Haul route repair description does not appear to cover this item.		6/4/2015	No quantities were provided for this in the Civil Design QTO but it is quite evide from Google Earth. Bike Trail is from ~STA 145+00 to 216+00 and appears to be about 20' wide. Quantities for removal of bike trail, replacement of AC portion of bike trail, and bike trail striping have been added as Relocations. Quantities for ABC below bike trail are included in ABC for levee.	X				Y	6/19/2015
24	24	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach E	5/22/2015	Slurry wall is down center of bike trail which is currently paved but no asphalt replacement included in estimate for repair of this path. Haul route repair description does not appear to cover this item.		6/4/2015	No quantities were provided for this in the Civil Design QTO but it is quite evide from Google Earth. Bike Trail is from ~STA 247+00 to 250+00 (20' w) and ~STA 317+00 to 343+00 (12' w). Quantities for removal of bike trail, replacement of AC portion of bike trail, and bike trail striping have been added as Relocations. Quantities for ABC below bike trail are included in ABC for levee.	X				Y	6/19/2015
25	25	Joe Reynolds, (916) 557-7573,	MII - ARS - Reach F	5/22/2015	ABC notes not clear that it includes the topping on the levee.		6/4/2015	Titles for ABC changed to reflect ABC at levee crest and levee maintenance road	X				Y	6/19/2015

26	26	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach G	5/22/2015	Appears headwall might need to be built out into middle of access road to business on south end of this improvement		6/4/2015	Response from Civil Designer (James Elsberry) - I would think that we would be able to dowel and bolster up this wall where it currently stands. There may need to be some fill brought in to tie-off the extra 1-2 foot of raise through the parking lot, or as comment #27 alludes to, the temporary floodwall system may be altered to add another board or two. We shouldn't need to extend the current length because it would be past the beach levee. If levees were to overtop just downstream, the ARS basin would be isolated. See comment attachment #26-27 (pdf of Google Earth snapshot with comments).		X			Y	6/19/2015
27	27	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARS - Reach G	5/22/2015	Appears existing deplyoable temporary emergency headwall will need to be modified to account for headwall raise. (In GE it appears that there is a concrete band in the existing asphalt that has removable plates to install temp posts.		6/12/2015	Response from Civil Designer (James Elsberry) - I would think that we would be able to dowel and bolster up this wall where it currently stands. There may need to be some fill brought in to tie-off the extra 1-2 foot of raise through the parking lot, or as comment #27 alludes to, the temporary floodwall system may be altered to add another board or two. We shouldn't need to extend the current length because it would be past the beach levee. If levees were to overtop just downstream, the ARS basin would be isolated. See comment attachment #26-27 (pdf of Google Earth snapshot with comments). NOTE from Cost Engineer - This appears to be a stoplog structure. Rough costs have been added assuming a 2 ft added height.	X				Y	6/19/2015
28	28	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.a		5/26/2015	Remove RR ties & track: is missing all removal from site (trucking & disposal). Keep in mind that the rail weighs about 35#/lf and will be cut in ~ 40' lengths		6/5/2015	Added removal costs, assumed 18 TN loads	X				Y	6/19/2015
29	29	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	There are several areas along this reach that will require special care during construction. Design branch needs to give you information or assumptions of scope for these areas. See me if you have questions as to where. These areas are readily visiable on Google Earth		6/5/2015	Response from Civil Designer (James Elsberry) -pump sta at LM 9.91: I would say that this area would be analyzed futher in PED to determine whether or not slope stability is even a problem here. The access ramp provides additional width to levee and serves as a stability berm (to a degree) and therefore geotextile may not need to be applied here. A fix type 3B was proposed here, however, it may be suitable for jetgrout depending on whether or not service of this utility can be interrupted. -It's unlikely that the freeport bridge area would require slope stability measures, it's a very wide levee here. If stability was still a concern it would likely be applied on the east side of hwy 160, where the embankment slopes gently down into the golf course. -marina wall: assume removal of keystone wall, placement of geotextile, and slope back from existing into parking lot. The real estate costs will handle the damages for taking and relocating some of their parking. See comment attachment #29 (pdf of Google Earth snapshot with comments). Note from Cost Estimator - quantities for geotextile and slope back are assumed to be covered by the quantities per the QTO as these were developed from cross-section templates. Costs have been added for removing keystone wall and parking lot paving. From above, assumes keystone wall IS NOT replaced.	X				Y	6/19/2015
	30	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Levee Stripping, to Spoil: Does not appear to have dump fees included unless there is a reason not to include.		6/4/2015	Spoil site is assume to be the borrow site, but this is left up the contractor. Material should be similar to the degraded levee spoil.		X			Y	6/19/2015
	31	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Levee Excavation, to Stockpile (Degradation of Levee): Consider reviewing this reach. Not all areas will allow this type of operation		6/5/2015	Turning on Terrain in Google Earth and taking measurements at what appears to be levee hinge points shows the typical top width of the leveee, even when RR present on 20 ft. This should be adquate to allow the levee degrade operation assumed.		X			Y	6/19/2015

32	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	Levee Excavation, to Spoil (Degradation of Levee)	5/22/2015	comment is the same as 31		6/5/2015	Turning on Terrain in Google Earth and taking measurements at what appears to be levee hinge points shows the typical top width of the leveee, even when RR present on 20 ft. This should be adquate to allow the levee degrade operation assumed.		X			Y	6/19/2015
33	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach A	5/22/2015	I'm assuming that Engineering gave you the quantity assumptions used in the estimate. From out conversations, it appears the same section used for American River is the same as that used for Sacramento River, they typically have little in the way of "fixes". See comment 35.		6/5/2015	Per the Civil Designer (James Elsberry) Yes, we did use the same 'bank' or 'no bank' section for both sides depending on the existing condition. The thought process here was that even if we made more cross section details for estimates, we still would be adapting the design to provide the same amount of launchable rock quantity (to address scour and erosion). In early estimates, we did have more cross sections and found that the quantities did not change significantly. Therfore, at the time we reduced the effort to a typical section since rock is the major cost driver for erosion protection fix, and the quantities would be designed very similarly.			X		Y	6/19/2015
34	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach B	5/22/2015	Fish monitoring included in "Fish & Wildlife mitigation", However there will be no inwater work in this reach. Is this item needed?		6/12/2015	Per the Environmental Planner (Anne Baker), The fish monitoring is for Green Sturgeon – critical habitat for Green Sturgeon goes to the Highway 160 Bridge on the American River, and all of the Sacramento River reaches. The monitoring would be mitigation efforts for effects we have on Green Sturgeon. The geographic extent of where we would be monitoring has not been determined yet – it is still being sorted out through our ESA consultation. But the likelihood is that we may have monitoring activities occurring anywhere that is critical habitat for green sturgeon in the study area. Additionally, we are assuming that we are having in water work on both rivers. It is only the reaches where we do launchable trench where there would be no in-water impacts. Removing the line item from Reaches B and C on the American River is reasonable, but make sure to maintain the same total for the fish monitoring effort, because that was based off of the efforts on SacBank. NOTE: Fish Monitoring removed from this reach. Per the requirement of the Environmental Planner, spread between other reaches on American River.	X				Y	6/19/2015
35	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Most if not all of the Fish and Wildlife Facilities work would be appropriate if the levee touched water, but the project levees in this reach do not normally touch unless the storm flows breach the normal river banks and actually get to the levees which are significantly away from the banks.		6/5/2015	Per the Civil Designer (James Elsberry) - We do have erosion protection work in Reach B, but not a lot (1000').		X			Y	6/19/2015
36	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach C	5/22/2015	See comment 35		6/5/2015	Fish and Wildlife Mitigation for Reach C is mitigation for vegetation removal, not fish monitoring.		X			Y	6/19/2015
37	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Hydroseed application time appears low. What does "Prep time" consist of? Does the .5 acr/hr include the double placement? Rough SWAG would hav been ~$4k/acre which includes mob/demob of crew/equip.		6/12/2015	Changed method of calculating these costs to using Cost Book assuming costs similar to seeding with field mix. This gave aunit costs of $4350/ACR.	X				Y	6/19/2015
38	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Levees and Floodwalls (Sta 39+50 to 52+00; cutoff wall): Estimate appears to be missing replacement of existing AC at top of existing levee.		6/5/2015	Levee is NOT topped with AC in this area (ABC only)		X			Y	6/19/2015
39	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Base rock placement looks short time wise. It is only 727 tn, but the thickness is thin, width is short and length is long. Consider 2 day min.		6/5/2015	Combined tonnage of ABC for the reach is actually 859+727=1586 TN. Total time for placement is 18 days calculated, 20 if productivity is factored in. Length is less than a mile combined. UC is almost $80/ton		X			Y	6/19/2015
40	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	CL stripe at (E) bike path		6/5/2015	Levee is NOT topped with AC in this area (ABC only)		X			Y	6/19/2015

41	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	It appears that levee improvements from station 49+50 to 65+00 may have been built already or are in final design stage. Please verify that this reach is needed in this project and can be removed from this project.		6/12/2015	Per Civil Designer (James Elsberry) The quantities under the feasibility folder <\\amethyst\civcad_2\AmerRiv\CommonFeaturesGRR\Civil\Feasibility Quantities\Alt 1\ARN> have accounted for the WRDA99 NEMDC North project. See comment attachment #41 for approximate clearances at the Arden Garden Connector Bridge in ARN Reach C. Suggest estimating the jet grout portion as 80' long x 80' deep = 6400SF. NOTE from Cost Engineer: Replaced 6400 SF of DSM Wall with Jet Grouting.	X				Y	6/19/2015
42	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach D	5/22/2015	Estimate missing removal of existing floodwall from ~sta. 68+00 to 110+00		6/12/2015	per Civil Designer (James Elsberry)Correct, originally we were just bolstering the existing wall along Arcade Creek because we did not have seepage improvements. However, the current geotech appendix has seepage/stability improvements for the whole length of Arcade reaches. Therefore, we cannot build the cutoff wall without the demo of existing floodwall and subsequent rebuild of a new larger floodwall. Reach F and G do not have existing floodwall. NOTE from Cost Engineer - Demo/Removal of existing concrete floodwall has been added to ARN, Reaches D and E	X				Y	6/19/2015
43	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Has additional time been added to production for crossing the major streets in this section? (Rio Linda Blvd, bike path, Norwood)		6/12/2015	Production Rate has been reduced for the crossings of major streets		X			Y	6/19/2015
44	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Repair of existing asphalt & concrete at the road crossings?		6/12/2015	Costs have been added for resurfacing AC and concrete at road crossings for Reaches ARSA, ARND and ARNE.	X				Y	6/19/2015
45	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	There are several storm drain closure valves along this reach. I do not see where the pipes are dealt with in any manner. Is there anything that needs to be done with these" (83+00 is in estimate, structures at 93+00, 102+50, 106+00 not in estimate)		6/12/2015	Excavation, removal and replacement of pipe added to estimate. Per the Relocation Inventory for Reach D, these stormdrains have existing positive closure structures. (Assumed Util Fix 3A, sans positive closure structure).	X				Y	6/19/2015
46	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach E	5/22/2015	From station 70+00 to 110+75 (~4075 lf), there appears to be a concrete flood wall. Estimate includes the construction of 4400 lf of floodwall. Is estimate appears to be missing the removal of this wall for the degrade of the new slurry wall.		6/12/2015	per Civil Designer (James Elsberry)Correct, originally we were just bolstering the existing wall along Arcade Creek because we did not have seepage improvements. However, the current geotech appendix has seepage/stability improvements for the whole length of Arcade reaches. Therefore, we cannot build the cutoff wall without the demo of existing floodwall and subsequent rebuild of a new larger floodwall. Reach F and G do not have existing floodwall. NOTE from Cost Engineer - Demo/Removal of existing concrete floodwall has been added to ARN, Reaches D and E	X				Y	6/19/2015
47	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Between stations 70+00 to 100+00, there appear to be several SD vaults with cooresponding outfalls shown on GE. Estimate does not indicate any relocations within these stations. Are these missing from the estimate/relocations list?		6/12/2015	Excavation, removal and replacement of pipe added to estimate. Per the Relocation Inventory for Reach D, these stormdrains have existing positive closure structures. (Assumed Util Fix 3A, sans positive closure structure).	X				Y	6/19/2015
48	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Please review fiber roll cost. $8/lf direct cost looks high. Maybe look at CalTrans for comparison		6/5/2015	Per CalTrans Historic Costs, this number shoud probably be more in the $4-$5/LF contract cost. Change made typically reflects $3.50/LF sub bid, $4.59/LF contract cost.	X				Y	6/19/2015
49	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Silt Fence Install: Consider adding riding trencher to help production of installation of fence.		6/5/2015	Per CalTrans Historic Costs, this number shoud probably be more in the $4-$4.50/LF contract cost. Adding trencher and bumping production to 120 LF/HR gives a contract cost of about $4.22/LF.	X				Y	6/19/2015
50	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach F	5/22/2015	Review this reach with engineer. More effort shold be done on the portion of wall that goes underneath I-80 bridge. Can excavator method or DSM physically be used or will jet grout be required?		6/5/2015	Discussed with Civil Designer, changed estimate to reflect jet grouting instead of DSM under bridge. Length of wall under I-80 would be ~145' at 80' depth = 116,000SF.	X				Y	6/19/2015

51	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		5/22/2015	Please review the haul costs associated with this reach. Access is limited due to RR and crossing points are beyond the reach limits		6/8/2015	Haul Costs revised to reflect longer access. Length of haul along levee increased to reflect 3.8 MI of levee.	X				Y	6/19/2015
52	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach G	5/22/2015	There is a power line at 25+50. How does this effect construction efforts?		6/8/2015	Power line will not affect construction efforts in this reach. Work is from Sta ~93+00 to 117+25	X				Y	6/19/2015
53	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach H	5/22/2015	No work, no comments		6/8/2015	FIO			X		Y	6/19/2015
54	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	MII - ARN - Reach I	5/22/2015	Box culverts mentioned in estimate, where is it being constructed?		6/8/2015	This quantity comes from the Magpie Creek CAP study quantities (basis for the work done in Reach I). The box culverts will actually be constructed in Reach G, where there is a bike trail that parallels Rose St and crosses the levee. There is a bike trail bridge over the Magpie Creek channel just North of the levee (between ARN-G Sta 90+00 to 95+00). The culverts will be built roughly adjacent to the bridge.			X		Y	6/19/2015
55	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	ARCF_GRR_SBW-Extend_Bridge (Alt2) MIIv4.2 141020	6/3/2015	Quantity of rail material is incorrect. 100 #'s is the correct weight per yrd (3 ft). Actual weight required is 33.3 #'s/lf = 106,560 #'s		6/8/2015	Weight revised to reflect 100 LB/YD (33.33 LB/LF) NOTE: # of ties revised to reflect 19.5" spacing	X				Y	6/19/2015
56	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil		6/3/2015	Verify quantities of tie plates, spikes. Quantities not making sense when comparing with Excel quantity sheet		6/8/2015	Revised quantities to reflect 2 tie plates per tie and 4 spikes per tie plate	X				Y	6/19/2015
57	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	TPCS form Alternate 1.	6/3/2015	Verify mid-points of construction. See spreadsheet that calculates midpoints. Keep in mind that the formulas are written to start at beginning of "Pre-construction" and end at the last task. Some of these are by construction season. Check not done on Alt2 but presume similar issue.		6/8/2015	Mid-points of construction will be verified from SS after final MII estimate completed.	X				Y	6/19/2015
58	Joe Reynolds, (916) 557-7573, Joe.L.Reynolds@usace.army.mil	TPCS form	6/3/2015	All numbers have not been reviewed and will be reviewed at a later time prior to Cost Cert. This will be an itterative process and will need to be looked at again.		6/8/2015	FIO			X		Y	6/19/2015
59	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil	Total Project Schedule	6/1/2015	Default Calendar for design is 5 day per week which provides a conservative timeframe at this stage of development	Robert Vrchoticky (916) 557-7336, Robert.D.Vrchoticky@usace.army.mil	6/3/2015	FIO			X		Y	6/19/2015
60	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	Plant Maintenance is an important feature of the schedule, but the roll up calendar does not break out this information in a clear manner. Construction is complete in Sept 2028; however, plant maintenance extends the overall duration out to Jan 2031. Consider grouping "Plant Maintenance" as a Maintenance group instead of including with construction in order to better convey the split in total time between construction and plant maintenance.		6/18/2015	Plantings 'Maintenance' (Establishment) has been split from Construction	X				y	6/19/2015
61	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	Task 3 "Collect field explorations" does not have a predesessor activity, but has a start constraint assigned for October 2017. Please confirm this is the intended start of the activity and consider removing the constraint if possible.		6/18/2015	Constraint removed. Start Date entere into Project Information	X				y	6/19/2015
62	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	Task 473 "Vault Foundation" does not have a predesessor activity		6/18/2015	Task has been given a predecessor activity	X				y	6/19/2015
63	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	Task 709 "Levee Excavation" does not have a predesessor activity		6/18/2015	Task has been given a predecessor activity	X				y	6/19/2015
64	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	There are 317 tasks without successor activities. Without proper assignments, it can be impossible to reflect a true critical path or understanding of the project		6/18/2015	All tasks have been given a successor activity	X				y	6/19/2015

65	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	The level of detail regarding construction and utility relocations is very detailed and appears to be very thourough for this stage of design		6/3/2015	FIO			X		y	6/19/2015
66	Cameron Sessions, (916) 557-7896, Cameron.L.Sessions@usace.army.mil		6/1/2015	Durations: There are 225 activitys with a duration of 5hrs - at the feasibility stage it is not normally recommended to have durations of less than 1 day. No need to revise, but please note for future estimates/schedules.		6/3/2015	FIO			X		y	6/19/2015

REVIEWER
BACK CHECK COMMENT (Needed Only If NOT Closing Comment)
Item will need to be updated to latest labor rates before you/we finalize TPCS prior to certification. Okay for now.

USACE District Quality Control / Quality Assurance

Project: American River Watershed Common Features, General Re-Evaluation Report (ARCF GRR)
Submittal: Attachment E, Erosion Protection Report
Section: Hydraulic Design Section (CESPK-ED-HD)

Hydraulic Design Documentation and Products reviewed:

1. Document, American River Watershed Common Features, General Re-Evaluation Report, Erosion Protection Report, Draft Version, Dated January 23, 2014

File Location:
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Limitations of Review:

The review is limited to the document which is a summary of existing documents, analysis, models, and data. The review does not include review of the referenced documents, analysis, models, or data. The review of these was conducted separately.

(1) Designers: We have prepared the above products in accordance with the Quality Control Plans meeting project requirements, standards of the profession and US Army Corps of Engineers policy, essential engineering guidelines and standards. All comments resulting from DQC review have been entered into DrChecks and resolved.

_____ 2/11/2014
Todd Rivas, P.E., Senior Hydraulic Engineer, CESPK-ED-HD Date

_____ 2/11/2014
Scott Stonestreet, P.E., Senior Hydraulic Engineer, CESPK-ED-HD Date

(2) DQC Reviewer: I have reviewed the above products and find them to be in accordance with the Quality Control Plans. This includes review of assumptions, methods, procedures, and material used in analyses, alternatives evaluated, the appropriateness of data used and level obtained, and reasonableness of the results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. All comments have been entered into DrChecks and resolved to my satisfaction.

_____ 2/11/2014
Ethan Thompson, P.E., Senior Hydraulic Engineer, CESPK-ED-HD Date

(3) QA Reviewer: I have performed Quality Assurance review of the above products and confirm that all critical and technical issues resulting from DQC/QA review have been addressed. All DQC comments and responses are loaded into DR Checks under Project ID: "*149827 GRR*", Project Name: "ARCF - General Reevaluation Report (GRR), TSP & Attachments, American River Common Features (ARCF)," Review Name: "*DQC Erosion Attachment*".

_____ 2/11/2014
Jesse Schlunegger, P.E., Acting Chief, Hydraulic Analysis Section, CESPK-ED-HA Date

_____ 2/11/2014
Greg Kukas, P.E., Chief, Hydrology and Hydraulic Branch, CESPK-ED-H Date

Public / SBU / FOUO

Comment Report: All Comments
Project: ARCF - General Reevaluation Report (GRR), TSP & Attachments, American River Common Features (ARCF), California (P2 #149827)
Review: DQC Erosion Attachment (23-29 Jan 2014)
Displaying 96 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
5501895	Civil	n/a	Page 22	n/a

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

Page 22, 3rd paragraph, second to last sentence, change "regarding" to "regrading".

Submitted By: Markus Boedtker ((916) 557-6637). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**
Thanks. Text has been changed to "re-grading".

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Markus Boedtker ((916) 557-6637) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5501899	Civil	n/a	Page 58	n/a

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

Page 58, paragraph 6.2, it should be recommended that the most recent Sac Bank designs should be used as the template for the bank protection design, due to this being the most recently coordinated design that does not require additional mitigation, other than the instream woody material, willow pole cuttings, and soil-filled quarry stone with various native plants and trees planted on the entire slope.

Submitted By: Markus Boedtker ((916) 557-6637). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**
The current design concept was developed with PDT input including geotechnical design and environmental planning. It has been analyzed and described within the EIS and any additional mitigation has been assessed (and costs added).

It is agreed that this design should be analyzed further in PED to determine if there's a more effective design but the current design should provide adequate costs for alternative selection.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Markus Boedtker ((916) 557-6637) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5501904	Civil	Figure 6-1	n/a	n/a

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

Figure 6-1 should be changed to the most recent Sac Bank design showing in-stream woody material, soil-filled quarry stone, and native trees and shrub plantings along the entire slope. This design is the only one that does not require additional mitigation outside of the bank protection work.

Submitted By: Markus Boedtker ((916) 557-6637). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**
The current design was developed with input from the PDT including geotechnical design and environmental planning. This design has been determined to be adequate to develop costs for alternative selection. For feasibility design, the PDT will need to either refine or revisit the design to determine if it is effective in setting costs for PED. Additional design effort or cost and schedule risk analysis will be performed to ensure costs are adequate for PED.

In PED, the final design will be determined based on additional analysis and coordination with environmental planning, geotechnical design, levee safety, and others.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Markus Boedtker ((916) 557-6637) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5502007	Civil	n/a	General Comment	n/a

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

This report is actually confusing. The report is the erosion attachment of the Common Features GRR and therefore it should evaluate the erosion and the necessary erosion protection for all channels considered in the American River Basins (north and south). It should describe in the same manner all channels such as Sacramento River north and south of the American River, American River, Natomas Cross Canal, NEMDC, Arcade and Dry Creek, eventually Pleasant Grove Creek if considered necessary. The erosion on the American River was detailed studied at the request of an expert elicitation team. Therefore there were additional subsurface investigations performed in the

riverbanks and riverbed to evaluate the erosion conditions of the soils. The results of this additional study should be included as a separate enclosure to this report and only the conclusion of the study and the proposed remediation actions should be described in the main erosion appendix. As the report is structured it goes back and front from detailed analyses and descriptions (for American Rover) to poor or lack of description, or even wrong description, of the conditions of the other channel.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Intro section text has been revised to clarify how erosion was handled on each reach for the study. Some reaches were handled as part of the Natomas PAC, and other small reaches were assumed to need minimal additional erosion analysis that will be deferred to PED.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502023	Civil	1.3 BAckground	n/a	n/a

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

Since this is the erosion report for the entire project area this figure should show also the Natomas Cross Canal and the levees on the Arcade and Dry Creek and the other tributaries discussed in the text. If these tributaries have no impact it should not even be mentioned in the text (i.e. Feather River is also a tributary and is not included). Also each channel name should be shown on the figure not only the American River and Sacramento River. This report will go to ATR outside the district which don't really know where these channels are located.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Intro section text has been revised to clarify how erosion was handled on each reach for the study. Some reaches were handled as part of the Natomas PAC, and other small reaches were assumed to need minimal additional erosion analysis that will be deffered to PED.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5502024 Civil 1.3 & 1.4 Background n/a n/a

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

The background description of the Natomas Cross Canal, NEMDC, Arcade and Dry Creeks should also be included

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Intro section text has been revised to clarify how erosion was handled on each reach for the study. Some reaches were handled as part of the Natomas PAC, and other small reaches were assumed to need minimal additional erosion analysis that will be deffered to PED.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502026 Civil 1.3 Background n/a n/a

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

The study done by AYRES in 20032 is complex and should be also used and listed in the references.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**

I am not aware of an Ayres report dated 2002; however, section 1.7.1.4 of the erosion report summarizes the 2-D analysis Ayres conducted which computed 2-D velocities and shears for a range of large steady-state discharges (Lower American River, Erosion Susceptibility Analysis for Infrequent Flood Events" dated July 2004 by Ayres Associates). Furthermore examples of the results from this investigation are presented in Section 4.2.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502029 Civil 1.3 Background n/a n/a

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

This is the erosion report for the entire American River Basin which includes the north and south basins with the tributaries and also Sacramento River. The report should clearly justify why the additional investigation was performed only in the American River riverbad and not also on Sacramento River, particularly that there is a known extremely deep (about 80 feet) scour in the Sacramento River close to the confluence with the American River.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

The erosion report is for the American River Common Features GRR. Text has been added to clarify how erosion conditions were addressed for each of the reaches in the study. The Sacramento River below the confluence does have an assessment of the erosion conditions in this report.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502086	Civil	1.4 Background	n/a	n/a

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

The title Middle Reach – Verona to Sacramento, it does not really make sense. Is this the City of Sacramento or only on Natomas? It should be described probably as Verona to American River confluence. Same to the next reach of the Sacramento it should be described as Confluence with the American River to Freeport eventually. Just River Miles are not sufficient to describe the reach. Show these reaches also on Figure 1-2

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

This text has been revised to remove the "middle" terminology and include more description of the reach.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502091	Civil	1.4 Background	n/a	n/a

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

As a general comment, the report is mostly an HH report but also it is related to levees. Therefore, it would be nice to have also the levee unit and levee mile shown in parentheses, since this is the unit shown on the O&M manuals

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

I concur that it would be "nice" to include a lot of the detailed mapping and other supporting information in th erosion report. However, inclusion of this information could require a lot of effort (which isn't readily available) and as stated in the comment, it is already available in the O&M manuals should this information be required. I am not sure how providing this detailed information would add to the discussions present in the document. The levee units and/or levee stationing is not referenced anywhere within the document.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502150	Civil	1.4 Background	n/a	n/a

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

Sacramento River South. There is a scour hole (stable in the last years) about 80 feet deep in the Sacramento River south of the American River. Even if the location of the channel did not move the last 150 years there are scours that should be considered and riverbank and levee erosions during high flood events that should be considered.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Clarified that even though the channel has not changed location much in 150 years, that local scour and erosion issues can still develop. Here is the language:

"The location of the channel has been relatively stable for the past 150 years although local scour and erosion can still be an issue."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502151	Civil	1.4	n/a	n/a

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

The description of the two reaches is wrong. The riverbanks are more used by the public on the Sacramento River north reach where there are houses and restaurants constructed on the waterside of the levees plus numerous docs. Both levees on the middle and south reaches are constructed of sand. What is typical on the middle reach closer to the American River is the fill placed on the riverbank against the levee and the numerous structures (residence and commercials) constructed on the fill. The south reach has no structures on the waterside of the levee but heavy vegetation, boat docks and indeed boating activity. Show a picture on the middle reach with boats and houses on it since this is the typical there. Indicate also the south reach has rock protection on the majority of the reach but there are places where the rock is missing.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Check and Resolve**

This section can be re-worded. Below is how this was done. The main changes are noting the waterside structures in the middle reach, noting that the middle reach is also constructed in the same manner as the south reach, and clarifying the general public foot access along the south reach contributes to levee and bank erosion while the waterside private residences of the middle reach limits the public access along the levee and banks.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

2-0 Evaluation **Check and Resolve**

I believe the word "middle" was either removed or clarified and discussed in the revised text. This revised text should be available soon (maybe by close of business today).

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

Backcheck not conducted

Current Comment Status: **Comment Closed**

5502154	Civil	1.4	n/a	n/a

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

Background description of the other channels (NCC, NEMDC, Arcade and Dry Creek) is missing. A brief description of these channels should be included, at least to justify why there is no analyses done and no protection recommended.missing

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**
Please refer to Section 1.3, paragraph 3, exclusion of these tributaries from this report (including the rational for doing so) is discussed therein.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5502156 Civil Figure 1-4 n/a n/a

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

Add (or replace this one)a picture of the Middle Sacramento River showing the fill on the waterside and the constructions on the fill.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**
Replaced with aerial photo showing the waterside fill with houses on top of the fill.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5502160 Civil Par. 1.5.1 n/a n/a

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

Was the discharge in 1986 130,000 or 134,000 cfs?

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**
Verified with Marcia Bond that the peak release from Folsom Dam was 130,000 cfs from report put together immediately after the event. Verified this by looking at actual gage records, too. Other gages downstream may have recorded higher discharges due to additional inflows and this may be where some people think of the peak flow in the LAR as 134,000 cfs. But the peak discharge from Folsom Dam was 130,000 cfs.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5502161 Civil Par. 1.5.1 n/a n/a

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

I believe significant erosions occurred also after the 2006 flood event.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**
Added language to clarify:

"In addition, erosion also occurred during a flood event in 2006."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5502167 Civil Par. 1.5.2 n/a n/a

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

It is important to describe more the bypass system and when it was constructed. This study will be reviewed by ATR and others outside the district and it is important for them to understand the bypass system and how it works.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**
The erosion report focuses on the segments of the lower American River and the Sacramento River in the study area. The report is an attachment to the Engineering Appendix which supports the GRR documentation. Those reports should provide an adequate description of the overall flood control system without the erosion report having to duplicate that information.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502172	Civil	Par. 1.5.2	n/a	n/a

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

The subparagraph describing how the levees were constructed is wrong. Levees on the Sacramento River north and south of the American River, considered as part of this study were all constructed in the same manner, of dredged material from the river, and therefore these levees have the same consistency of fine uniform sand extremely erodible. The difference is the fill placed on the riverside berm north of the American River where all these buildings were constructed.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

The paragraph was written to only describe the construction of the Sacramento River levees south of the American River confluence. The comment describes the method used in construction of the Sacramento River levee north of the American River. The text has been revised to describe the construction of the Sacramento River levees both norht and south of the American River confluence. The levees on the Sacramento River in Natomas were constructed with trainer dikes using excavated material from the center of the levee by dragline. The core was then filled using hydraulic dredges placing fine sand. There is no information which shows this was the case on the Sacramento River leves south of the American River. Instead the best information availble indicates the levees were constructed with clamshell dredges placing material on the channel bank to enlarge the original levee constructed in the mid 1800's.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5502182	Civil	Fig. 1-8	n/a	n/a

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

The Figure 1-8 represents flood fighting of seepage and slope instability of the levee and has nothing in common with erosion. Remove and replace it with an erosion picture but not with a seepage and slope stability issues picture

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Photo deleted. The intent was to show levee performance during a flood on the Sacramento River regardless of failure mode and this photo was available. However, it can be confusing to have a seepage/slope stability photo in a document focusing on erosion and therefore is deleted.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502195 Civil Par. 1.5.2 n/a n/a

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

The conclusion of the paragraph contradicts the paragraph 1.4 -Background, that indicated that the erosion on the Sacramento River is mostly due to waves created by boating and public activity

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Check and Resolve**
Section 1.4 concludes by stating:

"The causes of erosion in this reach are boat wake, wind-wave, mass failure, fluvial processes, and public use."

Section 1.5.2 states by stating:

"Since the completion of the Sacramento River Flood Control Project, significant floods have caused considerable erosion related damage to the levee system."

Erosion during floods occurs by fluvial process and it therefore appears to be consistent with section 1.4 where fluvial processes is mentioned as one of the erosion mechanisms.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

2-0 Evaluation **Check and Resolve**
Fluvial processes (section 1.4) = erosion by floods (section 1.5.2. So I believe they are consistent. Is there some specific language that you want changed?

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

Backcheck not conducted

Current Comment Status: **Comment Closed**

5502206 Civil Par. 1.6 n/a n/a

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

Even if there were no significant erosion observed at locations with concrete rubble on the slope, concrete rubble is not recommended for slope protection. It may hide undetected rodent holes or erosions underneath the concrete, there is no bedding or filter material between the rubble and the levee and also there is no correct rock size distribution. The only restriction in the past was that there should not be any R-bars sticking out of the rubble for safety of boating and other public activity.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**

Agree. The erosion report is only reporting observations of conditions from monitoring and is not endorsing use of concrete rubble.

Text changed to clarify:

"These sites reportedly have concrete rubble (does not meet USCAC standards) on the bank and at the toe that is in poor condition; no significant changes in condition have been observed between annual inspections."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5502211	Civil	Par. 1.6	n/a	n/a

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

The title should not be DWR but CVFPB

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Thank you. The text will be corrected.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502619	Civil	Par. 1.7.1.1	n/a	n/a

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

Somehow erosion of the riverbed and riverbanks has been mixed with seepage and stability. I agree erosion has an impact on seepage or piping and on the stability and this may need to be more detailed discusses (such as shortening the seepage path, undermining the levee foundation leading to slope failure and so on). But as it is explained and related to scouring and exposure of bridge footing it does not make sense.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Check and Resolve**

Paragraph 1.7.1.1 is a summary of a relatively comprehensive geomorphic analysis. It includes mutliple different observations and recommendations. One observation is that degradation could undermine levee foundations. Another observation is that seepage and piping may be more of an issue than erosion. However, it does not link the seepage and piping to scouring and exposure of bridge footings.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

2-0 Evaluation **Check and Resolve**

The following was deleted per recommendation by Mike:

"The report concludes that bank erosion is less of a problem as compared to seepage or piping although the report cites specific locations where erosion protection is needed."

The only place where the term "seepage" is now used in this section is:

"It is important to note that at the time this report was written, many of the seepage and stability mitigation features had not been constructed along the LAR."

This last sentence is important to keep so that the reader is aware of the time context of the statements and recommendations made by the report.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

Backcheck not conducted

Current Comment Status: **Comment Closed**

5502621	Civil	Par. 1.7.1.4	n/a	n/a

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

What was the reason of the selection of the flow of 145,000 cfs?

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

This section of the document is a summary of work already performed. At one time, this flow was one of the design flows for additional work at Folsom (the enlarged outlets that were then changed to a Spillway).

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502622	Civil	Par. 1.7.1.	n/a	n/a

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

Why is Ayres study done in 2002 for USACE not included. It has important information on shear stresses and velocities associated with different discharges.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**

I am not aware of an Ayres report dated 2002; however, section 1.7.1.4 of the erosion report summarizes the 2-D analysis Ayres conducted which computed 2-D velocities and shears for a range of large steady-state discharges (Lower American River, Erosion Susceptibility Analysis for Infrequent Flood Events" dated July 2004 by Ayres Associates). Furthermore examples of the results from this investigation are presented in Section 4.2.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502624	Civil	Par. 1.7.1..5	n/a	n/a

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

What is the frequency associated with 160,000 cfs and why was this the analyzed discharge?

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

This section of the document is a summary of work already performed. The flow of 160,000 cfs was chosen because that is the design flow of the Joint Federal Project Spillway. The flow of 160,000 cfs is approximately a 200-yr outflow from Folsom and this frequency will be re-evaluated by the Folsom Water Control Manual Update.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502661	Civil	Par. 1.8.1	n/a	n/a

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

Indicate what bench and levee, rich or left bank. Also indicate between what RM the investigation was done.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Check and Resolve**

The erosion attachment was intended as a summary of the erosion study performed as part of the ARCF GRR and as such several details of the study have not been included in the text of the report. We chose not to include a table of explorations as this was considered not a summary item but instead data included in one of the many reference reports.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5502663	Civil	Par. 1.8.2	n/a	n/a

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

Were the JET tests performed on samples collected from the riverbed or river banks?

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

Revised Jan 28 2014.

1-0 Evaluation **Concurred**
The erosion rate tests were performed on samples from both banks and from the riverbed.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5502677	Civil	Par. 2.	n/a	n/a

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

Concrete cobbles should be considered as inadequate for slope protection. The voids in the cobbles may be used for rodent animals also there is no bedding material between the cobbles and the levee embankment or riverbank and the erodible fine material may migrate into the voids in the cobble. Also these cobbles may hide defects in the levee slopes such as internal erosions, slope failures, rodent holes and other

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **For Information Only**
Agree. This document is reporting observed conditions from the field and is not advocating or even suggesting that concrete rubble is appropriate for slope protection.

Added a clarifying sentence at the end of the first paragrah in section 2:

"As shown in Figure 6-3, the tentatively selected plan is to replace the historic revetment (e.g. cobble) with modern revetment to protect the banks from anticipated future flows."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5502680	Civil	Par. 2	n/a	n/a

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

Par. 2. All the repairs shown on the figures 2-2 to 2-7 show riprap placed 1-2 feet above the water line, when the water was at a pretty low elevation. Is the riprap covered by brush and grass or it is only on a short height of the slope? Is this riprap considered adequate?

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

Revised Jan 28 2014.

1-0 Evaluation **For Information Only**

A channel stability analysis (Ayres Associates, 2010) was used to determine areas requiring revetment with the assumption that all areas without modern revetment will be protected. Modern protection was determined by areas defined as rock riprap with overall condition of good or very good.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5502689	Civil	Par. 3.1 & 3.2	n/a	n/a

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

Are the par. 3.1 and 3.2 not related only to the American River? If so say that in the title.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 28 2014

1-0 Evaluation **Concurred**

Titles for these two sections have been modified as follows:

3.1 Geologic and Geomorphic Mapping and Analyses of the Lower American River

3.2 3-Dimensional Stratigraphic Model of the Lower American River

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503129	Civil	Par. 4,3	n/a	n/a

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

The threshold analyses is currently ongoing but there are results are not yet available. This project si going on for more than 5 years. If something is not yet ready to be published I believe t would be better not to mention it at all. The report should be complete at this phase not with gaps.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Section 4.3 has been deleted as suggested. However, this is used as an example of ongoing work to be completed in the future to address observations and recommendations from the expert panels (section 1.7.2.3, last sentence has been added so it now reads: "The District envisions that, as appropriate, the remaining work efforts will be addressed in future studies. For example, there is currently an ongoing channel widening threshold analysis to support changing operations at Folsom Dam."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503155	Civil	Par. 5.1, Fig. 5-1 & 5-2	n/a	n/a

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

Were the studies by NHC in 2009 and 2012 not done as a contract with USACE? In this case,. Why the channel degradation in Fig, 5-1 and 5-2 are in meters?

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**

Figure 5-1 and 5-2 originally started in another (non-USACE and non-NHC related) document that was in meters. NHC plotted new data on top of this borrowed figure for illustration purposes and did not atttempt to find the original data supporting the original work effort and convert it to feet for NHC's report to USACE. However, it still provides good information and the effort and cost to convert these figures to feet far exceed the benefits and it may not be possible. However, it is important that the reader understand these figures are in meters and this as been added to the caption as:

"The elevations are given in meters in NGVD 1929 vertical datum and not in feet."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503183	Civil	Par. 5.4.1	n/a	n/a

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

It should be mentioned that the erosion component of the fragility curve is part of the judgment curve and was not estimated based on any analyses but on the experience of an expert elicitation panel, considering the location of the index points, the conditions of the foundation and levee material, water velocity at that specific location, and on past history.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

The discussion in Section 5.4.1, para. 1 will be expanded to include this information. The proposed modification now reads:

"...Furthermore, the engineering judgment component consists of considerations for vegetation, animal burrows, encroachments, utilities, and erosion. It should be noted that the erosion component was not estimated based on any analyses, but on the experience of an expert elicitation panel, considering the location of the index points, the conditions of the foundation and levee material, the water velocity at that specific location, and on past history."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503201	Civil	Fig. 5-12 to 5-14	n/a	n/a

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

Fig. 5-12 to 5-14 are not representative for the erosion report. The high risk of poor performance of the levee without the project is not due to erosion but mostly due to seepage or stability, erosion being a small part of the curve. The reduction in risk is not after erosion measures are considered but after seepage and stability deficiencies are mitigated. The figures should be replaced with the Judgment curves at the same locations , with or without project, to demonstrate the impact of the erosion control measures and the impact of the erosion on the poor performance of the levee.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

The report text has been updated to show the judgment with- and without-project curves as figures. The report text has been updated to explain the differences between the with- and without-project curves, the changes to the erosion portion of the curve, the residual risk captured in the with-project judgment curve, that the American River curves capture the existing cutoff walls, and that the Sacramento River combined curve has seepage and slope stability components as well.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503225 Civil Par. 5.4.1 n/a n/a

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

How par. 5.4.1 is written, it lead to the conclusion that cumulative probability of poor performance greater than 50% without project is reduced due to erosion measures to less than 20 percent. This is not correct, the majority of reduction of the probability of poor performance is done by the seepage and mitigation measures, and partially only by erosion protection measures. This is the reason I insist to replace the geotechnicalperformance curves with the judgment curves (Figures 5-12 to 45-14) before and after project which indicates the reduction of probability of poor performance by erosion control measures.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
The report text has been updated to show the judgment with- and without-project curves as figures. The report text has been updated to explain the differences between the with- and without-project curves, the changes to the erosion portion of the curve, the residual risk captured in the with-project judgment curve, that the American River curves capture the existing cutoff walls, and that the Sacramento River combined curve has seepage and slope stability components as well.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

2-0 Evaluation **Check and Resolve**
Report should be available by close of business today.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

Backcheck not conducted

Current Comment Status: **Comment Closed**

5503226 Civil Par. 5.4.2 n/a n/a

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

Same comment as for Par. 5.4.1 - American River

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

The report text has been updated to show the judgment with- and without-project curves as figures. The report text has been updated to explain the differences between the with- and without-project curves, the changes to the erosion portion of the curve, the residual risk captured in the with-project judgment curve, that the American River curves capture the existing cutoff walls, and that the Sacramento River combined curve has seepage and slope stability components as well.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503259	Civil	Par. Fig 6-1	n/a	n/a

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

The cross section should indicate what is the material placed within the launchable rock. If this is a launchable rook the mass of rock should move in case of undermining of the slope or riverbed. However, I assume there is a mass of soil within that rock, so the rock will be replaced by that material in case of undermining and the purpose of this launchable rock is lost, unless the entire mass is rock Also, the rock size distribution is dictated by the velocity in the channel. However, this launchable rock is not designed based on any velocity, it is "one size fits all" rock and may be easily washed away by high velocities. Also I am not sure the launchable rock respects the required specification for rock quality.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

Revised Jan 29 2014.

1-0 Evaluation **Concurred**

The material within the launchable rock portion of the design will be 100% rock. There is no soil within the rock mass that launches. The launchable section is buried to lower the amount that needs to launch and above that section soil is allowed. The rock size was determined on average velocities and verified with recent designs. The launchable rock (specification) is not as critical as volume of rock in determining costs. The design should provide an adequate volume of rock for alternative selection with actual site specific design occurring in PED.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503280 Civil Par. 6.3. n/a n/a

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

I suggest revising the title of the paragraph removing the word "Trench". This is not a trench but a mass of rock placed on the riverbank. There is no trench excavated in the riverbank of riverbed.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Non-concurred**

In this case, the launchable section will be placed in an excavated trench along the waterside levee toe. The detail in the erosion protection report is not as clear as the details in the engineering appendix. See attached detail. The Bank Protection method has a launchable component that is on the riverbank.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014
(Attachment: engineering_appendix_exerpt.docx)

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503383 Civil Par 7.1.3 n/a n/a

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

It should mention that the raise of discharge due to Folsom Dam modification leading to higher velocities in American River will have no impact on the propose slope protection. The proposed slope protection was not designed based on the velocity or depth of water, it is a launchable rock with no particularly designed rock size based on velocity and it is placed on the levee to the top of the levee. I assume it is to the top of the levee, however I did not see any recommendation regarding the top of slope protection on Sacramento or American River.

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

We added the following to paragraph 6.1 "The erosion protection was designed to convey the 0.5% ACE (200-year) future condition as described in Chapter 4."

The rock size was determined on average velocities and verified with recent designs. See response to comment 5503390 for discussion on whether design extends to top of levee.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503390 Civil Par 7.1.3 n/a n/a

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

General Comment: I understood the proposed protection is either launchable rock of launchable rock trench. However, I did not see any information if the protection on American River is on the riverbank only or it extends on the slope also, and I did not see any information on the height of the slope protection on the levee (if it is extended on the levee also0. One of the issue of the existing slope protection is that height may not be adequate, therefore on some places where the protection exists it needs to be raised either to the top of the levee or to the design water elevation. Also I did not see any conclusion of the extensive erosion investigation on American River on the riverbed erosion and the proposed mitigation (probable the launchable rock trench, but it is not specifically indicated).

Submitted By: Mary Perlea (916-557-7185). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
The erosion protection is either Bank Protection or Launchable Rock Trench. The Bank Protection protects the existing bank away from the levee toe. This toe protection is intended to protect the levee away from the levee and, typically, velocities at the levee are low enough that slope protection isn't required to the crown.

The Launchable Rock Trench will deploy when the existing berm is eroded away. The river will be allowed to meander and, therefore, the velocities along the levees may be high enough to require protection. The end result is a fully-protected slope to the crown.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Mary Perlea (916-557-7185) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503634 Hydraulics n/a n/a n/a

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

Section 1.1, paragraph 1. Is the rationale for the proposed erosion protection based on a quantification of the risk associated with erosion? Justification for project features normally has to go through such an analysis and that should be discussed further here.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Text added to clarify and confirm that a risk analysis was done for the feasibility study.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503635 Hydraulics n/a n/a n/a

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

Section 1.2, paragraph 2. The Natomas PAC did consider erosion, specifically for the Sacramento River north of the American River and the east side tributaries (NEMDC, Natomas Cross Canal, etc). This may not be clear in the PAC documentation, but it should be referenced and discussed. Does this new erosion appendix supersede anything discussed in the Natomas PAC for erosion?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Intro section text has been revised to clarify how erosion was handled on each reach for the study. Some reaches were handled as part of the Natomas PAC, and other small reaches were assumed to need minimal additional erosion analysis that will be deferred to PED.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503636 Hydraulics n/a n/a n/a

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

Section 1.3, paragraph 1. When talking about the system, it is not clear if you are referring specifically to the American River. If so, suggest referring to as the American River levees or American River levee system. It mentions the 1955 event required an emergency flood fight – was that for the American River levees? Please also see paragraph 4 of Section 1.5.1 for similar comment on "system".

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

I was hoping that the section title "Background – Lower American River (LAR) Overview" would help to tell the reader that this section was focusing on the Lower American River. With that said, the subject paragraph (Section 1.3, 1st para.) has been modified to the following:

"The American River levees were originally intended to convey a release from Folsom Dam of 115,000 cubic feet per second (cfs). During several events since the construction of Folsom Dam, flows have equaled or exceeded the design capacity and caused significant erosion distress. All four significant flood events since the completion of the Federal flood control system in the mid 1950s (1955, 1966, 1986, and 1997) caused considerable damage to the American River levee system due to erosion. The 1986 event had an imminent threat of levee failure. And, all four events required extensive repair after the event so the American River levee system could perform for the next major event. The objective release from Folsom Dam is currently under review as part of the Folsom Dam Reoperations Study and the Joint Federal Project is currently constructing improvements to the dam for a release of 160,000 cfs. Based on past performance and recent investigations, erosion is a serious threat to the American River levees that must be addressed."

Tibbitts let me know that flood fights were along the Feather in 1955 so that sentence has been deleted from the subject para. Additionally, the paragraph (Section 1.5.13, 4th para.) has been modified to the following:

"Sacramento experienced significant flood events again in 1964, 1986, and 1997. The 1964 flood event was the first time the complete American River levee system was tested with a flow of 115,000 cfs. The 1964 flood event showed considerable stress on the levee system for a flow of 115,000 cfs. An emergency flood-fight along the left bank of the American River near H Street was required to pass the flood event."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

This looks good, thanks.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503639 Hydraulics n/a n/a n/a

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

Section 1.3, paragraph 4. To help tell the story, it would be good to discuss the purpose for convening the expert panel in 2010 - mainly due to questions and uncertainties regarding previous design recommendations and the environmental sensitivity of doing extensive erosion work on the American River including grade control.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Thanks for the suggestion. The subject paragraph has been modified to:

"Following the 2010 report a panel of experts in engineering fields associated with erosion was convened by West Consultants for the USACE due to questions and uncertainties regarding previous design recommendations and the environmental sensitivity of doing extensive erosion work on the American River including grade control. The panel was tasked to consider the adequacy of studies conducted to..."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503640 Hydraulics n/a n/a n/a

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

Section 1.3, footnote 2. The text appears to be cutoff.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **For Information Only**

No; this short statement was made to differentiate that all of the references to river miles are based on the USGS index and not the Comp Study index.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503642 Hydraulics n/a n/a n/a

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

6. Section 1.3, paragraphs 5&6. Paragraph 6 seems to be repeating what is already said in paragraph 5. For clarity, please combine.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Considering that para. 5 told the story of additional data collection and investigations in a past-tense form and para. 6 told the story more from a point of view what was expected of the investigations, I went with just deleting para. 6 since all of the critical information is present in para. 5 and then the past vs. present issue goes away.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503643 Hydraulics n/a n/a n/a

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

Section 1.4, paragraph 2. Using the term "middle" reach is confusing for purposes of this discussion. It also mentions multiple diversion structures, but only the Sac Weir is located along this reach.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Text has been revised removing the "middle" terminology. The reference to multiple diversions has been replaced with a description of the Sac Weir only.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503644 Hydraulics n/a n/a n/a

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

Figure 1-4 and Figure 1-5 should include in the title the river mile or range of river miles they are supposed to represent.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Concur, figure titles has been been revised.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503646 Hydraulics n/a n/a n/a

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

Section 1.5.1, paragraph 5. Peak flow for 1986 was 134,000 cfs.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **For Information Only**

Please cite reference for the 134,000 cfs. Please don't include Tibbitts' September 2012 report on the Nov/Dec 2011 Advisory Panel – Dan hasn't been able to cite his source of the 134,000 value. I have spent some time investigating this item and cannot find any documentation that the peak flow (or peak release from Folsom) was anything but 130,000 cfs for the 1986 event. Corps' discharge records for Folsom Dam show a maximum release of 130,000 cfs. Please refer to the attachment which includes excerpts from the Folsom Dam & Lake water control manual (Dec. 1987) and from the Short Period Computation Sheet used during the flood event to track inflow, lake volume, and outflow by WATMAN.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014
(Attachment: Pages_from_Folsom1987CompleteManual3.pdf)

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503648 Hydraulics n/a n/a n/a

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

Figure 1-7. Add text noting peak flow of 115k to Jan 1997 hydrograph.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Will do.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503650 Hydraulics n/a n/a n/a

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

Section 1.7.1.4, paragraph 1. Other flows beyond 145,000 cfs were part of the study including 160,000 cfs. This should also be briefly discussed. 145,000 cfs was important because it was the flow used for levee certification.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Added the following clarifying language to the end of the section:

"Other discharges such as 160,000 cfs were also included in this document."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503652 Hydraulics n/a n/a n/a

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

Section 1.7.2. For better flow of the document, recommend removing 1.7.2.2 - 1.7.2.4 discussions on hydraulics and sediment transport and moving them up in the hierarchy – so they stand out a bit more. In brief, sections could be set up as follows (Sections 1.8 and 1.9 remain the same):

a. 1.7.2.1 2010 Panel
b. 1.7.2.2 2011 Panel
c. 1.7.2.3 2012 Panel
d. 1.10 Hydraulic and Sedimentation Studies
e. 1.10.1 Sedimentation Studies Completed Tasks
f. 1.10.2 Sedimentation Studies Tasks in Progress
g. 1.11 Levee Screening Tool

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Changes made as indicated.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503653 Hydraulics n/a n/a n/a

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

Section 1.7.2.3, paragraph 1. Ayres analysis for bankline migration indicates 1957 to 1998 and then states NHC confirmed Ayres analysis with 1998 to 2010 study. These are different time periods, so not sure how it can be confirmatory. Are the years correct or does there need to be some additional discussion?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Changed subject sentence for clarity to:

"NHC confirmed Ayres findings of no significant recent bankline migration by using aerial photos combined with survey data from 1998 to 2010 to develop more accurate banklines. NHC noted that significant differences shown in the previous Ayres analysis were the result of Ayres incorrectly identifying the top of bank from aerial images without the aid of relatively accurate topographic data."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503654 Hydraulics n/a n/a n/a

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

Section 1.7.2.4, paragraph 1. Is it correct saying USACE has not performed a review? It would seem if we are including results, that some level of review of the information has occurred– it does say results seem reasonable. It would certainly seem appropriate to indicate results are draft and have not undergone the full review process. Please also reference the appropriate section for geotechnical studies so it is clear what the source of the new information for the bed and banks is.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Changed the first paragraph to:

"This information is based on draft results that have not been fully reviewed by USACE and should be viewed with caution as they are subject to change."

Also, added the reference to the geotechnical information, section 1.9.2.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503657 Hydraulics n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

Section 1.7.2.4, paragraph 1. The results are called into question based on the hydrologic inputs and notes they should not be used for estimating long term trends, though the results do seem to be discussed later on in the report. It is not clear why they couldn't be used as a source for long term prediction of trends, despite uncertainties.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**
The explanation can be found in the paragraph:

"Other studies have found that trends from a single flood event may be opposite of the long-term trend and therefore these results should not be used for estimating long-term aggradation/degradation trends."

This is a summary of the following. NHC conducted HEC-6T sediment modelling for the Sac Bank project that included long-term hydrology (1997 - 2008)from actual gage data as well as only specific events (e.g. 1/50 ACE, 1/100 ACE). A comparison of the results for the same reach (Lower American River to Freeport) shows that the reach is degradational during a specific event but aggradational over the long-term. The implication is that using single event hydrology (e.g. the 1/100 ACE event) or a series of single event hydrology (e.g. 1/100 ACE event followed by a 1/200 ACE event) may provide evidence for the opposite trend (degradation) than if a wider range of flows (e.g. 1997 - 2008 "continuous" hydrology) is used for the same reach. So while specific event modeling is likely more conservative for design and cost of erosion counter-measures for this reach, it may not be helpful if long-term trends are needed for other purposes, such as for determining if future sedimentation will bury spawning gravel. Despite this limitation, the results do represent the latest geologic understanding and may still be informative and perhaps conservative relative to feasibility level designs and costs. There is a lot of uncertainty associated with all sediment models as noted in the comment. However, the Sac Bank Sediment Study shows that using event specific hydrology vs. long-term hydrology for the exact same model can lead the model to show opposite trends. Therefore the relative differences may lead to incorrect conclusions even though both models are subject to considerable inaccurracies.

If necessary, this longer explanation can be provided. However, I feel it disrupts the flow of the document and does not contribute significantly to the overall conclusions.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
This is good discussion and would be appropriate to add as a footnote so it doesn't disrupte the flow of the document.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Text was revised to add the discussion. This new proposed text is:

"The calibrated model was run for multiple synthetic hydrologic scenarios designed to mimic short-term and long-term morphological conditions. This does not include a full set of hydrographs over decades of future conditions but uses a series of individual events to approximate short-term and long-term conditions. This hydrologic approach to the sediment modeling is useful for relative comparison purposes and should not be used to estimate actual future conditions. Other studies have found that trends from a single flood event may be opposite of the long-term trend and therefore these results should not be used for estimating long-term aggradation/degradation trends.

NHC conducted HEC-6T sediment modeling for the Sacramento and Lower American rivers (NHC 2012) that included long-term hydrology (1997 - 2008)from actual gage data as well as only specific events (e.g. 1/50 ACE, 1/100 ACE). A comparison of the results for the same reach (Sacramento River from the Lower American River confluence to Freeport) shows that the reach is degradational during a specific flood event but aggradational over the long-term. The implication is that using single event hydrology (e.g. the 1/100 ACE event) or a series of single event hydrology (e.g. 1/100 ACE event followed by a 1/200 ACE event) may provide evidence for the opposite trend (degradation) than if a wider range of flows (e.g. 1997 - 2008 "continuous" hydrology) is used for the same reach. So while specific event modeling is likely more conservative for design and cost of erosion counter-measures for this reach, it may not be helpful if long-term trends are needed for other purposes, such as for determining if future sedimentation will bury spawning gravel.

Despite this limitation, the results do represent the latest geologic understanding and may still be informative and perhaps conservative relative to feasibility level designs and costs. There is a lot of uncertainty associated with all sediment models as noted in the comment. However, the Sac Bank Sediment Study shows that using event specific hydrology vs. long-term hydrology for the exact same model can lead the model to show opposite trends. Therefore the relative differences may lead to incorrect conclusions even though both models are subject to considerable inaccurracies.

The results from this study (NHC 2013) include:...."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503658 Hydraulics n/a n/a n/a

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

Section 1.7.2.6, paragraph 2. There should be more detail in terms of what was done and what wasn't done to address each of the conclusions and recommendations from the various panels including the why and the why not. While geotechnical, geologic, and geomorphic studies were referenced in Section 1.8, follow-on hydraulic and sedimentation studies were not. It would be good to draw a clear connection from the recommendation to the actual follow-on work or study. It would be especially important to note recommendations that were not addressed in some fashion and the reasoning for not doing so. While budget and schedule are important, there should also be some technical reasoning perhaps from a risk standpoint that played into it.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**

For the most part most of the items mentioned have been followed through with the exceptions noted below. The exceptions noted have been added to the text as follows in the parentheses. These include the following 2 bulleted items:

• Existing modern bank protection sites need to be analyzed to assure they can withstand a flow of 160,000 cfs. (Note: This recommendation has not been followed to date. The feasibility study assumes that recent erosion protection was designed and constructed adequately to withstand this discharge without the need for additional analysis beyond what was conducted for the design. It has not been verified that each site was designed for 160,000 cfs.)

• Because of the large extent of bankline/levee requiring armoring, a site prioritization method needs to be developed so that the sites being the most urgent will be addressed first when construction begins. (Note: This recommendation to develop this site prioritization method has not been completed at this time and will need to be developed in the future.)

In addition, language has been added at the end to highlight that some of the recommendations mentioned that were followed through are provided in parentheses:

"Some of the recommendations were not addressed due to budget and schedule considerations. Some of these recommendations that were not completed are noted above in parentheses. The District envisions that, as appropriate, the remaining work efforts will be addressed in future studies."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**

The 2nd to last bullet in 1.7.2.2, for note in () change to "The mehtod was not considered practical for use in the stability study and was not conducted". You probably should consult with Mike K, to make sure that is correct.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**

I am checking with Mike now. I have modified the language as indicated:

"• Characterization of materials is primarily being completed by the EFA and JET testing. Other methods to characterize engineering properties of geologic materials should be utilized. An example of one would be the NRCS soil/rock erosion model. Additionally, lab test results needs to be correlated to behavior in the field. (Status: The method was not considered practical for use in the stability study and therefore was not conducted)"

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Open Comment**

I am ok with the proposed modified language pending review by Mike.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

3-0 Evaluation **Concurred**

Confirmed that Mike is OK with the proposed language.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 10 2014

3-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 10 2014

Current Comment Status: **Comment Closed**

5503660	Hydraulics	n/a	n/a	n/a

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

Section 1.8.4, paragraph 3. Results were to identify locations requiring further study and investigation. Are those areas identified in this report? This should be addressed in some manner so it doesn't leave it as a question.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**

The study referenced in the comment was developed as a standalone document that described the surficial geology to varying levels of detail dependent on the location within the general study area. This mapping was developed using the best existing data. Where the quality of the data was improved it was incorporated into the study, but also highlighted where data gaps still existed. At one point additional investigation contracts were in process but that study was differed to PED. The erosion attachment assumes a certain level of detail in the data and resulting conclusions which comprised the study and admittedly assumes more detailed required for PED and construction. I believe several parts of the report address the idea of further study during PED, but a specific account of where further study is needed would essentially be a description of the PED scope which is likely too detailed and comprehensive for this report.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503661 Hydraulics n/a n/a n/a

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

Section 3.1, paragraph 7. The report in general seems to be saying erosion of the hard outcrops is not an issue, though it does state here several mechanisms of how they erode. Time scale likely is a key consideration in terms of how long it takes for these processes to occur and should be discussed briefly here.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**

The geotechnical and geologic study did vastly improve the knowledge of the properties and location of what was originally thought to be an erosionally resistant clay layer. The study referenced in the comment did find that due to the location and properties of the material, the risk posed to the flood control structure due to erosion of the so called ERU was likely low. Based on the new understanding of the material, it also proposed general failure mechanism of the ERU. However, those mechanisms were not studied. Any inference of the time required for the ERU to undergo its likely erosion process would require substantial additional data collection and analyses, based on the previous conclusion regarding consequence of failure of the ERU, that study would not be relevant to the flood control structure.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Open Comment**

Please add this explanation as a footnote in the document.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**

Added the following explanation to section 7.1.2 in coordination with Mike (copied and pasted from Mike as he suggested):

" Field observations suggested that erosion of the exposed erosionally resistant sediment occurs over time at both the granular- and outcrop-scale. However, the mechanisms and time scale associated with that erosion are not well understood and were not studied. Due to the location and properties of the material, the risk posed to the flood control structure from erosion of the erosion resistant sediment were estimated to be low and no further study of its erosion mechanisms or time scale were performed."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 10 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 10 2014
Current Comment Status: **Comment Closed**

5503663 Hydraulics n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

Section 3.2, paragraph 4. Along with describing the various stratigraphic features, the relative erodibility of these units should be discussed and how this information was used in the overall study.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
The subject section of the report gave a general summary of the process used to develop the layers of the model. These layers were developed by grouping material based on similar properties, which included erodibility as well as several other properties. This is described in as much detail as is relevant for this report in paragraph 3 of Section 3.2. As much of the erosion rate testing was in progress and also not nearly comprehensive enough to assign to each layer, the relative erodibility is evident by the material types and their mechanical properties described in the report.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Section 4.2 discusses the erodibility of materials lining the American River channel considering predicted velocities and shear stresses. This is an important link, that answers the comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503666 Hydraulics n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

Section 3.2, paragraph 5. Not sure Bouldery and cobbley are official terms. Please confirm.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Confirmed

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503668 Hydraulics n/a n/a n/a

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

Section 4.1, paragraph 1. The Folsom mini-raise should be referred to as 3.5 ft raise. This should be corrected throughout report.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Will do.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503671 Hydraulics n/a n/a n/a

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

Section 4.1, paragraph 1. Indicates it will be able to discharge 160k, but isn't that part of what the study is trying to figure out or justify? The reality is the JFP and Dam Raise projects, based on the 2007 PACR simply assumed downstream capacity was 160k without recognizing the current downstream limitations.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Concur, text has been revised to describe the "intent" of this what the project will accomplish not necessarily providing a technical opinion.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **For Information Only**

The GRR is not a design level document but is primarily concerned with conservatively estimating project costs, benefits, and environmental impacts. Additional analysis will need to occur during implementation to verify the assumption that existing rock (either mdoern revetment or cobblestones) are designed for 160,000 cfs. If the rock is designed and constructed in accordance with standard engineering practice and USACE guidelines, it should reasonably be expected to provide adequate erosion protection. However, continued maintenance is needed and may include installing additional bank protection as necessary. In addition, the bank protection needs to be monitored during and after flood events. Duration is not necessarily part of the riprap design criteria. However, this should be considered during design of the riprap along with the consequences when selecting an appropriate factor of safety. Site selection and prioritization will also need to occur during implementation.This information should be included in the cost schedule risk analysis and the risk register. Additional languag was added to address this in sections 4 and 7.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 10 2014

2-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 10 2014

Current Comment Status: **Comment Closed**

5503673 Hydraulics n/a n/a n/a

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

Table 4-1. These values were derived for the Common Features Study, but may have changed, specifically as part of the Water Control Manual update. This caveat should be added here in the text.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Concur, caveat has been added to text.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503675 Hydraulics n/a n/a n/a

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

Section 4.1, paragraph 4. Flow duration was identified as a source of uncertainty and could certainly be critical with the potential for large flows at longer durations under the new operation scenarios. How was this captured in the risk informed decision making, i.e. development of fragility curves?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

In developing the levee performance curves the best available data was used, including flood hydrographs which gave flow and duration information. This information was used in the estimation of the levee performance for each loading shown in the judgment curve. Of course, with increasing stage came increased loading on the levee (velocity and shear stress) as well as increased duration for which erosion flows would be seen on the levee slope.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503676 Hydraulics n/a n/a n/a

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

Section 5.1, paragraph 5. It notes that "this information with estimated relative sea level rise and other pertinent information should be used to inform risk based decisions". Which risk based decisions is it to inform? The feasibility study?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **For Information Only**

This can be used to inform feasibility level or design level risk based decision. For example, if scour counter-measures represent a significant component to the feasibility cost, adding the cost in would be conservative and may reduce risk by improving assurance that critical bridges used for evacuations are passable. It can also be used for design based decisions such as computing scour depths for design of erosion protection.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**

Comment response also indicates can be useful for design purposes, if true, indicate that as well at the end of paragraph 5.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Added additional sentence at the end so that it reads:

"This information together with estimated relative sea level rise and other pertinent information should be used to inform risk based decisions. This includes both feasibility and design level decisions."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503678	Hydraulics	n/a	n/a	n/a

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

Section 5.1, paragraph 6. Please be more explicit on describing "model differences".

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
This section has been revised for clarity and to call out the differences explicitly as indicated below (differences are now bulletted):

"The future trend noted in Figure 5 5 does not include more recent data on erosion resistance formation beneath the American River that could limit future vertical erosion. A more recent update of the model includes this new geotechnical information and draft results are shown below in Figure 5 9. The model used in figure 5-9 includes the updated geotechnical information but has other differences with the model used in Figure 5 5. The significant differences between the models used for Figure 5 5 and Figure 5 9 are:

• Figure 5 9 model includes the updated geotechnical information while Figure 5 5 model does not

• Figure 5 9 model is based on synthetic event hydrology while Figure 5-5 model is based on actual historical hydrology
• Figure 5 9 model is "fixed" at the downstream boundary by a rating curve while the Figure 5 5 model is allowed to adjust dynamically based on changes to the Sacramento River (i.e. Figure 5 9 is not "linked" to the Sacramento River HEC-6T model while Figure 5 5 is).

Therefore Figure 5 9 cannot be compared directly with Figure 5 5. The amount of scour seems to be much less than previously predicted which may be partially explained by model differences noted above. Despite these differences, by referencing Table 5 1 which lists the average expected channel erosion by reach for the Lower American

River for 50 to 100 years of simulation, it can be concluded that it is possible the channel may erode nearly fully to the erosion resistant material between RM 6.5 and 10 (as shown in Figure 5 9). It is also possible that the bed may erode to or nearly to the erosion resistant surface for portions of the reach above RM 15 (above where the current federal levees end). Especially since the depth of active erosion likely exceeds that observed or predicted by the models. This makes protecting the levee toe critical for flood risk reduction and future degradation upstream of the levees may have detrimental impacts on environmental and recreational interests in this reach."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503680 Hydraulics n/a n/a n/a

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

Section 5.1, paragraph 6. The non-continuous hydrographs were expected to represent the main opportunities for scour/aggradation. Please explain.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**
The non-contious hydrograph may show the main opportunities for scour/aggradation. However, it appears that the model may not be entirely representative of actual conditions because the downstream end is "fixed" by the downstream rating curve rather than being dynamically linked to the Sacramento River HEC-6T model. This "fixed" boundary may propogate upstream and affect the final solution. In addition, as indicated in another comment and in the report (section 5.1, paragraph 5), using individual events may be conservative for a design and feasibility cost perspective as it is likely to show more scour than long-term hydrology. This is likely OK for the feasibility study but the results should not be used to portray long-term trends for environmental considerations. Only for representing flood events.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503683 Hydraulics n/a n/a n/a

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

Section 5.1.1, paragraph 1. Please define "lower half of the study reach" more explicitly.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Revised language to clarify:

For the Sacramento River, simulated degradation or aggradation generally increase from 1 to 5 ft, with a prevailing aggrading trend in the lower half of the study reach (less than 1 ft in the lower portion – which is the lower ½ of the reach from Colusa to Freeport).

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503686 Hydraulics n/a n/a n/a

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

Section 5.1.1, paragraph 2. Explain the basis for decreasing other flows so total annual runoff does not change. Why does the total annual runoff remain the same?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **For Information Only**

For climate change, predicting whether this area will become wetter or drier is not simple. Based on conversations with hydrologists, the overall annaul rainfall over the long-term may not change significantly. Given the uncertainty involved, assuming that the overall amount of rainfall remains unchanged is reasonable for a sensitivity analysis. However, climate change is often thought by experts to exagerate heavy precipitation and exagerate low rainfall. Therefore by increasing some of the highest flows and decreasing some of the lowest flows is expected to be a reasonable assumption for modeling the sensitivity of the sediment model to climate change. It is not expected that it is modeling climate change exactly, but is modeling one of an infinite number of possibilities to get a sense for the model sensetivity to climate change.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503687 Hydraulics n/a n/a n/a

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

Section 5.1.1, paragraph 3. Hydrology developed for the HEC-6T for the American River was supposed to represent future operating conditions with Folsom projects in place and so that should be noted. However, with that said, there certainly will still be uncertainty in future hydrologic conditions as noted.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Added a clarifying sentence:

"The HEC-6T model developed by the ARCF GRR (e.g. Figure 5 9) used hydrology that is thought to be representative of changes to operations at Folsom Dam."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503688 Hydraulics n/a n/a n/a

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

Section 5.1.1, paragraph 4. Please note source of HEC-6T results – I assume they come from the latest NHC modeling, but wasn't sure.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Added language clarifying the results are from the HEC-6T model developed for the Sac Bank project:

"In general, however, degradation predicted by the model for the lower American River (the HEC-6T model developed for the Sac Bank Project, see Figure 5 5) agrees with the stage-discharge records obtained for the American River gage at Fair Oaks which shows ongoing channel degradation."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

1-2 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503690 Hydraulics n/a n/a n/a
Comment Classification: **For Official Use Only (FOUO)**

Section 5.1.2. If studies during PED yield results showing the need for grade control, how will this be taken under consideration seeing that the decision now is not to include it as part of the plan and only as OMRR&R? This could create a difficult situation down the road with the need to include, but without authorization to do so. Later in the document (Section 5.2.4), it indicates consequences with including in the plan are greater than not including. This should be explained further.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**
If grade control is needed in the future but not included as part of this feasiblity study originally, it is assumed the appropriate USACE planning and/or permitting process and necessary Congressional action will need to be followed. For example, perhaps a LRR and a new EIS/EA will be needed and new authorization may be needed. See planning for more detailed explanation.

The explanation for why not including grade control is the lower risk feature is currently explained. In summary the thought is that:

1) It is inconclusive if grade control will be needed (even by experts) and whether it is needed or not is well witin the uncertainty of any technological tools used to analyze the situation.
2) The need for grade control is likely to occur oover a longer period of time that can be monitored and remedial actions put in place and not during a single flood event. This "ductile" failure mode lowers the risk (similar to a ductile failure that can be observed in advance of failure and fixed in a structure lowers the risk more than having brittle failure that occurs suddenly without warning).
3) By including grade control, it guarentees financial expenditure likely on the order of $50 million) and associated detrimintal environmental impacts to address a percieved need when the need is debatable.

A monitoring approach will allow for determining if the need develops and take appropriate action in a timely manner only if needed and is considered lower risk than spending $50 million dollars and impacting the environment on something that likely is not needed.

Please advise on what if anyting needs to be added to explain further.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
The revised discussion is good. Only change - in first paragraph spell out OMRRR and in second paragraph use abbreviation only.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Agreed and completed as suggested so the OMRRR is spelled out in 1st paragraph and abbreviated subsequently.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503692 Hydraulics n/a n/a n/a

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

Section 5.2.1, paragraph 5. Please define "Common Feature GRR project vicinity".

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Modified sentence to clarify that only the Sacramento River within the ARCF GRR project is included in this statement:

"Therefore the Channel Evolution Model indicates lateral erosion and channel widening for both the Lower American River and Sacramento River within the Common Features GRR project."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503694 Hydraulics n/a n/a n/a

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

Section 5.2.3, paragraph 1. It notes work conducted along selected reaches. I assume that includes the American River. If so, please add, "including the American River".

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Added:

"The work was conducted along 300 miles (483 km) of Sacramento River main stem and selected reaches, including the Lower American River."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503697 Hydraulics n/a n/a n/a

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

Section 5.2.3. Only a few of the sites are within the study area and the basis for selection is not apparent. Some additional discussion would be helpful.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**
The basis for selection of the sites can be determined by reading the original USDA report for the Sacramento River Bank Protection Project. This is referenced and the reader can look here for how the Sacramento River Bank Protection Study set up this study and why they selected the sites. This is intended to be a summary document and not provide all the details, only the pertinent information (e.g. focus on the conclusions with references to other documents for more details). Paragraph 4 notes that the number of sites and location of the sites is not ideal for the ARCF study but still provides valuable insights to overall erosion trends for the study area and is in agreement with other findings:

"Of the 50 intensive sites analyzed, seven are within the Common Features GRR study area along the Sacramento River and three are located in the Common Features GRR study area along the Lower American River. While this may be appropriate for large scale studies like the Sacramento River Bank Protection Project, it is likely not a large enough sample for more narrowly focused feasibility studies such as the Common Features GRR. Also, no sites were located in the area constricted by levees between RM 5 and 10 on the Lower American River. In addition, the hydrology used for estimating erosion 48 years into the future generally had higher flow rates than long-term averages and therefore may over predict long-term sediment loading and bank retreat. However, the study still provides valuable insight into erosion in the Common Features GRR project. The estimated percent of total sediment derived from the banks agrees remarkably well with the results from a historic channel shift analysis (NHC 2012). This study by the USDA confirms the results of the Channel Evolution Model and the observations from annual erosion surveys and air photo analysis."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503698 Hydraulics n/a n/a n/a

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

Section 5.2.4, paragraph 3. Work required to protect infrastructure is not currently in the plan but no reasoning is provided for not including it, especially since it has been identified as a potential issue.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Added additional language:

"For both the Lower American River and the Sacramento River, infrastructure encroaching in the floodway, such as bridges and pipelines, need to be adequately protected from reasonably anticipated scour during design and construction. This effort is not included in the tentatively selected plan. It is assumed this effort will occur during future analysis and design efforts and likely needs to be coordinated with multiple agencies and infrastructure owners. Civil Design has also determined that the additional cost of the scour and erosion counter measures for the infrastructure is not significant compared to the overall cost of the erosion protection currently included in the tentatively selected plan and is well within the associated cost contingency.:

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503702 Hydraulics n/a n/a n/a

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

Section 5.3.1, paragraph 2. Please confirm results of wind-wave analysis by NHC. 46 miles of levees at high risk seems high. Is that high risk from failure due to wind-wave action or high risk of erosion happening? This should be briefly discussed.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**
Section 5.3.1, paragraph 1 states:

"Each site was assigned the highest risk computed for the site for either levee face erosion or overtopping for any wind direction at the site."

Therefore the high risk is from wave erosion or overtopping from waves for any wind direction.

Please see original report on wind-wave for additional information as this is only reporting the values in this original report on the wind-wave analysis and a determination on whether the values are apporpriate or not can only be made during a technical review of the wind-wave analysis. This is beyond the intent of this summary document.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

5503703	Hydraulics	n/a	n/a	n/a

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

Section 5.3.1, paragraph 2. It is not clear if high risk areas are included in the current plan of the GRR. Also there may be overlap with what was included in the Natomas PAC.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Text has been revised to better describe the risk.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
Change the last sentence of paragraph 2 of 5.3.1 to read, "The study included reaches that are part of the Natomas PAC".

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Agreed and completed as suggested.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503706 Hydraulics n/a n/a n/a

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

Section 5.3.3, paragraph 1. I would not think that relying upon the waiver process for ETL 1110-2-1571 would be a reasonable approach in the feasibility study. This may be a planning question.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Concur, this is a high risk. However, the feasibilility study believes they have concurrence on this path from higher level reviews and policy makers.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503708 Hydraulics n/a n/a n/a

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

Section 5.3.3. Further work is to happen during the refinement of the tentatively selected plan – when would that happen, is there really time for that? Comment also applies to Section 5.3.5 on scour analysis.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Text has been revised. This work will likely be done during PED.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
Strike, "of the study" at the end of section 5.3.3.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Agreed and completed as suggested.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503710 Hydraulics n/a n/a n/a

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

Section 5.4.1, paragraph 1. To my knowledge, levee performance curves were developed prior to gathering of additional geotechnical, geophysical, geomorphic data and further HEC-6T modeling. What, if anything, has been done to validate previous levee failure curves with new information? In addition, duration of flows have been identified as a key component in potential of erosion and has not been accounted for.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
The levee performance curves were developed in 2011 as required by the contemporary schedule. The judgment curves (erosion as a component) were developed using an expert elicitation in June 2009, as is the case for all the ARCF GRR judgment curves. The validity of erosion component of the performance curves was brought up at the expert panel meetings and at PDT meetings. It was found that the estimated levee performance captured by the curves was reasonable based on the available data and expertise. In consultation with PM and the PDT the decision was made to not pursue developing more rigorous analytical methods to refine the erosion portion of the curve.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Open Comment**
The response to comment is an important point of discussion and should be included in the documentation somewhere under Section 5.4.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Added the following as a new paragraph after the 2nd paragraph of section 5.4.1 on page 58 in coordination with Mike (copied and pasted paragraph Mike edited that contains Mikes edits):

"The levee performance curves were finalized in 2011 with the judgment curves (erosion as a component) that were developed using an expert elicitation in June 2009. The validity of the erosion component of the performance curves was discussed at the expert panel and project team meetings. It was found that the estimated levee performance captured by the curves was reasonable based on the available data and

expertise. In consultation with the project team the decision was made not to develop more rigorous analytical methods to refine the erosion portion of the curve."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 10 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 10 2014
Current Comment Status: **Comment Closed**

5503713 Hydraulics n/a n/a n/a

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

Section 5.4.1, paragraph 2. The fragility curves should show or it should otherwise be stated that the major component of the residual risk is erosion.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
This comment should be addressed by the document editor, the levee performance curves were included in the report by the editor and I too commented on the need to break out the component curves or only show the judgment curve and its components.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503714 Hydraulics n/a n/a n/a

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

Section 5.4.2, paragraph 2. Please reference the appropriate NHC study discussed here.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Added refernce to NHC 2012:

"The results of this effort by NHC (NHC 2012) are shown in Table 5 2 for the portion of the Sacramento River in the ARCF project footprint."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503715 Hydraulics n/a n/a n/a

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

Section 6.1, paragraph 2. Please be more specific on "future studies". Design during PED?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **For Information Only**
Originally, we used the terminology "during PED Studies". However, we were instructed, by Graff, to change the terminology to "future studies" since the project is already in PED.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014
Current Comment Status: **Comment Closed**

5503716 Hydraulics n/a n/a n/a

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

Section 6.2, paragraph 4. It is hard to follow what is being said here. Please clarify.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Removed last sentence. Basically it's saying that the design cross section (geometry) yielded sufficient rock for launching (so it should be conservative). The cross section also yielded enough environmental mitigation features to offset requirements (so no additional mitigation required).

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503718 Hydraulics n/a n/a n/a

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

Table 6-1. No information is provided on the assumed rock size. As discussed with the civil designers, rock sizing and gradation were preliminary estimates mainly for purposes of cost estimates. No further detailed design has taken place. This should be noted as part of Section 6.2, paragraph 3.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Added the following text to section 6.2:

Rock gradations were deemed less important for determining costs for this design level. The geometry of the design yielded sufficient volumes of rock to meet anticipated launchable rock requirements and sufficient mitigation features to offset environmental impacts. The launchable rock volume requirements were determined based on average velocities for above-mentioned typical sections. Site-specific design for erosion protection sites will occur in PED.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503719 Hydraulics n/a n/a n/a

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

Section 6.4, paragraph 2. It references Figure 6.3, noting no erosion protection features along the left levee of the Sac River north of the American. The figure only shows a small portion of that levee upstream of the American and so really doesn't illustrate no erosion fixes in that reach.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

The text will be modified to:
"Figure 6-3 depict s the footprints of the proposed erosion protection for both the Lower American and Sacramento Rivers. There are no proposed erosion protection features located along the left levee of the Sacramento River upstream of the American River confluence. The..."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Open Comment**
The frist sentence of 6.4 is repeated twice. Later on in 6.4, "PED" should be changed to "site specific design".

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Changed as requested.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503720	Hydraulics	n/a	n/a	n/a

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

Table 6-2. I was under the impression all un-reveted locations would receive treatment. What ultimately was the basis for including or not including protection? This needs to be clearly discussed.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Added to end of section 6.4 (after last paragraph):

A channel stability analysis (Ayres Associates, 2010) was used to determine areas requiring revetment with the assumption that all areas without modern bank protection will be protected. Modern protection was determined by areas defined as rock riprap with overall condition of good or very good. Additionally, there are some areas of high ground and areas with significant existing berm where protection is not required as shown in Figure 6.3.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
The Ayres report did not by itself recommend bank protection at all areas without modern bank protection. My understanding was other information was used, such as the 2004 Ayres report that looked at velocities and shear stresses for flows up to 160k. Newer studies should also be referenced to help support the conclusions reached, assuming this can be done.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**

We have discussed this issue with James Elsberry to get a better understanding of how Civil Design selected the locations of where bank protection was proposed and not proposed. H&H probably should have had a more involved role in the process. Nonetheless, the text of Section 6.4 will be modified as follows:

"6.4 Erosion Protection Footprints

Along the American River, the rationale used to determine where bank protection was required for the feasibility study involved consideration of several factors. The most important factors included: 1) the velocity computed by Ayres' 2-dimensional hydraulic modeling (Ayres 2004) for a discharge of 160,000 cfs, 2) the erodibility of the material near the levee prism, and 3) the past performance of the levee segment with respect to erosion. Figure 6-3 depicts the footprints of the proposed erosion protection for both the Lower American and Sacramento Rivers.

Using the above criteria, bank protection was determined to not be required along two segments of the right bank of the American River. The upstream segment, extending between the upstream end of the levee (~RM 14.4) and RM 10.4 and the downstream segment extending between a point near Cal Expo (RM 5.5) and the confluence with the Sacramento River (RM 0). In addition to following the above criteria, a portion of the upstream segment contains a 4000 foot-long reach wherein the channel includes a wide right overbank consisting of high ground (i.e., the location of a sewage treatment plant) in which the water surface elevation for a discharge of 160,000 cfs does not get near the levee and the levee essentially exists as a "freeboard" levee."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 10 2014

2-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 10 2014

Current Comment Status: **Comment Closed**

5503722 Hydraulics n/a n/a n/a

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

Section 7.1.2, paragraph 4. This is critical information and should be emphasized in the 3D stratigraphic discussion of the various layers.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Check and Resolve**

Section 3.2 of the report includes a detailed description of the geotechnical characteristics of the post-1850 alluvium as well as sample figures which show the location of the unit. As this unit was identified by engineering and geologic interpretation, few exploratory borings were drilled where this unit is present. These materials are the result of hydraulic mining erosion of soil and alluvium in the Sierra

Nevada and downstream deposition of this eroded material within the American River channel. The purpose of the 3-d model was not to make a judgment on the performance of the system but to graphically show the subsurface. Therefore the interference on the performance of this layer is correct in Section 7.1.2 but was appropriately not included in section 3.2.

Submitted By: Michael Kynett (916 557 7898) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503723 Hydraulics n/a n/a n/a

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

Section 7.1.3, paragraph 1. Recognizing the issue of erosion on the American River, they likely would operate differently. To make it fully functional and to realize the flood damage reduction benefits intended for the project, the erosion work is needed. Some additional discussion should be provided.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
The subject paragraph has been modified to:

"Once the JFP auxiliary spillway is constructed and functioning, new operations criteria are planned which would result in larger flood flows being conveyed through the American River with greater frequency compared to past conditions. These higher flood flows would exert additional pressure on the banklines and levees resulting in greater erosion, sediment transport, and potentially changes to the planform of the low-flow channel. Nonetheless, it is important to note that without inclusion of the proposed erosion protection features; the flood damage reduction benefits intended for the project cannot be fully realized since the lower American River channel will not be able to safely convey the new larger discharges."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
Add to the end of paragraph 1 of 7.1.3, "and flow restrictions from Folsom would likely be put in place.".

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
Agreed and comleted as suggested.

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503726 Hydraulics n/a n/a n/a

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

Section 7.1.4, paragraph 2. It indicates un-revetted portions are at risk, but what about revetted portions without modern bank protection? Though the statement indicates un-revetted portions should be protected, not all un-revetted locations are being recommended for fixes.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Changed to read "most un-revetted portions of the ...."

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
In paragraphs 2 of 7.1.4, instead of referencing "un-revetted" portions as needing protection, it really should be saying portions without modern bank protection.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
1) A basic assumption of the feasibility study was that all of the historic revetment sites (i.e., cobble sites) would be replaced with modern bank protection. Therefore, there are no revetted portions without modern bank protection in the current plan.

2) The text has been modified to replace the terminology of "un-revetted portions" with "portions without modern bank protection" as follows:

"The available information indicates that many of the levee segments without modern bank protection are at risk of erosion related failures along the Sacramento River and Lower American River in the Common Features project study area. The levees therefore need to be protected..."

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 10 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 10 2014
Current Comment Status: **Comment Closed**

5503727 Hydraulics n/a n/a n/a

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

Section 7.2. Some discussion should be added about how additional study would help prioritize the erosion work, noting that because of all the extensive work needed it would likely not take place all at once, but over a number of years.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Text has been added to include this additional task.

Submitted By: Jesse Schlunegger (916-557-6777) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Open Comment**
The text was added to the end of 7.3, and I think really should be added to the end of paragraph 4 of 7.2. The important point to make is one of the purposes of the need for additional study is to prioritize sites.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

2-0 Evaluation **Concurred**
The last sentence of paragraph 4 of 7.2 was modified as follows (section 7.3 is not modified):

"These sites must be assessed in future studies to confirm that these sites are stable, prevent erosion for discharges up to and including 160,000 cfs, and to prioritize sites to be constructed over a period of years."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 07 2014

2-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014

Current Comment Status: **Comment Closed**

5503728 Hydraulics n/a n/a n/a

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

Section 7.2, paragraph 3. It indicates that there is a need for bed protection to be assessed during final design, but this isn't consistent with what is stated Section 5.1.2.

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Added clarifying language in section 5.1.2:

"Grade control is not anticipated to be necessary but the need for this should be monitored as part of routine operation of the constructed project."

To be consistent clear and , the language in section 5.1.2 was changed from:

"The need for bed protection at key locations will need to be assessed and included, as required, in the final design during the future studies."

To this:

"The need for bed protection at key locations will need to be monitored in the future as part of operating the project."

Submitted By: Todd Rivas (916-557-7523) Submitted On: Feb 06 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503729 Hydraulics n/a n/a n/a

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

Section 7.2, paragraph 4. Please reference repair sites being discussed for assessment in future studies – modern or cobble sites or both?

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**
Added to end of section 6.4 (after last paragraph):

"A channel stability analysis (Ayres Associates, 2010) was used to determine areas requiring revetment with the assumption that all areas without modern bank protection will be protected. Modern protection was determined by areas defined as rock riprap with overall condition of good or very good. Additionally, there are some areas of high ground and areas with significant existing berm where protection is not required as shown in Figure 6.3."

Sites shown in figure 6-3 and described in section 7.2 are modern bank protection sites.

Submitted By: Thomas Goebel (916-557-7175) Submitted On: Feb 05 2014

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 07 2014
Current Comment Status: **Comment Closed**

5503734 Hydraulics n/a n/a n/a

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

Additional editorial comments – See attached document.

(Attachment: Erosion_Attachment_01232014_SS.docx)

Submitted By: Ethan Thompson (916-557-7142). Submitted On: Jan 29 2014

1-0 Evaluation **Concurred**

Thanks. The report has included almost all of the recommended modifications.

Submitted By: Scott Stonestreet ((916) 557-7719) Submitted On: Feb 04 2014

1-1 Backcheck Recommendation **Close Comment**

Closed without comment.

Submitted By: Ethan Thompson (916-557-7142) Submitted On: Feb 06 2014

Current Comment Status: **Comment Closed**

Public / SBU / FOUO
Patent 11/892,984 ProjNet property of ERDC since 2004.

QUALITY CONTROL CERTIFICATE
Real Estate Division, Acquisition and Management Branch

PROJECT NAME: AMERICAN RIVER COMMON FEATURES GRR
PRODUCT: REAL ESTATE APPENDIX FOR FRM MILESTONE
ACTUAL COMPLETION DATE: August 3, 2015

PROJECT MANAGER: DAN TIBBITTS

The Real Estate Appendix is intended to inform the reader of the major Real Estate factors which were considered in the investigation and influenced decisions documented in the main report. It also presents a summary of the real estate costs, inventory, and analysis and assumptions associated with the lands, easements, right of way, relocations and disposal required for the tentatively selected plan. This DQC effort has verified that the Real Estate analysis is compliant with clearly established U.S Army Corps of Engineers policies, regulations, and that the assumptions, methods, data and tools used are appropriate for purposes of a real estate plan and that the level of detail and scope are reasonable and consistent within the context of the Real Estate Appendix.

REAL ESTATE LEAD
I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved issues identified during District Quality Control (DQC) Review.

Lead Realty Specialist Name	Title: Realty Specialist	
Laurie Parker	Laurie Parker	8/10/2015
Print Name	Signature	Date

REVIEWER
I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer: Name	Title: Chief, Civil Works Section	
Paul Zianno	Paul Zianno	8/7/2015
Print Name	Signature	Date

QUALITY CONTROL CERTIFICATE
Real Estate Division, Acquisition and Management Branch

PROJECT NAME: AMERICAN RIVER COMMON FEATURES GRR
PRODUCT: REAL ESTATE APPENDIX FOR PUBLIC REVIEW MILESTONE
ACTUAL COMPLETION DATE: FEBRUARY 2015

PROJECT MANAGER: DAN TIBBITTS

The Real Estate Appendix is intended to inform the reader of the major Real Estate factors which were considered in the investigation and influenced decisions documented in the main report. It also presents a summary of the real estate costs, inventory, and analysis and assumptions associated with the lands, easements, right of way, relocations and disposal required for the tentatively selected plan. This DQC effort has verified that the Real Estate analysis is compliant with clearly established U.S Army Corps of Engineers policies, regulations, and that the assumptions, methods, data and tools used are appropriate for purposes of a real estate plan and that the level of detail and scope are reasonable and consistent within the context of the Real Estate Appendix.

REAL ESTATE LEAD
I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved issues identified during District Quality Control (DQC) Review.

Lead Realty Specialist Name	Title: Realty Specialist	
Laurie Parker	Laurie Parker	2/19/2015
Print Name	Signature	Date

REVIEWER
I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer: Name	Title: Chief, Civil Works Section	
Paul Zianno		2/24/2015
Print Name	Signature	Date

Common Features Real Estate Plan February 2015
DQC Comments
Reviewer: Paul Zianno, Chief, Civil Works Section

REPORT SYNOPSIS

DQC COMMENT	RESPONSE	BACK CHECK
Based on previous comments from HQ, make sure the maps are attached to the RE Plan and not on a DVD. You can send the DVD, just make sure the maps are attached to the REP. Page 4	Will include hyperlink in the document in lieu of a DVD. The reviewer can click on the link and the data will come up instantly	X
Please identify what the letters mean on the map. Need to identify as phases. Page 9	Concur	X
After reading through this section it needs to be rewritten describe in specific detail with the description of the estates required. List all of the estates required for this project and under each one describe the location, acreage, owner description (private or non-federal), tract #. Need to break out by Title of the Sacramento and American River Systems Mitigation discussion can be at the end of this section. Laurie, Please identify what the letters mean on the map. Need to identify as phases. Page 12	Concur -- rewriting section as stated above	X
Is this a Road Easement? Page 12	Yes it is a Road Easement	X
This is a non-standard estate? Page 12	No the mitigation is at a bank or on site. It could potentially become non standard if fee is not available on site.	X
This is also a non-standard estate? Page 12	Due to the SWIF variance this is no longer a requirement of the project and these section will be removed from the report	X
You need to include specifically and spell out each estates required for the project. Also, include the acreage, tract numbers and the number of and type owners impacted by this acquisition. Adding a Table showing all the estates with the required information might be beneficial to the reader. Page 15	Concur the table will be shown in Section 4. Description of LERRD's.	X
Is this a Road Easement? Page 13	No This was a vegetative free zone. Due to the SWIF variance it is no longer needed and will be removed from this report	X
Expand, include info as stated in comment 7. Page 13	This description is incorrect. It will be rewritten to reflect new levees, levee raises, seepage berms, cutoff walls, and floodwalls. There is no new setback in this project.	X
Road Easement? Page 13	Yes this is the road easement. I will rename the easement.	X
Road Easement or a non standard estate? Page 13	This would have been a nonstandard estate but due to the SWIF variance it is no longer a requirement and shall be removed from the report.	X
All of these estates need to be expanded to include the info I discuss in comment #7. Page 13	Concur this section is being rewriting in Section 4. Description of LERRD's.	X
Who are the owners? Specify. Page 13	No owners are identified at this time only areas where potential borrow may be available. Borrow may not be suitable after testing so more than one site has been identified and is shown in Figure 2 Proposed Borrow Sites	X

We need to explain to the reader how the SWIF relates to theis porposed Mitigation Sites. It might be better to include the SWIF discussion in this section. Page 15	Concur I will move the SWIF discussion to the mitigation sites. The SWIF variance relates to more than just mitigation areas. The SWIF eliminates the road easements and the vegetative free zone for almost the entire project.	X
The document needs to specifically state whether we are buying land for mitigation or are is the project purchasing mitigation bank creditd. Should include a map showing these proposed sites, owner description (Private or non-federal sponsor owned). Is this amount included in the 01 Account? Need to specify. Page 15	The project will be purchasing mitigation credits. There are no banks proposed yet to map.	X
Is this paragraph a part of the Flood Protection Levee Easement, if so, this section needs to be included in that discussion above. Page 17	Concur: This has been moved to the discussion above	X
This Figure needs to be referenced in the discussion on Borrow Easements. Need to include acreage, owner description, Tract number, if known, Need to discuss Environmental impacts, suitability of material, and costs associated with the Borrow Material. Page 18	We know how many cubic yards and how many acres of borrow we need but we do not know if the material is suitable so we have over identified borrow areas. At this time in the feasibility study I have not been provided which actual parcels we are going to use. Based on the Natural Resources Conservation Service soil survey data, there are approximately 425 million Cubic Yards of material that potentially meets geotechnical requirements for level fill within an approximate 25 mile radius of the City of Sacramento. A map that proposed potential sites was created and several potential sites identified. The rough assumptions the Corp used was the material had to meet geotechnical requirements either by open undeveloped land or agricultural areas, and was located between ground surface and a depth of 2.5 feet below ground surface. In the high confidence areas in each basin the estimated amount of borrow needed within a 25 mile haul route radius is calculated below with costs for borrow. The high confidence areas were defined as areas where up to 48 inches of borrow could be excavated as opposed to the low confidence areas where only up to 12 inches of material would be available where 3 times the amount of land would be required. Potential land costs for borrow sites were developed by the Appraisal Section, Sacramento District, Corps of Engineers. The below quantities estimate the potential quantities of material required and the cost. American River South Basin High Confidence Area requires 69.76 AC of land for 275,743 CY of borrow = $453,400 + (35% cont + 15% severance= 226,700) = $680,100 American River North Basin High Confidence Area requires 0.64 AC of land for 2,519 CY of borrow =$4,186 (35% cont + 15% severance $2,093) = $6,279 Natomas Basin High Confidence Area requires 337.43 AC of land for 1,333,747 CY of borrow = $2,193,295 (35% cont + 15% severance = $1,096,647.50) = $3,289,942. The below map shows high confidence areas of available borrow where up to 48" of material can be excavated at one time.	X
These Figures need to be referenced in the above text regarding the SWIF, Bank Protection, and Road Easement estate discussions. Page 19	Concur. The SWIF discussion will occur all in the same portion of the report.	X
Need to be more specific in what this entails. Does the project impact high traffic rail lines that will have to be relocated? What about Railroad bridges and approaches thereto? Is that bridge in the picture below need to be relocated?	Yes the railroad bridge and track crossing over the Sacramento Bypass will be unable to utilize that bridge for two years. The other easement areas should not prevent the trains from moving and include no closure structures. Page 20	X
Is this paragraph needed if so it needs to be wrapped up in the estate text above. Page 21	No this paragraph has been deleted it is not needed.	X

What's the required estate for these features. Need to revise the Table. Page 22	The estates are shown in Section 4 description of LERRD's. These tables have been deleted.	X
What does the Letters mean in the Figure please specify. Page 24	I will provide a definition of the letters in the report.	X
What are the estates required for these reaches? Page 25	The estates are shown in table 1 of Section 4. These tables have been deleted.	X
Again, these paragraphs need to be included in the required estate s language above. Page 26	These tables have been moved see comment L54.	X
Not quite sure what this figure is trying to show and is it needed in the REP? Page 32	These are the design feature maps that accompany the estates required tables. They are showing the construction area and the improvements we are making. This is needed in the REP.	X
Same as comments 26 above. The paragraphs below need to be included in the discussions on the required estates.	Concur will add this to Section 4. Page 33	X
In a previous section you mention that permanent flowage easements are required. Please clarify. Page 39	I will revise this to say permanent	X
There is no mention of Non-Standard Estates? What about the Environmental Mititgation lands required for the project?	No non standard estates have been identified thus far. Environmental mitigation is will be at banks. Page 37	X
We need to expand this paragraph on how we are going to apply Navigational Servitude. The ER 405 talks specific to the requirements. Page 39	Will include longer discussion.	X
Not quite sure why this map is shown here? It's not referenced in the text? Need to spell out NAT Page 40	I will delete this map	X
Based on the Figure below, the flowage easement will impact an industrial area? Is that one of the acquisitions for this project? Could be a business relocation under PL 91-646. Page 41	I have inserted a new map that does not show the relocation of any businesses. Civil Engineering has a new map I will be including.	X
This value seems low and it does not match Table 7. What are the contingency costs? Page 44	25% contingency included already	X
Need to describe specifically whether these relocations are business or residential. Any mobile home parks impacted? Page 44	The relocations are 13 residential, 2 commercial buildings and 2 marinas. No mobile homes impacted	X
Briefly describe what these UF Relocations are. Page 47	Concur I will add a category	X
Does the report need this table? Can we delete it and use the Table 8 below? A little confusing Page 47	I can delete it.	X
Briefly describe these relocations Page 48	Concur	X

QUALITY CONTROL CERTIFICATE

Economic Risk Analysis Section, Planning Division

PROJECT NAME: AMERICAN RIVER COMMON FEATURES GRR, CALIFORNIA
PRODUCT: ECONOMIC APPENDIX
Actual Completion Date: 13-Aug-15
PROJECT MANAGER: DAN TIBBITS

The economic analysis noted below describes in a clear and concise manner the major assumptions, methods, data, and analytical tools used in the analysis, and summarizes the results of the analysis using table and text formats. This DQC effort has verified that the economic analysis is compliant with clearly established U.S. Army Corps of Engineers policies, principles and procedures; that the assumptions, methods, data and analytical tools used are appropriate for purposes of an economic analysis; that the level of detail and scope of the analysis are appropriate for purposes of an economic analysis; and that they results are reasonable and consistent within the context of an economic analysis.

Specific product reviewed: This DQC review focused on the updated net benefits and benefit-to-cost ratios and other small changes incorporating review comments. Also reviewed were the FDA files and methodology for Emergency and Cleanup costs. This iteration represents the draft FINAL Economic Appendix for the FRM milestone and the CWRB.

ECONOMIC LEAD

I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved all issues identified during District Quality Control (DQC) review.

Lead Economist:	Title: Economist	
Timi Shimabukuro	SHIMABUKURO.TIMI.R.1232082522 Digitally signed by SHIMABUKURO.TIMI.R.1232082522 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=SHIMABUKURO.TIMI.R.1232082522 Date: 2015.08.13 11:42:31 -07'00'	13 Aug 2015
Print name	Signature	Date

REVIEWER

I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer:	Title: Chief, Economic & Risk Analysis Section	
Nicholas Applegate	APPLEGATE.NICHOLAS.JAMES.1246006640 Digitally signed by APPLEGATE.NICHOLAS.JAMES.1246006640 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=APPLEGATE.NICHOLAS.JAMES.1246006640 Date: 2015.08.13 09:50:39 -07'00'	13 Aug 2015
Print name	Signature	Date

RESOURCE PROVIDER

I have reviewed the quality control process and ensured that comments have been adequately address, documented and resolved.

Section Chief:	Title: Chief, Economic & Risk Analysis Section	
Nicholas Applegate	APPLEGATE.NICHOLAS.JAMES.1246006640 Digitally signed by APPLEGATE.NICHOLAS.JAMES.1246006640 DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=APPLEGATE.NICHOLAS.JAMES.1246006640 Date: 2015.08.13 09:51:05 -07'00'	13 Aug 2015
Print name	Signature	Date

Economic and Risk Analysis Section
District Quality Control Review Comments
American River Common Features GRR
August 2015

Comments submitted by: Nick Applegate, Chief, Economic Risk Analysis Section, SPK
Responses submitted by: Timi Shimabukuro, Regional Economist
Backcheck submitted by: Nick Applegate, Chief, Economic Risk Analysis Section, SPK

Editorial Comments:

1. **Comment:** List of Tables: The bookmark link for Table 17, 44 and 46 appears to be broken, i.e. *"Error! Bookmark not defined."*
   Response: Concur. The List of Tables has been updated.
   Backcheck: Change verified, comment closed.

2. **Comment:** Sec 2.7.4, par 4. "The maximum clean-up cost of $10/ft2 was used for the West Sacramento economic assessment…" I believe this should say "ARCF" instead of "West Sacramento." Please revise.
   Response: Concur. This sentence has been revised.
   Backcheck: Change verified, comment closed.

3. **Comment:** Pg. 41, "(The Emergency Cost analysis was performed after the determination of the Final Array of Alternatives. Since none of the alternatives include the Natomas Basin, the emergency cost analysis did not include the Natomas Basin. More information about the Final Array of Alternatives is presented in Chapter 4.)" I'm not sure you need the parenthesis around these two sentences. Consider removing.
   Response: Concur. The parentheses have been removed.
   Backcheck: Change verified, comment closed.

4. **Comment:** Pg. 41, "Tables 17 below display the results of the HEC-FDA analysis." Change to "Table 17 below displays the results of the HEC-FDA analysis."
   Response: Concur. This sentence has been edited.
   Backcheck: Change verified, comment closed.

5. **Comment:** Sec 3.3.3, par 2. "the AEP values listed in Table 19 for each index point…" I think you may mean Table 18 as Table 19 doesn't have AEP's. Please verify.
   Response: Concur. The reference to "Table 19" has been changed to "Table 18."
   Backcheck: Change verified, comment closed.

6. **Comment:** Sec 3.3.4, par 1. Fix Table reference from Table 18 to Table 19.
   Response: Concur. Reference to "Table 18" has been changed to "Table 19."
   Backcheck: Change verified, comment closed.

Technical Comments:

7. **Comment:** Section 2.2, par 1. Given the CWRB in Dec, we will most-likely be required to update prices to October 2015 using the new FY16 discount rate (when it comes out). We could update to Oct 2015 now using a trend analysis, but it's probably prudent to wait until the new discount rate is out.
   Response: Concur. Costs and benefits will have to be updated once the FY16 (October 2015) federal discount rate is available.
   Backcheck: Comment closed.

8. **Comment:** Section 2.3, par 1. "200-yr event." At the very least, recommend footnoting this to explain what a 200-yr event actually means. For example: "200-yr" refers to an event with a 1/200 (0.5%) chance of occurrence in any given year, also known as the 0.5% Annual Chance Exceedance (ACE) event. These terms will be used interchangeably throughout this document."
   Response: Concur. A statement identifying the various terms and that either is used throughout the Economic Appendix has been added.
   Backcheck: Change verified, comment closed.

9. **Comment:** Figure's 5 and 6 aren't very high quality and are difficult to read. Do we have any better graphics that show the delineation of the EIA's? In the case of Figure 5, there are no boundaries to understand where one area ends and another begins.
   Response: Concur. Figures 5 and 6 will be replaced with better quality maps during the next report update (October 2015).
   Backcheck: Comment closed.

10. **Comment:** Table 43. Costs for the "Fix Creeks" increment appear to have risen by ~$30M (15%) since the last iteration in March. What is the reason for this cost increase? This increase is significant because it appears to make that increment economically infeasible. Later discussions related to Emergency/Cleanup benefits seem to indicate a $1.45M annual benefit that is not included in this table, which would bump the BCR back up over 1:1. Can the emergency/cleanup benefits be added to this table?
    Response: Concur. Costs have increased for the tributaries. Alternative 1 has an additional $1.25 million in benefits associated with the prevention of emergency cost losses; Alternative 2 has an additional $1.45 million in benefits. The damages/benefits related to the prevention of emergency cost losses have been incorporated into the incremental analyses. Including the emergency cost benefits increases the BCRs for the "Creeks" increment to 1.0 (Alternative 1) and 1.2 (Alternative 2).
    Backcheck: Verified, comment closed.

11. **Comment:** Pg. 59, Emergency Cost discussion. Recommend moving this entire section (including Tables 45 & 46) up to the beginning of Section 4.11 and prior to the incremental Net Benefit Analysis tables. Then add in the emergency/cleanup benefit totals into the incremental tables 42, 43 and 44.

Response: Concur. The Emergency Cost section was moved up (to Section 4.9) prior to the incremental analyses. The incremental analyses now incorporate the damages/benefits related to emergency cost losses.
Backcheck: Verified, comment closed.

12. **Comment:** Tables 47 and 48. Please add a footnote to the Total First Costs indicating that Cultural Resources were removed per policy. I.e. "Cultural resources data recovery costs ($6.17M) are not included in economic costs per USACE policy."
Response: Concur. Footnotes explaining that cultural resource preservation costs have been excluded from the economic analysis have been added to Tables 44-45 and 49-50.
Backcheck: Verified, comment closed.

13. **Comment:** Attachment 3, OSE discussion. Please add a subsection with the same discussion of social justice for the "creeks" area that was added to the main report.
Response: Concur. A section discussing the social justice aspect of making FRM improvements to the creeks has been included in the OSE analysis/report (Life Safety Evaluation/Population at Risk section).
Backcheck: Verified, comment closed.

HEC-FDA Comments (Emergency/Cleanup):

14. **Comment:** The FDA models and output files associated with Emergency costs were reviewed and there were no significant issues. The Inventory values were input correctly using $10/square foot for cleanup costs on all structures and $11,244 for all residential structures for Temporary Housing assistance. Depth-damage curves were appropriately applied. The results and proportions relative to structure/content damages are consistent with the findings of the Authorized Sutter feasibility study (which used a similar methodology). Adding these categories into the final array makes the Economic analysis more complete. No response necessary.
Response: No response necessary.
Backcheck: Comment closed.

QUALITY CONTROL CERTIFICATE

Environmental Planning Section, Planning Division

PROJECT NAME: American River Common Features Project GRR
PRODUCT: Habitat Mitigation Monitoring and Adaptive Management Plan
ACTUAL COMPLETION DATE:

PROJECT MANAGER: Dan Tibbits

The District has completed review of the habitat mitigation monitoring and adaptive management plan for the American River Common Features Project General Reevaluation Report. Certification is hereby given that all quality control activities defined in the Project Review Plan appropriate to the level of risk and complexity inherent in the product have been completed. Documentation of the quality control process is enclosed.

Compliance with clearly established principles and procedures, utilizing clearly justified and valid assumptions, has been verified. This includes assumptions, methods, procedures and materials used in analyses; the appropriateness of data used and level of data obtained; and the reasonableness of the results, including whether the product meets consistency with law and existing Corps policy. All appropriate DQC comments have been incorporated into this project. The undersigned recommends certification of the quality control process for this product.

ENVIRONMENTAL LEAD
I have ensured that the above products were prepared in accordance with standard quality control practices. I have also incorporated or resolved all issues identified during DQC review.

Environmental Lead: Anne Baker Title: Senior Environmental Manager

Print Name | Signature | Date 12/1/15

REVIEWER
I have reviewed the products noted above and find them to be in accordance with project requirements, standards of the profession, and USACE policies and standards.

DQC Reviewer: Dan Artho Title: Senior Environmental Manager

Print Name | Signature | Date 12/1/15

RESOURCE PROVIDER
I have reviewed the quality control process and ensured that comments have been adequately addressed, documented, and resolved.

for Resource Provider: Josh Garcia Title: Chief, Environmental Analysis Section

Zimnoski, Mark T. | Signature | Date 1/7/16

Print Name

DQC BACKCHECK -- Appendix I Mitigation and Monitoring Plan_DFA.docx

Main document changes and comments

Page 4: Comment [DFA1]	L2PDRDFA	11/24/2015 3:37:00 PM

Repeat of statement above. Suggest deleting. Or is this supposed to be on American River?

RESPONSE: Combined the sentences so that the description seems less repetitive.

DFA BACKCHECK: Comment was in reference to the discussion about levee raising on the Sac River in the third sentence of the paragraph. However, this is more of an editorial comment than a content-related comment and the paragraph as it currently stands sufficiently provides the summary of the proposed measure. COMMENT CLOSED.

Page 5: Comment [DFA2]	L2PDRDFA	11/24/2015 3:38:00 PM

Does this apply to Sacramento River as well? Might want to indicate so in the Figure title if that is the case.

RESPONSE: Figure 1 is the American River scenario, while Figure 2 is the Sacramento River scenario. The rivers have been added to the two figures.

BACKCHECK DFA: Perfect. COMMENT CLOSED.

Page 2: Comment [DFA3]	L2PDRDFA	11/30/2015 4:00:00 PM

Are the HSIs for the future without project estimated to be the same as the future with-project? If so, you need to state that. If not, you should show a separate table for the FWOP HSI values for each target year.

Response: The FWOP HIS output is different so we've added in the table that show the values for each target year.

BACKCHECK DFA: Comment Closed.

Page 2: Comment [SRR4]	Sarah Ross	11/22/2015 9:36:00 PM

Add reference to paragraph above

Page 3: Comment [DFA5]	L2PDRDFA	11/30/2015 4:00:00 PM

This table shows the Mayhew Drain HEP results, correct? If that is the case, then you should indicate as such in the Table title. I would also recommend adding a footnote to the table explaining how this information was applied to ARCF mitigation requirements.

Response: Added Mayhew drain project to the title of the table and added a foot not explaining how the information was applied to ARCF.

BACKCHECK DFA: Acceptable. Comment closed.

Page 3: Comment [DFA6]	L2PDRDFA	11/30/2015 4:05:00 PM

Where are the results of the CE/ICA? Recommend showing the standard line and bar graphs that plot the CE plants and the incremental cost comparison between mitigation proposals.

Response: The CE/ICA results can be found at the end of Appendix I.

BACKCHECK DFA: Text needed a reference to where the CE/ICA is located. Reference included. Comment Closed.

Page 3: Comment [DFA7]	L2PDRDFA	11/30/2015 4:05:00 PM

Should this be AAHU's?

Response: Concur

BACKCHECK DFA: Comment Closed.

Page 5: Comment [DFA8]	L2PDRDFA	11/30/2015 4:06:00 PM

Indicate the specific source of these requirements; e.g., BOs, CAR, FWS Mitigation Policy, etc.

RESPONSE: Concur. Revised sentence to refer to the BOs and CAR.

BACKCHECK DFA: Comment Closed.

Page 6: Comment [DFA9]	L2PDRDFA	11/30/2015 4:06:00 PM

Make sure to remove this reference to West Sac GRR in the ARCF MMAMP, and vice-versa for the West Sac plan.

Response. Concur. Will remove all references to the other GRR when we finalize the HMMAMP

BACKCHECK DFA: Comment closed.

Page 6: Comment [DFA10]	L2PDRDFA	11/30/2015 4:07:00 PM

See comment above.

Response. Concur.

BACKCHECK DFA: Comment closed.

Page 7: Comment [DFA11]	L2PDRDFA	11/30/2015 4:08:00 PM

General question: Does onsite mitigation require purchase of land in fee title to guarantee land remains habitat mitigation in perpetuity?

Response. Yes, onsite mitigation must be purchased & protected in perpetuity. It might not be possible for bank protection sites though. For the Parkway, we are leasing the land, so there is an additional fee for land lease. Do you want us to add more info about this into the plan?

BACKCHECK DFA: Not necessary, if identified as such in the EIS. Comment closed.

Page 10: Comment [DFA12]	L2PDRDFA	11/30/2015 4:09:00 PM

Is this supposed to be 50%?

RESPONSE: Yes. The percent sign has been added.

BACKCHECK DFA: Comment closed.

Page 10: Comment [DFA13]	L2PDRDFA	11/30/2015 4:09:00 PM

Is there a specific depth that should be identified, or distance from shoreline?

Response. The specific depth is currently unknown and would be determined through preconstruction monitoring and modeling efforts. As a result, at this time based on current science the full width of the river/channel should be monitored. The table has been revised to reflect this.

BACKCHECK DFA: Comment closed.

Page 14: Comment [DFA14]	L2PDRDFA	11/30/2015 4:13:00 PM

What are these performance standards based off of? Recommend indicating the source that these standards were derived from.

RESPONSE: Added in the note below the table.

Dan, it would be helpful if you can weigh in on whether or not Natomas is a reasonable source for HQ purposes. I'm trying to use the proximity/habitat quality argument on why its valid, but it is not a Corps project, and I'm worried that they would prefer to see something from the Corps as a source. Sutter had very similar, but slightly lower performance standards that we could use as a Corps source – they range from 80% to 60% over time. I would be comfortable with switching to those if you think it is a stronger argument.

BACKCHECK DFA: Suggest keeping these in light of the fact that success criteria from several different projects were considered. Comment closed.

Page 15: Comment [DFA15]	L2PDRDFA	11/30/2015 4:13:00 PM

Where are the reference reaches? How do the success criteria relate to the reference reaches?

Response: I'm not sure that "reference reaches" was an appropriate goal. I think it would be more accurate to say that our long-term goal is to provide replacement habitat similar to the habitat that was impacted by project construction. The goal is compensation, not enhancement. The language has been adjusted to reflect this.

BACKCHECK DFA: Concur. Comment closed.

Page 16: Comment [DFA16]	L2PDRDFA	11/30/2015 4:14:00 PM

What sources, literature, expert opinion, etc., supports these performance standards?

Response. See above response and added footnote

BACKCHECK DFA: Comment closed.

Page 21: Comment [DFA17]	L2PDRDFA	11/30/2015 4:15:00 PM

What is the basis for these standards?

RESPONSE: Added note to table establishing the source of the standards.

BACKCHECK DFA: Comment closed.

Page 24: Comment [DFA18]	L2PDRDFA	12/1/2015 8:59:00 AM

I don't think you have included sufficient justification for development of a physical model for this study as called for by HQ review comments. Perhaps indicating that existing info and model outputs suggested a jeopardy opinion to green sturgeon. Also, why are both an EFM and Physical model necessary?

Response. Added language clarifying that the purpose of this modeling effort is to address the differing resource needs for each listed species and inform design refinements for the projects.

BACKCHECK DFA: Still not clear if this is needed per BiOp requirements. I'll defer to SME's about the need for this, but suggest presenting stronger justification for this extra cost. Comment closed.

Page 25: Comment [DFA19]	L2PDRDFA	12/1/2015 8:54:00 AM

Would it be from SAM or from the EFM Model developed for green sturgeon?

RESPONSE: I think the idea right now is that we don't know what the EFM model will tell us yet, therefore the SAM is still the best available tool, and the performance standards are currently developed from the SAM. With the long term goal to refine them based on the results of the EFM model. I reworded this paragraph slightly to focus on the present standard being from SAM. Also reworded the paragraph associated with the below bullet list to reflect that those could be future performance standards developed from EFM.

BACKCHECK DFA: Comment closed.

Page 26: Comment [DFA20]	L2PDRDFA	12/1/2015 8:54:00 AM

What establishes these as appropriate standards for sturgeon mitigation success? Is there literature, studies, etc., that supports this?

Response. The District fisheries team met with NMFS to coordinate appropriate performance standards based on the current best available science. Their determination was that the current best data is based on the SAM analysis, therefore they selected outputs from the SAM that they felt were likely relevant to sturgeon and that would likely remain relevant even with the future modeling efforts.

BACKCHECK DFA: Comment closed.

Page 30: Comment [DFA21]	L2PDRDFA	12/1/2015 8:47:00 AM

Per WRRDA 2007, you will need to identify the costs of monitoring separate from the costs for adaptive management.

Response. Concur. The section has been revised to present the monitoring costs separate from the adaptive management costs, and a total for the overall plan.

BACKCHECK DFA: Comment closed.

Header and footer changes

Text Box changes

Header and footer text box changes

Footnote changes

Endnote changes

FLOOD RISK MANAGEMENT
PLANNING CENTER OF EXPERTISE
REVIEW MANAGEMENT ORGANIZATION

AGENCY TECHNICAL REVIEW REPORT
SEPTEMBER 2015

Of the:

AMERICAN RIVER WATERSHED
COMMON FEATURES
GENERAL REEVALUATION REPORT
SEPTEMBER 2015 and ENVIRONMENTAL IMPACT STATEMENT/
ENVIRONMENTAL IMPACT REPORT
SEPTEMBER 2015

Sacramento District

US Army Corps
of Engineers ®

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AGENCY TECHNICAL REVIEW REPORT

1. Scope and Purpose of Review
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6. Summary.
7. Dr Checks Report.
8. ATR Completion Statement.

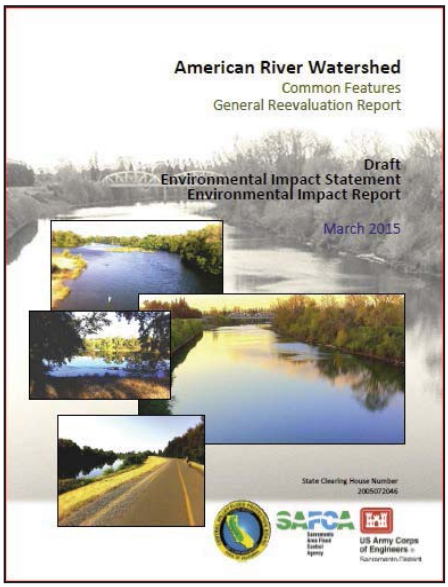
ENCLOSURES

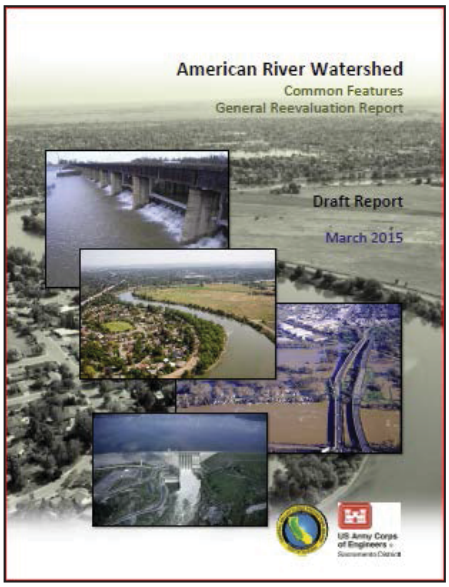
Enclosure 1: DRCHECKS REPORT OF ALL COMMENTS

Enclosure 2: COMPLETION STATEMENT OF AGENCY TECHNICAL REVIEW

Agency Technical Review Report

Subject: Review report for the **AMERICAN RIVER WATERSHED, COMMON FEATURES, FINAL GENERAL REEVALUATION REPORT, September 2015, and FINAL ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT, September 2015**, Sacramento District. Document covers below show the draft general reevaluation report (GRR) and National Environmental Policy Act document covers for the environmental impact statement/environmental impact report (EIS/EIR) as examples of the final report covers. At the request of the review team lead, the District provided track change documents to the review team to facilitate examination of the revisions made to the report between the backcheck documents used to complete the ATR of the draft GRR and EIS/EIR documents in the spring of 2015 and the final GRR and EIS/EIR documents used in August 2015 to start the ATR of the final GRR and EIS/EIR documents. Final report cover versions were not necessary.





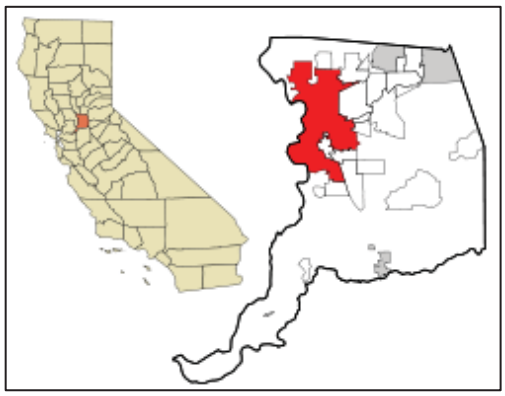
1. **Scope and Purpose of Review**. The purpose of this review report is to document agency technical review (ATR) for the subject product. The review was conducted for the Sacramento District (District). The primary point of contact for the District was Dan P. Tibbitts, CESPK-PM-C, Project Manager. The ATR team (ATRT) was lead by Marc L. Masnor, P.E., CESWF-PEC-PF (Tulsa, OK) for completion of the ATR. The Flood Risk Management (FRM) Planning Center of Expertise (PCX) was the Review Management Organization (RMO).

A previous ATR was initiated in September 2014 and completed in June 2015 for the draft general reevaluation report and draft environmental impact statement/environmental impact report.

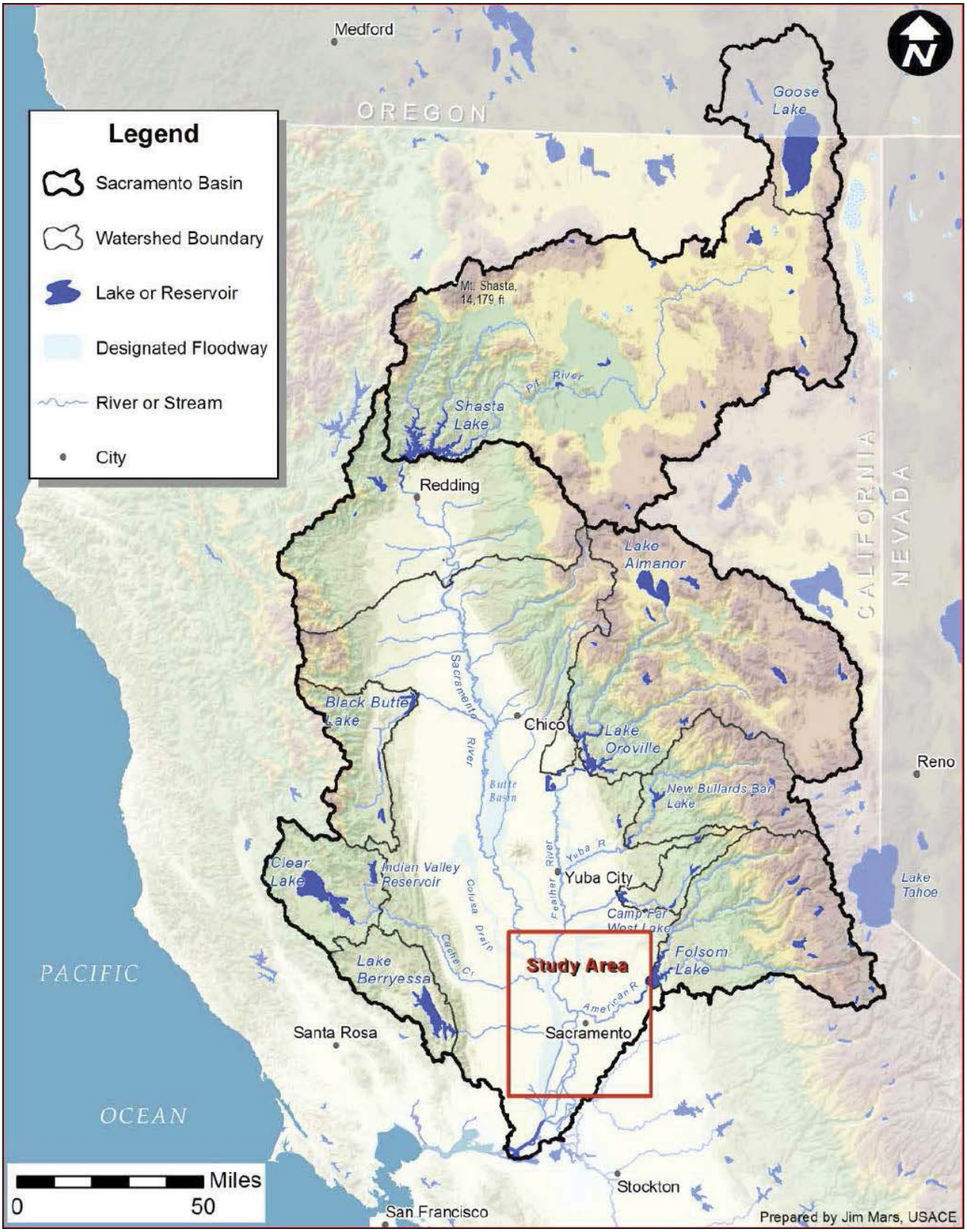
This ATR was initiated in August 2015. Comments were entered by the ATRT between August and September 2015. All comments were closed.

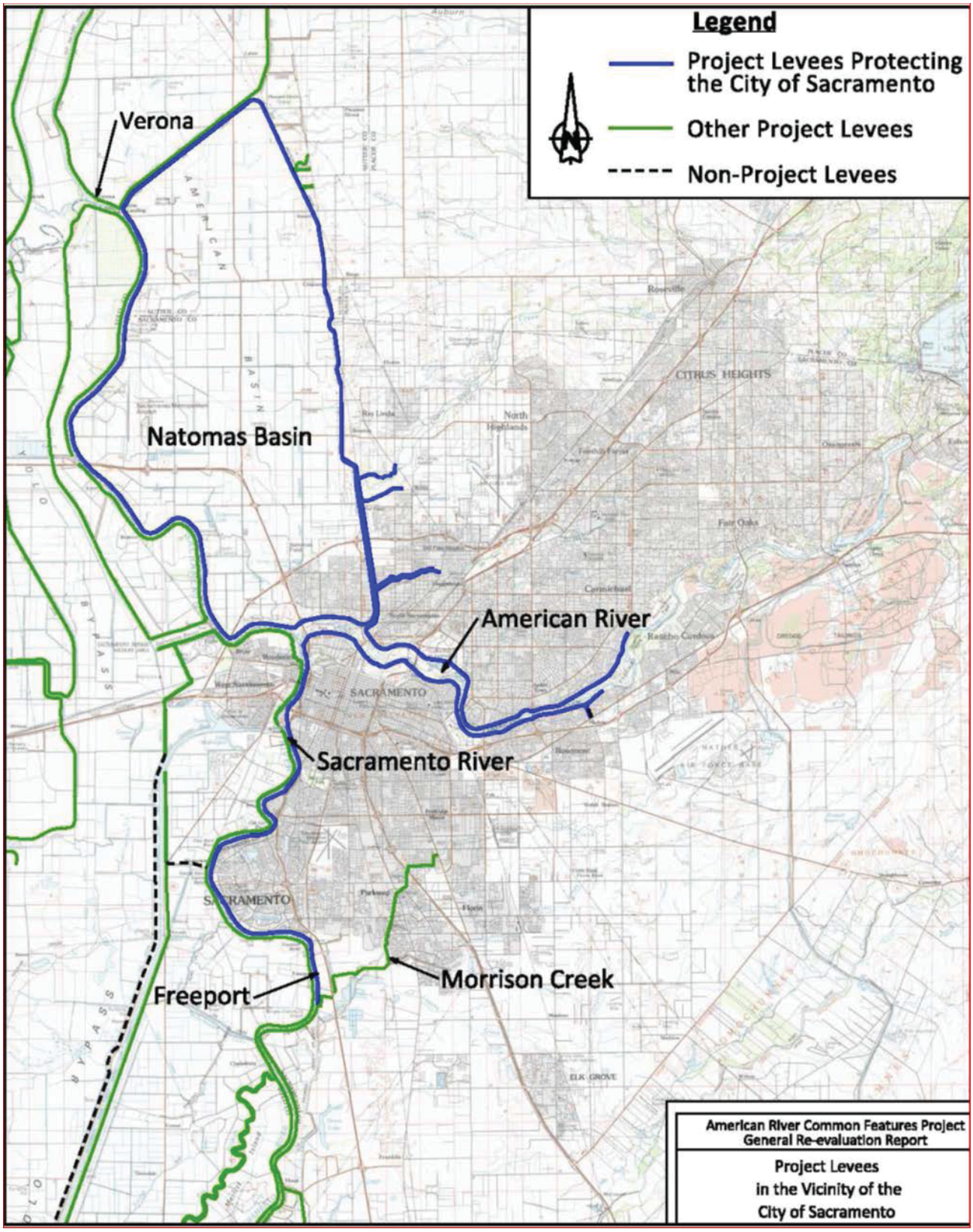
2. **References**. This review report was prepared in response to EC 1165-2-214, 15 December 2012, Water Resources Policies and Authorities, CIVIL WORKS REVIEW. The review documents reside online at ProjNet (www.projnet.org), DrChecks Project and Review titles: Project: ARCF - General Reevaluation Report (GRR), TSP & Attachments, American River Common Features (ARCF), California (P2 #149827), Review: Review: ATR Final EIS/EIR (10-14 Aug 2015) (00031).

3. **Project Description**. The study area is located in the general vicinity of the confluence of the Sacramento and American Rivers, and includes the City of Sacramento (right inset in red), CA (left inset), and surrounding areas in Sacramento County (left inset, county shown in red).



The Sacramento River is the largest river and watershed system in California and transports 31% of the state's total surface runoff. The upper watershed is drained by three rivers; the upper Sacramento River, the McCloud River, and the Pit River, which join at Lake Shasta, a 4.5 million acre foot reservoir formed by Shasta Dam. The Sacramento River then flows south through the northern Central Valley of California. The Sacramento River watershed covers an area of approximately 27,000 square miles. Major tributaries of the Sacramento River include the Feather River, the Yuba River, and the American River. (see figures next two pages)


Legend
Sacramento Basin
Watershed Boundary
Lake or Reservoir
Designated Floodway
River or Stream
City
Medford
OREGON
Goose Lake
Mt. Shasta, 14,179 ft
Pit River
Shasta Lake
Redding
Lake Almanor
CALIFORNIA
NEVADA
Sacramento River
Black Butte Lake
Chico
Lake Oroville
Reno
Butte Basin
New Bullards Bar Lake
Yuba R
Clear Lake
Indian Valley Reservoir
Colusa Drain
Feather River
Yuba City
Lake Tahoe
Camp Far West Lake
Cache Cr
Study Area
Folsom Lake
Lake Berryessa
American R
PACIFIC
Santa Rosa
Sacramento
OCEAN
Miles
0
50
Stockton
San Francisco
Prepared by Jim Mars, USACE


Legend
Project Levees Protecting the City of Sacramento
Other Project Levees
Non-Project Levees
Verona
Natomas Basin
American River
Sacramento River
Freeport
Morrison Creek
American River Common Features Project
General Re-evaluation Report
Project Levees
in the Vicinity of the
City of Sacramento

The study area consists of the north and south banks of the American River downstream of Folsom Dam, the Natomas Basin, the east bank of the Sacramento River, and areas surrounding five other smaller waterways which are sources of potential flooding. Each area is at risk of flooding from multiple sources.

The three basins are referred to as the American River South (ARS) basin, the American River North (ARN) basin, and the Natomas (NAT) basin. (see figure next page)

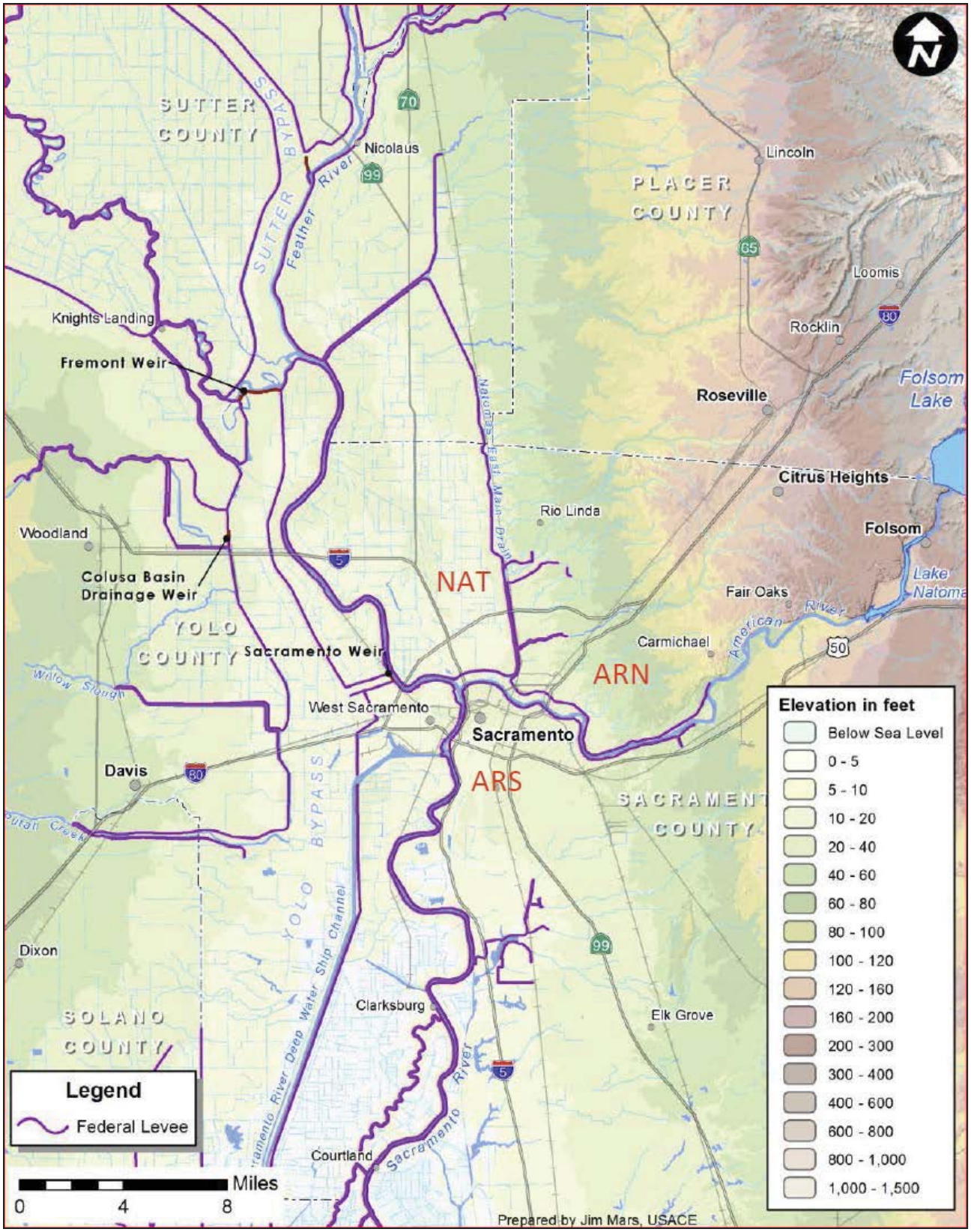
1. The ARS basin is protected by 25 miles of levee along the American and Sacramento Rivers. There are over 400,000 people at risk of flooding in this basin.

2. The ARN basin is protected by 25 miles of levee along the American River, the Natomas East Main Drainage Canal (NEMDC), Arcade Creek, and Dry/Robla Creeks. There are approximately 100,000 people at risk of flooding in this basin.

3. The NAT basin is protected by 42 miles of levee along the American and Sacramento Rivers, NEMDC, the Pleasant Grove Creek Canal, and the Natomas Cross Canal. There are approximately 100,000 people at risk of flooding in this basin.

The purpose of the study is flood risk management. Potential FRM measures range from modifying and/or increasing conveyance through raising and strengthening levees, widening channels and bypass areas, modifying weirs and bypasses. Non-structural floodplain management measures would also be considered. The estimated cost for the project is approximately $2 billion.

The authorized project features were developed to work in conjunction with the authorized Folsom Dam modifications and the increased flow releases that would be anticipated. These features included seepage remediation along approximately 22 miles of the American River and construction of levee strengthening and raising of 12 miles of Sacramento River levee in Natomas. Additionally, the authorization includes construction of seepage remediation and levee raises along four stretches of the American River and construction of levee strengthening and raising of 5 miles of the Natomas Cross Canal levee in Natomas.


SUTTER COUNTY
SUTTER BYPASS
Feather River
Nicolaus
Lincoln
PLACER COUNTY
Loomis
Rocklin
Knights Landing
Fremont Weir
Roseville
Folsom Lake
Natomas East Main Drain
Citrus Heights
Rio Linda
Folsom
Woodland
Colusa Basin Drainage Weir
NAT
Fair Oaks
Lake Natoma
American River
YOLO COUNTY
Sacramento Weir
Carmichael
ARN
Willow Slough
West Sacramento
Sacramento
Davis
ARS
SACRAMENTO COUNTY
Putah Creek
YOLO BYPASS
Sacramento River Deep Water Ship Channel
Dixon
Clarksburg
Elk Grove
SOLANO COUNTY
Sacramento River
Courtland
Legend
Federal Levee
Miles
0 4 8
Elevation in feet
Below Sea Level
0 - 5
5 - 10
10 - 20
20 - 40
40 - 60
60 - 80
80 - 100
100 - 120
120 - 160
160 - 200
200 - 300
300 - 400
400 - 600
600 - 800
800 - 1,000
1,000 - 1,500
Prepared by Jim Mars, USACE

4. **Review Team**. Disciplines identified in the review plan for the ATR were met by the following team members. Team members that completed the ATR are identified.

ATRT Lead – Marc Masnor P.E., Civil Engineer, CESWF-PEC-PF (Tulsa, OK) – 918-669-7349, Marc.L.Masnor@usace.army.mil. Mr. Masnor is a civil works water resources planner in the Plan Formulation Section of the Southwestern Division Office (SWD) Regional Planning and Environmental Center (RPEC), headquartered in the Fort Worth District Office (CESWF) in Fort Worth, TX. He works from the Tulsa District Office (CESWT) in Tulsa, OK, 1645 S. 101st East Ave, Tulsa, OK 74128-4609. He has 37 years of experience with the Corps of Engineers, Tulsa District, Tulsa, OK. Marc is a SWD regional technical specialist (RTS) for plan formulation and National Environmental Policy Act evaluation of flood risk management (FRM), ecosystem restoration (ECO), and water management and reallocation studies (WMRS). As a senior plan formulation specialist and regional technical specialist, he assists in the development of unique or complex formulation and analysis techniques within the framework of Corps of Engineers guidance; Federal, state, and local laws and regulations; and stakeholder interests. He has been both study manager and project manager for many Tulsa District planning studies that involved flood risk management, ecosystem restoration, comprehensive watershed studies, water supply, reservoir storage reallocation, navigation, hydropower, and chloride control. Mr. Masnor has worked in hydrology, design, project management, and civil works planning offices within the Tulsa District and has completed a wide variety of water resources studies in Kansas, Oklahoma, and Texas. Studies included the evaluation of navigation and hydropower expansion on the McClellan-Kerr Navigation system; a system of 122 small reservoirs in the Grand-Neosho Basin; chloride control evaluations in the Arkansas and Red River Basins; multiple purpose reservoirs system formulation; storage reallocation studies, regional needs studies; watershed ecosystem restoration evaluations; and several local levee, channel, detention, and buyout plans. He currently provides support for offices within (a) the RPEC and Districts within SWD, (b) three planning centers of expertise (PCX) review management organizations (RMO) for FRM, ECO, and WMRS, (c) multiple division office RMOs across the Corps, and (d) the Risk Management Center (RMC). He has participated in or lead roughly 100 ATRs or DQCs.

(a) He supports the RPEC and the SWD as the plan formulation RTS, as an agency technical review (ATR) team member or team lead for

continuing authority projects, as a district quality control (DQC) team member, and as a project delivery team (PDT) member.
(b) He supports three PCX RMOs as an ATR Team lead. In that capacity he selects and manages ATR teams to analyze pre-authorization feasibility studies conducted by Districts related to flood risk management, water management and reallocation, ecosystem restoration, and navigation. He has been the Southwestern Division Regional Manager for the FRM PCX National Manager, Eric Thaut (SPD) since 2008 through the present. Marc participates in a national team that develops tools in support of the PCX RMOs managing body called the PCX Guild. This team meets at the direction of the Guild to prepare supplemental review tools such as checklists, templates, and training materials for ATR and PDT teams.
(c) He supports Division RMOs as an ATR lead. In that capacity he selects and manages ATR teams to analyze post-authorization implementation studies including design documentation reports (DDR) and detailed project reports (DPR), and plans and specifications (P&S), generally for FRM, ECO, and WMRS. Other reviews include building replacements, water quality project modifications, and an upcoming desalinization plant.
(d) He supports the RMC RMO as an ATR lead, also to select and manage ATR teams for review of feasibility and implementation documents.

Plan Formulation - Eric S. Lynn, CENWK-PM-PF - 816-389-3258 Eric.S.Lynn@usace.army.mil. Mr. Lynn is a registered Professional Engineer in the state of Kansas and a registered Project Management Professional. He has a bachelors of science degree in environmental engineering from Rensselaer Polytechnic Institute and a Master's of Civil Engineering in Water Resources from the University of Kansas. Mr. Lynn joined the Corps of Engineers in Jan 2004 and serves as a Planner/Project Manager in the Planning Branch, Plan Formulation Section. Mr. Lynn's duties have included the management and successful completion of multiple Flood Risk Management Feasibility Studies under the General Investigations and Continuing Authorities Programs. Prior to serving with the Corps Mr. Lynn spent seven years working for local County and Municipal government agencies managing construction and rehabilitation of wastewater and stormwater infrastructure, including local sponsor maintenance requirements for Federal levees. Mr. Lynn is an approved plan formulation reviewer for FRM.

Economics - Michael Hallisy (CESPL-PD-E), 213-452-3815, michael.j.hallisy@usace.army.mil. Mr. Hallisy is the Chief of the

Economics Section for the Los Angeles District, Corps of Engineers. He has worked as an Economist for 21 years, including several years as SPD's Regional Technical Specialist in flood risk management economics, and the past seven years as the Chief of the Economics Section. He has also served temporary assignments as Division Economist for SPD and as Assistant Chief, Planning Division for SPL. In addition to his Corps work experience, he worked for 1.5 years for a financial consulting firm providing financial analysis and business valuations, primarily for litigation support cases. Michael holds a BS in Finance and Economics from the University of Oregon, and an MBA in Corporate Finance from the University of Texas at Austin. During his tenure with the Corps, Mike has served on dozens of ATR teams, primarily as an economics reviewer. He has also served as ATR Lead on several FRM studies. He is certified as an agency technical reviewer for both flood risk economics and risk analysis. Mr. Hallisy is an approved economic reviewer for FRM.

Biologist – Tiffany Bostwick, CESPL-PD-RN – 213-452-3845, Tiffany.Bostwick@usace.army.mil. Ms. Bostwick is a biologist and environmental coordinator with the Corps of Engineers Los Angeles District since 2002, and provides biological and environmental management support to the District on various flood risk management, navigation, and ecosystem restoration projects within the Corps civil works program. Prior to serving with the Corps Ms. Bostwick previously worked as a field crew member for the Maui Invasive Species Committee on the island of Maui, Hawaii. Ms. Bostwick earned a bachelor's of science degree in biology from the California Lutheran University. Ms. Bostwick was an initial team member and completed the review prior to the establishment of an approved list for environmental reviewers.

Archaeologist - Gregory D. Everhart, CESPA-PM-LE – 505-342-3352 gregory.d.everhart@usace.army.mil. Mr. Everhart serves as a District Archaeologist with the U.S. Army Corps of Engineers, Albuquerque District, in Albuquerque, New Mexico and is listed as a Corps Agency Technical Review Cultural Resources Subject Matter Expert. Mr. Everhart maintains credentials as a Principal Investigator to be listed on the New Mexico and Colorado lists of Permitted Professionals. Mr. Everhart has a Bachelor of Science degree in archaeology and came to the Corps Albuquerque District as an park ranger then as a archaeologist/student trainee working in that position from 1992 to 1997 while attending college. He was promoted to a Federal archaeologist position in September 1997 and has served in that professional position to this date (17 years). Mr. Everhart has an

intimate knowledge of the National Historic Preservation Act Section 106 consultation and compliance process working with the NM and CO State Historic Preservation Officers as well as with tribes and several Tribal Historic Preservation Officers. Mr. Everhart also has a thorough knowledge of the NEPA process and documentation thereof. Mr. Everhart has written over 100 archaeological survey reports and successfully conducted Section 106 consultation on those projects. He previously conducted independent technical and Agency Technical Reviews for three projects in CA.

Hydraulic Engineer - Shih (James) H. Chieh, CESPL-ED-HH - 213-452-3571, Shih.H.Chieh@usace.army.mil. Mr. Chieh is a registered professional engineer in California. James is a Senior Hydraulic Engineer, Hydrology & Hydraulics Branch, Los Angeles District. He conducts flood frequency analysis, rainfall runoff modeling, floodplain analysis, sediment transport analysis, and reservoir routing simulations for various water resources projects. He also conducts groundwater modeling, water budget analysis, and water quality analysis for various habitat restoration and wetland projects. He has served as ATR member and reviewed various project on hydrology, hydraulics, sediment transport, flood plain studies, and coastal engineering studies. He has both work and review experience in the area of hydrology (HEC-FFA, HEC-HMS), hydraulics (HEC-RAS, FLO2D), and groundwater (MODFLOW, MT3D). Mr. Chieh is approved for 50 HH&S areas of interest in CERCAP including the models and evaluations for this study.

Cost Engineering MCX - James G Neubauer, P.E. CENWW - 509-527-7332, James.G.Neubauer@usace.army.mil. Mr. Neubauer is the Technical Cost Engineering Lead for the Cost Engineering District of Expertise (DX) for Civil Works located in Walla Walla, WA. Jim has 12 years of civil and military cost engineer experience. He has been the lead estimator in Albuquerque, NM, Chief of Cost - Europe, and lead estimator Walla Walla, WA. He has 11 years civil works construction experience in Wyoming, Europe, and Walla Walla, WA. Mr. Neubauer has 5 years military and civil project manager experience for Europe and Albuquerque projects. Jim has participated on numerous technical review teams, including several projects with cost estimates greater than $1billion. Jim is the Cost DX ATR Coordinator, is a Certified Cost Engineer, and has his PM1 Certification.

Cost Engineering - Gary R. Smith, CENWW-EC - 651-731-3910, - grs52@comcast.net. Mr. Smith is a registered Professional Engineer in the state of Minnesota, has been a practicing engineer since 1974, and

has a bachelors of science degree in civil engineering from the University of Minnesota. Mr. Smith joined the Corps of Engineers in July 1974 and serves as a Cost Engineer for the Technical Center of Expertise Cost Engineering. Mr. Smith was approved and assigned to the ATRT by the Cost Engineering MCX.

Geotechnical - Glen M. Bellew, CENWK-ED-GD - 816-389-3553 Glen.M.Bellew@usace.army.mil. Mr. Bellew is a licensed Professional Engineer in the state of Missouri. He is a double graduate of the University of Missouri – Columbia, receiving a Bachelor's degree in Civil Engineering in 2002 and a Master's Degree in Civil Engineering with a Geotechnical emphasis in 2004. Mr. Bellew joinied the Corps in 2004, and he has worked extensively on flood risk management projects including dams, levees, and floodwalls. He has experience in feasibility studies, design, construction, risk assessments, inspection, and rehabilitation of flood risk management projects. Mr. Bellew served as a Regional Technical Specialist for 4 years prior to becoming Chief of the Geotechnical Design and Dam Safety Section in the Kansas City District in 2012. Although currently serving in a supervisory capacity, he remains actively engaged in geotechnical issues locally, regionally, and nationally. Mr. Bellew is approved for 32 different areas of interest in CERCAP, including various foundation and foundation risk assessment categoried.

Civil Design Engineer – Huma Nisar, CESPL-ED – 213-452-3665, Huma.M.Nisar@usace.army.mil. Huma Nisar is a Project Engineer for US Army Corps of Engineers at Los Angeles District. She assumed this position in June 2000. Ms. Nisar has a Bachelor of Science degree in Civil Engineering, from California State University Fullerton. Ms. Nisar has served in team leadership positions in the Civil Works sides of the Corps. She was involved in completing designs for key projects for both Chicago and Los Angeles District. She has extensive experience in levee and floodwall restoration, wetland enhancement, recreation facilities, environmental work and mitigation. From 1994 to 2000 she served with the Chicago District in Civil Design Branch as a Design Engineer. In 2000, Ms. Nisar assumed the Project Engineer position with the Los Angeles District. Prior to joining Corp of Engineers, She worked for McDonough and Associate as a Design Engineer on the Light Rail System for Chicago Area and for AT Curd Builders as a Field Engineer for MGM Grand Hotel project. Ms. Nisar is an approved civil engineering reviewer in CERCAP for earthen embankments, pump stations, and misc. structures.

Real Estate – Jason E. Meyer, CELRL-RE-C – 502-315-6956, Jason.E.Meyer@usace.army.mil. (Bio not available) Jason is an approved real estate reviewer.

Hydraulic Engineering and FRM Analysis – Michael K Deering, IWR-HEC-WRS – 530-756-1104 michael.k.deering@usace.army.mil. Mr. Deering is a registered Professional Engineer in the state of California, has been a practicing engineer since 1978, and has a Bachelors and Masters of Engineering degrees in civil engineering from UC Davis. Work Experience: 6 years - Senior Hydraulic Engineer, Water Resource Systems Division, Institute for Water Resources lead for the development of HEC-WAT with FRA compute option and member of the GUMP team for updating various policy and technical guidance. 2 years - Chief, Water Resource Systems Division IWR-HEC, Leading the Division in the development and application of Flood Damage Reduction, Ecosystem Restoration, and System Analysis software. Project Manager for the Helmand Valley Water Management Plan for Afghanistan. Lead manager for data and modeling project for Iraq. 2 years - Regional Design Team Lead, USDA – NRCS, Serviced four states providing engineering leadership and guidance to a group of design engineers and technicians. 7 years - Chief, Hydraulics/Hydrology Section and Senior Hydraulic Engineer, NWS. Chief, Civil Design Section, SPK provided engineering supervision to a staff of 22 engineers and technicians. 1 year - HEC, Planning Analysis Division –Senior Hydraulic Engineer assisting in the development of the next generation of the HEC-FDA and HEC – FIA. 1 year – Chief, San Joaquin River Section, SPK responsible levee rehabilitation projects associated with the PL84-99 Levee Rehabilitation Program. 13 years – Hydraulic Engineer, SPK – Hydraulic modeling technical expert particularly with multi-dimensional applications. 6 years - Design and Field Office Engineer -USDA– SCS - Flood risk management with risk analysis, impact analysis, ecosystem restoration, river hydraulics, stream stability and scour, surface water hydrology, water surface profile modeling, floodplain delineations, hydraulic structures. Mr. Deering is an approved FRM risk analysis reviewer and was assigned to the ARTR by the Hydrologic Engineering Center.

5. **Charge to Reviewers**. A charge was developed for the ATR of the draft GRR and EIS/EIR. There was no update to the charge for the final GRR and EIS/EIR. The ATRT Lead also discussed the roles and responsibilities with the ATRT members and the PDT. The ATRT Lead's electronic meeting notice to the ATRT provided the location and description of review documents, review schedule, labor codes and

amounts. The notice also identified the DrChecks project and review, and stated the requirement for four part comments. The notice provided schedule updates during the ATR.

6. Summary. The previous Draft ATR and targeted ATR reviews and coordination provided a strong foundation for the Final ATR. The Final ATR was completed without issues or controversy. All 56 comments received were closed to the satisfaction of the ATRT and the PDT.

The following paragraphs summarize the status of comments.

a. Critical. None. There was one comment with high significance regarding slurry wall placement and DSM method. This comment was closed after additional information provided.

b. Unresolved. None.

c. Lessons Learned. None.

7. **Dr. Checks Report**. The DrChecks report of all comments is attached as Enclosure 1.

8. **ATR Completion Statement.** Enclosure 2 contains the ATR completion statement.

Marc L. Masnor, P.E.
CESWF-PEC-PF (Tulsa, OK)
Regional Technical Specialist for Plan Formulation

Enclosure 1

DRCHECKS REPORT OF ALL COMMENTS

Comment Report: All Comments
Project: ARCF - General Reevaluation Report (GRR), TSP & Attachments, American River Common Features (ARCF), California (P2 #149827)
Review: ATR Final EIS/EIR (10-14 Aug 2015)
Displaying 56 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
6188524	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\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. Include an evaluation that indicates concur or not concur.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188525	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

2. CONCERN: Observation. ATR completion could be significantly delayed if additional rounds of backchecks and evaluations are required to get the clarification included in the 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: 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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188527	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

3. CONCERN: Observation: Estimate Structure
5668 Notes
939 Unique Notes
9082 detail
1540 upper folder
3491 lower folder
19781 Lines of Data

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. Include an evaluation that indicates concur or not concur.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188529 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

4. CONCERN: Observation: Total Project Cost Summary
Total Project Cost Non Construction Cost Construction Cost
865,835,141 94,347,658 771,487,483 Direct Cost
27,066,458 (0) 27,066,458 Sub CMU
793,553,939 (1) 793,553,940 Cost To Prime
247,134,031 0 247,134,031 Prime CMU
1,140,035,631 94,347,659 1,045,687,971 Contract Cost

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. Include an evaluation that indicates concur or not concur.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188530 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

5. CONCERN: Observation: Direct Cost Overrides
$ % of Labor, Equip, Material % of Total Direct Construction
M 630 19,573,323 10.74% 3% 630 MATERIAL Overrides, $19,573,323, 10.74% of Direct Construction Matl, 2.54% of Direct Construction Cost

N 5963 461,442,925 60% 5963 NO Overrides, $461,442,925, 59.81% of Direct Construction Cost

E 499 2,652,620 1.09% 0.34% 499 EQUIPMENT Overrides, $2,652,620, 1.09% of Direct Construction Equipment, 0.34% of Direct Construction Cost

O 2077 278,511,021 36.10% 2077 OUTPUT Overrides, $278,511,021, 36.1% of Direct Construction Cost

L 493 145,271 0.06% 0.02% 493 LABOR Overrides, $145,271, 0.06% of Direct Construction Labor, 0.02% of Direct Construction Cost

Sb 243 10,251,716 1.33% 243 SUB BID Overrides, $10,251,716, 1.33% of Direct Construction Cost

Total 3942 311,133,951 40.33% 3942 TOTAL Overrides, $311,133,951, 40.33% of Direct Construction Cost

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. Include an evaluation that indicates concur or not concur.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188531	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

6. CONCERN: Observation: Direct Construction Cost Summary
243,303,759 31.5% Direct Construction Labor $243,303,759, 31.54% of Direct Construction Cost
244,101,024 31.6% Direct Construction Equipment $244,101,024, 31.64% of Direct Construction Cost
487,404,783 63.2% Direct Construction Labor + Equipment $487,404,783, 63.18% of Direct Construction Cost
182,199,187 23.6% Direct Construction Matl $182,199,187, 23.62% of Direct Construction Cost
69,954,926 9.1% Direct Construction Sub Bid $69,954,926, 9.07% of Direct Construction Cost
31,928,588 4.1% Direct Construction User $31,928,588, 4.14% of Direct Construction Cost
771,487,484 100% Direct Construction Cost

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. Include an evaluation that indicates concur or not concur.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188533	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

7. CONCERN: Observation: : 90% Direct Cost Productivity markup. The basis for this markup is explained in the cost appendix "Normal Productivity/Task Durations are based on production for 50 minutes/hr to allow for meetings/breaks, accessing the working area/office trailer to get supplies, etc. Because overtime is expected to go on for months, productivity is reduced to 90% of normal."
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. Include an evaluation that indicates concur or not concur.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **For Information Only**
Observation Comment - FIO - Concur

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 21 2015

Current Comment Status: **Comment Closed**

6188537	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

8. CONCERN: Each of the prime contractors has a folder that includes JOOH items that could be used to included a calculated JOOH. In fact these calculated JOOH costs are not included in the estimate. Please verify that it is intended to NOT include the calculated JOOH in the estimate. Then, consider deleting these calculated JPOOH costs from the contractor to avoid this comment in the future.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**

Concur - It IS intended to NOT include calculated JOOH in the estimate.
In the past, when there are many reaches, the Cost Engineer has sometimes done detailed JOOH for several reaches, then changed to an average. Contractors with the detailed JOOH markups (that typically automatically shows a markup for small tools and with Direct % based on items in the Overhead List folder) can easily be changed to JOOH with a Running %. I believe the opposite is not true. A new contractor needs to be created, a JOOH list added, and all tasks reassigned. If it was possible to omit the Overhead List folder from this 'detailed JOOH' contractor when wanting to 'override' with a Running % markup, I would do so. That would appear cleaner.
I'll note this for the future, but I still believe it easier to use a 'dummy' detailed JOOH contractor, where I'm actually using a Direct % markup for the feasibility study. Then, when preparing PED estimates I can change quickly to the detailed JOOH contractor and revise/update the Overhead List items to reflect the actual contract. My primary preference doing this is that I don't have to reassign tasks.
I hope I explain this clearly.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

1-1 Backcheck Recommendation **Close Comment**

Understood. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188538 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

9. CONCERN: There are 10 different detail items totaling $99,347,660 that have no contractor assigned to them or to any folder above them. That is why the total direct cost $865,835,141 is greater than the Cost to Prime $793,553,939. I suggest that an additional contractor layer be added at the top, Project Contractor with no markups, to capture these costs in the cost to prime. The items with no contractor assigned include:

DESCRIPTION DIRECT COST FREQUENCY
detail Riparian Mitigation - for LS Construction Improvements 30,922,200 9
detail Fish Monitoring 24,500,000 12
detail Riparian Mitigation - for WS Construction Improvements 16,854,200 8
detail Riparian Mitigation - for Rock Trench Erosion Control 14,579,400 8
detail Mitigation for Elderberries 6,375,000 8
detail Loss of RR Service 5,000,000 1
detail Riparian Mitigation - for SWIF Constr Improvements 558,360 2
detail Mitigation for Vernal Pools 300,000 1
detail Non-Riparian Mitigation - for Veg Removal 206,800 6
detail Non-Riparian Mitigation - for SWIF Constr Improvements 51,700 1

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**

All items described above (and all items with no contractor assigned) have been assigned to 'Prime Contractor NO MARKUPS.' The total direct cost is no longer greater than the Cost to Prime.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188539 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

10. CONCERN: The total amount of work assigned to a subcontractor may not be high enough at a direct cost = 82,073,465, 10.64% of the direct construction cost $ 771,487,483 . For this project, I would expect to see 25% to 50% of the work assigned to a subcontractor. It is likely that Slurry Wall Placement, DSM Method would be subcontracted and this alone is $103,705,497, 13% of the direct cost. It is possible that all or most of the hauling could be sub contracted at a cost of 67,574,638 or 9% of the direct construction cost. It is likely that acquisition strategy would require more sub contract work. Please consider what would likely be subcontracted and adjust the contractor assignments.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
Use of subcontractors have been re-examined. In general, cutoff wall placement (slurry or DSM) is assumed to be subcontracted. Hauling had reflected (and continues to reflect) use of a Trucking 'Broker' (basically already a sub). Notes have been added to the top folder of each reach to more clearly show subcontractor use and also to state that Bank Stabilization is assumed to be a separate contract from Levee Improvements and Relocations.
NOTE that use of subs for Alt 2 includes other changes as well. The portion of the work for widening the bypass is very similar to Levee Improvements and another contractor has been added to reflect this.
The prime contractor for the new Weir and Bridge has been renamed and modified to reflect concrete work for the structure with subs for the bridge (steel struct, 2nd tier sub for bridge painting) plus a miscellaneous sub for earthwork, relocations, and removal of existing rail line.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 11 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised documents for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents provided. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6188540 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

11. CONCERN: Filename ARCF_GRR-Feas_Report_Cost_Engr_Appendix-20150511.docx indicates "In general, a prime contractor for projects of over $10-12M (considered large business) has profit set at 8.48% based on PWG. Home Office Overhead is considered to be 7% for the Prime's own work..."

28 Prime Contractor has a direct cost = 87,743,041 and a HOOH = 10%. Verify if this should be changed to 7%

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
HOOH for prime contractor of extended weir has been left at 10% per comment 6188555.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188544 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: Filename ARCF_GRR-Feas_Report_Cost_Engr_Appendix-20150511.docx indicates "In general, a prime contractor for projects of over $10-12M (considered large business) has profit set at 8.48% ...".It appears that the profit is actually 10.00% or 10.01%. Please verify if the profit should be 8.48% or 10.00% and adjust so the appendix matches the estimate.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
PWG have been applied for each contractor/reach as suggested per comment 6188551 (using spreadsheets being sent as part of Backcheck Submittal). CE Appendix is updated to reflect the various PWG ranges.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188546 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

13. CONCERN: Filename ARCF_GRR-Feas_Report_Cost_Engr_Appendix-20150511.docx indicates " Job/Field Office Overhead (JOOH) is also set at 15% for small businesses and 10% for SubWork". It is not clear what is meant by 15% for small businesses and 10% for SubWork. Is this referring to a small business prime contractor markup on own work 15% and small business prime contractor markup on sub work 10%? Please clarify and reconcile with the estimate markups.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
It is believed that the markups by a small business for JOOH will be greater than those for large business, so these are set at 15% rather than 10%. After discussions with our RTS, markups for JOOH and HOOH previously indicated as prime markup on subcontractor's work have been removed. It is expected that the subs for this project will provide for their own JOOH and no HOOH markup by the prime for subcontractors is believed needed either. The ATR reviewer will be provided a spreadsheet of markups for all contractors and subs for clarification. Cost Engineering Appendix is updated to reflect the new markups.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents provided. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6188550 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

14. CONCERN: The estimate is set up with a separate prime and sub contractor for each reach. Subcontractor markups are consistent at 15.00% 10.00% 10.00% 1.20% for JOOH HOOH Profit Bond. Prime contractor markups on sub work are consistent at 10.00% 10.010% 1.200% for JOOH_PRM Profit_PRM Bond_PRM. However Prime markup on sub work for HOOH is either 5% or 10%. Please explain this inconsistence in the prime contractor markup on sub work and reconsile with Filename ARCF_GRR-Feas_Report_Cost_Engr_Appendix-20150511.docx indicates "Home Office Overhead is considered to be 7% for the Prime's own work and 5% for SubWork for these relatively large projects. " and "In general, a prime contractor for projects of under $10-12M is considered small business and has profit set at 10%. Home Office Overhead is considered to be 15% for the Prime's own work and 10% for SubWork."

Description HOOH_PRM
2.2 Sub Misc Reach A, ARS 5.00%
4.2 Sub Misc Reach B, ARS 5.00%
6.2 Sub Misc Reach C, ARS 5.00%
8.2 Sub Misc Reach D, ARS 5.00%
10.2 Sub Misc Reach E, ARS 5.00%
12.2 Sub Misc Reach F, ARS 5.00%
14.2 Sub Misc Reach G, ARS 5.00%
16.2 Sub Misc Reach A, ARN 5.00%
18.2 Sub Misc Reach B, ARN 10.00%
20.2 Sub Misc Reach C, ARN 10.00%
21.2 Sub Misc Reach D, ARN 5.00%
22.2 Sub Misc Reach E, ARN 5.00%
23.2 Sub Misc Reach F, ARN 5.00%
24.2 Sub Misc Reach G, ARN 10.00%
26.2 Sub Misc Reach I, ARN 10.00%

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
After discussions with our RTS, markups for JOOH and HOOH previously indicated as prime markup on subcontractor's work have been removed. It is expected that the subs for this project will provide for their own JOOH and no HOOH markup by the prime for subcontractors is believed needed either. The ATR reviewer will be provided a spreadsheet of markups for all contractors and subs for clarification. Cost Engineering Appendix is updated to reflect the new markups.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents provided. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6188551	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

15. CONCERN: Prime Contractor profit on subcontractor work is based on the same WPG for each reach with the resultant same profit. The profit % from the WPG is dependent on the contract amount, period of performance and level of subcontracting. These factors are different for each reach. Please address this assumption in the cost appendix.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
As suggested, PWG have been computed for all contractors/subcontractors for each reach based on Contract amount, duration, subcontracting, etc. Spreadsheet calculations for each PWG are being sent to the ATR reviewer as part of the backcheck submittal. This has also been explained further in the Cost Engr Appendix.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188554	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

16. CONCERN: Filename ARCF_GRR-Feas_Report_Cost_Engr_Appendix-20150511.docx. Several cost appendix references appear to conflict with the estimate documents as noted in "":

CONTRACTING PLAN Subcontractors are provided for two categories, miscellaneous/general and "bank stabilization from the waterside". Miscellaneous/General Subcontractors are expected to be utilized for hydroseeding, geotextile, vibration monitoring and paving. Bank stabilization from the waterside subcontractors are not applied in the estimate. Please clarify.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
After discussions with our Cost Engineering RTS for Civil Works, is is believed that the Prime Contractor for Bank Stabilization will do most of the work for bank protection (sans reveg and vibration monitoring).
For clarity, all subs not used have been delete. Typically only one misc sub is indicated, except for the Sac Weir Extension in widening the Sac Bypass. Notes have been added to the top folder in each reach to provide clarification.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188555	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

17. CONCERN: It is my opinion that Prime Contractor 7% HOOH and 10% JOOH on own work is not high enough to capture all costs. These rates are applied to the larger projects and to be understated could result in significant understated total costs. I suggest that these rates be increased to 10% and 13% based on experience with similar projects.

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
Markups for all primes have been increased to 13% for JOOH. HOOH for most contracts (considered big business) have been increased to 10%. HOOH for small business is believed to have a somewhat higher HOOH markup (15%).

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188557	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

18. CONCERN: SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm and other csra files. Cost Risk Model tab
TL5 Design Criteria and Assumptions low = $38,576,400
TL7 Vegetation Variance low = $43,712,400

Normally low values are negative indicating a possible cost savings. Please explain why these 2 low values are not negative. And then why the most likely is not between the low and the high

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
Risk TL5 and TL7 are modeled as a potential range of costs with a probability of occurrence. For example, Risk TL7 models the Very Unlikely chance that vegetation removal will be required. The probability of occurrence is 5% and if that vegetation removal is required costs could range anywhere from $43.7M to $72.8M.
(evaluation by William Bolte, NWW, 509-527-7585; Bill developed CSRA results)

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188558	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

19. CONCERN: SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm and other csra files. Cost Risk Model tab. Please explain why the assumption parameters are set at custom 20% and 80% instead of Min Most Likely Max and why the parameters are not based on the Low Most Likely and High from the cost model

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
Assumptions were modeled at 20%, most likely and 80% data points which gives a higher resulting contingency then modeling the same numbers at Min, Most Likely and Max. Trying to define the tails is difficult to impossible, true worst case is infinity. The logic behind modeling at 20/mostlikely/80 is because we use the 80% confidence for our funding request. It's also a number we conceptually can understand. At the time this was originally modeled we then also would model the low as a 20% confidence for symmetry. But only recently, upon closer inspection, modeling $0 impacts at 20% confidence would result in risks with potential negative costs (savings) at the 0% confidence, which isn't possible. So we've now started modeling the lower bound as a minimum cost. I've updated this model to reflect a Minimum/Most Likely/80% cost distribution. The most likely costs have remained unchanged. Changing the lower parameter from 20% to minimum increased overall project contingency some 7%.
(evaluation by William Bolte, NWW, 509-527-7585; Bill developed CSRA results)

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188562	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

20. CONCERN: SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm and other csra files. Cost Risk Model tab.
ESTIMATE AND SCHEDULE RISKS

Estimate Assumptions and Quantities should be broken out into Estimate Assumptions, and Quantities .

Given the pdt discussion "No PED level survey is available. No specific designs/quantities based on surveyed cross sections has been developed, it does not seem reasonable to build a quantity opportunity into the model at this time.

Add a risk for modifications due to design changes as a worst case maybe 15% applied to all construction features

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
Variations in Quantities are modeled under Risk ET1 - Quantities and Estimate Assumptions are handled in Risk ET6 - Level of Estimate. As for the potential reductions in quantities that were modeled, quantities are thought to be conservative. As stated in the justifications of potential project impacts "Earthwork cross sections were developed in primarily 5 foot intervals, with no interpellations. Quantities were always rounded up to next larger typical cross section."
(evaluation by William Bolte, NWW, 509-527-7585; Bill developed CSRA results)

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188563	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

21. CONCERN: SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm and other csra files. Cost Risk Model tab.
CONSTRUCTION RISKS
Differing Site Conditions at 3% of Levees & Floodwalls and Bank Stabilization is not sufficient. Consider a much higher percentage as a worst case maybe 15% applied to all construction features

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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

1-0 Evaluation **Concurred**
Risk CO1 has been renamed Modifications and Claims to be more all encompassing. Risk has now been modeled with most likely defined as an increase of 3% of construction cost and 80% as a 5% increase in construction cost. Overall project contingency increased some 1%.
(evaluation by William Bolte, NWW, 509-527-7585; Bill developed CSRA results)

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 17 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6188565	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

22. The following 2 folder items include riprap purchase as detail items,. The material unit prices are 23.33 TON and 32.55 ton. It seems like the material price would be the same. Please explain why these material prices are not the same

22.1. lower folder Riprap (Rock Slope Protection) (EP) , 1,483,116 TON @ $47 per TON = $69,672,096, 9% of the estimated direct construction cost, used 5 times in the estimate, overrides = 0 23.33 TON

22.1.1. detail Riprap Placement (Work Cond - Average) , 1,483,116 TON @ $29 per TON = $43,339,374, 6% of the estimated direct construction cost, used 5 times in the estimate, overrides = 1 5.89 placement, 23.33 material

22.1.2. detail Hauling (TN), from commercial source or borrow site (20 CY end dumps) , 1,483,116 TON @ $18 per TON = $26,332,723, 3% of the estimated direct construction cost, used 5 times in the estimate, overrides = 1

22.2. upper folder Rip Rap (Waterside Placement) , 1,280,294 TON @ $48 per TON = $61,850,376, 8% of the estimated direct construction cost, used 4 times in the estimate, overrides = 0 15.76 32.55 ton

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 07 2015

Revised Aug 07 2015.

1-0 Evaluation **Non-concurred**
Riprap is anticipated to come from different suppliers/quarries dependent on waterside vs landside placement. The material price for riprap per these suppliers ARE NOT the same.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 21 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Aug 24 2015

Current Comment Status: **Comment Closed**

6197434 Risk Assessment n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Discussed updated report materials for the risk assessment/analysis with PDT member. PDT member responsible for executing the risk assessment and documenting the risk analysis stated that the applied procedure and the report language are essentially the same as in the previous version thus no further comments are provided here.

Submitted By: Michael Deering (5307561104). Submitted On: Aug 14 2015

1-0 Evaluation **Concurred**
Concur with Comment.

Submitted By: Sara Schultz ((916) 557-7368) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Concur with evaluation

Submitted By: Michael Deering (5307561104) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6198478 Cultural Resources n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

No Comment.
I have reviewed Section 3.9 Cultural Resources, Section 4.2.5, and the appropriate cultural resources portions of Sections 5.0 and 6.2 of the Admin_FINAL_ARCF_GRR_EISEIR_13Aug15.docx and have No further Dr.Cks. comments.
I have coordinated with the cultural resources PDT contact and provided some small editorial type comments/recommendations for clarification purposes.

Submitted By: Gregory Everhart (505-342-3352). Submitted On: Aug 14 2015

1-0 Evaluation **Concurred**
Concur with comment. Thank you for your review.

Submitted By: Sara Schultz ((916) 557-7368) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Comment closed.

Submitted By: Gregory Everhart (505-342-3352) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6200594 Real Estate n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

The Real Estate Plan (REP) dated August 2015 that is to accompany the ARCF GRR has been reviewed. No further Real Estate comments are warranted at this stage of the planning procees. Additional review should take place during/after the PED phase or as revisions to the REP occur.

Submitted By: Jason Meyer (502-315-6956). Submitted On: Aug 17 2015

1-0 Evaluation **Concurred**
Concur with the comment. Thanks for your review.

Submitted By: Sara Schultz ((916) 557-7368) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Comment closed.

Submitted By: Jason Meyer (502-315-6956) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6207088	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

23. CONCERN: Significant Detail Items: Labor, Equipment, Materials, detail Slurry Wall Placement, DSM Method
13% detail Slurry Wall Placement, DSM Method , 35,490 HR @ $2,922 per HR = $103,705,497, 13% of the estimated direct construction cost, used 28 times in the estimate, overrides = 1
Direct unit cost at 2,922 per hour is consistent across all applications.
I reviewed the work analysis indicated in a folder 2 levels up at 5.2.17.3 Cutoff Wall, DSM, 3' wide, 105 ft deep. This is the most expensive Slurry wall. The work analysis indicates that the number of panels is determined by dividing the wall length by the panel width to arrive at 874 panels.
Length of Wall 3,500.00 LF
Number of Wall Panals 874.00 EA
Panel Length 4.00 FT
Deep soil mixing is done with augers. If the wall width is 3 ft a 3 ft auger would be used. Overlaps would be significant, reducing the effective panel length to 2.4 ft.
My concern is that the wall is to be 3 ft wide and with panel overlaps, the effective panel width may be 2.4 ft wide requiring 1458 panels.
Width of Wall 3.00 FT
Overlap 80%
Effective Width 2.40 FT
Number of Wall Panels Required 1,458.33 EA
If this is correct, when applied to all the walls, costs could increase significantly.
Please verify the effective panel width.
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: High
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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
In a project recently constructed by SPK (Marysviller Ring Levee), a 3-auger rig was utilized with an effective panel width of 4 ft (7 ft total width of panel with 3 ft overlap). This was assumed here. Cost engineer consulted Geotech Engineer on placement rate of panels and DSM cost in estimate is typically about $24-$25/SF. DQC cmt 17 has indicated wall price is consistent with what SPK has been seeing.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please include the evaluation information in MII. Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents provided. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207091	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

24. CONCERN: Significant Detail Items: Labor, Equipment, Materials, detail Slurry Wall Placement, DSM Method , 35,490 HR @ $2,922 per HR = $103,705,497, 13% of the estimated direct construction cost, used 28 times in the estimate, overrides = 1
I suggest that a quote for this work be obtained to verify the estimated costs. Several DSM contractors will be willing to discuss this project and offer their opinion of costs.
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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Non-concurred**
It is the experience of SPK Cost Engineering that quotes at feasibility stage are wide ranging with great uncertainty as contractors will not take the time to provide a detailed quote when no reasonable prospect of getting the work since on average the first construction projects are 4 to 6 years away.
DQC cmt 17 has indicated wall price is consistent with what SPK has been seeing in the last year or two. Cost engineer consulted Geotech Engineer on placement rate of panels and DSM cost in estimate is typically about $24-$25/SF. Geotech Engineer who often works in the field has verbally stated that upper limit for unit cost should be no more than $25/SF.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

Current Comment Status: **Comment Closed**

6207097 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

25. CONCERN: Significant Detail Items: Labor, Equipment, Materials, detail Slurry Wall Placement, DSM Method
13% detail Slurry Wall Placement, DSM Method , 35,490 HR @ $2,922 per HR = $103,705,497, 13% of the estimated direct construction cost, used 28 times in the estimate, overrides = 1
Notes indicate: "This is specialized construction. If cutoff wall construction is the major work, this job will be bid by a Prime Contractor. If cutoff wall construction is mixed in with other construction work, the cutoff wall construction will be subcontracted out, and the cost should include mob and demob."
I suggest that this work be included in the estimate as a subcontracted cost.
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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
DSM slurry walls have been made a subcontracted cost in the revised estimates.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207098 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

26. CONCERN: Significant Material Items: The following significant detail material items lack notes to support the costs.
detail Rip Rap , 1,280,294 TON @ $32.55 per TON = $41,673,570, 23% of the estimated direct Material Construction Cost, 5% of the estimated total Direct Construction Cost, used 4 times in the estimate, overrides = 0 Cost supported by note : "(Note: Price from San Rafael Quarry)". Quotes should include the source contact information, date, amount, and conditions such as includes sales tax, includes delivery, excludes loading.
detail Riprap Placement (Work Cond - Average) , 1,483,116 TON @ $23.33 per TON = $34,597,389, 19% of the estimated direct Material Construction Cost, 4% of the estimated total Direct Construction Cost, used 5 times in the estimate, overrides = 0 There are no notes to support the material cost for this material.
detail Borrow Site Loading , 2,222,787 LCY @ $7.4 per LCY = $16,447,960, 9% of the estimated direct Material Construction Cost, 2% of the estimated total Direct Construction Cost, used 47 times in the estimate, overrides = 0 There are no notes to support the material cost for this material.

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: Please obtain material quotes that include the source contact information, date, amount, and conditions such as includes sales tax, includes delivery, excludes loading. If quotes is more than 2 years old, a new quote should be obtained.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Notes have been added to reflect riprap costs from the likely supplier for waterside placement and a possible supplier for landside placement.

For borrow, assumes material costs for developing any borrow site result in similar costs to that of purchase at a supplier.

A Central Valley supplier has indicated $7.17/TN for fill and engineered fill. Notes have been added to the estimate to reflect this. It is assumed that 1 LCY of fill ~1.1 TN. Unit Cost for 1 LCY is set at $7.90.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207099 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

27. CONCERN: Notes for the following items refer to ProdQuant WORKSHEETS
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: Please provide the cited document
27.1. Significant Labor and Equipment Items: detail Levee Excavation , 3,588,117 BCY @ $10.2 per BCY = $36,595,442, 8% of the estimated direct Labor and Equipment Construction Cost, 5% of the estimated total direct construction cost, used 156 times in the estimate, overrides = 0
27.2. Significant Labor and Equipment Items: detail Random Levee Material Placement, Shaping, and Compaction, Sheepsfoot , 2,618,609 ECY @ $11.64 per ECY = $30,475,505, 6% of the estimated direct Labor and Equipment Construction Cost, 4% of the estimated total direct construction cost, used 167 times in the estimate, overrides = 0

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Production Quantity Excel spreadsheet will be provided with backcheck submittal.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised documents for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207100 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

28. CONCERN: Significant Labor and Equipment Items: detail Disposal of non compliant material , 2,653,337 LCY @ $10.64 per LCY = $28,233,443, 6% of the estimated direct Labor and Equipment Construction Cost, 4% of the estimated total direct construction cost, used 101 times in the estimate, overrides = 0
Direct Cost unit price varies from $16 to $0.12 per LCY. 5 of the 101 instances refer to (Note: for Haul Rate (Crew Output), see ProdQuant WORKSHEETS.xls)
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: Please provide the cited document and recheck the unit price development

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Unit Price development has been checked and Production Rate spreadsheet will be provided with backcheck submittal. Notes have been added at the folder levels reflecting the spreadsheet calculations.

Unit costs DO vary widely, primarily due to variations in cycle time and assumed minimum placement time. The various reaches in this project vary quite a bit when it comes to accessibility. For small quantities, such as at utility relocations, one hour has basically been used as the minimum placement time, even for very small loads (less than 1 full load).

The $0.12 was a bust and has been fixed.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207101	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

29. CONCERN: Significant Labor and Equipment Items: detail Hauling (TN), from commercial source or borrow site (20 CY end dumps) , 1,483,116 TON @ $17.75 per TON = $26,332,723, 5% of the estimated direct Labor and Equipment Construction Cost, 3% of the estimated total direct construction cost, used 5 times in the estimate, overrides = 0
No notes to document crew and production rate development
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: Please provide notes to document crew and production rate development

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Unit Price development has been checked and Production Rate spreadsheet will be provided with backcheck submittal. Notes have been added at the folder levels reflecting the spreadsheet calculations.

The various reaches in this project vary quite a bit when it comes to accessibility and therefore, cycle time/haul time.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised documents for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207102	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

30. Significant Labor and Equipment Items: detail Delivery of Levee Material from Borrow Site , 2,222,787 LCY @ $11.7 per LCY = $26,009,756, 5% of the estimated direct Labor and Equipment Construction Cost, 3% of the estimated total direct construction cost, used 47 times in the estimate, overrides = 0
Direct Cost unit price varies from $16 to $10 per LCY. Some instances include note "(Note: for Haul Rate (Crew Output), see ProdQuant WORKSHEETS.xls)
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: Please provide the cited document and recheck the unit price development

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Unit Price development has been checked and Production Rate spreadsheet will be provided with backcheck submittal. Notes have been added at the folder levels reflecting the spreadsheet calculations. The notes in the CSI tasks relative to 'Note: for Haul Rate...' have typically been deleted.

Unit costs DO vary widely, primarily due to variations in cycle time and assumed minimum placement time. The various reaches in this project vary quite a bit when it comes to accessibility. For small quantities, such as at utility relocations, one hour has basically been used as the minimum placement time, even for very small loads (less than 1 full load).

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised documents for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207104 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

31. CONCERN: Significant Sub Bid Items: 94,347,660, 12% of the total direct cost consist of non construction items listed below. Notes included in the estimate are not very helpful in supporting the costs.
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: Please include a paragraph in the cost appendix discussing the source and development of these costs. Reference other documents for support.
31.1. detail Riparian Mitigation - for LS Construction Improvements , 184 ACR @ $168,055.43 per ACR = $30,922,200, 44% of the estimated direct Sub Bid Construction Cost, 114% of the estimated total Direct Construction Cost, used 9 times in the estimate, overrides = 1
31.2. detail Fish Monitoring , 21 EA @ $1,166,666.67 per EA = $24,500,000, 35% of the estimated direct Sub Bid Construction Cost, 91% of the estimated total Direct Construction Cost, used 12 times in the estimate, overrides = 1
31.3. detail Riparian Mitigation - for WS Construction Improvements , 163 ACR @ $103,400. per ACR = $16,854,200, 24% of the estimated direct Sub Bid Construction Cost, 62% of the estimated total Direct Construction Cost, used 8 times in the estimate, overrides = 1
31.4. detail Riparian Mitigation - for Rock Trench Erosion Control , 141 ACR @ $103,400. per ACR = $14,579,400, 21% of the estimated direct Sub Bid Construction Cost, 54% of the estimated total Direct Construction Cost, used 8 times in the estimate, overrides = 1
31.5. detail Mitigation for Elderberries , 75 ACR @ $85,000. per ACR = $6,375,000, 9% of the estimated direct Sub Bid Construction Cost, 24% of the estimated total Direct Construction Cost, used 8 times in the estimate, overrides = 1
31.6. detail Riparian Mitigation - for SWIF Constr Improvements , 5 ACR @ $103,400. per ACR = $558,360, 1% of the estimated direct Sub Bid Construction Cost, 2% of the estimated total Direct Construction Cost, used 2 times in the estimate, overrides = 1
31.7. detail Mitigation for Vernal Pools , 1 ACR @ $300,000. per ACR = $300,000, 0% of the estimated direct Sub Bid Construction Cost, 1% of the estimated total Direct Construction Cost, used 1 times in the estimate, overrides = 1
31.8. detail Non-Riparian Mitigation - for Veg Removal , 2 ACR @ $104,444.45 per ACR = $206,800, 0% of the estimated direct Sub Bid Construction Cost, 1% of the estimated total Direct Construction Cost, used 6 times in the estimate, overrides = 1
31.9. detail Non-Riparian Mitigation - for SWIF Constr Improvements , 1 ACR @ $103,400. per ACR = $51,700, 0% of the estimated direct Sub Bid Construction Cost, 0% of the estimated total Direct Construction Cost, used 1 times in the estimate, overrides = 1

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Language has been added to the Cost Engineering Appendix explaining the process under which the mitigation costs were estimated. The write ups include references to the documents that support/justify the mitigation cost esimates, including the Biological Opinions, Mitigation and Monitoring Plan, and the Cost Effectiveness/Incremental Cost Analysis.

Submitted By: Anne Baker ((916) 557-7277) Submitted On: Sep 03 2015

1-1 Backcheck Recommendation **Close Comment**
ATR lead has asked for this comment to be closed. Revised documentation has not been provided so that the comment evaluation can be verified. Since the comment is for additional cost support and not a change to the cost, the comment will be closed.
Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 07 2015

Current Comment Status: **Comment Closed**

6207105 Cost Engineering n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

32. CONCERN: Significant Sub Bid Costs, Quote lacks detail or does not exist, , and including this material cost as a sub bid item causes the sales tax to be not applied.
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: Please obtain material quotes that include the source contact information, date, amount, and conditions such as includes sales tax, includes delivery, excludes loading. If quotes is more than 2 years old, a new quote should be obtained. Please include these costs a s material costs so that the appropriate sales tax is applied.
32.1. detail Cement , 129,559 TON @ $110.67 per TON = $14,338,295, 20% of the estimated direct Sub Bid Construction Cost, 2% of the estimated total Direct Construction Cost, used 57 times in the estimate, overrides = 1
32.2. detail Fiber Rolls , 2,634,050 LF @ $3.5 per LF = $9,219,175, 13% of the estimated direct Sub Bid Construction Cost, 1% of the estimated total Direct Construction Cost, used 31 times in the estimate, overrides = 1
32.3. detail Dump Fees - from Clearing & Grubbing , 147,943 TON @ $33. per TON = $4,882,124, 7% of the estimated direct Sub Bid Construction Cost, 1% of the estimated total Direct Construction Cost, used 89 times in the estimate, overrides = 1
32.4. detail Approximate Pump Station Cost, Approx size 50 cfs , 1 EA @ $4,200,000. per EA = $4,200,000, 6% of the estimated direct Sub Bid Construction Cost, 1% of the estimated total Direct Construction Cost, used 1 times in the estimate, overrides = 0
32.5. detail Bentonite, 1ton bag , 128,432 EA @ $102.17 per EA = $13,121,897, 19% of the estimated direct Sub Bid Construction Cost, 2% of the estimated total Direct Construction Cost, used 36 times in the estimate, overrides = 1

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
32.1 Updated quotes are being obtained and will be added to the Cost Estimate.
32.2 Notes/Quotes have been added to the estimate.
32.3 Note/Quotes have been added to the estimate.
32.4 A general layout plan of the pumping plants is being provided by the Civil Designers. Quantities will be based on work on similar pumping plants for the Natomas PACR project. Most costs are updated to reflect current labor-equipment-material costs.
32.5 Notes/Quotes have been added to the estimate. Material Cost is $98/TON for bentonite, DDelivery (FOB) is $102.17/TON.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Aug 31 2015

1-1 Backcheck Recommendation **Open Comment**
Please provide revised MII for verification. Comment remains open.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 02 2015

1-2 Backcheck Recommendation **Close Comment**
Documents Received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6207106	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

33. CONCERN: I have 4 CSRA files, each with a tab Base Cost Summary and a line item on row 29 that reads " Summary Construction Costs and L&D. Is it intended that the total for the line include the lands and damages?
SPK - American River Common Features - CSRA - 2015-07-13 DRAFT - ALT 2 (LPP).xlsm
SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm
SPK - American River Common Features - CSRA - 2015-07-08 DRAFT - ALT 2 (LPP).xlsm
SPK - American River Common Features - CSRA - 2015-07-13 DRAFT - ALT 1 (NED).xlsm
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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Per the Note on line 8, the Lands and Damages ARE NOT part of the Summary Construction Costs used in calculation of construction contingencies.

I will advise the preparer of the CSRA to revise the titles in Row 29 for future projects. - Note this is incidental as I don't believe these tables are placed in the CSRA report that will be attached to the Cost Engr Appendix in the final Feasibility Report.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Sep 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 14 2015

Current Comment Status: **Comment Closed**

6207107	Cost Engineering	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

34. I have one MII file called "CE-ARCF_GRR-MII4_2-20150708.mlp" with a total estimated amount = 1,140,035,630.76. And I have 4 CSRA files, each with a tab Base Cost Summary and a line item on row 29 that reads " Summary Construction Costs and L&D". (The total cost for that line do not actually include lands and damages).
How do I get from the costs in the MII file to the costs in the csra files in tab Base Cost Summary, Summary Construction Costs and L&D line item on row 29?
SPK - American River Common Features - CSRA - 2015-07-13 DRAFT - ALT 2 (LPP).xlsm
SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm
SPK - American River Common Features - CSRA - 2015-07-08 DRAFT - ALT 2 (LPP).xlsm
SPK - American River Common Features - CSRA - 2015-07-13 DRAFT - ALT 1 (NED).xlsm
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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
The costs in the upper part of the spreadsheet (rows 1-56) are compiled from the data input in rows 57- for all the reaches in the alternative. Rows 57- are not compiled directly from the MII file, but from the TPCS. The TPCS reflects the MII files (column M, Estimated Cost Column C) for each Reach of Alts 1 and 2 relative to construction costs.
Note that all these values have changed based on the ATR comments and must be input into the CSRA spreadsheet, from which a CSRA report is being developed for inclusion in the final feasibility report.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Sep 11 2015

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

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 14 2015

Current Comment Status: **Comment Closed**

6207109 | Cost Engineering | n/a | n/a | n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

35. It appears to me that the costs in the TPCS files do not match up with the costs in the csra files::
ARCF-TPCS Form-Alt2-Multi Phase - Multi Contract 20150804.xlsx
ARCF-TPCS Form-Alt1-Multi Phase - Multi Contract 20150804.xlsx
SPK - American River Common Features - CSRA - 2015-07-13 DRAFT - ALT 2 (LPP).xlsm
SPK - American River Common Features - CSRA - 2015-07-06 DRAFT - ALT 1 (NED).xlsm
SPK - American River Common Features - CSRA - 2015-07-08 DRAFT - ALT 2 (LPP).xlsm
SPK - American River Common Features - CSRA - 2015-07-13 DRAFT - ALT 1 (NED).xlsm
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.

Submitted By: Gary Smith (651 260 1819). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
It was my understanding from the developer of the CSRA that, at the time of submittal, these matched, but that is irrelevant now as the costs have changed.

The revised CSRA spreadsheet and report will be checked versus the revised TPCS submitted for backcheck to insure the costs match.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Sep 11 2015

1-1 Backcheck Recommendation **Open Comment**
This comment will remain open until a set of matching files has been provided for verification:
MII
TPCS
CSRA
Comment remains open

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 14 2015

1-2 Backcheck Recommendation **Close Comment**
Matching Documents have been received. Comment Closed.

Submitted By: Gary Smith (651 260 1819) Submitted On: Sep 14 2015

2-0 Evaluation **Concurred**
Per this comment and relevant emails between reviewers and Cost Engineers.
Updated CSRA results (spreadsheet including contingencies) and TPCS files utilizing those contingencies have been sent today.

The cost indicated in the previously provided MII file and the TPCS do match. See cell M76.
Cell M19 is a summation of costs for Relocations, including Construction of Relocations (M76), PED for Relocations (cell M105) and Construction Mngt for Relocations (cell M111).
This is typical for all reaches.

Submitted By: Robert Vrchoticky ((916) 557-7336) Submitted On: Sep 14 2015

Backcheck not conducted

Current Comment Status: **Comment Closed**

6207452 | Economics | n/a | Econ Appendix, p. 33. | n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: TEHRA – Depth damage for TEHRA – It does not appear that separate TEHRA curves were developed and applied for 1 story vs. 2 story vs. MH structures, although the depth of flooding causes substantially different percent damages to these different structure types. BASIS: Documentation included in updated Economic Appendix. SIGNIFICANCE: Low. RECOMMENDED ACTION: Recommend either updating the analysis to include separate functions by structure type or justify application of a single curve for all types.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
The following verbiage will be added to the final Economic Appendix "Although this analysis uses the same depth-damage curves for all residential structures, in reality there would be some differences in TEHRA costs between 1-story vs. 2-story vs. Mobile Homes. Because the majority of the residential structures in the study area are 1 story, these differences will have a limited impact on the result and would not affect plan selection." There is also a precendent for using this same methodology in the Sutter Feasibility study.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
Response adequately addresses concern.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207458	Economics	n/a	Econ Appendix, Table 14	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Table 14 shows that damages by Basin and ACE changed for ARS (F) and ARN (A) from the prior submittal, but the EAD by Index Point values shown on Table 15 did not change. BASIS: Damage estimates in referenced tables. SIGNIFICANCE: Low (likely). RECOMMENDED ACTION: Please explain/verify these results (why EAD did not change despite changes in damages by ACE).

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Changes will be verified to ensure consistency with FDA outputs. This update will be made at the same time the Appendix is updated for the final cerified costs. This will not impact the Recommended plan.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
Closing comment, but please note resolution of this issue when submitting updated Econ Appendix.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207461	Economics	n/a	Econ Appendix, Table 17	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Emergency Costs – Table 17 shows without project EAD results for emergency costs separate from the other damage categories, which is fine. However, these damages/costs are part of total without project EAD. BASIS: The report should show total without project EAD that includes these damages/costs, as they represent approximately 13% of total computed damages. Also, this would serve as a matching reference later in the report where without project damages and benefits are shown for the ARS and ARN basins (Tables 46-50) that include emergency costs. SIGNIFICANCE: Low. RECOMMENDED ACTION: Recommend either moving the emergency cost analysis prior to the tables 15 and 16, and then including a column for these damages in the summary tables, or otherwise including an additional table after the emergency cost analysis showing total EAD that includes these costs.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
The emergency cost analysis will be moved up prior to tables 15 and 16 and these costs will be added to the total EAD shown in those tables.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
Comment closed - will review when updated econ appendix is submitted.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207465	Economics	n/a	Econ Appendix, Section 4.3-4.5	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: These sections present without project damages and with project benefits that do not consider/include emergency costs. Preferably these costs would have been incorporated into these sections and result tables. BASIS: Project alternative evaluation should include all primary damage/benefit categories. SIGNIFICANCE: Low. RECOMMENDED ACTION: As noted preferably these costs should be incorporated into Sections 4.3-4.5. However, at a minimum, documentation should be added to the beginning of these sections that explain that the benefits presented do not include reductions in emergency costs, which are later discussed in Section 4.6, and why they are not included.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Emergency costs were only run for the dominant reaches, so they cannot be incorporated into all of the relevant tables in Sections 4.3-4.5. Text will be added to the final document describing this nuiance.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
proposed action adequately addresses concern.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207467	Economics	n/a	Econ Appendix, p. 55	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Report notes that Alt 2 provides benefits to West Sacramento (and no longer refers to potentially offsetting increases in damages). It would be beneficial to elaborate on the significance/magnitude of these potential benefits and whether if considered and factored into the analysis, could result in Alternative 2 having greater net benefits/being the NED Plan. BASIS: Report should consider all significant benefit categories in the determination of the NED Plan. SIGNIFICANCE: Medium. RECOMMENDED ACTION: As noted, recommend this section elaborate on the significance/magnitude of these potential benefits to West Sacramento that were not quantified and whether if considered and factored into the analysis, could result in Alt 2 being identified as the NED Plan.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
The offsetting of damages still exist and this section will be updated as follows: "The City of West Sacramento is located on the right bank (west side) of the Sacramento River adjacent to the confluence with the American River and directly across the river from the city of Sacramento. Widening the Sacramento Bypass (Alternative 2) results in water surface elevation reduction downstream on the Sacramento River adjacent to the city of West Sacramento. However, these potential benefits are not effectively realized because the highest damages within West Sacramento are instead driven by flooding coming from the Yolo Bypass, which does not see any decrease in water surface elevation as a result of the Sacramento Bypass widening."

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
Thanks - this is an important clarification.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207470	Economics	n/a	Econ Appendix, Tables 46 & 48	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Please verify the results shown on these tables. Specifically, the incremental and cumulative average annual benefits for fixing and raising or widening the Sacramento River are exactly the same as reported in the prior submittal, although the without project EAD now appears to include the emergency costs. The total benefits of $308.5M for Alt 1 and $309.4M for Alt 2 correspond with the computed benefits earlier in the report of $264M for structs/contents, plus $44M for emergency costs. However, all of the assigned increase in benefits in the incremental benefit/cost tables are assigned to 2B (Fix American River). So while the incremental benefits for 2b were previously around $25M, they are now around $68M. Presumably the increase in benefits associated with the emergency cost reductions would be spread between the increments. Results on this table do not appear to be correct. BASIS: Evaluation of updated damages/benefits. SIGNIFICANCE: Medium. RECOMMENDED ACTION: Please verify results and revise as necessary.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Need to verify this with the lead Economist when he returns from emergency leave, but presumably this is because the emergency costs were not calculated incrementally and instead only using the dominating without and with project FDA models. Resolution will be either a) the table will be revised to include emergency cost benefits spread out among the increments or b) text will be added describing why the benefit is not spread out.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207474	Economics	n/a	Econ Appendix, p. 60	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN:. The Fix Creeks increment has very marginal economic justification for the ARN Basin. Concern is risk of including features as part of the NED Plan that may not be economically justified. BASIS: Reported results. SIGNIFICANCE: Medium. RECOMMENDED ACTION: Recommend adding a discussion of the probability this increment is economically justified based upon the HEC-FDA results showing probability EAD reduced exceeds indicated values.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Though the Fix Creeks increment is marginal and will likely remain very marginal, we are further justifying this increment based upon a social justice (OSE) argument as described in the text following Table 48. HQ made the same comment and were satified with the added OSE justification to move forward with including it as part of the NED plan. A probability table can be added to the report if absolutely necessary, but it will likely just show that it's essentially a 50% chance it will be above or below unity.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
I am ok with not including the suggested table and instead just acknowledging the marginal justification. There is of course a risk that if there are any increases in costs for this increment this component of the project will not be economically justified.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207476 Economics n/a Econ Appendix, Section 4.13 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: I would recommend renaming this section NED Optimization – Levee Raises for Alternative 1. BASIS: Title for this section of the appendix vs. the content. SIGNIFICANCE: Low. RECOMMENDED ACTION: Within this section, I would note that the two alternative levee heights were considered to verify that the NED levee scale was properly identified. This section is supporting the selected levee height as the NED levee height, rather than presenting an HEC-FDA sensitivity analysis.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
This section will be re-named/revised as recommended.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
response addresses concern

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6207477 Economics n/a Econ Appendix, Section 4.14 n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

REVIEW CONCERN: Accuracy of statement that net benefits between alternatives are essentially equal. BASIS: Statement made in appendix regarding net benefits for Alts 1 and 2. SIGNIFICANCE: Low. RECOMMENDED ACTION: Recommend revising text to state that BENEFITS for the two plans are very similar and are essentially equal from an R&U perspective, rather than NET benefits. Given that the two plans have essentially the same benefits, the NED Plan is pretty clear as Alt 1, given it costs nearly $200M less.

Submitted By: Michael Hallisy (213-452-3815). Submitted On: Aug 21 2015

1-0 Evaluation **Concurred**
Statement will be revised as recommended.

Submitted By: Nicholas Applegate (916-557-6711) Submitted On: Sep 08 2015

1-1 Backcheck Recommendation **Close Comment**
response addresses concern.

Submitted By: Michael Hallisy (213-452-3815) Submitted On: Sep 09 2015

Current Comment Status: **Comment Closed**

6212786 Geotechnical n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

I reviewed the ARCF EIS/EIR located at \\155.88.8.200\pe\Elmo\Marc_Masnor\American_River_Common_Features\3_Final_GRR_ATR__Aug2015\Review_Documents_for_ATR_Comments. i have no comments on this document and no additional comments on the GRR.

Submitted By: Glen Bellew (816.389.3553). Submitted On: Aug 26 2015

Revised Sep 02 2015.

1-0 Evaluation **Concurred**
Concur with the comment. Thanks for your review.

Submitted By: Sara Schultz ((916) 557-7368) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Glen Bellew (816.389.3553) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6225189 Planning - Plan Formulation n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

I reviewed the American River Common Features Final General Reevaluation Report, Chapters 1-8, and Appendix A - Plan Formulation. I have no technical comments on these documents. Editorial comments were provided directly to the ATR Lead and the PDT.

Submitted By: Eric Lynn (816-983-3258). Submitted On: Sep 04 2015

1-0 Evaluation **Concurred**
Concur with the comment. Thanks for your review.

Submitted By: Sara Schultz ((916) 557-7368) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Eric Lynn (816-983-3258) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6225198 Hydraulics n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

I reviewed the final H&H appendices. I have provided my editorial comments to the PDT in an email.

No technical comment for this current review.

Submitted By: Shih-Huang Chieh (213-452-3571). Submitted On: Sep 04 2015

Revised Sep 04 2015.

1-0 Evaluation **Concurred**
Concur with the comment. Thanks for your review.

Submitted By: Sara Schultz ((916) 557-7368) Submitted On: Sep 04 2015

1-1 Backcheck Recommendation **Close Comment**
Comment closed.

Submitted By: Shih-Huang Chieh (213-452-3571) Submitted On: Sep 08 2015

Current Comment Status: **Comment Closed**

6229108 Civil n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

I have no further comments

Submitted By: Huma M Nisar (213-452-3665). Submitted On: Sep 09 2015

1-0 Evaluation **Concurred**
Thank you.

Submitted By: James Elsberry (916-557-5276) Submitted On: Sep 09 2015

1-1 Backcheck Recommendation **Close Comment**
The ATRT Lead has closed the "no comment" comment.

Submitted By: Marc Masnor (918-669-7349) Submitted On: Sep 10 2015

Current Comment Status: **Comment Closed**

6230558 Environmental n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Mitigation Monitoring Plan, Section 1.1 Purpose and Goals, para 1, last sentence, states that this plan "will also establish an adaptive management plan to allow for accomplishment of the goals and requirements of the mitigation...." Text is not clear whether the adaptive management plan would be a separate document or be contained within the mitigation and monitoring plan. If the intent is for the adaptive management plan to be an element of this plan, then recommend text be revised to clarify. Also, if the adaptive management plan element would be developed at a later time, then recommend adding text to state. If the intent is to have the adaptive management element in the plan now, then text should be clarified so reader has a clear understanding.

Submitted By: Tiffany Bostwick (213-452-3845). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Text modified to "This HMMP is a living document and will be modified as part of an adaptive management strategy to allow for the accomplishment of the goals and requirements in a constantly changing environment." Please note change of MMP to HMMP (Habitat Mitigation and Monitoring Plan) in order to be consistent with requests from NMFS.

Submitted By: Anne Baker ((916) 557-7277) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Tiffany Bostwick (213-452-3845) Submitted On: Sep 11 2015

Current Comment Status: **Comment Closed**

6230559 Environmental n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Mitigation Monitoring Plan -- responsible parties, roles. The plan lacks information on who are the responsible parties for implementing the plan, when, etc. Plan should include text to identify the roles and responsibilities of the Corps versus the local sponsor or other partners with respect to implementation of this plan. Also, in the context of adaptive habitat management, plan should indicate the decision maker(s) and identify, as appropriate, any other parties/entities that would be involved in an advisory capacity.

Submitted By: Tiffany Bostwick (213-452-3845). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
At this time some of the specifics (when implementation would take place) are yet to be determined, but the roles and responsibilities are part of the agreement between the Corps, USFWS, and NMFS. Added text: "The HMMP would be implemented by U.S. Army Corps of Engineers (Corps) staff through coordination with USFWS and NMFS. Monitoring would be conducted by qualified biologists from the Corps, USFWS, the Department of Water Resources (DWR), and the Sacramento Area Flood Control Agency (SAFCA) as necessary. Upon completion of the monitoring term as established by USFWS and NMFS, the land would be turned over to the non-Federal sponsor to be maintained in perpetuity."

Submitted By: Anne Baker ((916) 557-7277) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Tiffany Bostwick (213-452-3845) Submitted On: Sep 11 2015

Current Comment Status: **Comment Closed**

6230560 Environmental n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Mitigation Monitoring Plan Table 3 - Did not find Table 3 referenced in the text, or explanation of significance of the table. Recommend adding text to provide context for inclusion of the table.

Submitted By: Tiffany Bostwick (213-452-3845). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Added text: Table 3 describes the types and amounts of habitat that would be potentially impacted by the project, the duration of the impacts, the amount of mitigation according to the requirements provided by USFWS and NMFS, and projected costs as estimated according to existing mitigation prices."

Submitted By: Anne Baker ((916) 557-7277) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Tiffany Bostwick (213-452-3845) Submitted On: Sep 11 2015

Current Comment Status: **Comment Closed**

6230562 Environmental n/a n/a n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Mitigation Monitoring Plan Section 2.0. Para 4 identifies the consideration of application of adaptive management principles to the project. The text places emphasis on the potential changes to project objectives, expectations, assumptions, and success criteria. However, the text does not give consideration to potential changes or alternatives (adapting of) to management actions on the habitat/mitigation area based on monitoring results, which is one of the main aspects of adaptive management. Recommend adding text to identify the potential need for changes or alternatives in management actions on the habitat/mitigation area based on monitoring results.

Submitted By: Tiffany Bostwick (213-452-3845). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
Added text: "In addition to modifying project objectives, there is a potential for changes to or adaptation of management actions based on monitoring results. The purpose of adaptive management is to enable strategic changes to improve the mitigation sites to functioning habitat."

Submitted By: Anne Baker ((916) 557-7277) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Tiffany Bostwick (213-452-3845) Submitted On: Sep 11 2015

Current Comment Status: **Comment Closed**

6230563	Environmental	n/a	n/a	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

Mitigation Monitoring Plan Section 2.6 Special Status Fish Species makes a number of references to a green sturgeon mitigation and monitoring plan. It is not clear in the text whether this is a separate MMP to be developed, or the green sturgeon element would be further developed within this MMP during design. Recommend text be revised to clarify.

Submitted By: Tiffany Bostwick (213-452-3845). Submitted On: Sep 10 2015

1-0 Evaluation **Concurred**
The green sturgeon plan would be a part of the HMMP described in the remainder of the document. Revised text: "The Corps' final EIS/EIR for the American River Common Features GRR includes a proposal to further develop this HMMP to include a refined green sturgeon plan with the specific elements that are described below."

Submitted By: Anne Baker ((916) 557-7277) Submitted On: Sep 10 2015

1-1 Backcheck Recommendation **Close Comment**
Closed without comment.

Submitted By: Tiffany Bostwick (213-452-3845) Submitted On: Sep 11 2015

Current Comment Status: **Comment Closed**

Enclosure 2

COMPLETION STATEMENT OF AGENCY TECHNICAL REVIEW

COMPLETION OF AGENCY TECHNICAL REVIEW

The Agency Technical Review (ATR) has been completed for the **AMERICAN RIVER WATERSHED, COMMON FEATURES, FINAL GENERAL REEVALUATION REPORT, September 2015, and FINAL ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT, September 2015**, Sacramento District. The ATR was conducted as defined in the project's Review Plan to comply with the requirements of EC 1165-2-214, 15 December 2012, Water Resources Policies and Authorities, CIVIL WORKS REVIEW. During the ATR, 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 results, including whether the product meets the customer's needs consistent with law and existing US Army Corps of Engineers policy. The District quality control review was found to be adequate. All comments resulting from the ATR have been resolved and the comments have been closed in DrChecks.

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Date: 2015.09.14 13:20:08 -07'00'

Miki Fujitsubo, NTS for
Marc L. Masnor, P.E. Date
ATR Team Leader
CESWF-PEC-PF (Tulsa, OK)

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Date: 2015.09.14 13:54:31 -07'00'

Eric Thaut Date
Review Management Organization
Representative
CESPD-PDS

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Date: 2015.09.15 08:06:46 -07'00'

Dan P. Tibbitts Date
Project Manager
CESPK-PM-C

DISTRICT'S STATEMENT

CERTIFICATION OF AGENCY TECHNICAL REVIEW
SEPTEMBER 2015

Of the:

AMERICAN RIVER WATERSHED
COMMON FEATURES
FINAL GENERAL REEVALUATION REPORT
September 2015

And

FINAL ENVIRONMENTAL IMPACT STATEMENT/
ENVIRONMENTAL IMPACT REPORT
September 2015

Sacramento District

US Army Corps
of Engineers ®

CERTIFICATION OF AGENCY TECHNICAL REVIEW

Subject: Agency Technical Review (ATR) of the **AMERICAN RIVER WATERSHED, COMMON FEATURES, FINAL GENERAL REEVALUATION REPORT, September 2015, and FINAL ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT, September 2015, Sacramento District**.

Significant concerns and the explanation of the resolution of agency technical review comments for the subject ATR are as follows:

- None

References.

a. ATR guidance: EC 1165-2-214, 15 December 2012, Water Resources Policies and Authorities, CIVIL WORKS REVIEW.
b. The Review Management Organization for this review was the Flood Risk Management Planning Center of Expertise (FRM-PCX), Eric Thaut.
c. The ProjnetTM DrChecks Project and Review titles are: Project: ARCF - General Reevaluation Report (GRR), TSP & Attachments, American River Common Features (ARCF), California (P2 #149827), Review: ATR Final EIS/EIR (10-14 Aug 2015) (00031).
d. The ATR review report is titled: FLOOD RISK MANAGEMENT, PLANNING CENTER OF EXPERTISE, REVIEW MANAGEMENT ORGANIZATION, AGENCY TECHNICAL REVIEW REPORT, SEPTEMBER 2015, Of the: AMERICAN RIVER WATERSHED, COMMON FEATURES, FINAL GENERAL REEVALUATION REPORT, September 2015, And, DRAFT ENVIRONMENTAL IMPACT STATEMENT/ENVIRONMENTAL IMPACT REPORT, September 2015, Sacramento District, and contains the ATR Completion Statement.

I certify that all comments resulting from ATR of the subject report have been closed to the satisfaction of the agency technical review team and the project delivery team has completed revisions as indicated in the evaluation of comments.

Rick L. Poeppelman

Rick L. Poeppelman, P.E.
Chief, Engineering Division
CESPK-ED

16 Sept 2015
Date

for Alicia E. Kirchner
Chief, Planning Division
CESPK-PD

9-14-15
Date

Comment Report: Comment Evaluation/Backcheck Contribution by Michael Scuderi
Project: ARCF - General Reevaluation Report (GRR), TSP & Attachments, American River Common Features (ARCF), California (P2 #149827) **Review**: ATR Final EIS/EIR (10-14 Aug 2015) (*00031*)
(sorted by Discipline , ID)

Displaying 6 comments for the criteria specified in this report.

Id	Discipline	Section/Figure	Page Number	Line Number
6308793	Environmental	n/a	2. Mitigation Ratios for threatened and endangered species not explained	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: While the inclusion of the Mayhew HSI does help to explain why the 1:1.6 ratio is suggested there is an incomplete explanation of the mathematics that produced that number.
BASIS FOR CONCERN: ER 1105-2-100, C-3(e) (2) does require clear justification of ratios.
SIGNIFICANCE OF CONCERN: High
ACTION NEEDED TO RESOLVE CONCERN: Further explain the development of the 1:1.6 ratio for Mayhew and then carry this forward to American River example. A justification for the bump-up to 2:1 can be found at:
http://training.fws.gov/courses/csp/csp3112/resources/Mitigation/WetlandMitigationRatios.pdf and https://fortress.wa.gov/ecy/publications/documents/1006011.pdf and https://fortress.wa.gov/ecy/publications/documents/1006011.pdf
http://escholarship.org/uc/item/6x36z0r6, and
http://www.ecy.wa.gov/programs/sea/wetlands/bas/vol2final/Appendix%208-F_Volume%202_.pdf are two examples of research into why higher ratios are justified for temporal loss.

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Nov 30 2015

1-0	Evaluation **Concurred** The District will update the HMMAMP to elaborate on how the 1:1.6 ratio was calculated for Mayhew. Additionally, further justification will be included regarding the need for 2:1 mitigation based on the quantity of habitat lost and the habitat quality and function lost through mitigation when creating new habitat to replace mature riparian habitat. Thank you for providing the attached articles as a resource for this justification. Submitted By: Anne Baker ((916) 557-7277) Submitted On: Dec 01 2015

1-1	Backcheck Recommendation **Close Comment** Explanation sufficient. Revised language should be reviewed. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 03 2015.
1-2	Backcheck Recommendation **Open Comment** Revised language does not reflect justification for 2:1 ratio. Suggest either eliminate ratio or provide jsutification Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 18 2015.
1-3	Backcheck Recommendation **Close Comment** SPK provided justification of 2:1 ratio related to temporal loss and habitat benefits. Explanantion is sufficient to close out comments. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 18 2015.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6308794	Environmental	n/a	3. Performance standards for mitigation measures are not included in mitigation plan	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: Performance criteria were changed to reflect physical aspects of the mitigation features (mainly survival) but are other measures such as percent cover better indicators of success. Also, that variable would better track with the HEP model (Northern Oriole) variables used in the impact analysis. Survivability might not be a consistent measure to use. Comment from Chemine Jackels "I imagine that percent survivability is difficult to assess after a couple of years. Percent coverage seems like a better metric, and should go up over time. We typically hold the contractor responsible for %100 survival after the first year. They need to replace plants that have died in the first year. These comments apply to all the vegetation monitoring metrics. "
BASIS FOR CONCERN: Required for Section 2036 of WRDA 2007. Performance criteria should be identified related to physical characteristics of the project and not on the survey of populations of species of concern.
SIGNIFICANCE OF CONCERN: Medium
ACTION NEEDED TO RESOLVE CONCERN: Consider adding other variables to monitor. At a minimum add some more explanatory text on why survivability is the best criteria to use (See my email notes also).
Submitted By: Michael Scuderi (206-764-7205). Submitted On: Nov 30 2015

1-0	Evaluation **Concurred** The District will update the performance standards. Concur that we will require the contractor to be responsible for 100% survivability during the first year. The District's assessment is that survivability percentage is a reasonable metric for the first three years, minimum. In addition, the District will monitor for percent cover starting at year one, and will include a performance standard for cover as a success criteria. The District also proposes to revise the criteria that requires the mitigation to meet "three consecutive years of survival" to "three consecutive years of survival following removal of supplemental irrigation". Submitted By: Anne Baker ((916) 557-7277) Submitted On: Dec 01 2015
1-1	Backcheck Recommendation **Close Comment** Explanation sufficient. Revised language should be reviewed. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 03 2015.
1-2	Backcheck Recommendation **Close Comment** Evaluation criteria changed to reflect cover as a criteria. Response is sufficient. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 08 2015.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6308795	Environmental	n/a	3. Performance standards for mitigation measures are not included in mitigation plan	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: Why is there an expected decline in survivability from 75% to 60%
BASIS FOR CONCERN: It appears that there is a downward trend in vegetation survival that might continue after monitoring.
SIGNIFICANCE OF CONCERN: Medium
ACTION NEEDED TO RESOLVE CONCERN: Please explain if it is expected that survivability will level off and not continue declining trend. You can use or elaborate on past Sacramento projects.
Submitted By: Michael Scuderi (206-764-7205). Submitted On: Nov 30 2015

1-0	Evaluation **Concurred** The performance standards established in the table were not intended to portray a declining trend. Rather, they were intended to provide an outlet for meeting success in a scenario where a mitigation site is struggling. For example, if the site is not

	meeting success criteria following year 6, then the performance standard reduces to allow the mitigation to meet a lower standard instead. The District proposes to revise the performance standards to focus on percent cover in addition to survivability. The tables will be removed or revised to reflect the new standards. Ensuring that the vegetation meets survival criteria for three consecutive years following the removal of supplemental irrigation would ensure that any downward trends would not occur. Submitted By: Anne Baker ((916) 557-7277) Submitted On: Dec 01 2015
1-1	Backcheck Recommendation **Close Comment** Explanation sufficient. Revised language should be reviewed. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 03 2015.
1-2	Backcheck Recommendation **Close Comment** Survivability criteria have been downplayed verus usig cover as a monitoring criteria. Response sufficient. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 08 2015.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6308797	Environmental	n/a	4. Adaptive Management is not included in mitigation plan.	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: No adaptive management plan was previously included
BASIS FOR CONCERN: Requirement of Section 2036 WRDA 2007
SIGNIFICANCE OF CONCERN: HIGH
ACTION NEEDED TO RESOLVE CONCERN:. AMP was added to HMMAMP. In section 2.6.4 at the beginning refer back to table 2. The only other factor to consider is are the costs details of the AMP sufficient for HQ review. Should not the costs be broken out by mitigation measure?
Submitted By: Michael Scuderi (206-764-7205). Submitted On: Nov 30 2015

1-0	Evaluation **Concurred** Will refer to the correct table in Section 2.6.4. The District will update the AMP to elaborate on the components of the cost estimate per year in tabular form. Submitted By: Anne Baker ((916) 557-7277) Submitted On: Dec 01 2015

1-1	Backcheck Recommendation **Close Comment** Explanation sufficient. Revised language should be reviewed. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 03 2015.
1-2	Backcheck Recommendation **Close Comment** Costs have been added to table. Thank you. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 08 2015.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6308798	Environmental	n/a	5. Discounting of onsite mitigation and mitigation bank measures	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

CONCERN: Not enough detail is provided to justify the exact values of the discount rates. Why was .2 and .3 used and not 0 and .1? or some other numbers? It is also not clear how the temporal loss aspect factors into the mitigation determination.
BASIS FOR CONCERN: ER 1105-2-100 par. C-3(d)(5) requires justification for replacement rates.
SIGNIFICANCE OF CONCERN: HIGH
ACTION NEEDED TO RESOLVE CONCERN: Provide additional justification for discount rates even if it is BPJ or local expert analysis.
Submitted By: Michael Scuderi (206-764-7205). Submitted On: Nov 30 2015

1-0	Evaluation **Concurred** Justification for the 20% discount rate on onsite mitigation is provided through the HEP discussion. Please see Table 4 for justification of this discount. The District concurs that the additional 10% discount for mitigation banks is not justified. The ARCF GRR CE/ICA is being revised to remove this reduction. It was not applied to the West Sac GRR CE/ICA. Submitted By: Anne Baker ((916) 557-7277) Submitted On: Dec 01 2015
1-1	Backcheck Recommendation **Close Comment** Explanation sufficient. Revised language should be reviewed. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 03 2015.

1-2	Backcheck Recommendation **Close Comment** Discount has been explained by revised text. Removal of 0.10 for off-site is acceptable. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 08 2015.
	Current Comment Status: **Comment Closed**

Id	Discipline	Section/Figure	Page Number	Line Number
6308799	Environmental	n/a	Responses to 6, 7, and 8 HQ Responses	n/a

Comment Classification: **Unclassified\\For Official Use Only (U\\FOUO)**

FOR INFORMAITON ONLY: Mitigation Plan rewrite is adequate.

Submitted By: Michael Scuderi (206-764-7205). Submitted On: Nov 30 2015

1-0	Evaluation **Concurred** Thank you for your concurrence/review. Submitted By: Anne Baker ((916) 557-7277) Submitted On: Dec 01 2015

1-1	Backcheck Recommendation **Close Comment** Closed without comment. Submitted By: Michael Scuderi (206-764-7205) Submitted On: Dec 03 2015.
	Current Comment Status: **Comment Closed**

Report Complete

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- Patent 11/892,984 property of ERDC since 2004.

CESWF-PEC-PF (Tulsa, OK) January 14, 2016

MEMORANDUM FOR RECORD

SUBJECT: Targeted Agency Technical Review of the Habitat Mitigation Monitoring and Adaptive Management Plan, December 2015 - AMERICAN RIVER WATERSHED, COMMON FEATURES, FINAL GENERAL REEVALUATION REPORT, and FINAL ENVIRONMENTAL IMPACT STATEMENT / ENVIRONMENTAL IMPACT REPORT, Sacramento District.

1. The Chief of Planning in Sacramento District requested the subject review. The District had received comments from HQUSACE in November 2015, regarding the mitigation plans for the subject project and WEST SACRAMENTO PROJECT, FINAL GENERAL REEVALUATION REPORT, AND FINAL ENVIRONMENTAL IMPACT STATEMENT /ENVIRONMENTAL IMPACT REPORT, September 2015. The District agreed with the comments and recognized that substantive revisions of the mitigation plans would be necessary. The HQUSACE comments applied to the methodology applied to the mitigation plans for the two projects. The agency technical review for both projects final general reevaluation reports and NEPA documents had been completed in September 2015. The Sacramento District contacted the Flood Risk Management Planning Center of Expertise to coordinate a targeted review.

2. The charge for the review reflected the HQUSACE comments and was summarized as verifying that mitigation plan revisions were consistent with the Water Resources Development Act of 2007, Section 2036. Because the methodology was the same for the two projects, the review document would be the subject project mitigation plan. The applicable mitigation plan revisions would be made by the District for both projects.

3. The revised mitigation plan was reviewed by Mr. Michael R. Scuderi, CENWS. Mr. Scuderi provided five technical comments and the subsequent sixth comment concluded that District evaluations and mitigation plan revisions had adequately addressed his comments. In general, the technical comments suggested additional discussion be added to more clearly present the mitigation plan.

4. The targeted review is complete. Mitigation plans for both projects have been revised. No further action by the District is required for agency technical review. A report of all comments is enclosed for the subject project.

District.

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1 Encl

Marc L. Masnor
ATR Team Lead

DEPARTMENT OF THE ARMY
SOUTH PACIFIC DIVISION, CORPS OF ENGINEERS
1455 MARKET STREET
SAN FRANCISCO, CALIFORNIA 94103-1399

REPLY TO
ATTENTION OF

CESPD-PDP (FRM-PCX) 27 July 2015

MEMORANDUM FOR Commander Sacramento District, U.S. Army Corps of Engineers (CESPK-PM-C/Mr. Dan Tibbitts)

SUBJECT: Final Comment Response Record for the Independent External Peer Review (IEPR) of the American River Common Features General Re-evaluation Report (GRR)

1. References:

a. EC 1165-2-214, Civil Works Review, 15 December 2012.

b. Memorandum, CESPD-PDP (FRM-PCX), 8 June 2015, subject: FRM-PCX Transmittal of Final Independent External Peer Review (IEPR) Report for American River Common Features General Re-evaluation Report (GRR).

2. Enclosed is the Final Comment Response Record for the IEPR of the American River Common Features GRR.

3. The Flood Risk Management Planning Center of Expertise (FRM-PCX) coordinated the IEPR, which was conducted by an external panel of experts selected and managed by the Battelle Memorial Institute. The IEPR panel comments are documented in the Battelle report titled Final Independent External Peer Review (IEPR) Report for American River Common Features General Re-evaluation Report (GRR), dated 3 June 2015.

4. Seventeen IEPR final comments were developed by the panel, one of which was identified as having high significance. The Comment Response Record documents the Sacramento District responses to the panel comments and the IEPR panel backcheck of the responses. Concurrence was reached between the panel and District on all of seventeen responses; however, the panel provided clarifying statements as part of its concurrence with the District response to the final panel comments 1, 7, 14 and 15.

5. Based on the Comment Response Record, the Sacramento District should prepare a written proposed response to the Final IEPR Report in accordance with reference 1a. The proposed response should be coordinated with the Major Subordinate Command District Support Team and HQUSACE to ensure consistency with law, policy, project guidance, ongoing policy and legal compliance review, and other USACE or National considerations.

CONTRACT NO. W912HQ-10-D-0002
Task Order: 0068

Comment Response Record for the Final Panel Comments for the American River Common Features GRR IEPR

Prepared by

Battelle
505 King Avenue
Columbus, Ohio 43201

for

Department of the Army
U.S. Army Corps of Engineers
Flood Risk Management Planning Center of Expertise
Baltimore District

July 24, 2015

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LIST OF ACRONYMS

ADM	Agency Decision Milestone
AEP	annual exceedance probability
ARCF	American River Common Features
ATR	Agency Technical Review
BA	Biological Assessment
BMP	best management practices
CDFW	California Department of Fish and Wildlife
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
COI	Conflict of Interest
CRPR	California Rare Plant Rank
CVFPB	Central Valley Flood Protection Board
CWRB	Civil Works Review Board
DrChecks	Design Review and Checking System
DWR	Department of Water Resources (CA)
EAD	expected annual damages
EC	Engineer Circular
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
FWOP	future without-project
GRR	General Re-evaluation Report
H&H	Hydrologic and Hydraulic
HEP	Habitat Evaluation Procedure
HSI	Habitat Suitability Index
IEPR	Independent External Peer Review
IWR	Institute for Water Resources

JFP	Joint Federal Project
NED	National Economic Development
NEPA	National Environmental Policy Act
OEO	Outside Eligible Organization
OMB	Office of Management and Budget
PCX	Planning Center of Expertise
PDT	Project Delivery Team
SAFCA	Sacramento Area Flood Control Agency
SAR	Safety Assurance Review
SRA	Shaded Riverine Aquatic
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Services
VELB	valley elderberry longhorn beetle
WRDA	Water Resources Development Act

Final Panel Comment 1

It is not clear why the hydraulic profile for the future without-project condition is significantly higher than the profile for Alternative 1.

Basis for Comment

Based on Section 3.4 of the Hydraulic Appendix Executive Report (Appendix C, Attachment B of the GRR), the future without-project (FWOP) conditions "will serve as the baseline for alternative comparison" in this GRR and, based on Section 2.2 of the Hydraulic Appendix, the FWOP conditions include the change in operations at Folsom Dam due to the Joint Federal Project (JFP).

In Plate 44 of the Hydraulic Appendix, the 200-year water surface profile for the baseline condition (i.e., FWOP) appears to be significantly higher than the profile for Alternative 1. Based on the information above, it would seem that, hydraulically, Alternative 1 would only be affected by raised levee heights south of the American River confluence, which in turn would potentially cause Alternative 1 to be higher than the baseline condition. In addition, since the Natomas levees are not being raised for this analysis and therefore would have no effect on the baseline condition or Alternative 1, the baseline condition would not be expected to be higher than Alternative 1.

For the 10-year flood event, it is not clear why the baseline and Alternative 1 would be any different (see Plate 42 as an example) since the 10-year event would not be expected to overtop levees under either condition.

Plates 42 and 44 represent examples of the two profile issues noted above. These issues are apparent on several other profiles between Plates 31 to 56. Each profile represents a different reach of the rivers and canal systems for either the 10-year (Plates 31 to 43) or the 200-year (Plates 44 to 56) events.

Significance – High

If the baseline condition is not correct, there is a high risk that the flood damage estimates will be incorrect. If, on the other hand, Alternative 1 is incorrect, then there is a risk that the National Economic Development (NED) plan has not been identified.

Recommendation for Resolution

1. Verify the baseline conditions and Alternative 1 profiles on all Plates 31 to 56 in the Hydraulic Appendix Executive Report and adjust analysis as necessary.

PDT Final Evaluator Response (FPC#1):

Concur. The water surface profiles for Alternative 1 and the future without-project condition are identical. The differences observed in the plates were from a superseded and now out of date strategy to measure hydraulic effects of a combination of projects along the American River including the Joint Federal Project Auxiliary Spillway.

Recommendation #1: Adopt

Plates 31 to 56 in the Hydraulic Appendix Executive Report have been verified for baseline conditions and Alternative 1 profiles.

Panel Final BackCheck Response (FPC#1):

Concur. By replacing the plates in the Hydraulic Appendix Executive Report with up-to-date plates, the USACE response adequately addresses the FPC.

Final Panel Comment 2

Details as to why non-Federal agencies would not continue to undertake incremental improvements to the levee system in the future without-project condition are not included in the GRR.

Basis for Comment

The GRR describes work the non-Federal sponsors have done, and are currently doing, to improve the levee systems in the study area. However, the FWOP condition described in the report assumes that no additional improvements will be made to the levee system by USACE, the non-Federal sponsors, or other local agencies. It is not clear why local interests would not continue or even increase their efforts to make improvements to the levee system if no USACE project was anticipated. A clear understanding of the rationale supporting the projected FWOP condition is needed to provide confidence in the results of the evaluation and comparison of alternative plans.

Significance – Medium

If, in the future, non-Federal agencies would continue to make improvements to the levee system in the absence of a Federal project, then the flood risk management benefits of the action alternatives for the ARCF GRR may be overstated.

Recommendation for Resolution

1. Explain in the GRR and Economics Appendix why it is anticipated that local interests will not make improvements to the levee system in the FWOP condition.

PDT Final Evaluator Response (FPC#2):

Concur. The non-Federal sponsor, in addition to partnering with USACE on ongoing and completed flood risk management projects in the study area, has undertaken several large levee improvement projects on their own, including the Natomas Levee Improvement Program (NLIP). The sponsor has also indicated that they will be seeking both permission to alter the Federal Flood Management Project (Section 408) and Credit Consideration (Section 221) for levee improvement work they intend on constructing prior to implementation of the ARCF GRR recommended project. Section 221 of the Flood Control Act of 1970 as amended by Section 2003 of the Water Resources Development Act (WRDA) of 2007 (42 U.S.C. 1962d-5b) allows the sponsor to seek credit for the study, design and construction of Federally authorized water resources development projects that are carried out after the execution of an agreement with the ASA(CW). Where there is a cost sharing agreement, the sponsor may provide in-kind contributions in accordance with the terms of the applicable agreement. The sponsor has indicated that they intend to construct portions of the levee improvements recommended by the GRR that are considered the highest risk areas and seek credit for those improvements. These actions will not be considered part of the without project condition however, in order that the sponsor may receive credit consideration in the future.

With the construction of these multiple projects, SAFCA, the local cost sharing sponsor, had indicated that they are reaching the limit of their funding capabilities with the existing parcel assessments they use to fund flood risk management projects. The State of California, which is the direct cost sharing partner with

USACE, has a larger funding capability, but they would like to distribute funding to other underserved areas beyond the Sacramento Region.

Recommendation #1: Adopt
Additional language has been added to Section 2.8 (Future Without-Project Condition) of the GRR and the Economics Appendix to explain that the non-Federal sponsor will have future funding limitations that will hamper their ability to construct the project without the involvement of the Federal Government. It will also note that the sponsor will be seeking both permission to alter the Federal Flood Management Project (Section 408) and Credit Consideration (Section 221) for levee improvement work they intend on constructing prior to implementation of the ARCF GRR recommended project. These actions will not be considered part of the without project condition however, in order that the sponsor may receive credit consideration in the future.

Panel Final BackCheck Response (FPC#2):

Concur.

Final Panel Comment 3

Baseline conditions for invasive plants in the project area, and an effects analysis for invasive plant spread as a result of project construction, have not been presented.

Basis for Comment

The Draft EIS/EIR does not discuss the baseline conditions for invasive plants in the project area (e.g., their presence or potential to occur) and how project implementation could result in their introduction or spread. For example, invasive plants could be inadvertently introduced or spread in the project area during construction activities if nearby source populations passively colonize disturbed ground, or if construction and personnel equipment is transported to the site from an infested area. In addition, soil, vegetation, and other materials transported to the project area from off-site sources for best management practices (BMPs), revegetation, or fill for project construction could contain invasive plant seeds or plant material that could become established in the project area.

Executive Order 13112 (E.O.13112, 1999), which established a National Invasive Species Council, directs all Federal agencies to prevent the introduction and control the spread of invasive species in a cost-effective and environmentally sound manner to minimize their economic, ecological, and human health impacts. If significant impacts could occur, standard invasive plant management practices are available and should be considered as part of the project design or mitigation. However, the Draft EIS/EIR does not present an effects analysis of invasive plant spread as a result of project construction.

Significance – Medium

The Draft EIS/EIR is not clear whether the effects related to invasive plants have been adequately evaluated and, if needed, mitigated. The potential for construction-related introduction and spread of invasive species that is not addressed or mitigated would elevate the risk to native biological communities and may affect project approval/implementation.

Recommendations for Resolution

1. Discuss existing conditions for invasive plants/noxious weeds in the project area in Section 3.6 (Vegetation and Wildlife) of the Draft EIS/EIR. If recent field or other site-specific data to characterize invasive plant conditions in the study area are not available, then a summary of the expected or likely conditions there based on land cover types, levels of disturbance, and known invasive plant occurrences in nearby areas would be adequate.
2. Discuss construction-related impacts in the effects analysis and consider whether mitigation to prevent invasive plant spread during construction is needed.

PDT Final Evaluator Response (FPC#3):

Concur. The requested information will be added to the appropriate sections of the report.

Recommendation #1: Adopt
Will add invasive species discussion to vegetation and wildlife section.

Recommendation #2: Adopt
Will add discussion of invasive species introduction during construction and include mitigation measures to address this.

Panel Final BackCheck Response (FPC#3):

Concur.

Literature Cited:

E.O. 13112 (1999). Invasive Species. Executive Order 13112, 64 Federal Register 6183 (February 8, 1999). Available online at http://www.gpo.gov/fdsys/pkg/FR-1999-02-08/pdf/99-3184.pdf

Final Panel Comment 4

Some biological resources in the study area potentially affected by project implementation have not been analyzed or presented in sufficient detail to describe the existing conditions and support the Draft EIS/EIR analysis.

Basis for Comment

The Panel found that several biological resource issues were not addressed or presented clearly in the Draft EIS/EIR. The following points summarize the Panel's concerns:

- Although the Draft EIS/EIR discusses vegetation/habitat types within the study area, it does not include supporting figures/maps showing the distribution and types of land cover and other biological resources in the study area potentially affected by project implementation. Detailed representations of the distribution and types of land cover and other potentially affected biological resources, using graphics and/or tables, are important for describing the existing conditions and evaluating potential impacts. Also important would be a table that quantifies (in acres) and compares the amount of each land cover type, including waters of the U.S., assumed to be affected under each alternative.
- In Section 3.6 (Vegetation and Wildlife), it is not clear whether or how the vegetation variance to protect riparian vegetation on the waterside of improved levees was factored into the quantification of riparian vegetation impacts (locations, acreages). It is important to describe whether the estimate of riparian/Shaded Riverine Aquatic (SRA) habitat loss presented in the analysis already accounts for reduced impacts under the vegetation variance.
- Section 3.8 (Special-Status Species) does not address any special-status plant species, which include those considered by California Department of Fish and Wildlife (CDFW) to be "rare, threatened or endangered in California" and have a California Rare Plant Rank (CRPR); listed or designated as a candidate as threatened or endangered under the Federal Endangered Species Act (ESA) or California Endangered Species Act (CESA); etc. For projects subject to California Environmental Quality Act (CEQA), effects on special-status plant species must be considered. In addition, effects on special-status plant species are included in the "Basis of Significance" for evaluating impacts in the Draft EIS/EIR (p.127); however, they are not mentioned elsewhere in the environmental setting or impact analysis.
- Section 3.8 lacks discussion and analysis of several special-status species that could occur in the study area and be affected by project implementation, such as burrowing owl, tricolored blackbird, northern harrier, special-status bats, and others.
- The quantification of impacts on elderberry shrubs and valley elderberry longhorn beetle (VELB) is not clear. Tables 9, 10, and 11 of the Draft Biological Assessment (BA, p. 71) summarize the number of elderberry shrubs and stems that would be affected, observed exit holes, and proposed compensation for loss of shrubs. However, on page 65, the BA states: "The Corps conducted surveys in 2012 of the levee systems within the action area … The survey located elderberry clusters, however, actual shrubs, stem size, nor exit hole presence were determined." These two statements appear inconsistent. Because VELB is listed as threatened under ESA, and the U.S. Fish and Wildlife Service (USFWS) requires the implementation of specific mitigation requirements for impacts on VELB and its habitat (elderberry shrubs), clarifying how impacts on elderberry shrubs and VELB were estimated is important for evaluating the adequacy of the impact analysis and proposed mitigation.

- In the Draft EIS/EIR, tree removal is discussed in adequate detail. However, how it relates specifically to compliance or conflict with the American River Parkway Plan, the Sacramento County Tree Preservation Ordinance, or the City of Sacramento Protection of Trees Ordinance is not discussed. Conflict with these plans and ordinances is listed as a criterion for significance in the Draft EIS/EIR (p. 98). However, how the proposed mitigation would achieve compliance with these plans and ordinances is not described.
- Section 3.6 (Vegetation and Wildlife) does not fully discuss project-related impacts on Federally protected wetlands and other waters of the United States, and how those effects would be mitigated (e.g., completion of a wetland delineation and appropriate compensation, as needed). The effects on stream habitats protected under Section 1600 of the California Fish and Game Code (Streambed Alteration Agreements) and mitigation of those effects are also not addressed.
- The discussion of cumulative effects on special-status species in the Draft EIS/EIR (Section 4.2.4) is limited to only special-status fish and giant garter snake. However, other special-status species evaluated in Section 3.8 (Special-Status Species) (e.g., valley elderberry longhorn beetle, Swainson's hawk, etc.) belong in the cumulative effects analysis.

Significance – Medium

Some of the biological rationale and evidence to evaluate the magnitude of effects and support the conclusions are not clearly presented, which is a substantive issue for California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) review. Not addressing or mitigating (if needed) these potential project-related impacts would increase the risk to special-status species and other biological resources and may affect project approval/implementation.

Recommendations for Resolution

1. Prepare and add to the Draft EIS/EIR figures that depict biological resources within the study area, including vegetation/habitat types in relation to proposed project features.
2. Add a table in Section 3.6 that quantifies (in acres) and compares the amount of each land cover type, including waters of the U.S., assumed to be affected under each alternative.
3. Clarify in Section 3.6 whether the vegetation variance to protect riparian vegetation on the waterside of improved levees was factored into the quantification of riparian vegetation impacts (locations, acreages); describe whether the estimate of riparian/SRA habitat loss presented in the analysis already accounts for reduced impacts under the vegetation variance.
4. In Section 3.8, define which categories of special-species were evaluated (e.g., species listed as threatened or endangered under ESA or CESA, designated by CDFW as species of special concern, Fully Protected under the California Fish and Game Code, plant species with a CRPR rank [formerly California Native Plant Society list], etc.)
5. Add an analysis of special-status plant species to Section 3.8, including information on existing conditions, a table that summarizes special-status plant species with potential to occur in the study area (similar to Table 17 for wildlife), an analysis of potential effects, and proposed mitigation.
6. Expand the analysis in Section 3.8 to include all special-status animal species with potential to occur in the study area (e.g., add species such as tricolored blackbird, northern harrier, special-status bats, etc.). In Table 17, include all special-status animals initially considered or with

potential to occur. For any of those species that could occur and be affected, analyze potential effects of project implementation and, if needed, describe the proposed mitigation for any significant effects. For a more complete list and discussion of species in the area, refer to USACE's West Sacramento Project EIS/EIR.

7. In the Draft BA and the Draft EIS/EIR, clarify how impacts on elderberry shrubs and VELB were quantified from the survey data; resolve the inconsistency in survey information presented in pages 65 and 71 of the Draft BA.
8. In Section 3.6, add a discussion of tree removal as it relates to compliance or conflict with the American River Parkway Plan, the Sacramento County Tree Preservation Ordinance, or the City of Sacramento Protection of Trees Ordinance. Describe whether tree removal would conflict with these plans and ordinances, and how the proposed mitigation would achieve compliance with these plans and ordinances.
9. In Section 3.6, add a discussion of project-related impacts on Federally protected wetlands and other waters of the United States, and how those effects would be mitigated (e.g., completion of a wetland delineation and appropriate compensation, as needed). Also discuss the effects on stream habitats protected under Section 1600 of the California Fish and Game Code (Streambed Alteration Agreements) and mitigation for those effects.
10. In Section 4.2.4, expand the discussion of cumulative effects to include all special-status species addressed in Section 3.8 (e.g., VELB, Swainson's hawk, etc.).

PDT Final Evaluator Response (FPC#4):

Concur. Additional analysis will be conducted as noted below:

Recommendation #1: Adopt
Figures will be added to the EIS/EIR denoting the vegetation/habitat types within the study area.

Recommendation #2: Adopt
A table that quantifies habitat types affected by alternative will be included. .

Recommendation #3: Adopt
Will clarify language in the document to ensure that it is clear that the estimate of SRA habitat loss includes the reduced impacts under the vegetation variance.

Recommendation #4: Adopt
Will give designations to special status species listed in the table in Section 3.8 and describe which species were evaluated.

Recommendation #5: Adopt
Will add a section on special-status plant species affected by the project and will include those considered by CDFW, CNPS and USFWS.

Recommendation #6: Adopt
Will review the species lists generated by USFWS and CDFW to ensure all special status species that could occur in the project area are addressed in the document and will add them to the table.

Recommendation #7: Adopt
Will ensure that language and impacts regarding VELB are consistent between the BA and the EIS.

Recommendation #8: Adopt
Will add a discussion on how tree removal for the project relates specifically to the American River Parkway Plan, the Sacramento County Tree Preservation Ordinance, and the City of Sacramento Protection of Trees Ordinance. Will describe how the proposed mitigation would comply with the plans.

Recommendation #9: Adopt
Will clarify wetland impact discussion and mitigation as well as stream habitats protected under Section 1600. Wetland delineations will be conducted in PED.

Recommendation #10: Adopt
Will add discussion of all special status species to the cumulative effects section.

Panel Final BackCheck Response (FPC#4):

Concur.

Final Panel Comment 5

The justification to use a content-to-structure value ratio of 50% to calculate the value of contents of residential structures has not been explained and the reasonableness of this ratio is unknown.

Basis for Comment

The damageable value of the contents of residential structures is estimated to be over $12 billion. This is the second highest category of damageable property for structures or contents – only the damageable value of residential structures is higher. The Economics Appendix (Section 2.7) describes significant field investigation and analyses for estimating the damageable value of residential and non-residential structures.

Given the magnitude of the value of damageable contents of residential structures, it is important that the methodology or rationale for estimating the value be presented. The Economics Appendix (p. 29) states that a 50% content-to-structure ratio was used. The evidence provided to support this assumption is that it was used in prior American River Watershed studies. The GRR does not offer an explanation of why a 50% content-to-structure value ratio is reasonable for use in this study, or how it is specific to the study area and the period of analysis.

Significance – Medium/Low

The value of damageable contents of residential structures represents a significant portion of the total damageable property and requires an explanation of why use of a 50% content-to-value ratio is reasonable in order to provide confidence in the computed flood damages.

Recommendation for Resolution

1. Provide an explanation in the Economics Appendix of why use of a 50% content-to-structure value ratio is appropriate to calculate damageable property for this study.

PDT Final Evaluator Response (FPC#5):

Concur. The residential content-to-structure value ratio (CSVR) of 0.5 (50%) was used to derive an order of magnitude estimate of the value of damageable property (contents) for reporting purposes only; please note that the ratio was not used to estimate actual residential content values for use in the calculation of expected annual damages (EAD) or annual benefits. While it is understood that the 0.5 CSVR cannot realistically be applied broadly to all homes in the study area, it has been used in past District studies as a simple but adequate way to help derive an estimate of the total value of property in the study area and as a way to gage the magnitude of content damages should a flood event occur. The 0.5 CSVR, as used specifically and solely for reporting purposes in this study, does not have any effect on EAD, annual benefits, net benefits, or benefit-to-cost ratios (BCR).

The economic analysis used the generic depth-percent damage curves (contents) provided in the USACE Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships* (2000), so it was not necessary to explicitly estimate residential content values for use in the damage/benefit analyses. The EGM 01-03 curves for contents are adjusted curves that rely on structure values to derive content

damages; structure values were explicitly estimated for residential structures in the study area.

Recommendation #1: Adopt
The Economic Appendix will provide clarifying language which explains the primary purpose for using a residential 0.5 CSVR in this study.

Panel Final BackCheck Response (FPC#5):

Concur.

Final Panel Comment 6

The magnitude of impacts and level of significance for the effects of sedimentation and turbidity on fisheries resources are not easily determined.

Basis for Comment

The analysis presented in Section 3.7 (Fisheries) of the Draft EIS/EIR concludes that an increase in sedimentation and turbidity would result from project construction. In-stream effects such as suspended sediment, turbidity, and sediment deposition is mentioned generally, but the specific types and expected magnitude of these effects under each alternative are not described.

In terms of the specific significance criteria used for fisheries resources (Draft EIS/EIR, p.111), it is not clear how the level of significance was determined. For example, it is not certain what assumptions were made about the amount of increased sedimentation and turbidity that would be considered substantial and therefore significant.

Significance – Medium/Low

Without a discussion of the specific types and magnitude of impacts on fisheries resources relative to baseline conditions, the quality and completeness of the analysis are limited, and the biological rationale to support the conclusions and adequacy of proposed mitigation (e.g., BMPs) are not clear.

Recommendations for Resolution

1. Expand the discussion of anticipated project effects on fisheries resources. The discussion should describe impact mechanisms and the types and magnitude of biological effects. Any applicable modeling projections for project-generated in-stream effects (e.g., sediment and turbidity) and/or modeling of effects on fish habitat that may have been conducted for the project would be appropriate to reference in the fisheries analysis.
2. Discuss the assumptions made about the amount of project-related increased sedimentation and turbidity (relative to baseline conditions) that would result from project implementation, and the amount that would be considered substantial and therefore significant. If any amount of increase is considered significant, then clarify that point.

PDT Final Evaluator Response (FPC#6):

Concur. The Corps will update the EIS/EIR to include the recommendations discussed below.

Recommendation #1: Adopt
The Corps will ensure that the fisheries section includes impact mechanisms and the types and magnitude of biological effects. These analyses will be prepared and included in the final report.

Recommendation #2: Adopt
The Corps will ensure that the fisheries section includes a discussion regarding the assumptions made about project-related increased sedimentation and turbidity (relative to baseline conditions). The significance criteria will be clarified.

Panel Final BackCheck Response (FPC#6):
Concur.

Final Panel Comment 7

It is unclear why several of the planning objectives are required; some are redundant or not appropriate to fully evaluate alternatives.

Basis for Comment

Limiting the number of planning objectives (and associated metrics) to only those that are necessary to fully evaluate alternatives helps focus the planning process and helps clarify decision making. The GRR presents five planning objectives. The first two appear to be redundant: (1) reduce the probability of flooding, based on annual exceedance probability (AEP), and (2) reduce the consequences of flooding, based on expected annual damages (EAD). The probability of flooding (AEP) is only useful for comparing alternatives if the consequences of flooding are known. The EAD is a measure of both the probability and consequences of flooding. If EAD is used, evaluation of AEP provides no additional information that is useful to decision-making and should not be included.

Given that Sacramento is the state capital and is home to many agencies that are responsible for administering essential state programs, the third planning objective (to reduce impacts on critical infrastructure) provides important information to decision makers that is not addressed in the EAD (or the AEP) and should be retained.

The final two planning objectives identified in the GRR (to encourage wise use of the floodplain and to educate the public about residual risks) are non-structural management measures directed at the objective of reducing EAD. They are a means of achieving an objective. Furthermore, these measures are already in place as part of the existing flood risk management project for the American River. Since the final two planning objectives (to encourage wise use of the floodplain and to educate the public about residual risks) are management measures that should be part of the FWOP condition, they should be eliminated as planning objectives.

The five planning objectives established in the GRR could be reduced to two without losing any information that would be critical to decision making. The remaining planning objectives would be:

1. Reduce flood risk in the study area as measured by the EAD
2. Reduce impacts on critical infrastructure.

Significance – Medium/Low

Streamlining the planning objectives will focus the evaluation of alternatives on the most critical metrics and will simplify decision-making.

Recommendations for Resolution

1. Combine the first and second planning objectives into one: reduce the EAD in the study area. This captures both the frequency of flooding and the consequences of flooding in one metric.
2. Eliminate the final two planning objectives (to encourage wise use of the floodplain and to educate the public about residual risk) and add them to the FWOP condition.

PDT Final Evaluator Response (FPC#7):

Concur. As the commenter noted, Expected Annual Damages (EAD) are an effective metric for calculating the reduction of both probability and consequences of flooding and therefore a single objective can be used to articulate this goal. Therefore, the first two objectives have been combined to avoid redundancy. Planning objectives are used to formulate solutions by clarifying what a plan is desired to achieve which goes beyond just the evaluation of alternatives. Objectives can also be understood as a means to articulate a mission statement of the Federal and non-Federal planning partnership that further emphasizes the importance of including actions the sponsor would continue to implement. Maintaining focus on both the wise use of the floodplain and communication of residual risk are important outcomes for the GRR.

Recommendation #1: Adopt
The first and second planning objectives have been combined into one objective to reduce flood risk in the study area. Section 2.5 (Objectives) and Section 3.9 (Screening of measures) have been modified to reflect this change.

Recommendation #2: Not adopt
The two final planning objectives have not been eliminated. These objectives are needed to highlight the importance of addressing life safety and residual risk management and communication.

Panel Final BackCheck Response (FPC#7):

Concur. The Panel agrees that the last two objectives included in the report (to encourage wise use of the floodplain and to educate the public about residual risks) are important and should be emphasized. However, both are actions that can (and should) be taken to achieve an objective (e.g., reduce flood risk) and should be *considered management measures*. In the ARCF GRR, they are both included in the no action alternative and all action alternatives and as a result, their inclusion as objectives does not detract from the evaluation and comparison of alternatives. For this reason, the Panel is concurring with this Evaluator Response because, overall, including the last two objectives in the ARCF GRR, did not affect the planning process.

Final Panel Comment 8

The basis for the assumption that the project will receive total Federal and non-Federal funding for implementation at a rate of $44 million to $197 million per year over the entire 10-year implementation period has not been provided, and the construction period may be too short, which would result in an underestimate of the cost of interest during construction.

Basis for Comment

GRR Table 5-5 summarizes annual Federal and non-Federal funding for implementation of the project (e.g., design, land acquisition, construction) from 2018 through 2027: $29 million to $128 million per year in Federal funding and an additional $16 million to $91 million per year in non-Federal funding. The GRR assumes the project will receive Federal and non-Federal funding for implementation at a rate of $44 million to $197 million per year over the entire period. The Panel cannot determine whether this is a reasonable funding schedule since the GRR does not provide a rationale for the schedule. In addition, there are several concurrent Federal and non-Federal projects competing for the same funding. If funds are not available at the assumed schedule, the project will accrue additional interest costs that have not been considered in the economic analysis of the TSP.

Significance – Medium/Low

If funding is not available at the proposed schedule, additional interest costs may be incurred. However, given the high benefit-to-cost ratios, this should not affect the recommendation of the TSP or justification of the project.

Recommendations for Resolution

1. Add a description of the basis for the assumption that the project will receive $44 million to $197 million per year during the implementation of the project, including an explanation of why concurrent Sacramento District project funding requirements will not impact the availability of funds for this project.
2. Provide a revised funding schedule to evaluate the potential impact on the TSP benefit-to-cost ratio to account for additional interest costs if the project completion date is extended.

PDT Final Evaluator Response (FPC#8):

Concur. More clarity on the funding assumptions has been added to the GRR.

Recommendation #1: Adopt
Optimal funding from Federal and Non-Federal Sponsors was used as a baseline comparison between the final array of alternatives as a matter of policy. Standard practice for Corps civil works project is to reflect design and construction how it would be best to play out and assume that funding will be provided in time to support this schedule. The duration was determined based on a variety of factors including construction rates, air emissions, property acquisitions, and resource capacity to execute the design and construction of the features. The cost risk contingencies also considered the possibility of competition between flood risk projects in the same area. The description in the text will be expanded to clarify this.

In addition, Civil Works Transformation, which began in 2012, emphasizes the need to fund high-risk projects more efficiently. This funding assumption is consistent with Civil Works Transformation.

Recommendation #2: Not adopt
As stated above, standard practice is to assume optimal funding. If during construction, optimal funding does not keep pace, it will be reflected in the mandated Economic Updates which are required at least every three years. However, by policy, "interest during construction will only be calculated based on remaining construction costs and a schedule to complete that assumes adequate funding." Based on this guidance, a schedule delay will impact BCR updates less significantly than if all sund IDC was included. Additionally, with the nature of federal funding, as part of Civil Works Transformation, less projects are being funded, but they are being fully funded; the projects that are in the highest federal interest are the ones that are being fully funded. This project, because of the large population at risk and the strong economic justification, makes it a good contender to being one of these projects that are fully funded. Therefore, it is unlikely that the schedule will be significantly delayed causing a higher IDC cost.

Panel Final BackCheck Response (FPC#8):

Concur.

Final Panel Comment 9

The rationale and process for selecting the index points are not described or consistently listed in figures, making it difficult to assess whether the index points are representative of potential economic impacts.

Basis for Comment

The GRR does not discuss the relevance of the index points to the extent of flood plain inundation or land use/density. It is therefore unclear whether these index points provide a representative assessment of potential economic impacts. The GRR (and its supporting appendices) discusses the selection of index points used to calculate annual damages on the basis of hydraulic reaches defined by geotechnical conditions. The GRR (p. 3-31) states that index points "are located on the main flood sources, were chosen in order to be able to reasonably characterize the flood risk associated with each of the three main basins by accounting for the multiple sources of flooding in each basin." Appendix C, Attachment C Draft Geotechnical Report (also called Appendix F of the Geotechnical Report) provides the cross-sectional detail of the selected index points, while the Hydraulic Appendix Executive Report provides hydraulic inputs to the various index points.

The Economics Appendix states (p. 24) that 25 reaches were identified and five were selected by the project team for use in economic modeling and the associated without-project damage and with-project benefit analyses; however, no explanation is provided for why the 25 reaches were reduced to five or how the five were selected. Three additional points were added at locations where there are no levees. An additional index point ARS B was added, but only used to "estimate damages associated with emergency cost losses." The Economics Appendix references Figure 7 relative to the location of the index points used in the economics analysis; however, ARS B is not shown on the figure.

In addition, Figure 8 from the Hydraulic Appendix Executive Report also does not include all index points that were considered, and the Geotechnical Report references Plate 2 as showing the index point location; however Plate 2 was not included in the review materials.

Significance – Medium/Low

A concise explanation of the basis for index point selection will add clarity to the report and provide additional justification for the economic analysis.

Recommendations for Resolution

1. Explain the rationale for index point selection.
2. Include Index Point ARS B on Figure 7 of the Economics Appendix.
3. Confirm that all the figures showing index points in the various appendices are consistently listed.

PDT Final Evaluator Response (FPC#9):

Concur. Additional explanation has been included in the Economic Appendix that describes the rationale for choosing the representative index points used in the economic analysis.

Consistent with SMART planning principles, the PDT's intent was to balance rigor with practicality in choosing the number of index points to use in the analysis. Once the number of index points was determined for this GRR – essentially one index point to represent a major source of flooding (per bank side) plus several others to be able to check for residual damages (e.g., outflanking locations on the American River), the PDT then made a preliminary comparison of the chance of flooding and the consequences of flooding – in other words the overall flood risk associated with a levee breach at various locations – in selecting the representative index points. In order to make this comparison, the PDT used preliminary floodplains, geotechnical levee fragility curves showing probabilities of failure, and preliminary engineering performance results generated from HEC-FDA. During the course of the study, two of the index points that were originally selected (ARS B and ARS E) were replaced by alternate index points ARS A and ARS F (and their respective engineering data). The PDT believes that the index points used in the current analysis allows for a fair characterization of both the future without-project and with-project conditions.

Recommendation #1: Adopt
Additional language regarding the selection of representative index points has been included in the Economic Appendix.

Recommendation #2: Not adopt
Index point ARS B was originally selected but has been replaced with ARS A. Any reference to ARS B in the Economic Appendix was incorrect and has been replaced with a reference to ARS A.

Recommendation #3: Adopt
Cross check of appendices to ensure consistent presentation of index points will be performed.

Panel Final BackCheck Response (FPC#9):

Concur.

Final Panel Comment 10

The Geotechnical Report does not include interpretive cross-sections of the five index points chosen to represent critical surface and subsurface conditions in the selected reaches.

Basis for Comment

As summarized in Section 8.0 of Appendix C, Attachment C Draft Geotechnical Report (also called Appendix F of the Geotechnical Report), five index points were selected to represent the critical levee section throughout the project. While the sections are generally described, there are no interpretive cross-sections showing the surface and subsurface conditions, the water levels considered, proposed improvements, or failure mechanisms considered. The clarity of the geotechnical analysis would be greatly enhanced by the inclusion of interpretive cross-sections.

Significance – Medium/Low

Without cross-sections it is difficult to evaluate the reasonableness of the geotechnical analyses summarized in the appendix.

Recommendations for Resolution

1. Provide an illustrative, interpretive cross-section of each of the five index points where geotechnical analysis was conducted
2. Show topography, subsurface conditions, water levels, phreatic surfaces, and the failure modes considered.

PDT Final Evaluator Response (FPC#10):

Concur. The Geotechnical Attachment will be revised to include raw data associated with the geotechnical analysis organized into enclosures. The raw data, including the geotechnical cross sections showing stratigraphic interpretations, being provided as the response to this comment will be included in those enclosures.

Recommendation #1: Adopt
The geotechnical cross sections are being provided as recommended.

Recommendation #2: Adopt
The requested data included in raw format as part of the response to this comment, will also be crafted into formal enclosures to the geotechnical attachment.

Panel Final BackCheck Response (FPC#10):

Concur.

Final Panel Comment 11

The seismic vulnerability of the project has not been discussed in the GRR and a strategy to address earthquake-related damage to the project area has not been identified.

Basis for Comment

The GRR does not address the seismic vulnerability of the project levees. However, Appendix C, Attachment C Draft Geotechnical Report (also called Appendix F of the Geotechnical Report) indicates that the liquefaction potential is high at all of the reaches for Natomas Basin, Reach A of the American River, and Reaches C to G of the American River southern Basin. Furthermore, the Geotechnical Report (p. 21) states that post-earthquake deformation as a result of liquefaction is a "global or structural failure mode that is very likely to compromise the ability to provide flood protection at these critical locations."

While neither USACE (USACE, 2011) nor the local sponsor under California Department of Water Resources (DWR) guidance (URS, 2012) commonly undertakes levee improvements to address seismic stability, the typical practice is to evaluate the range of deformations that could be sustained during a 200-year earthquake. Once a range of deformations has been evaluated, a post-earthquake remediation plan is developed that addresses emergency preparations, mobilization, data gathering, actions, interim repairs, long-term repairs, and public notification. Costs will be associated with planning and post-earthquake response; however, the Panel cannot determine if these costs have been considered.

Significance – Medium/Low

USACE and the local sponsor will be responsible for earthquake preparedness and post-earthquake remediation; whether costs have been allocated to these activities cannot be determined.

Recommendations for Resolution

1. Describe seismic vulnerability and post-earthquake remediation strategies in the GRR.
2. Consider the cost of post-earthquake remediation in the economic analysis and allocate the cost among Federal and non-Federal interests.

PDT Final Evaluator Response (FPC#11):

Concur. As per the ULDC (DWR, 2012) and Sacramento District internal guidelines for seismic evaluation of levees (USACE, 2013), an intermittently-loaded levee is a levee that does not experience a WSE of 1 foot or higher above the elevation of the landside levee toe at least once a day for more than 36 days per year on average. The ARCF GRR Study Area has low frequencies of measurable channel flow, resulting in the Study Area levees to be considered intermittently loaded. This classification results in the determination that coincident flood and seismic events are not likely and do not need to be accounted for during the levee improvement design process (no seismic specific design measures). Therefore, seismic failure of levees does not significantly contribute to the levee performance curve when compared to seepage, stability, erosion, vegetation, utilities, encroachments, and animal activity.

The Sacramento District performed a seismic evaluation as part of the ARCF General Reevaluation Report (USACE, 2010). For the Study Area, liquefactions analyses and seismic vulnerability analyses

were performed for the most critical cross-section in each reach. Based on the seismic vulnerability analyses, the majority of reaches within the Study Area were classified as “Very Likely Compromised” with respect to post-seismic flood protection ability. As part of DWR’s ULE Project, URS also performed a seismic evaluation. The ULE study provides results of seismic vulnerability evaluations, including liquefaction potential analysis and post-seismic vulnerability analyses. Based on the ULE seismic evaluations, the levees were identified as having “low to medium seismic vulnerability”.

Therefore, for purposes of this study, it is assumed that if liquefaction of a segment of levee occurs as a result of an earthquake during the life of the project, agencies will perform the necessary inspections of the infrastructure for visible signs of damage. If there was a change in the structure’s ability to perform as intended, an emergency flood fight would be initiated by state and local agencies. If the flood fight in the area exceeded the state’s ability to respond, then PL 84-99 flood fight assistance could be requested through a governor’s letter. Following the flood event, if necessary the request for PL 84-99 rehabilitation assistance could be requested/sought to address the areas with damage. The USACE policy does not require consideration of PL 84-99 in the project economics.

Recommendation #1: Adopt
Language has been added to the GRR, Section 2.3, addressing the intermittent loading of levees in the study area, and the seismic vulnerability of the levees, and to Section 4.5 of the GRR addressing post earthquake remediation strategies.

Recommendation #2: Not adopt
The U.S. Army Corps of Engineers Policy does not require consideration of PL 84-99 in the project economics.

Panel Final BackCheck Response (FPC#11):

Concur.

Literature Cited:

USACE (2011). Guidelines for Seismic Stability Evaluation of USACE Levees. U.S. Army Corps of Engineers Sacramento District. December 2.

URS (2012). Development of a 200-year Return Period Seismic Hazard Map for the Urban Levee Evaluation Program. URS Corporation, California DWR Urban Levee Evaluation Program. February 24.

Final Panel Comment 12

It is not clear in the GRR whether a water control plan has been developed and will be adopted when construction of the Joint Federal Project auxiliary spillway at Folsom Dam is complete.

Basis for Comment

The GRR states that a new water control manual will be adopted when the Folsom Dam Joint Federal Project (JFP) is complete. This water control plan will specify an operating strategy that will govern future discharges from the dam, allowing larger discharges to be made when lake stages are at lower levels. The rate and frequency of discharges from Folsom Dam are important factors affecting the risk of flooding in the study area.

Although the water control plan is adequately defined in the Hydrology Appendix to the GRR, it is not clear in the GRR itself whether the plan defined in the Hydrology Appendix has been developed and will be adopted when the JFP is complete or whether the plan is under development. The likelihood that the operating strategy for the water control plan assumed in the GRR could change in the future is not made clear in the GRR.

Significance – Low

A description of the water control plan that is assumed to be in place for the future without- and with-project conditions will provide a better understanding of how the alternative plans were evaluated.

Recommendation for Resolution

1. Add a brief description to the GRR defining the Folsom Dam water control plan that is assumed in the GRR for the future without- and with-project conditions.

PDT Final Evaluator Response (FPC#12):

Concur. The ARCF GRR without-project condition assumed that the JFP is constructed and the update to the water control manual is complete. The ARCF GRR with-project conditions do not include any proposed changes in operation at Folsom Dam; therefore, the operations at Folsom would be the same for the with- and without-project conditions. This assumption includes a 400,000 acre-feet to 600,000 acre-feet (400/600) variable flood space operation that takes incidental storage space in upstream reservoirs into consideration when determining how much flood storage is needed at Folsom Dam during the flood season.

Recommendation #1: Adopt
The following additional detail has been added to the description of the JFP water control plan for the without project condition in Section 2.8.3 of the GRR. “In 2017, the Folsom Joint Federal Project (JFP) auxiliary spillway at Folsom Dam (Figure 2-10) will be completed and a new water control manual will be adopted (Folsom Dam Modifications). This includes a 400,000 acre-feet to 600,000 acre-feet (400/600) variable flood space operation that takes incidental storage space in upstream reservoirs into consideration when determining flood storage requirements at Folsom Dam during the flood season.

Panel Final BackCheck Response (FPC#12):
Concur.

Final Panel Comment 13

Several of the proposed non-structural management measures are already in place and should not be considered management measures in the GRR.

Basis for Comment

The GRR is evaluating the feasibility of modifying an existing flood risk management project that is being operated in accordance with laws, executive orders, policies, and regulations that are applicable to USACE flood risk management projects.

Executive Order 11988 (1977) directs Federal agencies to "… avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative." Accordingly, the terms of local cooperation for USACE flood risk management projects (including the existing American River Project) require non-Federal sponsors to (among other things):

- Prepare and implement a floodplain management plan designed to reduce the impact of future flood events in the project area (ER 1105-2-100; USACE, 2000).
- Not less than once each year, inform affected interests of the extent of protection afforded by the project.

The terms of local cooperation for USACE flood risk management projects require that the non-Federal sponsors implement several measures that are included as non-structural management measures considered for the GRR. Non-structural management measures identified in the GRR that are currently requirements of local cooperation are floodplain management, providing floodplain information to regulatory agencies, local building codes, annual publication of residual risks, and a Federal flood insurance program (USACE, Project Partnership Agreements website). Since these measures should be in place now and in the future, it is not appropriate to include them as management measures for consideration in the GRR. Including these non-structural management measures in the GRR implies that they are not currently in place or will not be in place in the future. Since these measures should be in place now and in the future, they should be part of the FWOP condition.

Significance – Low

Elimination of non-structural management measures that are currently in place as requirements of local cooperation for the existing flood risk management project will reduce the potential for confusion and improve the overall understanding of the proposed versus existing non-structural management measures for the project.

Recommendation for Resolution

1. Review the proposed set of non-structural management measures and eliminate those that are currently in place.

PDT Final Evaluator Response (FPC#13):

Concur. The non-structural management measures that are currently in place as requirements of local

cooperation for the existing flood risk management project have been removed to reduce the potential for confusion and improve the overall understanding of the proposed versus existing non-structural management measures.

Recommendation #1: Adopt
Tables 3-3 and 3-5 and Section 3.8 of the GRR have been modified to remove the non-structural measures that are currently in place (telemeter stream flow gages and modifications to the flood warning system) as well as the measures that are considered items of local cooperation. The following description has been added to explain how these measures are treated: "Other measures, including floodplain management, providing information to regulatory agencies, local building codes, annual publication of residual risk and participation in Federal flood insurance programs are all existing measures that are currently in place but these will also be items of local cooperation to be agreed to by the sponsor as part of implementation of the Recommended Plan".

Panel Final BackCheck Response (FPC#13):

Concur.

Literature Cited:

E.O. 11988 (1977). Executive Order 11988 – Flood Plain Management. 42 FR 26951, 3 CFR, 1977 Comp. Issued May 24, 1977. Available online at: https://www.fema.gov/executive-order-11988-floodplain-management.

USACE (2000). Planning – Planning Guidance Notebook. Engineer Regulation (ER) 1105-2-100. U.S. Department of the Army, U.S. Army Corps of Engineers, Washington, D.C. April 22.

USACE. Project Partnership Agreements. U.S. Army Corps of Engineers Headquarters website. Online at: http://www.usace.army.mil/Missions/CivilWorks/ProjectPartnershipAgreements.aspx

Final Panel Comment 14

The critical volume durations in the Hydrology Executive Report appear to be inconsistent, which makes the discussion of the hydrology difficult to understand.

Basis for Comment

Section A-3 (p. B2-2) of the Hydrology Executive Report (Appendix C, Attachment A of the GRR) first refers to Figure A-1 when discussing inflow hydrographs into the Folsom Reservoir. Figure A-1 appears to show flood waves composed of 4-day volumes. This section then notes that "The 3-day duration is considered the most critical within the American River Basin." The connection between the text and the figure is unclear.

Significance – Low

The discrepancy between Figure A-1 and the text of Section A-3 is confusing; if the analysis is based on the incorrect critical duration, the results of the hydrologic analyses may be different than documented.

Recommendations for Resolution

1. Verify the critical volume durations in the text vs. Figure A-1 and modify text or graph, as necessary.
2. If text and graph are correct, add text to Section A-3 to clarify the relationship between the stated 3-day critical duration and Figure A-1.

PDT Final Evaluator Response (FPC#14):

Concur. The description below will be added to clarify critical volume duration.

Section A-3 (which describes the critical duration volume as the 3-day duration) and the hydrographs shown in Figure A-1 are correct. There is no discrepancy. Each wave of inflow is composed of 4 to 5 days of runoff, but this does not negate the fact that critical duration is 3-days. Longer duration hydrographs (more than 3-days) are utilized in the modeling because a) atmospheric rivers tend to produce 3 - 5 day precipitation waves in this region b) after a levee break, the large, flat floodplain areas in the Sacramento area may take more than 3 days to fill c) More than 3 days must be simulated to account for timing between the larger Sacramento River and smaller American River.

Critical duration is the most challenging volume to the safe operation of the project to protect downstream. The maximum storage (filling of the reservoir) and maximum downstream discharge occurs during the maximum 3-day unregulated inflow, rather than after that period. While critical duration is described as the 3-day, the Folsom Dam inflow hydrographs are actually balanced to multiple durations (including the critical 3-day volume). The hydrograph is balanced to all durations shown in Table A-1 (page B2-4) which includes the peak, 1-, 3-, 7-, 15-, and 30-day durations.

Recommendation #1: Adopt
The critical duration has been verified, and was determined to be correct in the appendix. The text given

above will be added to clarify the ambiguity regarding the critical volume duration in Figure A-1.

Recommendation #2: Adopt
The text above will be added to clarify critical volume duration.

Panel Final BackCheck Response (FPC#14):

Concur. The USACE response clarified that the hypothetical inflow hydrographs were not the basis for the 3-day critical volume, but serve to cover the critical 3-day duration of the inflow for the analysis. It is therefore reasonable for these hydrographs to be longer than three days. The balanced hydrograph (runoff) approach also seems reasonable given similar approaches used with rainfall patterns for smaller watersheds across the country. Based on the explanation above, USACE has adequately addressed the FPC.

Final Panel Comment 15

The reason for updating the flow record with additional data for Arcade Creek but not Dry Creek is unclear.

Basis for Comment

Sections 5.2 (p. B3-11) and 6.2 (p. B3-14) of the Hydrology Executive Report (Appendix C, Attachment A of the GRR) both state that updating the flow record with additional data did not seem to make much difference in the frequency curves. However, while the data for Dry Creek were not updated (Section 5.2), the data for Arcade Creek were updated with Peer Review statistics (Section 6.2). The Panel did not find any explanation for these decisions.

Significance – Low

The two different responses to updating the flow record without a rationale for the decisions is confusing and/or may suggest bias in the frequency curves.

Recommendation for Resolution

1. Provide additional text in Section 6.2 or both sections (Sections 5.2 and 6.2), as needed, to clarify the decision to update one set of data and not the other.

PDT Final Evaluator Response (FPC#15):

Concur. We agree that there is ambiguity in the way that the hydrologic periods of record were presented for the two creeks in question. Our review however confirms that both creeks (Dry and Arcade) rely on the statistics for the Peer Review Findings (Adjusted Gage Measurement) which was a study conducted in 1996. These statistics are shown in Table 3, column 2. The statistics are based on the hydrologic data set from 1962 to 1995, rather than updated statistics based on data from 1950 - 2009. The reasoning to use the 1996 analysis are as follows: a) the curve did not change significantly; and b) multiple agencies had worked together to analyze the data and results for the Peer Review Study which gave it importance.

Recommendation #1: Adopt
Text has been added to sections 5.2 and 6.2 to clarify that both creeks use the same hydrologic period of record and the reasons why the updated information was not used.

Panel Final BackCheck Response (FPC#15):

Concur. The PDT response and reasons used to support the response clarified that neither gage was updated to add data to the period of record, and that adding data to the period of record at either gage did not change the statistical mean at that particular gage. Based on this information, USACE has adequately addressed the FPC.

Final Panel Comment 16

The use of the 1-year event stage data has not been described in sufficient detail to understand how it was derived.

Basis for Comment

Section 6.2 of the Hydraulic Appendix Executive Report (Appendix C, Attachment B of the GRR) states (p. 24) that "1-year and 2-year event stage data was derived via a different process using gage data." A "1-year event" is a statistical impossibility, indicating that it has a 100% chance of being equaled or exceeded in any given year.

The Panel also noted that Section 5 of the Memorandum for the Hydrologic Engineering Center's Flood Damage Reduction Analysis (HEC-FDA) Inputs (USACE, 2013) references use of the 99% event. It may be that this is what is meant by a "1-year event." Plates 2 through 9 of the same memorandum indicate that "1yr = .999" (or 99.9% ACE)

Significance – Low

The reference to a "1-year event" is confusing and affects the understanding of how stage data were derived.

Recommendation for Resolution

1. Add a brief description of the meaning of "1-year event" for clarification, since a 1-year event cannot be statistically quantified.

PDT Final Evaluator Response (FPC#16):

Concur. The reviewer is correct that a 1-yr stage is a statistical impossibility and correctly noted that is meant to be a frequent event that approaches a 1-yr stage. The language will be updated to be consistent with the FDA Inputs Technical Memorandum, using Annual Chance Exceedance and a value that approaches a 1-yr event (now to be called a 99% (1/1.01) ACE). The frequent stages of the 1-yr and 2-yr are needed to produce for a full range of the stage frequency curve for HEC-FDA.

Recommendation #1: Adopt
The language will be updated to be consistent with the FDA Inputs Technical Memorandum, using Annual Chance Exceedance and a value that approaches a 1-yr event (now to be called a 99% (1/1.01) ACE).

Panel Final BackCheck Response (FPC#16):

Concur.

Literature Cited:

USACE (2013). Memorandum for File: American River Common Features GRR Feasibility Study. HEC-FDA Inputs. U.S. Army Corps of Engineers, Hydraulic Analysis Section, Sacramento District, Sacramento, CA. 15 May.

Final Panel Comment 17

The level of significance of impacts on biological resources after mitigation is not presented in sufficient detail.

Basis for Comment

In the Draft EIS/EIR, Table ES-3 summarizes environmental effects, mitigation, and levels of significance for each alternative. Under the "Vegetation and Wildlife" category (p. ES-11), the effects are listed as "significant" (with mitigation incorporated). At the mid-review of the IEPR, the Panel asked USACE if that means the conclusion is "significant and unavoidable," even with mitigation incorporated; and, if so, whether that was because permanent loss of riparian vegetation is assumed despite compensatory mitigation. In response, USACE clarified that long-term effects on vegetation would be less than significant with the compensatory mitigation; however, the short-term effect would be significant and unavoidable due to the temporal loss of habitat (because of the amount of time it takes for the new habitat to reach the same quality). The Panel agrees with USACE that addressing both short- and long-term effects of project implementation on vegetation is a good approach for this project. However, if separate significance findings are concluded and presented for short- and long-term effects, then those should be clarified and stated in the appropriate sections of the EIS/EIR (i.e., Executive Summary and Section 3.6) for clarity. Clarifying this would make the link between the specific impact and proposed mitigation more transparent.

For biological resources impacts discussed in Sections 3.6 (Vegetation and Wildlife), 3.7 (Fisheries), and 3.8 (Special-Status Species), the level of significance after mitigation is not clearly presented. These sections lack a conclusion about which potentially significant effects have been reduced to a less-than-significant level and why, and which have not.

Significance – Low

The biological rationale and evidence to support the conclusions of the analysis of impacts on biological resources are not consistent or clearly presented, which limits the completeness and technical quality of the Draft EIS/EIR. The nexus between the context, intensity, and significance (per NEPA and CEQA requirements) is important for supporting the analysis, conclusions, and whether proposed mitigation is adequate.

Recommendations for Resolution

1. For the biological resources impact discussions presented in Sections 3.6, 3.7, and 3.8 of the Draft EIS/EIR, add a conclusion statement about which potentially significant effects have been reduced to a less-than-significant level and why, and which (if any) have not. (For consistency, this revision could be made to all of the resource sections.)
2. Review and, if needed, revise Table ES-3 to make it consistent with the analysis conclusions for biological resources.

PDT Final Evaluator Response (FPC#17):

Concur. Will state in Section 3.6 and in the Executive Summary table that short term impacts to vegetation are significant but that in the long term those effects will be less that significant with mitigation.

Will add or clarify conclusion statements in Sections 3.6, 3.7, and 3.8 to ensure they state the level of significance and whether or not it's reduced with mitigation

Recommendation #1: Adopt
Will add conclusion statements to the resource sections clarifying whether effects are potentially significant and whether they are reduced to less-than-significant with mitigation or not.

Recommendation #2: Adopt
Will update table ES-3 to make it consistent with the conclusions in the analysis sections.

Panel Final BackCheck Response (FPC#17):

Concur.

6. For further information, please contact me at (415) 503-6852 or Ms. Anastasiya Hernandez, PCX IEPR Lead for this effort, at (410) 962-2558.

Encl

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American River Common Features, California, Flood Risk Management Project
General Reevaluation Report and Impact Statement\ Environmental Impact Report

DRAFT

U.S. Army Corps of Engineers Response to
Independent External Peer Review
September 2015

Independent External Peer Review (IEPR) was conducted for the subject project in accordance with Section 2034 of WRDA 2007, EC 1165-2-209, and the Office of Management and Budget's Final Information Quality Bulletin for Peer Review (2004).

The goal of the U.S. Army Corps of Engineers (USACE) Civil Works program is to always provide scientifically sound, sustainable water resources solutions for the nation. The USACE review processes are essential to ensuring project safety and quality of the products USACE provides to the American people. Battelle Memorial Institute (Battelle), a non-profit science and technology organization with experience in establishing and administering peer review panels for the USACE, was engaged to conduct the IEPR of the American River Common Features, California Flood Risk Management Project General Reevaluation Report and Environmental Impact Statement and Environmental Impact Report (EIS\EIR).

The Battelle IEPR panel reviewed the Draft General Reevaluation Report (GRR) and Draft EIS/EIR, as well as supporting documentation. The Final IEPR Battelle Report was issued in June 2015.

Overall, 17 comments were identified and documented; one was identified as having high significance, three were identified as having medium significance, seven had medium/low significance, and six were identified as having low significance. The following discussions present the Final Response to the 17 comments.

Based on the technical content of the study documents and the overall scope of the project, Battelle identified candidates for the panel in the field of Civil Works Planning, National Environmental Policy Act (NEPA) and Biology, Hydrology and Hydraulics Engineering, and Geotechnical Engineering. Four panel members were selected for the IEPR.

1. IEPR Comment – *High Significance*. It is not clear why the hydraulic profile for the future without-project condition is significantly higher than the profile for Alternative 1. If the baseline condition is not correct, there is a high risk that the flood damage estimates will be incorrect. If, on the other hand, Alternative 1 is incorrect, then there is a risk that the National Economic Development (NED) plan has not been identified.

The comment includes one recommendation for resolution which was adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended verifying the profiles and adjusting the analysis as necessary. In response, plates 31 to 56 in the Hydraulic Appendix Executive Report were verified for baseline conditions and Alternative 1 profiles. The water surface profiles for Alternative 1 and the future without-project condition are identical. The differences observed in the plates were from a superseded and now out of date strategy to measure hydraulic effects of a combination of projects along the American River including the Joint Federal Project Auxiliary Spillway.

2. IEPR Comment – *Medium Significance*. Details as to why non-Federal agencies would not continue to undertake incremental improvements to the levee system in the future without-project condition are not included in the GRR.

The comment includes one recommendation for resolution which was adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended explaining in the GRR and Economics Appendix why it is anticipated that local interests will not make improvements to the levee system in the FWOP condition. Additional language has been added to Section 2.8 (Future Without-Project Condition) of the GRR and the Economics Appendix to explain that the non-Federal sponsor will have future funding limitations that will hamper their ability to construct the project without the involvement of the Federal Government. It will also note that the sponsor will be seeking both permission to alter the Federal Flood Management Project (Section 408) and Credit Consideration (Section 221) for levee improvement work they intend on constructing prior to implementation of the ARCF GRR recommended project. These actions will not be considered part of the without project condition however, in order that the sponsor may receive credit consideration in the future.

3. IEPR Comment – *Medium Significance*. Baseline conditions for invasive plants in the project area, and an effects analysis for invasive plant spread as a result of project construction, have not been presented.

The comment includes two recommendations for resolution which were both adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended discussing existing conditions for invasive plants/noxious weeds in the project area in Section 3.6 (Vegetation and Wildlife) of the Draft EIS/EIR. If recent field or other site-specific data to characterize invasive plant conditions in the study area are not available, then a summary of the expected or likely conditions there based on land cover types, levels of disturbance, and known invasive plant occurrences in nearby areas would be adequate.

<u>USACE Response (#2): Adopted</u>

Action Taken: The IEPR panel recommended discussing construction-related impacts in the effects analysis and to consider whether mitigation to prevent invasive plant spread during construction is needed. This discussion was added.

4. IEPR Comment – *Medium Significance*. Some biological resources in the study area potentially affected by project implementation have not been analyzed or presented in sufficient detail to describe the existing conditions and support the Draft EIS/EIR analysis.

The comment includes ten recommendations for resolution which were all adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended adding figures that depict biological resources within the study area, including vegetation/habitat types in relation to proposed project features.

<u>USACE Response (#2): Adopted</u>

Action Taken: The IEPR panel recommended adding a table in Section 3.6 that quantifies (in acres) and compares the amount of each land cover type, including waters of the U.S., assumed to be affected under each alternative.

<u>USACE Response (#3): Adopted</u>

Action Taken: The IEPR panel recommended clarifying in Section 3.6 whether the vegetation variance to protect riparian vegetation on the waterside of improved levees was factored into the quantification of riparian vegetation impacts (locations, acreages) and describing whether the

estimate of riparian/SRA habitat loss presented in the analysis already accounts for reduced impacts under the vegetation variance.

USACE Response (#4): Adopted

Action Taken: The IEPR panel recommended defining in Section 3.8 which categories of special-species were evaluated (e.g., species listed as threatened or endangered under the Endangered Species Act or California Endangered Species Act, designated by California Department of Fish and Wildlife as species of special concern, Fully Protected under the California Fish and Game Code, etc.).

USACE Response (#5): Adopted

Action Taken: The IEPR panel recommended adding an analysis of special-status plant species to Section 3.8, including information on existing conditions, a table that summarizes special-status plant species with potential to occur in the study area, an analysis of potential effects, and proposed mitigation.

USACE Response (#6): Adopted

Action Taken: The IEPR panel recommended expanding the analysis in Section 3.8 to include all special-status animal species with potential to occur in the study area. In Table 17, include all special-status animals initially considered or with potential to occur. For any of those species that could occur and be affected, analyze potential effects of project implementation and, if needed, describe the proposed mitigation for any significant effects. For a more complete list and discussion of species in the area, refer to USACE's West Sacramento Project EIS/EIR.

USACE Response (#7): Adopted

Action Taken: The IEPR panel recommended clarifying in the Draft Biological Assessment (BA) and the Draft EIS/EIR how impacts on elderberry shrubs and the Valley Elderberry Longhorn Beetle (VELB, special status species) were quantified from the survey data; resolve the inconsistency in survey information presented in pages 65 and 71 of the Draft BA.

USACE Response (#8): Adopted

Action Taken: The IEPR panel recommended adding, in Section 3.6, a discussion of tree removal as it relates to compliance or conflict with the American River Parkway Plan, the Sacramento County Tree Preservation Ordinance, or the City of Sacramento Protection of Trees Ordinance. Describe whether tree removal would conflict with these plans and ordinances, and how the proposed mitigation would achieve compliance with these plans and ordinances.

USACE Response (#9): Adopted

Action Taken: The IEPR panel recommended, in Section 3.6, adding a discussion of project-related impacts on Federally protected wetlands and other waters of the United States, and how

those effects would be mitigated (e.g., completion of a wetland delineation and appropriate compensation, as needed). Also discuss the effects on stream habitats protected under Section 1600 of the California Fish and Game Code (Streambed Alteration Agreements) and mitigation for those effects.

USACE Response (#10): Adopted

Action Taken: The IEPR panel recommended, in Section 4.2.4, expanding the discussion of cumulative effects to include all special-status species addressed in Section 3.8 (e.g., VELB, Swainson's hawk, etc.).

5. IEPR Comment – *Medium/Low Significance*. The justification to use a content-to-structure value ratio of 50% to calculate the value of contents of residential structures has not been explained and the reasonableness of this ratio is unknown.

The comment includes one recommendation for resolution which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended providing an explanation in the Economics Appendix of why use of a 50% content-to-structure value ratio is appropriate to calculate damageable property for this study.

6. IEPR Comment – *Medium/Low Significance*. The magnitude of impacts and level of significance for the effects of sedimentation and turbidity on fisheries resources are not easily determined.

The comment includes two recommendations for resolution which were both adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended expanding the discussion of anticipated project effects on fisheries resources. The discussion should describe impact mechanisms and the types and magnitude of biological effects. Any applicable modeling projections for project-generated in-stream effects (e.g., sediment and turbidity) and/or modeling of effects on fish habitat that may have been conducted for the project would be appropriate to reference in the fisheries analysis.

USACE Response (#2): Adopted

Action Taken: The IEPR panel recommended discussing the assumptions made about the amount of project-related increased sedimentation and turbidity (relative to baseline conditions) that would result from project implementation, and the amount that would be considered

substantial and therefore significant. If any amount of increase is considered significant, then clarify that point.

7. IEPR Comment – *Medium/Low Significance*. It is unclear why several of the planning objectives are required; some are redundant or not appropriate to fully evaluate alternatives.

The comment includes two recommendations for resolution, one of which was adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended combining the first and second planning objectives into one: reduce the Expected Annual Damages in the study area. This captures both the frequency of flooding and the consequences of flooding in one metric.

<u>USACE Response (#2): Not Adopted</u>

Action Taken: The IEPR panel recommended eliminating the final two planning objectives (to encourage wise use of the floodplain and to educate the public about residual risk) and adding them to the future without-project condition. The two final planning objectives have not been eliminated, as these objectives are needed to highlight the importance of addressing life safety and residual risk management and communication.

8. IEPR Comment – *Medium/Low Significance*. The basis for the assumption that the project will receive total Federal and non-Federal funding for implementation at a rate of $44 million to $197 million per year over the entire 10-year implementation period has not been provided, and the construction period may be too short, which would result in an underestimate of the cost of interest during construction.

The comment includes two recommendations for resolution, one of which was adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended adding a description of the basis for the assumption that the project will receive $44 million to $197 million per year during the implementation of the project, including an explanation of why concurrent Sacramento District project funding requirements will not impact the availability of funds for this project.

<u>USACE Response (#2): Not Adopted</u>

Action Taken: The IEPR panel recommended providing a revised funding schedule to evaluate the potential impact on the Tentatively Selected Plan benefit-to-cost ratio to account for additional interest costs if the project completion date is extended. Standard practice is to assume optimal funding. If during construction, optimal funding does not keep pace, it will be

reflected in the mandated Economic Updates which are required at least every three years. However, by policy, "interest during construction will only be calculated based on remaining construction costs and a schedule to complete that assumes adequate funding." Based on this guidance, a schedule delay will impact BCR updates less significantly than if all sund IDC was included. Additionally, with the nature of federal funding, as part of Civil Works Transformation, less projects are being funded, but they are being fully funded; the projects that are in the highest federal interest are the ones that are being fully funded. This project, because of the large population at risk and the strong economic justification, makes it a good contender to being one of these projects that are fully funded. Therefore, it is unlikely that the schedule will be significantly delayed causing a higher IDC cost.

9. IEPR Comment – *Medium/Low Significance*. The rationale and process for selecting the index points are not described or consistently listed in figures, making it difficult to assess whether the index points are representative of potential economic impacts.

The comment includes three recommendations for resolution, two of which were adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended explaining the rationale for index point selection.

<u>USACE Response (#2): Not Adopted</u>

Action Taken: The IEPR panel recommended including Index Point ARS B on Figure 7 of the Economics Appendix; however, index point ARS B was originally selected but has been replaced with ARS A. Any reference to ARS B in the Economic Appendix was incorrect and has been replaced with a reference to ARS A.

<u>USACE Response (#3): Adopted</u>

Action Taken: The IEPR panel recommended confirming that all the figures showing index points in the various appendices are consistently listed.

10. IEPR Comment – *Medium/Low Significance*. The Geotechnical Report does not include interpretive cross-sections of the five index points chosen to represent critical surface and subsurface conditions in the selected reaches.

The comment includes two recommendations for resolution, both which were adopted as discussed below.

<u>USACE Response (#1): Adopted</u>

Action Taken: The IEPR panel recommended providing an illustrative, interpretive cross-section of each of the five index points where geotechnical analysis was conducted.

USACE Response (#2): Adopted

Action Taken: The IEPR panel recommended showing topography, subsurface conditions, water levels, phreatic surfaces, and the failure modes considered.

11. IEPR Comment – *Medium/Low Significance*. The seismic vulnerability of the project has not been discussed in the GRR and a strategy to address earthquake-related damage to the project area has not been identified.

The comment includes two recommendations for resolution, one of which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended describing seismic vulnerability and post-earthquake remediation strategies in the GRR.

USACE Response (#2): Not Adopted

Action Taken: The IEPR panel recommended considering the cost of post-earthquake remediation in the economic analysis and allocating the cost among Federal and non-Federal interests; however, the U.S. Army Corps of Engineers Policy does not require consideration of PL 84-99 in the project economics.

12. IEPR Comment – *Low Significance*. It is not clear in the GRR whether a water control plan has been developed and will be adopted when construction of the Joint Federal Project auxiliary spillway at Folsom Dam is complete.

The comment includes one recommendation for resolution, which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended adding a brief description to the GRR defining the Folsom Dam water control plan that is assumed in the GRR for the future without- and with-project conditions.

13. IEPR Comment – *Low Significance*. Several of the proposed non-structural management measures are already in place and should not be considered management measures in the GRR.

The comment includes one recommendation for resolution, which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended reviewing the proposed set of non-structural management measures and eliminating those that are currently in place.

14. IEPR Comment – *Low Significance*. The critical volume durations in the Hydrology Executive Report appear to be inconsistent, which makes the discussion of the hydrology difficult to understand.

The comment includes two recommendations for resolution, both of which were adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended verifying the critical volume durations in the text vs. Figure A-1 and modifying text or graph, as necessary.

USACE Response (#2): Adopted

Action Taken: The IEPR panel recommended adding text to Section A-3 to clarify the relationship between the stated 3-day critical duration and Figure A-1.

15. IEPR Comment – *Low Significance*. The reason for updating the flow record with additional data for Arcade Creek but not Dry Creek is unclear.

The comment includes one recommendation for resolution, which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended providing additional text in Section 6.2 or both sections (Sections 5.2 and 6.2), as needed, to clarify the decision to update one set of data and not the other.

16. IEPR Comment – *Low Significance*. The use of the 1-year event stage data has not been described in sufficient detail to understand how it was derived.

The comment includes one recommendation for resolution, which was adopted as discussed below.

USACE Response (#1): Adopted

Action Taken: The IEPR panel recommended adding a brief description of the meaning of "1-year event" for clarification, since a 1-year event cannot be statistically quantified.

17. IEPR Comment – *Low Significance*. The level of significance of impacts on biological resources after mitigation is not presented in sufficient detail.

The comment includes two recommendations for resolution, both which were adopted as discussed below.

USACE Response (#1): Adopted

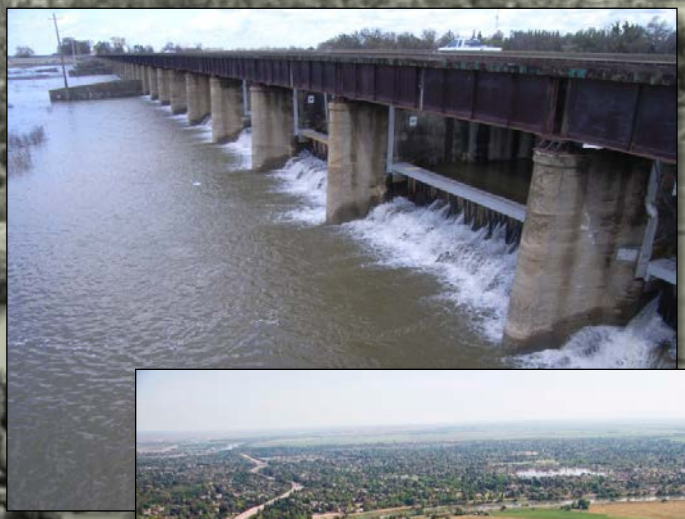
Action Taken: The IEPR panel recommended, for the biological resources impact discussions presented in Sections 3.6, 3.7, and 3.8 of the Draft EIS/EIR, adding a conclusion statement about which potentially significant effects have been reduced to a less-than-significant level and why, and which (if any) have not. For consistency, this revision could be made to all of the resource sections.

USACE Response (#2): Adopted

Action Taken: The IEPR panel recommended reviewing and, if needed, revising Table ES-3 to make it consistent with the analysis conclusions for biological resources.

American River Watershed

Common Features
General Reevaluation Report



Engineering Appendix

December 2015

SAFCA
Sacramento Area Flood Control Agency

CENTRAL VALLEY FLOOD PROTECTION BOARD
PUBLIC SAFETY
WITH FLOOD PROTECTION
STATE OF CALIFORNIA

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Engineering Appendix

U.S. Army Corps of Engineers
Sacramento District

December 2015

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CHAPTER 1 – INTRODUCTION

1.1 Introduction

This engineering appendix documents the design for the American River Common Features General Reevaluation Report (ARCF GRR). The purpose of the ARCF GRR is to evaluate the level of Federal interest in measures needed to reduce the flood risk to the City of Sacramento and surrounding areas. The study area includes the American River Watershed with several tributaries, the Sacramento River, and the Yolo and Sacramento Bypasses. This appendix summarizes the existing conditions, proposed alternatives, design considerations, costs, and schedule for the alternatives retained in the final array of alternatives leading up to the identification of the National Economic Development (NED) plan and Tentatively Selected Plan (TSP). Information and analysis for other alternatives in the preliminary array of alternatives were developed by various sources including previous USACE and sponsor provided reports. The detail provided by these sources varies but were considered adequate for screening alternatives and were adapted for use in the final array.

1.2 Project Location and Background

The ARCF GRR analyzed over 90 miles of levee and associated features in Sacramento, Sutter, and Yolo Counties that reduced flood risk in the greater Sacramento Area. Many of these levees were initially constructed by local interests. The levees were generally built close to the rivers to use as much land as possible for agricultural production and flush out hydraulic mining debris which had contributed to flooding in the past. The historic floods of 1907 and 1909 initiated a new comprehensive approach to flood management within the area. Since then, the United States Army Corps of Engineers (USACE) along with the State of California have managed flood risk in the Sacramento Area using an integrated system of levees, overflow bypasses, and dams known as the Sacramento River Flood Control Project (SRFCP).

The study area includes portions of the Sacramento and American River Watersheds. The flood plain includes most of the developed portions of the City of Sacramento, the Natomas basin, and portions of Sacramento and Sutter Counties. The study area also includes other flood facilities including the Fremont and Sacramento Weirs and Yolo Bypass. The Natomas Post Authorization Change Report (NPACR) and resulting Chief's Report were completed in December 2010. The remaining portion of the project, including potential Natomas Basin levee raises, is being addressed in this report.

1.3 Reach Delineation

The ARCF GRR study area, shown in Figure 1, has been divided into three basins; Natomas (NAT), American River North (ARN), and American River South (ARS), which were further subdivided into study reaches. In addition, the Sacramento Bypass was also included within the project study area. This report covers the approximate areas:

- 12 miles of the north and south banks of the American River immediately upstream of the confluence with the Sacramento River
- 18 miles of the east bank of the Sacramento River, downstream of the NCC down to the American River

- 5 miles of the south bank of the Natomas Cross Canal (NCC)
- 3 miles of the Pleasant Grove Creek Canal (PGCC)
- 26 miles of the Natomas East Main Drainage Canal and tributaries (NEMDC)
- 15 miles of the east bank of the Sacramento River downstream of the American River down to Morrison Creek
- 1.8 miles of the Sacramento Bypass upstream from confluence with American River

For the purposes of the feasibility planning process, the three study area basins were further subdivided into reaches based on common elements, such as geographic features. In general, this report presents information either by basin or reach. However, in some cases the report structure deviates from basin or reach based organization. For instance, geology and geomorphology, construction history, and past performance are better related to channel features than basin related reaches. Therefore, for those topics, the information has been presented in the following groups: American River (both banks), Sacramento River (south of the American River confluence), East Side tributaries (Dry and Robla Creeks, NEMDC east, and Arcade Creek), and Natomas Basin.

The American River North Basin (ARN) includes levees on the north (right) bank of the American River upstream of NEMDC, the east (left) bank of NEMDC from the American River to Arcade Creek and from Arcade Creek up to Dry/Robla Creeks, both banks of Arcade Creek from NEMDC up to Marysville Blvd, both banks of Dry/Robla Creek from NEMDC up to Marysville Blvd, and Magpie Creek between Vinci Ave and Raley Blvd. The levees in the American River North Basin have been divided into nine planning reaches; ARN A, B, C, D, E, F, G, H, and I.

The American River South Basin (ARS) includes levees on the south bank (left) bank of the American River upstream of the Sacramento River and the east (left) bank of the Sacramento River from the American River down to Morrison Creek. The levees in the American River South Basin have been divided into seven planning reaches; ARS A, B, C, D, E, F, and G.

The Natomas Basin (NAT) includes levees on the east (left) bank of the Sacramento River from Verona to the American River, the south (left) bank of the NCC, the west (left) bank of the PGCC, west (right) bank of the NEMDC, and the north (right) bank of the American River from the NEMDC to the Sacramento River. The levees in the Natomas Basin have been divided into nine planning reaches; NAT A, B, C, D, E, F, G, H, and I.

The Sacramento Bypass includes the northern (right) bank levee of the bypass from the Sacramento River into the Yolo Bypass. The area also includes the existing Sacramento Weir structure.

1.4 Coordination

The Project Delivery Team, consisting of U.S. Army Corps of Engineers (USACE), the State of California Department of Water Resources (DWR), the Central Valley Flood Protection Board (CVFPB), and Sacramento Area Flood Control Agency (SAFCA), coordinated in the preparation of this appendix. The designs for the identified alternatives were developed by the Sacramento District Corps of Engineers using assumptions and guidance as described in this Appendix.

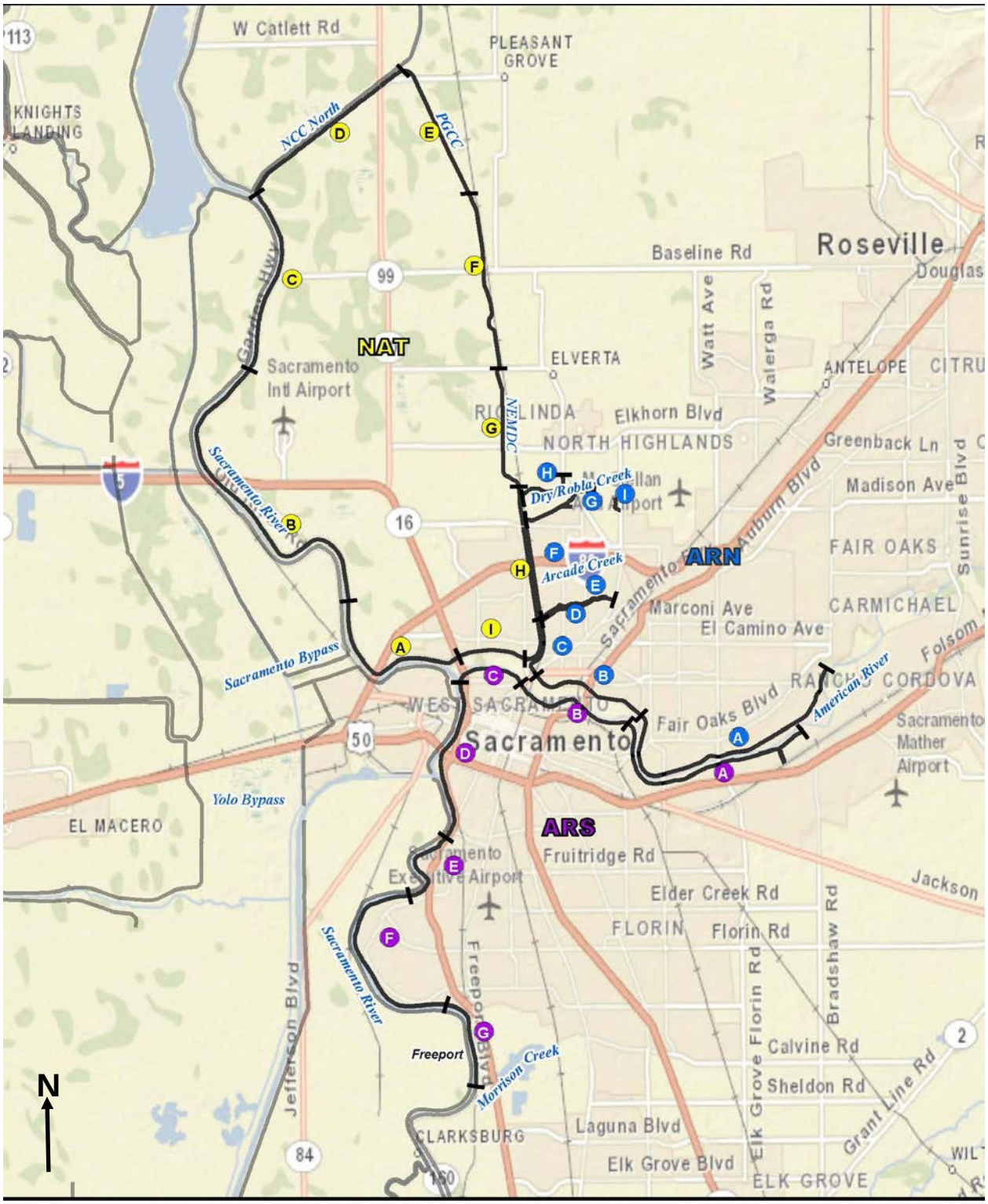

Figure 1 – Study Area Map

CHAPTER 2 – GENERAL DESIGN CONSIDERATIONS

2.1 General

The GRR includes a discussion of the full array of measures and alternatives. The technical appendices only include the Final Alternatives for which qualitative analysis was conducted. The Final Alternatives consist of three alternatives including the No Action Plan. This chapter summarizes the design considerations necessary for evaluation of the without-project condition and for development of the alternatives.

2.2 Hydrology

The hydrologic information used in support of this study is presented in *Synthetic Hydrology Technical Documentation* (USACE 2009) which completed ATR certification in January 2009. For details about the boundary conditions, calibration, data verification, and other topics related to the hydraulic modeling See Attachment A – Hydrology Executive Report for information.

2.3 Hydraulic Design

For alternative selection, the water surface for a median 200-year Annual Chance of Exceedance (ACE) event plus 3 feet was chosen as the top of levee (TOL) design profile. The profiles generated were used in quantitative development for final array and feasibility level costs. This approach is supported by an economic analysis of levee raises above existing TOL discussed within the economic appendix. The design profile also aligns with the sponsor's Urban Levee Design Criteria and the intent of Folsom Dam JFP to control releases up to a 200-year event. Raises beyond the 200-yr event were determined infeasible because the American River system could not contain the releases from Folsom Dam JFP to within the channel and both ARN and ARS basins would be inundated by water outflanking the levee system. In areas where the existing top of levee was higher than the criteria, the top of levee was used for the design profile.

The water surfaces were developed using hydraulic modeling by the Sacramento District Hydraulic Design Section. Much of the hydraulic data used to calibrate this data came from the Comp Study UNET model and flow/stage data from the 1997 flood event. See Attachment B – Hydraulic Executive Report for more information.

2.4 Geotechnical Design

This section summarizes the geotechnical analysis and resulting recommendations. See Attachment C – Geotechnical Report for additional detail.

2.4.1 Geotechnical Analysis

For the purposes of problem identification and alternatives analysis, several different failure modes have been evaluated for the without project condition. The failure modes included seepage (under and through), slope stability, erosion, overtopping and seismic. The details of the analysis and full report are included in Attachment C – Geotechnical Report.

Where levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies were identified (criteria not met) improvement measures consisting of cutoff walls, seepage berms, relief wells, stability berms, geotextile reinforcement, flattened embankment slopes, flood walls, retaining walls, sliver fills, and various other measures were included in development of conceptual alternative cross-sections.

2.4.2 Vegetation Variance

The majority of the Sacramento River levee within the study area, requires seepage, slope stability, height, and erosion improvements in order to meet USACE criteria. In areas requiring levee raising, construction of the levee improvements will require complete vegetation removal on the levee from approximately 15 feet landward of the landside toe to approximately 1/2 the height of the levee on the waterside slope. On the waterside, where construction does not remove vegetation, Army Corps ETL 1110-2-583, *Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures,* would require a vegetation free zone on the levee slope to 15 feet waterward of the waterside levee toe. The Sacramento District will instead seek a Vegetation Variance Request (VVR) which will keep the remaining vegetation left in place.

To show that the safety, structural integrity, and functionality of the levee would be retained, an evaluation of underseepage and waterside embankment slope stability was performed using a realistic vegetation scenario. The scenario analyzed the effects of a tree falling during a flood event and the resulting scouring of the root ball area based on tree species and size.

The analyses section/index point at LM 5.92 was chosen for the VVR analyses because it was considered to be representative of the most critical channel and levee geometry and the without project analyses showed the section does not meet underseepage and slope stability criteria. The cross-section geometry of the index point incorporated tree fall and scour by using a maximum depth of scour for cottonwoods as approximately 11.0ft; the associated soil removed was projected at a 2:1 slope from the base of the scour toward both the landside, and waterside slopes. The base scour width was equal to the maximum potential diameter at breast height (dbh) of Cottonwoods (12.0ft) projected horizontally at a depth of 11.0ft below the existing ground profile. The results show that the tree fall and scour did not significantly affect levee performance and that the levee meets USACE seepage and slope stability criteria considering the seepage and stability improvement measures are in place (“with project” conditions). Therefore, it is a reasonable conclusion that with a VVR to allow vegetation to remain, the safety, structural integrity, and functionality of the levees within the study area would be retained. More information on the VVR and graphical representation can be found in the draft EIS/EIR under chapters 1 and 2 respectively.

2.4.3 Borrow and Stockpile Sites

It is anticipated that significant quantities of material will be required for construction of the proposed project. Several different improvement measures such as seepage berms, cutoff walls, embankment construction/reconstruction, and erosion protection are proposed. The Sacramento District Geotechnical Engineering Branch, SOP-003 *Geotechnical Levee Practice*, (SOP-003)

established the requirements of engineered fill to be used for the construction of the levee embankments.

The material is expected to be sourced from several sites including; newly identified borrow sites within approximately 25 miles of the study area, existing borrow sites identified for the Natomas Basin by SAFCA, the Deep Water Ship Channel dredge disposal area, the existing levees, and existing commercial sources. Test pits and laboratory testing on materials collected from test pits were provided by SAFCA as part of the Natomas Levee Improvement Program (NLIP) for borrow sites established for the Natomas Basin. Additionally, the Sacramento District has studied the Deep Water Ship Channel spoil areas as a borrow source several times in the past. Typically projects constructed by the Sacramento District utilize commercial borrow sites near the project area.

It is anticipated that the required soil fill import for the proposed project will exceed the capacities of the already identified borrow sites in the Natomas Basin, and obtaining significant quantities of material from commercial sites may be cost prohibitive. Therefore, a desktop regional borrow study was performed to identify potential borrow sites, within 25 miles of the study area, where enough soil could be sourced to satisfy the project needs. This study was performed by obtaining National Resources Conservation Service (NRCS) National Cooperative Soil Survey (NCSS) data, sorting the NCSS data based on material classification and engineering properties, using aerial photographs to identify areas of open or agricultural land, and then merging the sorted NCSS data with the open or agricultural land areas to obtain locations, acreage, and volume of potential borrow sites. Results of the desktop regional borrow study indicate adequate materials available within the assumed 25 mile area. A map which indicates these areas is included in the Geotechnical Appendix – Attachment C.

Depending on the selected improvement measure, it is possible that existing levee material could be used as a source of borrow material. Typically, the existing levee is composed of poorly graded sands, silty sands, and sandy silts on the rivers and streams, while the bypass levees were constructed of fat clays. This material can be considered suitable for use in the construction of some stability berms, seepage berms, and for reconstructing the levee embankment where a cutoff wall with an impervious clay cap is proposed. Additionally, the widening of the Sacramento Bypass in Alternative 2 may provide another borrow opportunity from levee degrade and grading efforts within the new floodway channel.

Levee materials such as impervious fill, sand filter, and topsoil are largely expected to be import materials. These materials will be stockpiled or delivered and placed at the same time to construct the proposed levee improvements.

2.5 Civil Design

2.5.1 General

This section describes the civil design and site considerations required for construction of project features, access roads, contractor staging areas, real estate requirements, relocations, and quantities developed for the alternatives analyzed for the GRR. Design consideration

information includes floodwall and levee construction guidance, EM 1110-2-1913 *Design and Construction of Levees*, and ER 1110-2-1150 *Engineering and Design for Civil Works Projects*.

2.5.2 Alignment and Stationing

For purposes of this report, river miles were used for figures and display purposes as they were a common reference between hydraulics and geotechnical disciplines. Levee stationing in feet was developed for each feature for design and quantity take-offs. Alignments for fix in-place levee improvements were determined by the existing levee features such as existing landside or waterside toe, waterside crest, etc.

The landside toe was determined using the Light Detection and Ranging (LiDAR) data along with recent aerial photos and was visually located by Civil Design. Most of the access-related improvements were developed using offsets of this approximation.

2.5.3 Topographic Data

The topographic data used for civil design alternative quantity estimates were based on LiDAR surveys conducted in 2007. The surveyed area consisted of a larger survey contract through the DWR in support of its Urban Levee Evaluation (ULE) geotechnical evaluations. Bathymetry data along the Sacramento and portion of American River was also used in conjunction with the LiDAR surveys under the same DWR geotechnical evaluations. Additional bathymetry was used to complete the rest of the American River study area from an updated 2006 Ayres model.

2.5.4 Datum/Units

The North American Datum of 1983 (NAD83) was used throughout the project area for horizontal control. For vertical control, some of the older datasets used were developed using the National Geodetic Datum of 1929 (NGVD29). These datasets were converted to the National American Vertical Datum of 1988 (NAVD88). English units have been used on this project as preferred by the Non-Federal Sponsor (NFS).

2.5.5 Relocations and Utilities

Utilities and various encroachments were researched and identified using a variety of sources including: State DWR Levee Logs, USACE Periodic Inspection data, and Central Valley Flood Protection Board (CVFPB) permitting data. All of these sources were compiled into a central spreadsheet for organization and priority identification purposes. Field surveys followed the research, attempting to identify both public and non public encroachments as well as verifying existing descriptions, materials, and sizes. The surveys were conducted for the ARS and ARN basins due to the higher risk associated with utilities near urban areas and the proposed levee improvement features within the area. The Natomas basin was not included because the NPACR was assumed authorized and built which included utility relocations.

The field survey and spreadsheet data were combined into a final document recording basic descriptions, owner, and permit number as applicable. Typical fixes were created to reflect

existing conditions and proposed improvements to accommodate levee construction features and USACE policy compliance. Features like replacement/relocation of pipe, impervious fill around pipes, and positive closure represented a majority of the reoccurring items requiring relocation. Larger pumping stations were not assigned a typical fix; instead they were estimated by comparing to similar fixes identified in the NPACR and pro-rating. The pro-rate was related by pipe size and quantity of pipes penetrating the levee, assuming that all of the pipes would require relocation, positive closure, and new pumping equipment to meet USACE policies. The typical fixes and pumping plant pro-rates were then assigned to the utilities outlined in the document and evaluated for compensability.

Private encroachments identified in the field surveys were tabulated separately from the utilities and recorded for the NFS. These were items such as fence intersections, landscaping, pools and stairs along the landside of the levee which are included into the total project cost for alternative selection. ARS Reaches E-G were chosen as the best representation of NFS estimated costs for private encroachments as these reaches contained a majority of the private encroachments. The impact of the encroachments will vary between the alternatives due to the differences in levee raise which requires additional easement to construct and maintain, beyond that which is covered by the System Wide Implementation Framework (SWIF).

2.5.6 Construction Access, Haul Routes, and Staging Areas

Permanent access along most of the project is currently available using existing levee access roads. For scour protection, sites along the Sacramento River are anticipated to be constructed using barges. For the American River, additional waterside access roads will be constructed for the bank protection sites.

Access for constructing cutoff walls will be accomplished using existing levee access roads and public roads. For levee raising, access will be needed along the landside toe for construction and maintenance. Relocations will be accessed through the routes already mentioned. Further refinement of access requirements will be analyzed during the Preconstruction, Engineering and Design (PED) phase.

Haul routes will generally use existing public roadways that connect to the existing project. As borrow sources were not specifically identified, exact haul routes were not identified.

Since there have been many projects along the levees in this study, it is expected that previously used staging areas will be the primary location for staging for this project. There are other available sites such as parks, levee ramps, widened levee areas, and vacant land along the levees that may serve as staging areas. Refinements of staging requirements and identification of staging areas will be completed during the PED phase. For feasibility level cost estimates, it is estimated that approximately one acre of staging area will be needed per mile along the project features.

2.5.7 Real Estate Requirements

Real estate requirements for the study area consist of Flowage Easements (FE), Flood Protection Levee Easements (FPLE), Temporary Work Area Easement (TWAE), and Bank Protection Easement (BPE). These easements were needed to provide adequate construction room to build proposed flood risk management features and secure lands needed for Operations and Maintenance (O&M). The easements are described in Engineering Circular (EC) 405-1-11, and summarized below as they apply to the project.

Bank Protection Easement (BPE) – Easement needed for construction and maintenance of erosion protection features. Included are the rights to trim and cut vegetation, shape and grade slope, and place riprap. The easement includes all area required to construct and maintain erosion protection features that are outside of the FPLE.

Flowage Easement (FE) – Lands that will be subject to permanent and occasional flooding as a result of levee setbacks and degrading of existing levees within the project. This easement will be used for the widened Sacramento Bypass and Magpie floodplain detention features.

Temporary Work Area Easement (TWAE) – Easements needed for a limited duration such as during construction. These include areas needed for access roads and staging areas.

Flood Protection Levee Easement (FPLE) – Needed for levee setback areas and in locations where the local maintaining agency does not have sufficient rights on the levee. These include the right to construct, maintain, repair, operate and patrol the flood protection features. This easement includes all area from landside toe to waterside toe of the existing and/or proposed levee.

In areas where levees will be raised, a FPLE is needed for construction and maintenance for the expanded levee footprint. The easement needed for the expanded footprint is estimated to be 15 feet landward from the existing landside levee toe. Only levee raise areas will require the additional landward FPLE, with remaining areas to be included under the SWIF. See the GRR chapter 2 paragraph 6.6 for discussion of without project future conditions.

During PED, slope flattening will be analyzed further and it is expected that areas with proposed construction improvements will require slopes to be flattened. It is anticipated the slope flattening will not have impacts on permanent easements but will require a TWAE for construction when not coincident with levee raise. The slope flattening work will require approximately 10 feet extending from the toe of the levee towards the landside or waterside for construction. The work does not alter the project footprint for either alternative; instead it reestablishes design slopes with the sloughed material at the toe of the levee. The areas for slope flattening were not defined in this study along the Sacramento River due to the extensive analysis required to define these areas. However, it is estimated that slope flattening could occur on 15% of the levee lengths (9,300 feet) to allow estimation of Real Estate costs for this study. The qualitative estimate came from reviewing levee LiDAR data using slope shading techniques to indicate potential areas where levee slopes were over steepened. The real estate requirement will not be needed in areas of levee raising so it primarily affects the cost for Alternative 2. There is potential for slope flattening for Alternative 1 but it has been reduced to 5,300 feet for estimation of Real Estate costs. In ARN, both sides of Arcade Creek appear to require slope

flattening. On the north side of Arcade, the TWAE extends to the landside as there appears to be minimal impact to existing homes and it is preferable to extend towards the landside to avoid hydraulic impacts to the creek. On the south side, the TWAE extends towards the waterside to avoid impact to existing residential property.

The project does not include work or real estate requirements to bring levees in compliance with Engineering Technical Letter (ETL) 1110-2-583. For areas along the Sacramento River with vegetation that doesn't meet the ETL, this report assumes the Sponsor has sufficient rights to meet requirements of the variance described in paragraph 2.4.2 Vegetation Variance. All work and real estate needs related to vegetation removal or access requirements on the landside of the levee will be covered under a System Wide Improvement Framework (SWIF).

More information on the types of easements, relocations, and estimates can be found in Appendix D – Real Estate.

2.6 Scour Protection Analysis

This section summarizes the erosion protection analysis and resulting recommendations. See Attachment E – Erosion Protection Report for additional detail.

Two erosion protection measures have been proposed that could be implemented in combination along the levee alignment depending on factors such as bank/bench geometry, existing habitat, and existing land use among other considerations. The location of these fixes relied heavily on the existing ground constraints and whether the waterside bench was large enough for the buried trench.

From engineering design perspective and initial environmental input, the Launchable Rock Trench method was preferred and used wherever physically possible and bank protection only when necessary. Because of the differences between the American River and Sacramento Rivers within the study area, this approach led to the majority of the erosion fixes on the American River as Launchable Rock Trench and the majority on the Sacramento River as Bank Protection. However, after impact analysis it was later determined that bank protection would be preferred because of the reduced impacts to vegetation requiring removal during the trench construction. A sensitivity analysis between the two designs was evaluated and costs were determined to be similar with regards to construction and real estate. Therefore, prior to the planning feasibility report milestone (FRM), updates to the plates and quantities will be performed to capture the preferred erosion protection method.

Both erosion designs used the same rock revetment gradations which were calculated using the CHANLPRO software and hydraulic inputs. Section design thicknesses, launching distances, and quantities were dictated by the revetment size and guidance from EM 1110-2-1601, *Hydraulic Design of Flood Control Channels*. The amount of launchable rock needed for both designs was close to 10 cubic yards per lineal foot to account for scour and will potentially allow launching distances up to 25 feet with 3 feet design thickness. Depending on site conditions, sand filters and geotextiles would be used accordingly.

Both erosion protection measures propose planting areas within the design. Plantings are not considered detrimental to the erosion protection features if, at a minimum, they are not within the vegetation free zone and the roots will not penetrate into the launchable rock trench. As shown in Figures 2, 3, and 4, the erosion protection includes 1) a sand filter (minimum 1-foot thick) to prevent migration of material, 2) rock sized as described in paragraph above, 3) cut slopes are no steeper than 1.5H:1V but should also match the waterside levee slope angle when excavating against the levee, and 4) the base of the launchable rock trench should correspond to the elevation of the summer mean water surface elevation to limit the vertical distance the rock must launch to during an event.

2.7 Environmental Impact Assessment

The waterside and landside areas of levees provide a large amount of habitat for the Sacramento Area. These areas are important for nesting and roosting habitats for a variety of wildlife species, some of which are special-status. The waterside wooded areas are especially valuable because of the Shaded Riverine Aquatic (SRA) habitat which creates nutrient rich areas and cooler temperatures for fish to take shelter.

The harmful effects that construction could have within the project area were considered during alternative evaluation. The affected areas are described in the Environmental Impact Statement along with any options that may reduce or mitigate for the proposed flood features.

2.7.1 Hazardous, Toxic, and Radioactive Wastes (HTRW)

A Phase 1 Environmental Site Assessment (ESA) was performed in accordance with the scope and limitations of ASTM E 1527-05 and USACE ER 1165-2-132 for the American River Common Features GRR study. There are many contaminated properties adjacent to the landside of the levees that should be avoided due to the nature of the contamination or the nature of the work proposed on the levees. The ESA has identified sites with recognized and probably unavoidable environmental conditions at the locations shown in Table 1 below.

Table 1 - Sites with Recognized Environmental Conditions

Site Name	Reach	Issue
Old North Sacramento	ARN Reach C NEMDC	CVOC, TPH Groundwater Plumes adjacent to levee, multiple properties
Full Stop Mini Mart	ARN Reach D Arcade Creek	TPHg plume at levee bridge crossing with air sparging
Robertson/Harbor Sand & Gravel	ARS Reach B American River	Levee Encroachment, recycled pavement
TOSCO Corp. Conoco-Phillips Sacramento Terminal	ARS Reach D Sacramento River	Petroleum release site on water side of the levee
TOSCO Corp./ Conoco-Phillips	ARS Reach D Sacramento River	Petroleum release site on land side of the levee. Petroleum

Sacramento Terminal		pipelines pass through the levee.
Southern Pacific Rail Yard	ARS Reach D Sacramento River	CVOC, TPH Groundwater Plume, land use restrictions
Old Bryte Landfill	Sacramento Bypass	Lead in soil

The historical land uses of the region may also contribute to residual contamination of the entire project area with agricultural fertilizers, herbicides, and pesticides as well as arsenic and mercury from mining operations in the region. Additional sampling will be required during subsequent investigations to determine if project areas have been impacted by these historical contaminants.

On-line records are limited. For contaminated sites identified as unavoidable under the alternatives considered by the American River Common Features GRR, a public records review is recommended at the Central Valley Regional Water Quality Control Board office and the Sacramento Regional Office of the Department of Toxic Substances Control as the next step to determine if additional investigation is required to determine the impact of these sites on the proposed project. Current groundwater plume maps and environmental liens / deed restrictions incorporating land use controls are particularly needed. Emphasis is needed on the Sacramento Terminal Bulk Fuel Handling Facility, the Old Southern Pacific Rail Yard, and the Old Bryte Landfill.

A follow on Phase 1 ESA will need to be performed at the beginning of Preconstruction Engineering and Design (PED). The subsequent Phase 1 ESA(s) will investigate if new sites have emerged and if existing sites still need to be addressed prior to construction.

2.7.2 Environmental Commitments

The summaries below discuss environmental impacts and mitigation values for vegetation and wildlife. More information on these impacts including fisheries, water quality, special status species, and cultural resources can be found in the EIS/EIR Chapter 3, Affected Environment and Environmental Consequences.

American River

During the PED phase, plans will be evaluated to reduce the impact on vegetation and wildlife. Refinements that could be implemented to reduce the loss of riparian habitat are; reduced footprint and replacing the trench cross section with bank protection and planting berm cross section where large riparian habitat areas exist adjacent to the levee toe (when no hydraulic impacts would occur).

Where the bank protection cross section and planting berm can be constructed, trees would remain in the area that is 15 feet from the levee toe and complies with the Corps vegetation policy. Trees would be protected in place to the extent practical along the natural channel during the placement of rock. The rock would anchor the trees in place and reduce the risk of them falling over during a high flow event. Additional plantings would be installed on the newly constructed berm to provide habitat for fish and avian species. The planting berm would be used

to minimize impacts to fish and wildlife species; however, the impact to riparian habitat would still be significant.

To compensate for the removal of 65 acres of riparian habitat on the American River, approximately 130 acres of replacement habitat will be created. Species selected to compensate for the riparian corridor removal will be consistent with the approved list of trees, shrubs, and herbaceous plants native to the American River Parkway. The 130 acres will create habitat connectivity and wildlife migratory corridors that provide for the habitat needs of important native wildlife species, without compromising the integrity of the flood management facilities, the flood conveyance capacity of the Parkway, and Parkway management goals in the Parkway Plan (See EIS for more information on the Parkway Plan). Some of the 130 acres of riparian would be planted on top of the rock trench. Corps vegetation policy allows for trees to be planted 15 feet from the levee toe. In order to comply with this policy and reduce the amount of maintenance on the compensation lands, trees could be planted on top of the rock trench starting at 15 feet from the waterside toe. In other words if the trench is 70 feet wide the outer 55 feet could be planted with riparian habitat. Additionally, to comply with the Parkway Plan, lands within the Parkway will be evaluated for compensation opportunities. The exact location of the compensation lands in the Parkway will be coordinated in the PED phase of the project with Sacramento County Parks Department and comply with the Parkway Plan objectives and goals. It is assumed that sufficient lands will be available within the Parkway, however, if there is not sufficient land, other locations within Sacramento County will be identified and public coordination will occur.

East Side Tributaries

Compensation for the removal of approximately 200 trees in the Arcade Creek and NEMDC areas will be done in compliance with the Sacramento City tree ordinance. It is estimated that 2 acres will be required to accommodate the planting of approximately 450 trees. There are multiple locations that are suitable for planting the compensation trees within the City of Sacramento Parks land.

Sacramento River

Avoidance and minimization measures incorporated as part of the Sacramento River design include compliance with the Corps vegetation policy through a vegetation variance, and installation of a planting berm where erosion protection is required.

The vegetation variance would allow waterside trees on the lower 1/2 of the waterside slope to remain in place. This allows approximately 930 trees along 10 miles of the Sacramento River from the American River confluence to Freeport to continue to provide habitat for fish and wildlife species. Along with retaining the trees, additional plantings of small vegetation will be done on the newly constructed berm. Species of plants will be coordinated with the National Marine Fisheries Service, Fish and Wildlife Service, and State and local partners.

Within the half levee degrade portion of the levee, there are approximately 750 trees of various sizes and species that will be removed to facilitate construction. On the landside area, where the

footprint cannot be reduced, approximately 1300 trees will be removed to construct the levee features and provide access in accordance with Corps and State policy. These trees are considered to be riparian habitat because of the close proximately to the waterside riparian corridor. Compensation for the tree removal was evaluated based on other projects in the Central Valley where riparian trees were removed, coordination with FWS, and local tree ordinances. Based on this evaluation and the lack of riparian habitat in the urban area, up to 95 acres could be required to compensate for the loss of these trees. There are parcels of land within a short distance that could be planted, however, further evaluation on availability of these lands and coordination with the resource agencies will be needed. Lands within the extended Sacramento Bypass could be used to compensate for some of the landside trees being removed. A hydraulic analysis would need to be done to determine what extent planting could occur. If sufficient compensation lands cannot be located, credits in a FWS approved mitigation bank will be purchased to meet the requirement of 95 acres.

Sacramento Weir and Bypass

Impacts associated with the Sacramento Weir and Bypass are related to the construction of Alternative 2 (See Section 4.3 Alternative 2 – Sacramento Bypass and Weir Widening**)** only. Avoidance, minimization, and mitigation measures discussed in this section would only be implemented if Alternative 2 is constructed.

It is estimated that 8-acres of riparian vegetation will be removed to construct the 1,500 foot long weir. Compensation was determined by evaluating other projects with similar impacts in the Central Valley, coordination with resource agencies, and evaluation of compensation plantings ability to provide similar wildlife habitat. Because new plantings will take many years to establish a temporal loss was considered in the calculation for compensation acreage. A total of 20 acres would be needed to compensate for the removal of the vegetation along the Sacramento River and within the new weir footprint. Plantings could be accomplished within the expanded bypass if hydraulic analysis determines that it would result in no reduction in conveyance capacity. Specific lands for compensation have not been identified; however, lands considered will provide similar habitat to that being impacted. If appropriate lands cannot be located, a FWS approved mitigation bank may be used to offset the impacts.

2.8 Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

The Non-Federal Sponsor (NFS) is responsible for project Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) for project features. The costs of OMRR&R are represented as the averaged annualized cost to maintain the flood control features over the project lifespan. The regulation which governs this work is under the provisions of Title 33, Flood Control Regulation, Maintenance and Operation of Flood Control Work approved by the Secretary of the Army, published 17 August 1944 Federal Register.

The GRR evaluates the additional effort required by the local maintaining agency (LMA's) to Operate, Maintain, Repair, Replace, and Rehabilitate (OMRR&R) for the added features of the alternatives. The following paragraphs provide a general description of additional features

proposed as part of the GRR study and describe the Corps understanding of increases/decreases in OMRR&R effort as a result.

USACE worked with staff from the LMA's to develop the differential costs associated with the project features. Costs associated with OMRR&R are presented in section 5.4.1 Cost Engineering Data & Results.

Cutoff Walls

Cutoff walls are proposed in levees along the Sacramento River, NEMDC, and Arcade Creek. The cutoff wall will be within the subsurface of the levee and therefore no additional maintenance cost is needed for the cutoff wall features. However, in the future, features or natural events which disturb the wall will require additional costs to repair and replace portions of the wall.

Construction Access for Operations and Maintenance

Construction access to the levee toe will be provided in areas where the levee is being raised or slopes are flattened to allow for OMRR&R. The access requirements include a 10 foot wide easement on the landside of the levee. Generally, the local sponsor will need to increase mowing, rodent control, and encroachment removal to include this additional area. For purposes of this GRR, the Corps has included costs equivalent to increasing the current budgets for vegetation control, rodent control, and mowing by 15 and 5 percent to account for the additional area for alternatives 1 and 2, respectively.

Floodwalls and Retaining Walls

The required maintenance for the floodwalls and retaining walls includes caulking and graffiti removal. The exposed area for the proposed floodwalls and retaining walls is minimal and impact on OMRR&R is considered negligible. Therefore, no cost increase is included.

Erosion Protection

There is new erosion protection proposed for most areas along the American and Sacramento Rivers that are not currently protected with modern bank protection. The erosion protection along the Sacramento River is mainly bank protection type similar to existing Sacramento River Bank Protection Project sites. The maintenance required for these areas includes replacing rock damaged by floods or other means. The bank protection will offset the need to repair levees with erosion damage after flood events.

The maintenance required for the launchable rock trench includes vegetation control and mowing from levee crown to 15' waterside of the toe. The vegetation and mowing are typically already included in existing OMRR&R operations. The required efforts are considered offsetting and no additional costs were calculated.

There will also be vegetation (mainly trees) planted in designated areas for both bank protection and launchable rock trench control types. The vegetation will be outside the 15' waterside of the levee toe boundary. The proposed plantings are native plants and should regenerate and require no maintenance. Additional costs for establishment period have been included into the construction costs and are not part of O&M. No additional costs were calculated for additional plantings.

2.9 Cost Engineering

2.9.1 General

The project cost estimates were prepared by Cost Engineering Section, Sacramento District, and based on quantities and data furnished by the Civil Design Section A, Environmental Planning, and Real Estate sections. Each project delivery team (PDT) member was responsible for defining confidence/risk levels associated with their products. During preliminary alternative development an abbreviated cost risk analysis was prepared by the PDT leading up to the TSP milestone. Following that milestone, a formal cost risk and schedule analysis was prepared for feasibility level design leading to the final report milestone (FRM). Project cost related items that were considered in the analysis included but was not limited to:

- Project Scope Growth
- Construction Schedule
- Contract Acquisition Strategy
- Construction Elements
- Construction Quantities
- Specialty Fabrication or Equipment
- External Project Risks

During the course of the feasibility study, the cost estimate level progressed from a class 5 to a class 3. The basis of the estimates goes from very little design definition (plan formulation - alternatives screening) to a refined design (refinement of the NED and LPP plans for authorization). The estimate class definition and progression is explained under ASTM E 2516-06 *Standard Classification for Cost Estimate Classification System*. The evaluation and summary of the initial array of alternatives through to the final array of alternatives can be found in Chapter 3 of the GRR. For the FRM, the Total Project Cost Summaries (TPCS) and Cost and Schedule Risk Analysis (CSRA) were prepared for the NED and LPP plans and are provided under Attachment D – Cost Estimates.

Additionally, real estate estimates were based on footprint requirements for project construction. Operation and maintenance estimates were provided by Civil Design Branch. Alternative level estimates were prepared based on refinements to the preliminary layouts, features, and measures as determined by screening analysis done by Planning Division, and input from the potential non-Federal sponsors.. Design guidance came from ER 1110-2-1302, *Civil Works Cost Engineering*. Detailed preparation and the format of all estimates follow the guidance in Engineer Technical Letter (ETL) 1110-2-573.

A combined Value Engineering study for this project and the West Sacramento study was completed in November 2013. The study had the following objectives: validate alternatives, facilitate communication, manage risk, and improve value. It analyzed an array of alternatives and provided a comparison of value between alternatives. Results indicate Alternative 1 has the highest value with Alternative 2 as the second highest value.

CHAPTER 3 – EXISTING CONDITIONS

3.1 General

The purpose of this chapter is to provide an overview of the existing levee system in the study areas. The discussion will focus on describing the existing features. Hydraulic and geotechnical analyses of the existing condition and performance of the levee system are discussed in paragraphs 2.3 and 2.4 of this report. Refer to the Attachment B – Hydraulic Executive Report and Attachment C – Geotechnical Report for more detail.

The levees providing flood risk management to the ARCF GRR study area are susceptible to through seepage, underseepage, slope stability, overtopping, and erosion. In addition to these problems there are instances of utility facilities, existing drainage ditches and irrigation structures and other encroachments landside of the levee which compromise levee integrity. This section presents the problems that remain for the levees within the ARCF GRR study area.

3.2 American River

On the American River (both banks, Reaches ARN A and B and ARS A, B, and C) seepage and stability improvements have been accomplished as authorized by WRDA 1996 and 1999. Geotechnical seepage and slope stability analyses performed for the ARCF GRR confirmed that at the critical cross-sections, the improvements constructed for WRDA 1996 and 1999 negate need for additional seepage and stability improvements as part of the ARCF GRR. The WRDA improvements also have addressed height issues by designing the TOL design profile to convey 160,000cfs with 3 feet of freeboard.

The American River levees were originally intended to convey a release from Folsom Dam of 115,000 cfs. During several events since the construction of Folsom Dam, flows have exceeded design capacity and caused significant erosion distress. Additionally, the objective release from Folsom Dam is for 160,000 cfs. Due to the past performance and future without project conditions, erosion is the driving potential failure mode along the American River requiring additional improvements to convey design flows.

3.3 Sacramento River South

On the Sacramento River east levee south of the confluence with American River (Reaches ARS D through G), the need for further seepage and slope stability improvements has been identified through geotechnical analyses. Although the majority of the levee embankments contain a through seepage cutoff wall from the Sacramento Urban Area Levee Reconstruction Project of the early 1990s, analyses and past performance indicate a deeper underseepage and underseepage induced slope stability deficiency exists. In these areas, the low permeable confining layers are typically found deep below the levee and may require deep cutoff wall construction methods. Additionally, the levee at Pioneer Reservoir was improved by the Sacramento District with relief wells and a landside seepage berm in 2006 to meet criteria at the 100 year flood event.

Levee and existing floodwall height deficiencies have been identified along the Sacramento River levee for the 200-year event. Deficiencies ranged from 1 to 2 feet with a majority beginning at the end Reach E and carried through Reach G. Some of the existing improvements in the area had already built up the levees which would not require any further height improvements.

At several locations the typical design levee section criteria is not applicable due to geometric configuration, historic encroachments, roadways adjacent to the levee, or high ground adjacent to the embankment. These locations include several segments of high ground (typically man-made such as the Sacramento Railyards or the Interstate-5 embankment) downstream of the confluence with the American River and adjacent to the levee embankment. Through portions of Old Sacramento the "Boat Section" of Interstate-5 parallels the floodwall and levee alignment. The "Boat Section" consists of a deep cut for the roadway supported by two retaining walls that buttress I-5 off ramp embankments. At this location, a system of floodwalls, retaining walls and pumped wells operate for the interstate and City of Sacramento waterfront. The features mentioned are expected to handle any seepage and stability issues.

Slope stability issues have been identified for certain areas along the Sacramento River. Over steepened slopes combined with loadings from adjacent roads, railroads, and structures may result in stability issues which need to be addressed.

The Sacramento River levees also have erosion problems similar to the American River. Analysis performed under programs such as the DWR Urban Levee Geotechnical Evaluations (ULE) and the USACE levee screening tool indicate that there is medium to high risk of breach due to erosion. Additional information can be obtained under Attachment E – Erosion Protection Report.

3.4 East Side Tributaries

Based on hydraulic modeling, areas of the East Side Tributaries have been identified with overtopping issues for the 200-year Annual Chance of Exceedance (ACE) design event. The existing top of levee for NEMDC is above the mean 200 year ACE event with varying degrees of assurance. There are also existing levee crown floodwalls within Arcade Reaches D and E starting approximately halfway through the reach terminating at the upstream terminus of the study area. The floodwalls were built up to several feet high by SAFCA under the Arcade Creek Levee Improvements project in 1996 which targeted the FEMA 100-year design surface.

The NEMDC, Arcade Creek north, Dry Creek, and Robla Creek levees sections were improved in the 1990's to early 2000's by SAFCA, and although they did not include internal seepage improvements, the levees meet geotechnical analyses criteria for seepage and slope stability, except in limited segments. The NEMDC segment south of the Arden-Garden Connector Bridge is also currently finishing up WRDA 1999 improvements which have installed cutoff walls to address seepage/stability related issues. Portions that did not meet criteria were limited to a portion of NEMDC in the vicinity and north of the Arden-Garden Connector Bridge, both banks of Arcade Creek, and a section of NEMDC north where the historic Magpie Creek intersects the levee foundation. These areas have been identified as having underseepage and underseepage

induced slope stability problems. NEMDC segments also have an active railroad operated by Union Pacific Railroad (UPR) running parallel and within close proximity of the levee. This railroad cannot be relocated or temporarily shut down, therefore design of the seepage mitigation features will need to consider the most appropriate construction methods. Seepage and stability improvements were also recently constructed in Reach C under the WRDA 99 authorization. These improvements extend from the downstream end of Reach C upstream near the Arden-Garden Connector Bridge.

Dry Creek, Reach H and Dry/Robla Creek, Reach G were evaluated and were determined to have low probability of failure with regards to seepage and stability issues and there were no overtopping or erosion improvements needed. The driving factors for levee fragility were judgment based and were tied primarily to encroachments and utilities. The SWIF will address these issues and therefore the reaches will no longer be considered for project features.

The Arcade Creek north bank has a large open channel landside ditch used to collect stormwaters and deliver them to nearby City Sump No. 158. There are seepage and stability concerns for this particular area which will need to be addressed.

3.5 Natomas Basin

Levee improvements to address seepage, stability, and erosion problems in the Natomas Basin were addressed in the 2010 Natomas PACR and authorized in WRRDA 2014. Additional improvements, consisting of levee raises, were analyzed as part of this study but are not included in the recommendation in light of other ongoing work by local interests which could render these improvements unnecessary. See Chapter 3 of the GRR document for additional information.

3.6 Magpie Creek

The existing Magpie Creek Diversion Channel (MCDC) was constructed as a 1950's era flood control project. The diversion channel intercepts upstream flows near Raley Boulevard at the confluence of Don Julio and Magpie Creeks. Flow is diverted northwestward to Robla (also known as Rio Linda) Creek, rather than through the original Magpie Creek channel. Downstream of the diversion point, the original Magpie Creek channel still carries local runoff. Magpie and Robla Creeks both discharge into the NEMDC about 2.5 miles west of Raley Boulevard.

In the early 1990’s, the Sacramento District and SAFCA began studying the Magpie Creek and MCDC flood control project after the realization that the system was overtopped during frequent events. In the late 1990’s and early 2000’s, both the Sacramento District and SAFCA developed various improvement alternatives for the project. No construction occurred as a result of these studies. While the alternatives varied slightly, they included similar measures such as, levee raises (either embankment or floodwall), new levee construction, channel improvements (deepening or widening), and construction of detention basins.

There are no seepage and stability issues noted for this area. Design of features will focus on the hydraulic conveyance of the 200-year event.

3.7 Sacramento Bypass

The existing Sacramento Weir structure and bypass were completed by 1916. The geotechnical performance of the north levee is relatively unknown, with no significant exploratory data to conduct an evaluation. However, there have been some instances where the north and south levees experienced underseepage and slope stability related distresses. Therefore seepage and stability issues should be implemented within the design. The weir structure also has no known deficiencies or performance issues.

In summary, the project area has erosion, stability, seepage, and height issues which require flood risk mitigation. The following table summarizes the existing issues by reach:

Table 2 - Reach Issues

BASIN/ AREA	REACH	REACH LENGTH (MI)	EXISTING ISSUES
ARS	A	6.9	EROSION
	B	3.3	EROSION
	C	1.9	EROSION
	D	4.3	SEEPAGE, STABILITY, HEIGHT, EROSION
	E	2.4	SEEPAGE, STABILITY, HEIGHT, EROSION
	F	5.4	SEEPAGE, STABILITY, HEIGHT, EROSION
	G	2.5	SEEPAGE, STABILITY, HEIGHT, EROSION
ARN	A	7.5	EROSION
	B	3.1	EROSION
	C	1.5	SEEPAGE, STABILITY, HEIGHT
	D	2.1	SEEPAGE, STABILITY, HEIGHT
	E	2.1	SEEPAGE, STABILITY, HEIGHT
	F	2.6	SEEPAGE, STABILITY, HEIGHT
	G	2.2	HEIGHT
	H	1.6	-
	I	0.6	HEIGHT
SWB	-	1.8	SEEPAGE, STABILITY

CHAPTER 4 – ALTERNATIVE DESCRIPTIONS

4.1 General

The project final array of alternatives consisted of: no-action, fix in-place (Alternative 1), fix in-place with bypass widening (Alternative 2). These alternatives were carried through for economic analysis and into the selection of the Tentatively Selected Plan (TSP) milestone.

The no-action alternative does not include any additional features for this project. As such, there is no cost estimate or additional description for the no action alternative provided in this Appendix.

4.2 Alternative 1 – Fix In Place

The fix in-place method would combine a variety of flood risk management improvements and keep the project features within the existing levee footprint as much as possible. This method is a traditional approach to providing flood protection without the use of various structures, detention basins or bypasses. It is also a widely utilized flood protection fix in the Sacramento region in general and a prominent existing feature along the American River levees within the project area. The following table summarizes the features for Alternative 1:

Table 3 – Alternative 1 Improvements

FEATURES GRR - ALTERNATIVE 1						
WATER-COURSE	BASIN	REACH	REACH LENGTH (FEET)	FEATURE LENGTH (FEET)	IMPROVEMENT	FEATURES
NEMDC	ARN	C	8,330	1,250	SEEPAGE/ STABILITY	80' CUTOFF WALL
Arcade Creek (S. Bank)		D	10,965	10,965	HEIGHT	1 - 4' FLOODWALL
				10,965	SEEPAGE/ STABILITY	45' CUTOFF WALL WITH GEOTEXTILE REINFORCED SLOPE
Arcade Creek (N. Bank)		E	11,155	11,155	HEIGHT	1 - 4' FLOODWALL
				11,155	SEEPAGE/ STABILITY	45' CUTOFF WALL
				2,900	DRAINAGE CHANNEL	REPLACE EXISTING DITCH W/CLOSED BOX CULVERT
NEMDC		F	13,710	5,700	SEEPAGE/ STABILITY	80' CUTOFF WALL
Robla/ Dry Creek Left Bank		G	11,725	0	NONE	-
Dry Creek Right Bank		H	8,420	0	NONE	-
Magpie Creek		I	-	3,100	HEIGHT	NEW LEVEE WITH FLOODGATES, LEVEE RAISE, FLOODPLAIN PRESERVATION, CULVERT IMPROVEMENTS

Table 3 – Alternative 1 Improvements (Continued)

COMMON FEATURES GRR - ALTERNATIVE 1 (CONTINUED)						
WATER-COURSE	BASIN	REACH	REACH LENGTH (FEET)	FEATURE LENGTH (FEET)	IMPROVEMENT	FEATURES
AMERICAN RIVER	ARS	A	36,190	6,850	EROSION PROTECTION	BANK PROTECTION
				17,750		ROCK TRENCH
		B	17,405	850	EROSION PROTECTION	BANK PROTECTION
				6,400		ROCK TRENCH
		C	9,895	3,800	EROSION PROTECTION	BANK PROTECTION
				2,150		ROCK TRENCH
	ARN	A	36,400	18,150	EROSION PROTECTION	ROCK TRENCH
		B	1,100	950	EROSION PROTECTION	ROCK TRENCH
SACRAMENTO RIVER	ARS	D	22,825	9,200	EROSION PROTECTION	BANK PROTECTION
				2,100		ROCK TRENCH
				3,000	HEIGHT	2 - 4' FLOODWALL
				4,500		1 - 2' RAISE EXISTING FLOODWALL
				600	SEEPAGE/ STABILITY	~3' SEEPAGE BERM AT PIONEER RESERVOIR
				2,500		80' CONVENTIONAL CUTOFF WALL
				6,500		120' DSM CUTOFF WALL
		E	12,560	8,850	EROSION PROTECTION	BANK PROTECTION
				3,200	HEIGHT	LEVEE RAISE
				8,400	SEEPAGE/ STABILITY	95 - 135' DSM CUTOFF WALL
		F	28,635	21,100	EROSION PROTECTION	BANK PROTECTION
				1,000		ROCK TRENCH
				20,700	HEIGHT	LEVEE RAISE
				2,300	SEEPAGE/ STABILITY	80' CONVENTIONAL CUTOFF WALL
				24,250	SEEPAGE/ STABILITY	95 - 145' DSM CUTOFF WALL
		G	13,105	11,150	EROSION PROTECTION	BANK PROTECTION
				1,000	SEEPAGE	95' DSM CUTOFF WALL
				11,500	STABILITY	GEOTEXTILE STABILIZED SLOPE
				11,700	HEIGHT	LEVEE RAISE
		ALL	62,000	5,300	STABILITY	SLOPE FLATTENING

4.3 Alternative 2 – Sacramento Bypass and Weir Widening

Alternative 2 includes expanding the Sacramento Weir and Bypass (SWB) which will allow more water to be released upstream of ARS sub-basin, Reaches D-G; therefore, reducing the need for height improvements in these areas. However, this alternative does not reduce the need for seepage, stability and erosion improvements within those reaches. Alternative 2 includes all of the fix-in-place methods proposed in Alternative 1, with the exception of levee raising on the Sacramento River. The following table summarizes the features in Alternative 2:

Table 4 – Alternative 2 Improvements

COMMON FEATURES GRR - ALTERNATIVE 2						
WATER-COURSE	BASIN	REACH	REACH LENGTH (FEET)	FEATURE LENGTH (FEET)	IMPROVEMENT	FEATURES
NEMDC	ARN	C	8,330	1,250	SEEPAGE/ STABILITY	80' CUTOFF WALL
Arcade Creek (S. Bank)		D	10,965	10,965	HEIGHT	1 - 4' FLOODWALL
				10,965	SEEPAGE/ STABILITY	45' CUTOFF WALL WITH GEOTEXTILE REINFORCED SLOPE
Arcade Creek (N. Bank)		E	11,155	11,155	HEIGHT	1 - 4' FLOODWALL
				11,155	SEEPAGE/ STABILITY	45' CUTOFF WALL
				2,900	DRAINAGE CHANNEL	REPLACE EXISTING DITCH W/CLOSED BOX CULVERT
NEMDC		F	13,710	5,700	SEEPAGE/ STABILITY	80' CUTOFF WALL
Robla/ Dry Creek Left Bank		G	11,725	0	NONE	-
Dry Creek Right Bank		H	8,420	0	NONE	-
Magpie Creek		I	-	3,100	HEIGHT	NEW LEVEE WITH FLOODGATES, LEVEE RAISE, FLOODPLAIN PRESERVATION, CULVERT IMPROVEMENTS

Table 4 – Alternative 2 Improvements (Continued)

COMMON FEATURES GRR - ALTERNATIVE 2						
WATER-COURSE	BASIN	REACH	REACH LENGTH (FEET)	FEATURE LENGTH (FEET)	IMPROVEMENT	FEATURES
AMERICAN RIVER	ARS	A	36,190	6,850	EROSION PROTECTION	BANK PROTECTION
				17,750		ROCK TRENCH
		B	17,405	850	EROSION PROTECTION	BANK PROTECTION
				6,400		ROCK TRENCH
		C	9,895	3,800	EROSION PROTECTION	BANK PROTECTION
				2,150		ROCK TRENCH
	ARN	A	36,400	18,150	EROSION PROTECTION	ROCK TRENCH
		B	1,100	950	EROSION PROTECTION	ROCK TRENCH
SACRAMENTO RIVER	ARS	D	22,825	9,200	EROSION PROTECTION	BANK PROTECTION
				2,100		ROCK TRENCH
				800	HEIGHT	2 - 4' FLOODWALL
				600	SEEPAGE/ STABILITY	~3' SEEPAGE BERM AT PIONEER RESERVOIR
				2,500		80' CONVENTIONAL CUTOFF WALL
				6,500		120' DSM CUTOFF WALL
		E	12,560	8,850	EROSION PROTECTION	BANK PROTECTION
				8,400	SEEPAGE/ STABILITY	95 - 135' DSM CUTOFF WALL
		F	28,635	21,100	EROSION PROTECTION	BANK PROTECTION
				1,000		ROCK TRENCH
				1,200	HEIGHT	LEVEE RAISE
				2,300	SEEPAGE/ STABILITY	80' CONVENTIONAL CUTOFF WALL
				24,250	SEEPAGE/ STABILITY	95 - 145' DSM CUTOFF WALL
		G	13,105	1,000	SEEPAGE	95' DSM CUTOFF WALL
				1,600	HEIGHT	RAISE EXISTING FLOODWALL
				11,500	STABILITY	GEOTEXTILE STABILIZED SLOPE
		ALL	62,000	9,300	STABILITY	SLOPE FLATTENING
	SWB	-	-	1,500	HEIGHT	SACRAMENTO WEIR AND BYPASS WIDENING

4.4 Feature Descriptions

4.4.1 Erosion Protection Improvements

For both Alternatives, erosion protection extents are the same as shown in the above tables. Two erosion protection measures have been proposed that could be implemented in combination along the levee alignment depending on factors such as, bank/bench geometry, existing habitat, and existing land use among other considerations.

Bank Protection

The Bank Protection fix will include placing revetment on the existing levee waterside and project the revetment to a finished surface slope of 2H:1V or 3H:1V. The revetment will begin at the existing levee waterside hinge (when no bench exists) or waterside bench hinge depending on site conditions. Revetment will be placed on existing slope with little to no engineered slope reconstruction. Layer thickness will be approximately 1.5 feet deep and continue down to the Summer Mean Water Surface Elevation (SMWSE). At the SMWSE, there will be a riparian bench formed with a soil trench wrapped in geotextile within the design section. After the bench, the slope continues to project down to channel bottom at an increased slope of 1:1 (see Figure 2).

Existing large vegetation will be allowed as described in section 2.4.2 Vegetation Variance and to the extent practical during construction. Plantings and woody vegetation will be established within the design to create a self mitigating design, as acceptable. Factors which affected the design and quantity of revetment needed within the design were: the amount of launchable rock needed, the location of the SMWSE, and existing ground and channel geometry.

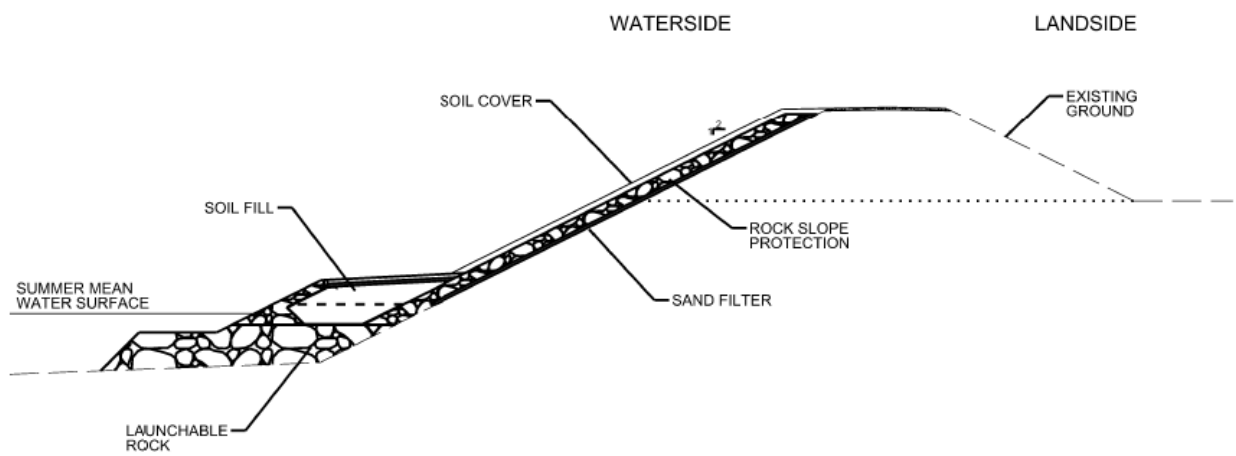

Figure 2 - Bank Protection Erosion Protection (insufficient bench)

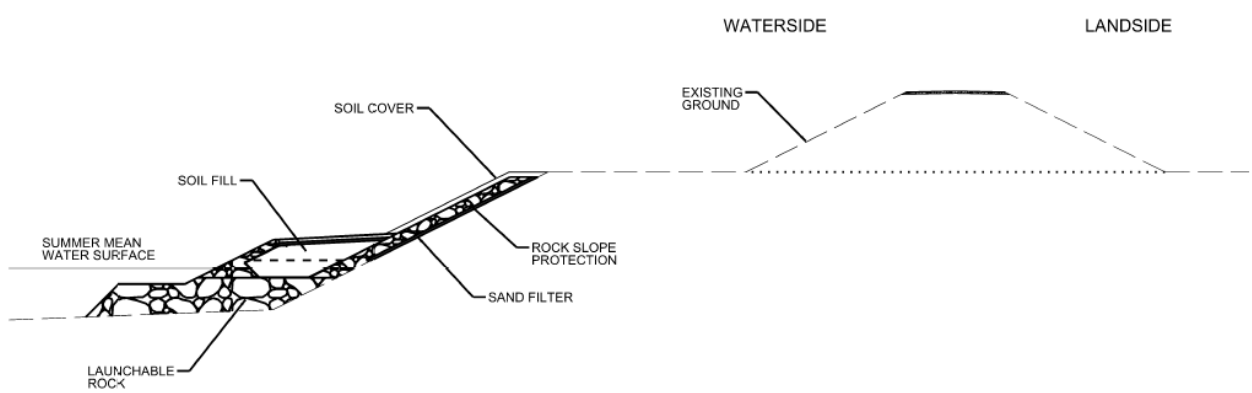

Figure 3 - Bank Protection Erosion Protection (sufficient bench)

Launchable Rock Trench

The Launchable Rock Trench fix provides the same protection to the levee as the bank protection by allowing the existing berm to be sacrificial. In order to be considered, the waterside berm width needed to be at least 50 feet wide for construction. The construction methodology would follow the trenchfill methods widely used on the Arkansas and Mississippi Rivers. The rock trench is constructed at the waterside toe of the levee and is excavated to a level that reduces the revetment launching distance and increases the reliability of design. The trench then is backfilled with rock revetment to provide enough quantity for launching. The typical design trench was approximately 10 feet wide at bottom, 40 feet wide at top, and 10 feet deep (see Figure 4). The trench would then be covered with native fill at a minimum of 3 feet thickness to allow for mitigation features such as vegetation and woody plantings to be replanted above the trench but outside the vegetation free zone.

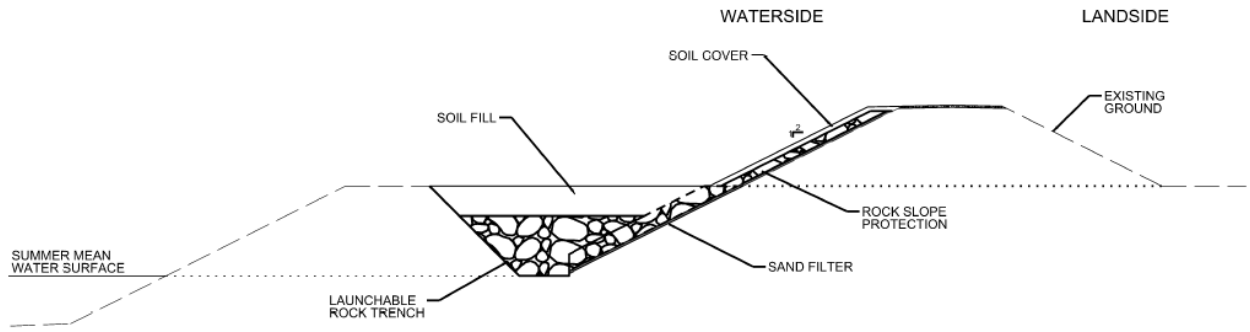

Figure 4 – Launchable Rock Trench Erosion Protection

4.4.2 Seepage/Stability Improvements

For both Alternatives, there are seepage and stability improvements proposed. Cutoff walls, seepage berms, geotextile stabilized slopes, and slope flattening are features proposed for seepage and stability improvements.

To address seepage and seepage related slope stability problems, the predominant recommendation is cutoff walls. Due to several factors, including constraints on expanding the levee footprint restricted by urban development, seepage berms, relief wells, and the majority of other seepage improvement measures were considered infeasible by the PDT.

Sacramento River

Figure 5 shows a typical seepage and stability fix for the Reaches D through F on the Sacramento River. Based on the seepage cutoff wall depths, a combination of conventional open trench and Deep Soil Mixing (DSM) cutoff wall construction methods is anticipated. Both Soil Bentonite (SB) and Soil Cement Bentonite (SCB) cutoff walls are appropriate in these reaches. The conventional method is used for wall depths of up to 85 feet and the DSM method was used for walls deeper than 85 feet. Both methods provide a barrier of low-permeable material within the levees which typically consist of sandy material. The depths of wall were determined by

geotechnical analysis and typically tie into a confining low permeable layer. The levee will be degraded by approximately half its height in order to establish a working platform as well as provide levee stability during construction.

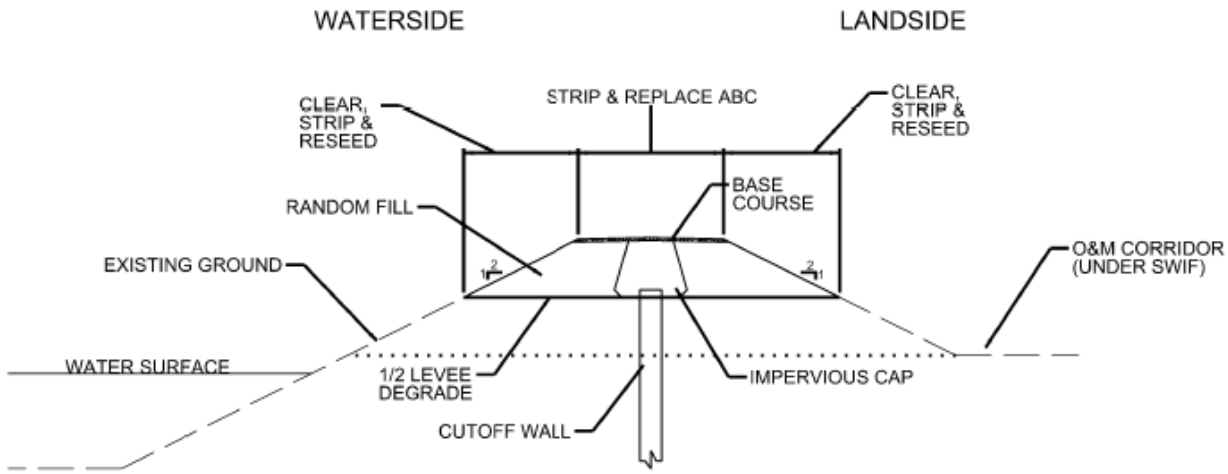

Figure 5 - Sacramento River Reaches D through F Cutoff Wall Typical Section

Levee reconstruction includes placement of random fill with an impervious cap above the cutoff wall. The levee fill will have side slopes graded to a minimum of 2H:1V slopes or existing slope if greater. The levee crown will be constructed to a minimum width of 20 feet and surfaced with aggregate base for the levee road.

Through portions of Old Sacramento and the "Boat Section" of Interstate-5 no improvement are recommended due to system of floodwalls, retaining walls and pumped wells operated for the interstate and City of Sacramento. In the same vicinity, the past Pioneer Reservoir improvements by the Sacramento District (berm and relief wells) targeted the 100-year event for design criteria. At this location additional thickness should be added to the seepage berm to increase the level of protection.

There are areas along the Sacramento River that will require slope flattening. Slope flattening will reestablish existing design slopes primarily by reusing existing levee material and mechanically strengthening. The areas are intermittently dispersed along most of these reaches and will be influenced by proposed fixes. It is estimated the total length will be approximately 15% of the existing levee lengths (not including Reach G or areas for levee raising) or approximately 9,300 lineal feet for Alternative 2. Alternative 1 has a greater amount of raise within the reaches D – G therefore additional slope flattening will be less, approximately 5,300 lineal feet. It is assumed the slope flattening can be completed without any additional permanent real estate easements but will require temporary easements during construction. A typical slope flattening section is shown below in Figure 6.

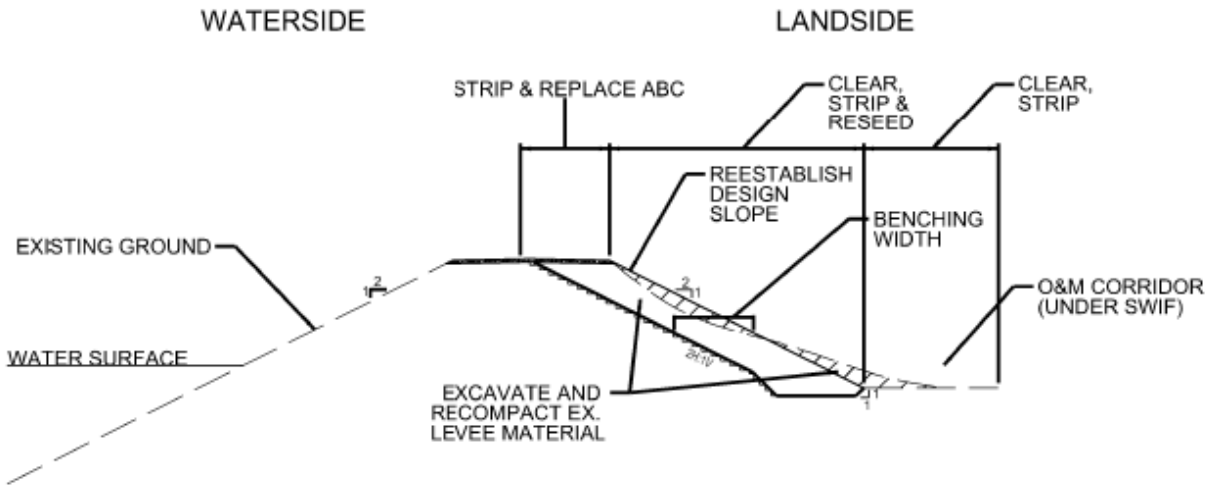

Figure 6 - Sacramento River Slope Flattening Typical Section

In ARS Reach G a slope stability deficiency has been identified. Due to adjacent roadways, railroad embankments, and structures, more common slope stability improvements, such as stability berms, were deemed not feasible. Therefore, to address the slope stability deficiency, a partial levee degrade and placement of geotextile within the reconstructed levee embankment spaced approximately 3 feet vertically is recommended. A typical geotextile section is shown in Figure 7 below.

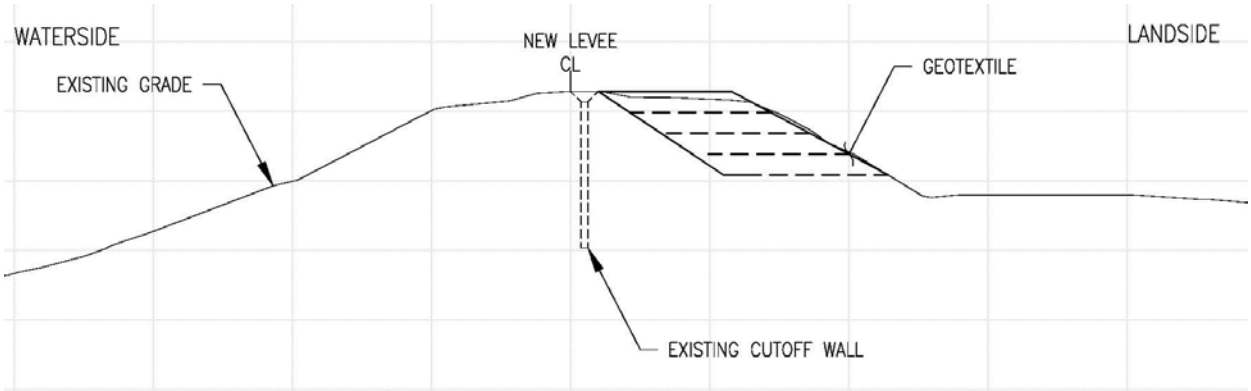

Figure 7 - Sacramento River Reach G Typical Section

Tributaries - NEMDC

A typical NEMDC levee improvement cross-section is shown in Figure 8. The measure includes a cutoff wall that will be constructed by conventional open trench methods (SB or SCB). For levee segments which run parallel and in close proximity of the active UPR railroad, SCB methods should be considered in order to mitigate the risk of trench collapse from the railroad surcharge and dynamic vibrations during construction.

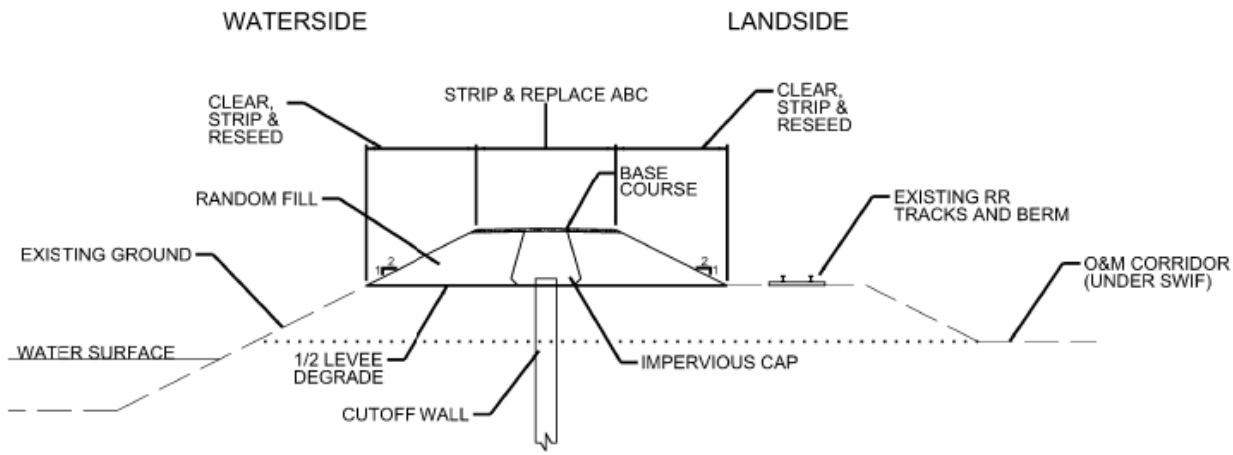

Figure 8 – NEMDC Cutoff Wall Typical Section

Tributaries – Arcade Creek

The Arcade Creek south bank cutoff wall is proposed in conjunction with a full levee height degrade and incorporation of geotextile. The improvements are proposed from the confluence of NEMDC upstream to Rio Linda Blvd. The geotextile is placed within the reconstructed levee embankment spaced approximately 3 feet vertically allowing for the existing levee slopes (steeper in some locations than 2H:1V) to remain and allow for landside access under the SWIF (see Figure 9).

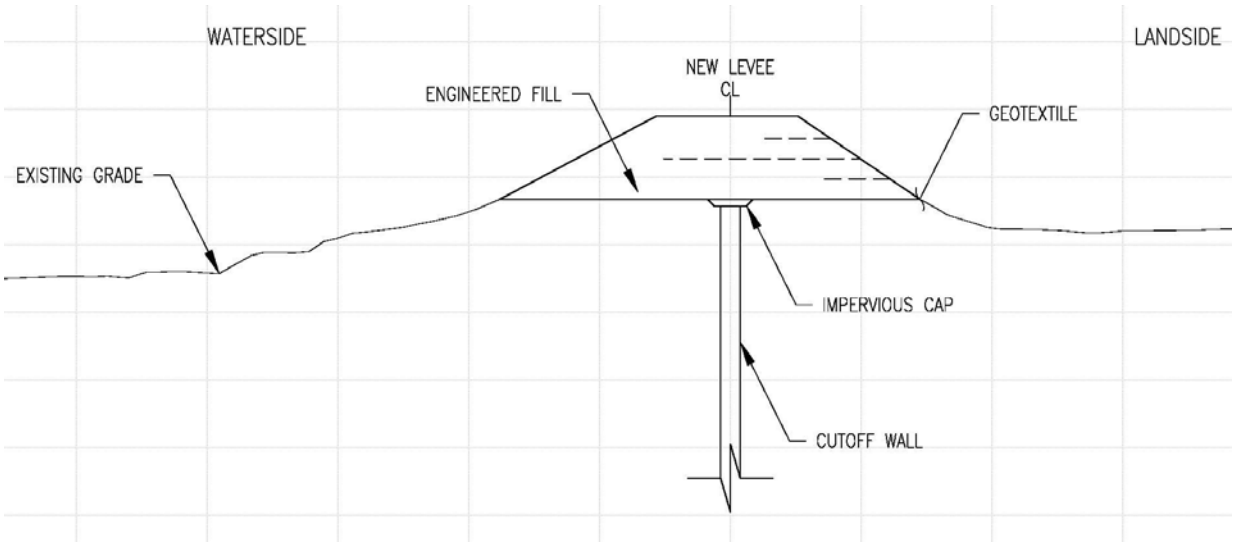

Figure 9 - Arcade Creek South Cutoff Wall Typical Section

The Arcade Creek north bank cutoff wall is proposed from the confluence of NEMDC upstream to Rio Linda Blvd. In addition, a landside ditch from the confluence to Sump Station 158 will be replaced with a box culvert or buried conduits as shown in Figure 10.

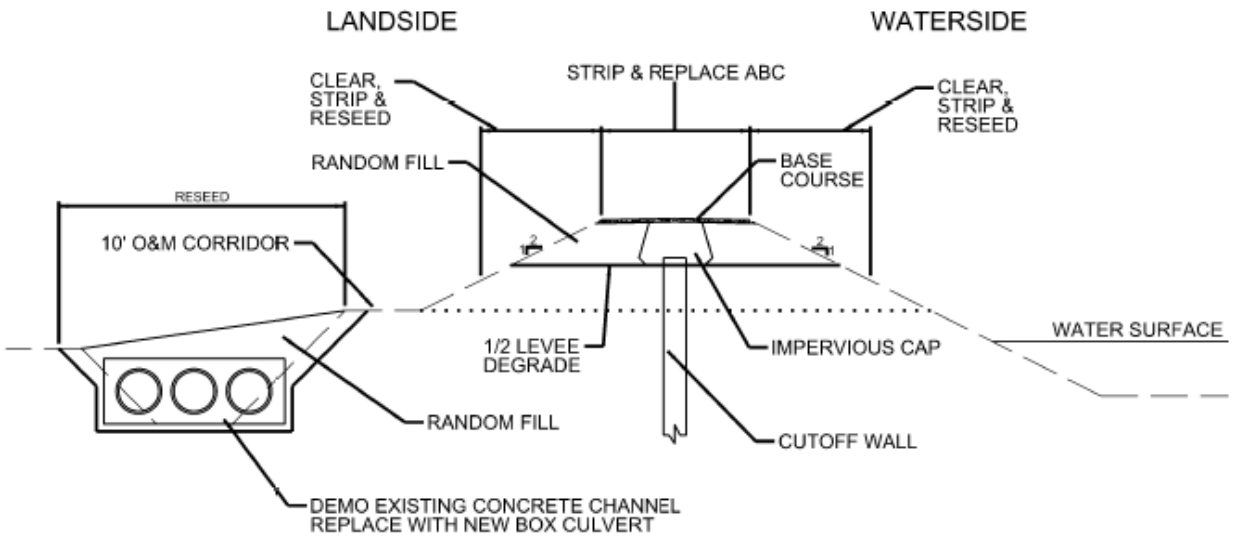

Figure 10 - Arcade Creek North Cutoff Wall Typical Section

4.4.3 Height Improvements

There are height improvements proposed for both Alternatives. The height improvements include levee raising, floodwalls, height improvements to existing floodwalls, and bypass and weir widening. During PED, other feasible methods to address height may be considered such as landside/waterside levee raising, or retaining walls.

Sacramento River

Height fixes are proposed in some segments of the Sacramento River levee which consist of a levee embankment raise, sliver fills, raising existing floodwalls, or a floodwall constructed at the levee crest. Parts of Reach D and Reach G will require new floodwalls or raising and bolstering of existing floodwalls to meet the design profile with required assurance. Figure 11 shows a typical Sacramento River levee section with the proposed levee raise improvement measures. Additional FPLE and TWAE easements will be required where levee raising occurs.

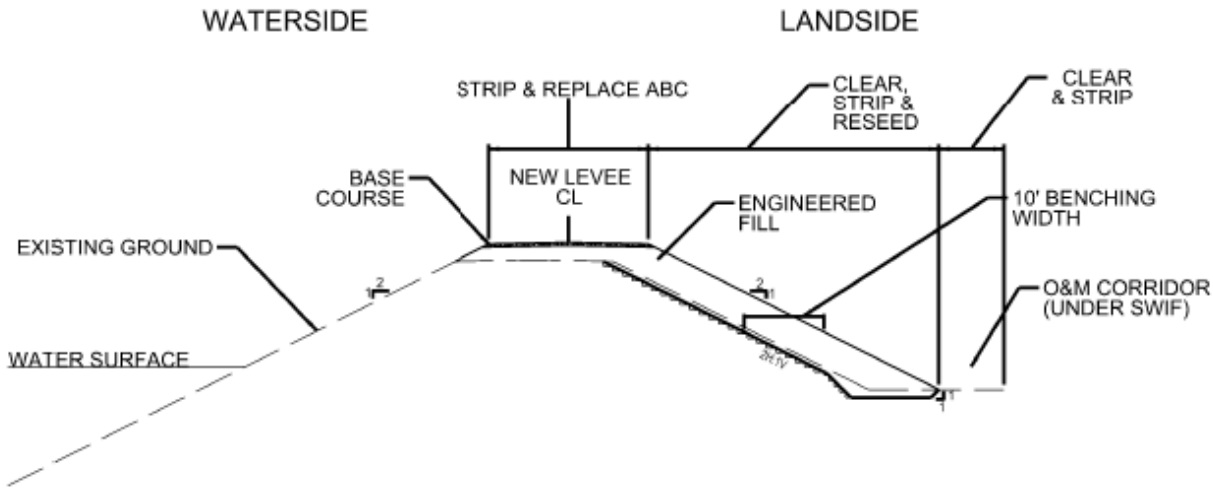

Figure 11 - Sacramento River Reaches D through F Levee Raise Typical Section

Tributaries – NEMDC, Robla/Dry Creek, Arcade Creek

Height improvements are proposed in Arcade Creek segments and will typically consist of floodwalls (see Figure 12). Within these areas, the 1 -2' raises recommended would provide assurance of containing the 200 ACE event for the American River North Basin. Additionally, there may be minor low spots within the levee profile which would be re-graded during construction. The recommended levee raises would bring the east side tributary levees to a consistent level of performance. Existing floodwalls on Arcade Creek will be removed during seepage and stability improvements and new floodwalls designed to the 200 ACE event will be constructed in those reaches.

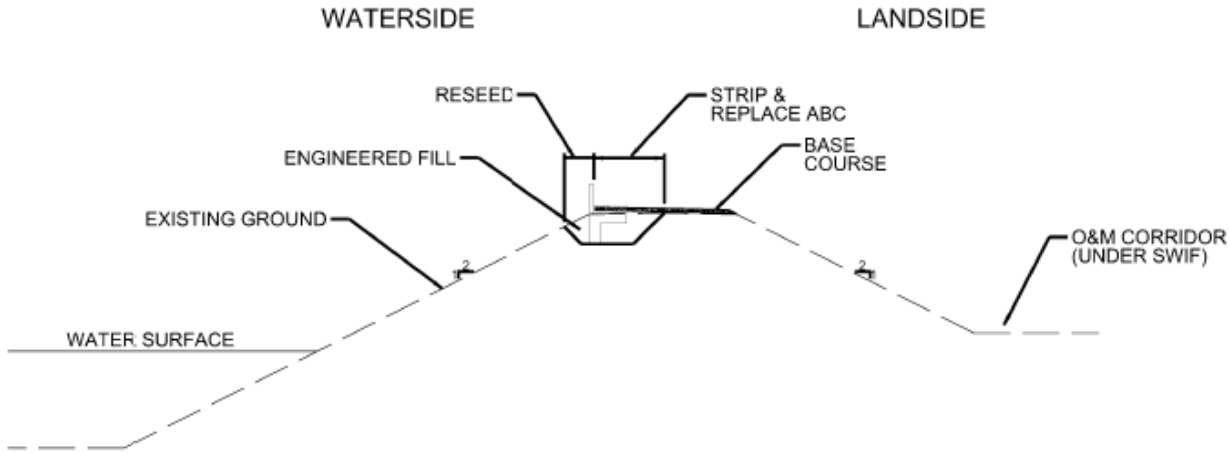

Figure 12 - Floodwall on Levee Crest

Tributaries – Magpie Creek

A number of features are proposed for the Magpie Creek Diversion Canal (MCDC) under Alternative 1 and 2. The features are consistent with the 2003 USACE Magpie Creek project report. The project includes raising the existing left bank levee (looking downstream, see Figure 13) of the MCDC for a distance of approximately 2,100 feet. The levee raise would begin just downstream from Raley Boulevard and continue to about 100 feet south of Vinci Avenue Bridge. In addition, a new 10-foot-wide maintenance road will be graded at the landside base of the new raised MCDC levee. A new levee would be constructed along the west side of Raley Boulevard south from the bridge down to Santa Ana Avenue for a distance of approximately 1,000 feet. The new levee would prevent floodwaters upstream of Raley Blvd from outflanking the existing levee.

A 5-foot high floodgate will be installed across the driveway of the Kelly-Moore paint store. An additional 4-foot high floodgate will be required at the driveway of a new development just south of the Kelly-Moore Paint Store property. A new aggregate base maintenance road will be constructed between Vinci Avenue and Dry Creek Road adjacent to the left bank (looking downstream) of the MCDC for a distance of approximately 2,700 feet.

A new culvert is also proposed under the Sacramento Northern Railway Bike Trail embankment. During high water events, this area has been a hydraulic pinch point and the additional culvert will help convey waters past this structure reducing stage further upstream. The culvert will be a triple 5-foot by 5-foot reinforced concrete box. A new channel would be excavated upstream and downstream from the culvert, connecting the culvert with Robla Creek. The new channel would be slightly above the existing channel invert to allow low flows to continue through the existing bridge. Stone protection would be placed in the bed and sides of the new channel to minimize erosion.

The area inundated east of Raley Blvd by a design event without the project in place is estimated to be 76 acres (excluding roadways and channels, the inundated land would be 73 acres). Construction of the proposed improvements would slightly increase the water surface elevation during all flood events greater than a 5-year frequency. The project would seek a total of 79 acres of land to preserve the existing floodplain in perpetuity and mitigate for proposed project features.

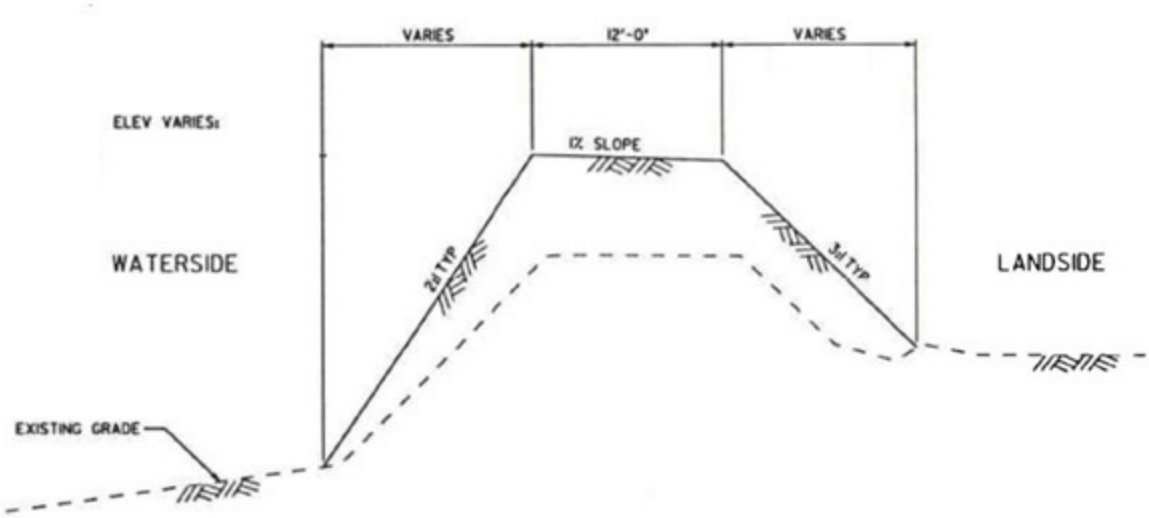

Figure 13 - Typical MCDC Levee Embankment Improvement Cross-Section

Sacramento Bypass and Weir Expansion

The Sacramento Bypass and Weir currently allows excess flood waters to spill out of the leveed river system into the Yolo Bypass thereby reducing the loading on the levees downstream. Alternative 2 expands capacity for the weir and bypass by constructing a new weir structure and relocating the bypass levee. Based on preliminary hydraulic analysis, to meet objective flows the proposed weir expansion and levee offset is approximately 1,500 feet and would be located to the north of the existing bypass. The weir operations will be tied to Folsom Dam releases which exceed 115,000cfs. This currently happens beyond a 1% and 0.5% ACE event. More detail can be found in the Hydraulic Appendix under Attachment B.

For this alternative, the existing north levee of the Sacramento Bypass would be degraded and a new levee constructed approximately 1,500 feet to the north. A new weir would also be extended approximately 1,500 feet north of the existing Sacramento Weir without impacting the existing structure. The weir will be similar to the existing structure which also includes an elevated roadway deck and railroad bridge. The extended alignment will include both of these features and will also be constructed with a seepage cutoff wall below. The alignment will be offset from existing railroad alignment so that there will be minimal interference with the railroad during construction and only temporary closure when the existing alignment is tied into the new weir structure. See Figure 14 for proposed weir structure cross section.

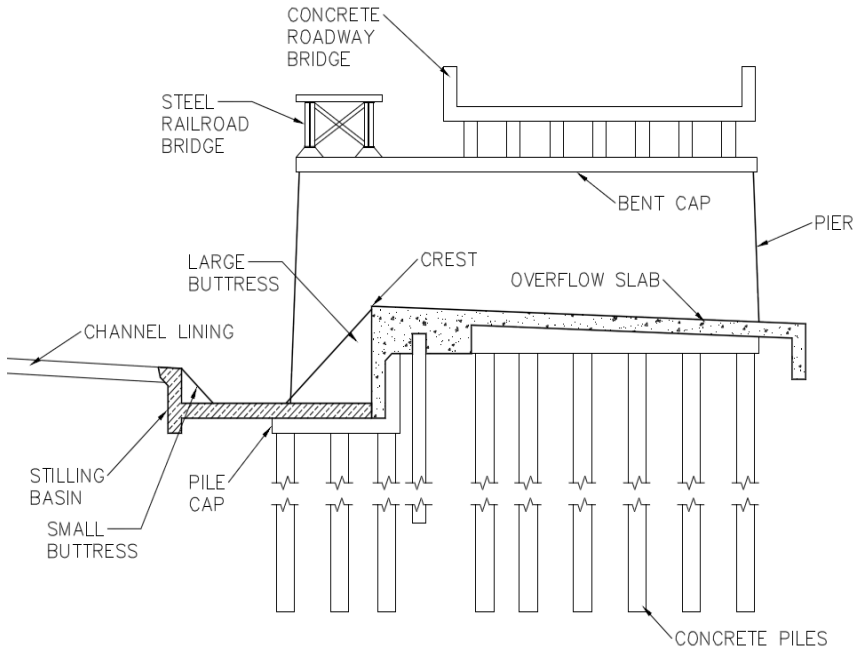

Figure 14 – Sacramento Weir Extension

The new north levee of the Sacramento Bypass would be constructed per the standard levee section for new construction which includes 3H:1V waterside and landside slopes, and a minimum crest width of 20 feet. The new north levee would include a 300-foot wide drained landside seepage berm ranging from 5 feet thick at the landside levee toe tapering to 3 feet thick at the berm toe and constructed of random fill with a 1.5-foot thick drainage and filter layer at the base. In addition to the seepage berm, a system of relief wells spaced at 200-foot intervals with a connecting drainage channel is proposed 15 feet landward from the berm toe. See Figure 15 below for a typical section of the bypass levee.

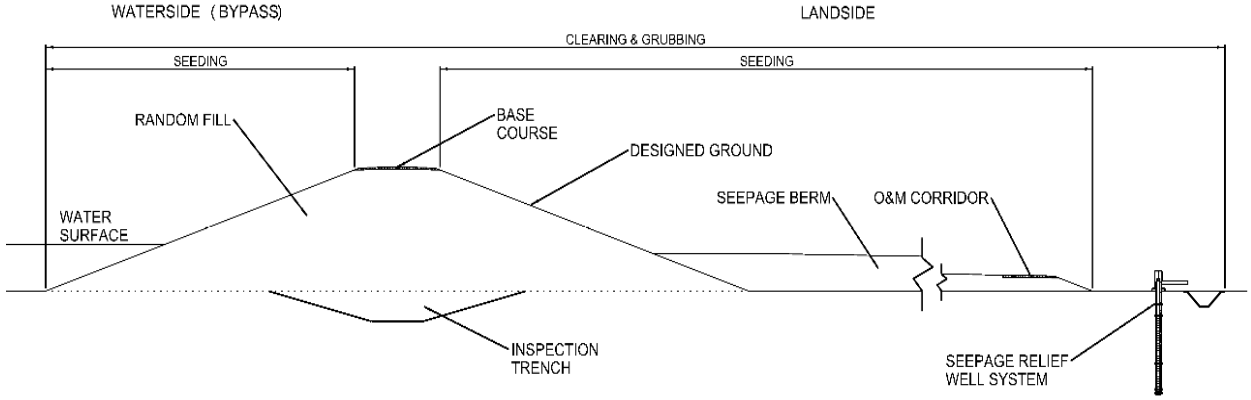

Figure 15 – Sacramento Bypass Levee

Existing infrastructure, including roads, railways, canals, and pump stations will be relocated to maintain current operation. Construction phasing will be important when coordinating these features along with the degrading of existing levees in order to maintain the integrity of the flood

works system. Refinements to this feature in PED include optimizing width of weir and bypass, possible environmental corridor alternatives, the need for operable gates, and system operation.

CHAPTER 5 – QUANTITY DEVELOPMENT, CONSTRUCTION SCHEDULE, AND COST ENGINEERING

5.1 General

The combination of improvements were quantified for the alternatives and estimated at a preliminary design level for the project area. Quantities were determined with cross sections of typical fixes to develop a civil cost estimate. These estimates would then have additional costs added to them like: Storm Water Pollution Prevention Plan (SWPPP), cultural resource preservation, Preconstruction Engineering and Design (PED), construction management costs, real estate and relocation costs, and fish and wildlife facilities. Cost risk contingencies were also assigned to these estimates to determine the initial cost for the alternative.

5.2 Preliminary Design and Quantity Development for Alternatives

Preliminary design for the alternatives were based on information developed for previous studies and engineering reports as well as new information developed for this study. For Magpie Creek features, the previous Corps Continuing Authorities Program (CAP) study features were used from the 2003 report. For the Sacramento Bypass and Weir widening, the design and cost engineering information was partially derived from previous work by Parsons Brinkerhoff (Parsons Brinkerhoff, 2008) and supplemented with information by the PDT.

Preliminary design for the erosion control features were based on typical cross sections that were based on previous erosion protection projects on the American River. A channel stability analysis (Ayres Associates, 2010) was used to determine areas requiring revetment with the assumption that all areas without modern revetment will be protected. Modern protection was determined by field inspection of areas having rock riprap with overall condition of good or very good. Additional analysis and supporting data are discussed under Attachment E – Erosion Protection Report.

Quantities were calculated for the proposed types of features and tabulated per reach, and by basin. Typical cross sections were generated to capture the types of fixes needed along the levee as well as the existing geometry of the levee. These sections were then referenced into a dynamic spreadsheet where the type of fix, hydraulic data, and existing levee geometry would be identified. By developing many fixes with varying levee geometry, the spreadsheet would calculate civil quantities using average end area method and generate better quantities than standard typical section methods allow. These quantities were then delivered to cost engineering where unit costs, site specific factors, and risk assessment were evaluated to determine initial alternative costs.

Quantities for construction of the proposed features were developed by District Civil Design staff. The engineering design and quantity development was in accordance with ETL 1110-2-573 *Construction Cost Estimating Guide for Civil Works* and ER 1110-2-1302 *Civil Works Cost Engineering*. Quantities do not include shrinkage and bulking factors or loss and waste factors for handling and hauling. For Preliminary Cost Estimates, design features focused on the cost drivers (i.e. Pareto Principle) such as cutoff wall, rip rap, levee excavation, and backfill quantities, etc.

5.3 Preliminary Construction Schedules

For economic and construction assessment, it was assumed that after authorization, the project would receive optimal annual funding appropriations and would be accomplished without resource limitations. When generating the schedule the PDT also considered a variety of factors such as: construction production rates, contractor capacity and availability, air emissions, sponsor capability, and design complexity. Considering these factors, both Alternatives 1 and 2 were estimated to take approximately 10 years. Annual appropriations under both Alternatives would vary because of phasing and feature differences, however, typical annual appropriations ranged between $100 – 200M..

A construction priority analysis was performed using levee fragility curves, hydraulic stage-frequency data, and economic data for the without project condition. The results determined which reaches had the highest risk of failure as a function of their economic consequences (see tables below). For Alternative 2, the Sacramento Bypass and Weir (SBW) widening is shown as starting after most of the levee fixes since it has no impact on the damages for more frequent events.

Table 5 - Reach Construction Priority

BASIN	INDEX POINT	HYDRAULIC STAGE (NAVD 88)		PR (FAILURE)		CONSEQ-UENCE	IMPACT	CONSTRUCTION PRIORITY
		100-YR	200-YR	100-YR	200-YR			
ARS	F	29.29	30.99	0.32	0.399	13600	5426	1
ARS	E	32.46	34.26	0.327	0.398	13600	5413	2
ARS	A	48.03	53.08	0.066	0.458	9800	4488	3
ARS	G	28.21	29.85	0.254	0.33	13600	4488	4
ARS	D	33.28	35.11	0.148	0.229	13600	3114	5
ARS	B	38.15	41.35	0.221	0.315	9800	3087	6
ARN	A	46.26	51.1	0.1179	0.463	4500	2084	7
ARS	C	35.86	38.23	0.092	0.14	9800	1372	8
ARN	B	37.01	39.89	0.102	0.145	4500	653	9
ARN	D	39.03	41.3	0.514	0.72	733	528	10
ARN	F	40.1	42.18	0.578	0.686	733	503	11
ARN	E	39.09	41.35	0.451	0.663	733	486	12
ARN	C	38.79	41.21	0.124	0.448	733	329	13
ARN	G	41.49	43.24	0.088	0.152	733	111	14
ARN	I	-	-	-	-	-	*	15
SBW	-	-	-	-	-	-	*	16

* Not included in evaluation priority, will be refined in PED

The following tables were generated using the reach priorities and cost estimates to form rudimentary diagrammatic construction schedules for the alternatives (see tables below).

Table 6 - Alternative 1 Preliminary Construction Schedule

AMERICAN RIVER COMMON FEATURES CONSTRUCTION SCHEDULE - ALTERNATIVE 1												
PRIORITY	BASIN	REACH	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
1	ARS	F										
2	ARS	E										
3	ARS	A										
4	ARS	G										
5	ARS	D										
6	ARS	B										
7	ARN	A										
8	ARS	C										
9	ARN	B										
10	ARN	D										
11	ARN	F										
12	ARN	E										
13	ARN	C										
14	ARN	I										

Table 7 - Alternative 2 Preliminary Construction Schedule

AMERICAN RIVER COMMON FEATURES CONSTRUCTION SCHEDULE - ALTERNATIVE 2												
PRIORITY	BASIN	REACH	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 7	YEAR 8	YEAR 9	YEAR 10
1	ARS	F										
2	ARS	E										
3	ARS	A										
4	ARS	G										
5	ARS	D										
6	ARS	B										
7	ARN	A										
8	ARS	C										
9	ARN	B										
10	SBW											
11	ARN	D										
12	ARN	F										
13	ARN	E										
14	ARN	C										
15	ARN	I										

These tables do not represent the final project schedules and were instead used as a guide and to convey a prioritization strategy. The final project schedules are contained within the Cost Engineering Appendix – Attachment D.

5.4 Cost Engineering

5.4.1 Cost Engineering Data & Results

Quantity Takeoffs

Quantities for most project items were provided by the Civil Design Section, primarily using typical cross sections of levee improvements or utility penetrations. See Section 5.2 – Preliminary Design and Quantity Development for Alternatives for more information.

General Methodology in Cost Estimate Preparation

Preliminary level cost estimates (Class 4) were used in the evaluation of the final array of alternatives and the identification of the tentatively selected plan. The Cost Engineering team utilized a number of different methods to determine project costs, including the following:

Generic/parametric/characteristic unit construction costs for typical levee improvements were developed using pro-rated unit costs from the estimating software MII (MCACES, 2nd Generation). During the final array and selection of the TSP, MII was not used exclusively to develop costs or add refinement. For a typical task such as slurry wall placement or borrow material acquisition and placement, a unit cost was established based on a 'typical' crew, production rate, material cost, assumed/typical haul distance, etc. Current Davis Bacon labor rates, MII Equipment rates, current fuel prices and generic/typical Contractor markups were utilized to establish unit costs.

Historical cost data for some items have been utilized based on past projects in the vicinity of Sacramento, such as the Sacramento Bank Protection Project. Pump station costs were based on costs for similar pump stations from the Natomas PACR.

Cost Data from previous studies in the Sacramento area, specifically, those developed for SAFCA by Parsons-Brinckerhoff for the Sacramento Bypass Expansion (March 2009) were utilized to develop costs for the proposed Sacramento Bypass Expansion for Alternative 2. These costs were escalated to October 2014 for the purposes of the TSP milestone.

Cost Data supplied by other Disciplines, specifically Real Estate Division and Environmental Resources Branch (Mitigation and SWPP/Storm Water Pollution Prevention).

Cost Engineering judgment and experience was used to base some costs on a percentage of construction costs (e.g. Cultural Resources, Traffic Control, PED cost, Construction Management cost). The percentages are based on historical data and typical rates used by SPK Cost Engineers in the past.

The estimated project cost summaries (first cost) follow the Civil Works Work Breakdown Structure (CWWBS) code of accounts. Feature codes typically involved in this estimate are:

01-Lands and Damages (Real Estate)
02-Relocations
06-Fish and Wildlife Facilities
11-Levees and Floodwalls
13-Pumping Plants
15-Floodway Control Diversion Structures
18-Cultural Resource Preservation
30-Preconstruction Engineering and Design
31-Construction Management

The 30 and 31 accounts involve any costs associated with USACE staffing on the project for the federal share and anticipated costs associated with local sponsor costs for the non-federal share. The cost estimate for each Alternative is the summation of the costs from the major cost categories. The costs do not account for life cycle costs.

OMRR&R Costs

Sacramento District Civil Design Section developed OMRR&R costs associated with the project features. The costs were developed with input and review from two of the local maintaining agencies (LMA). Specifically, several meetings and conversations between the Corps, the Department of Water Resource's Maintenance Area 9 (MA-9), and American River Flood Control District (ARFCD) staff resulted in a mutual understanding of the increased efforts as a result of new project features and the impact on costs. Some of the OMRR&R costs considered related to inspection, mowing, rodent control, mechanical maintenance, and graffiti removal.

A few of the OMRR&R feature costs were developed quantitatively, however, many of the costs were developed using qualitative judgment by Corps and LMA staff. The following Table 8 shows the increased OMRR&R Costs for each alternative:

Table 8 – Annual Increase in OMRR&R Costs

ANNUAL INCREASE IN OMRR&R COSTS			
LMA	**Description**	**Alternative 1 Cost**	**Alternative 2 Cost**
MA-9	WEIR WIDENING	$ -	$ 56,250
	NORTH BYPASS LEVEE	$ -	$ 137,400
	BYPASS CHANNEL	$ -	$ 15,000
	LEVEE MAINTENANCE	$ 49,400	$ 49,400
ARFCD	GENERAL MAINTENANCE	$ 235,900	$ 235,900
OMRR&R Total		**$ 286,000**	**$ 494,000**

Total Project Schedule

A formal construction schedule coordinated with an MII cost estimate has been developed at this stage. Based on the assumption of optimal funding and resources, the yearly federal monetary allotment for the project will be approximately $100-200M. The initial PED portion and real estate efforts are assumed to take between 1-3 years prior to construction depending on the reach and types of features. These durations were evaluated on a reach by reach basis and are incorporated in Tables Table 6 and Table 7. For the purposes of alternative selection and economic analysis, the construction durations for both Alternative 1 and 2 were estimated to be 10 years. For more information, see section 5.3.

Cost Uncertainties and Cost Risk Analysis

There are inherent uncertainties in the costs at this preliminary level of design (screening alternatives) since there are no detailed designs, plans or specifications. There are also inherent uncertainties as the construction contractor(s) are responsible for obtaining the construction materials, accomplishing the work in a timely manner as per the project due date, using overtime and/or multiple crews to accomplish the same, etc. Funding appropriations are uncertain. The Central Valley of California is home to many threatened/endangered species that require much of the work to be done within certain construction windows, typically May-October.

More than 50% of the costs for this project are directly related to levee improvements. A large percentage of these costs come from obtaining and hauling materials for levee protection (stone) and placement of levee fill or impervious fill material (clay cap). For the purposes of the cost estimates, the assumption has been made that stone material will be placed from the waterside (via barge) for work along the Sacramento River and from the landside (trucked) for work along the American River. Stone materials are expected to come from either the Bay Area (via barge) or the Sierra Nevada mountains (via trucks). In either case, haul distance is approximately 75-100 miles (one-way). Much of the existing levee material can be re-used but still must be hauled to/from stockpiles. Impervious fill (clay) is assumed to come from within 25 miles (one-way haul). The potential contractors are free to obtain borrow from wherever they see fit, as long as it meets specifications. Haul costs in general have some uncertainty as material supply locations are up to the contractor and there is inherent risk that fuel prices may increase during the long construction duration anticipated for the project. The PDT acknowledges the risk of not specifically identifying borrow sites, and for the purposes of this study, have instead performed a regional borrow study which indicated more than enough suitable impervious material exists within 25 miles of the project. See paragraph 2.4.3 for more information. Another work feature of high risk/costs are the cutoff walls, which have large quantities of deep cutoff walls along the Sacramento River, requiring use of the deep soil mixing method (DSM), or some comparable method. DSM will require significant placement time.

Risk analysis results are intended to provide project leadership with contingency information in order to support decision making and risk management as the project progresses from planning through implementation. For the final array of alternatives, an abbreviated Cost Risk Analysis (CRA), using the Cost MCX Abbreviated Risk Analysis Template (spreadsheet), was performed

for each alternative. The risk analysis process involved dividing project costs into typical risk elements and placing them into a Risk Register, then holding discussions among the PDT members to identify the risks/concerns relative to those risk elements and then justify the likelihood and impact. A Risk Matrix utilizing weighted likelihood/impacts is used to establish the cost contingency to use for each risk element (work feature) for use in alternatives comparisons. To fully recognize its benefits, cost and schedule risk analysis must 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, budgeting and scheduling.

The CRA workshop was held in January 2013 with participation from most PDT members. The workshop focused primarily on risk identification using the CRA template and brainstorming techniques. Project risks were identified and were added to the risk register portion of the spreadsheet. The likelihood of and impact on each risk element was assessed by the PDT and after the meeting, the draft risk register and results were forwarded to the PDT for review. The results of the CRA were considered adequate for establishing contingencies for alternatives comparison.

Risk elements were identified for each alternative based on work feature. Prime features identified were categorized to allow relatively easy comparison of the different alternatives. The prime feature items typically accounted for 70 percent or more of the costs. The remaining work features are lumped together in a category for 'Remaining Construction Items'. The items are typically low-level risks but remain within the risk register for historical purposes as well as to support follow-on risk studies as the project and its accompanying risks evolve.

.A formal Cost and Schedule Risk Analysis (CSRA), supporting the feasibility level design refinements, was held during December 2015. Members of the PDT including Sponsors and construction field personnel were in attendance. The CSRA was similar to the CRA, however, was more detailed in identifying the risks associated with the project. The materials and results are presented within the Cost Engineering Appendix - Attachment D, for the NED and TSP (LPP), Alternatives 1 and 2 respectively.

Feasibility Level Costs

Total Project Costs have been prepared for the FRM and the cost summaries, including contingencies and escalation (per the construction schedule) and are under Attachment D – Cost Engineering. The cost summaries are presented for the NED and TSP plans. These costs include refinements to the design and feasibility level details (by Civil Design) and Cost Engineering data. This includes creation of feasibility level quantities, development of a detailed MII estimate, a Total Project Schedule (including Construction), PDT estimates for Planning, Engineering and Design, an updated Cost and Schedule Risk Analysis and a Total Project Cost Summary (TPCS) extending costs out through the life of the Project. The MII estimate includes detailed information indicating labor, equipment and materials with accompanying production rates.

Review

The cost estimates from screening level up through alternative selection have been reviewed for quality control at the Sacramento District and have also been through agency technical review (ATR). The costs currently shown in the Cost Engineering Appendix have been prepared for the FRM and are in the process of seeking cost certification from the cost center of expertise in Walla Walla District. These costs include refinements to the design where applicable including any changes from real estate and environmental disciplines.

REFERENCES

U.S. Army Corps of Engineers (USACE), *American River Common Features Project General Reevaluation Report, Placer, Sacramento, Sutter Counties, California, Synthetic Hydrology Technical Documentation, Sacramento District, United States Army Corps of Engineers*, USACE Sacramento District, September 2008. Revised January 2009.

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PLATES

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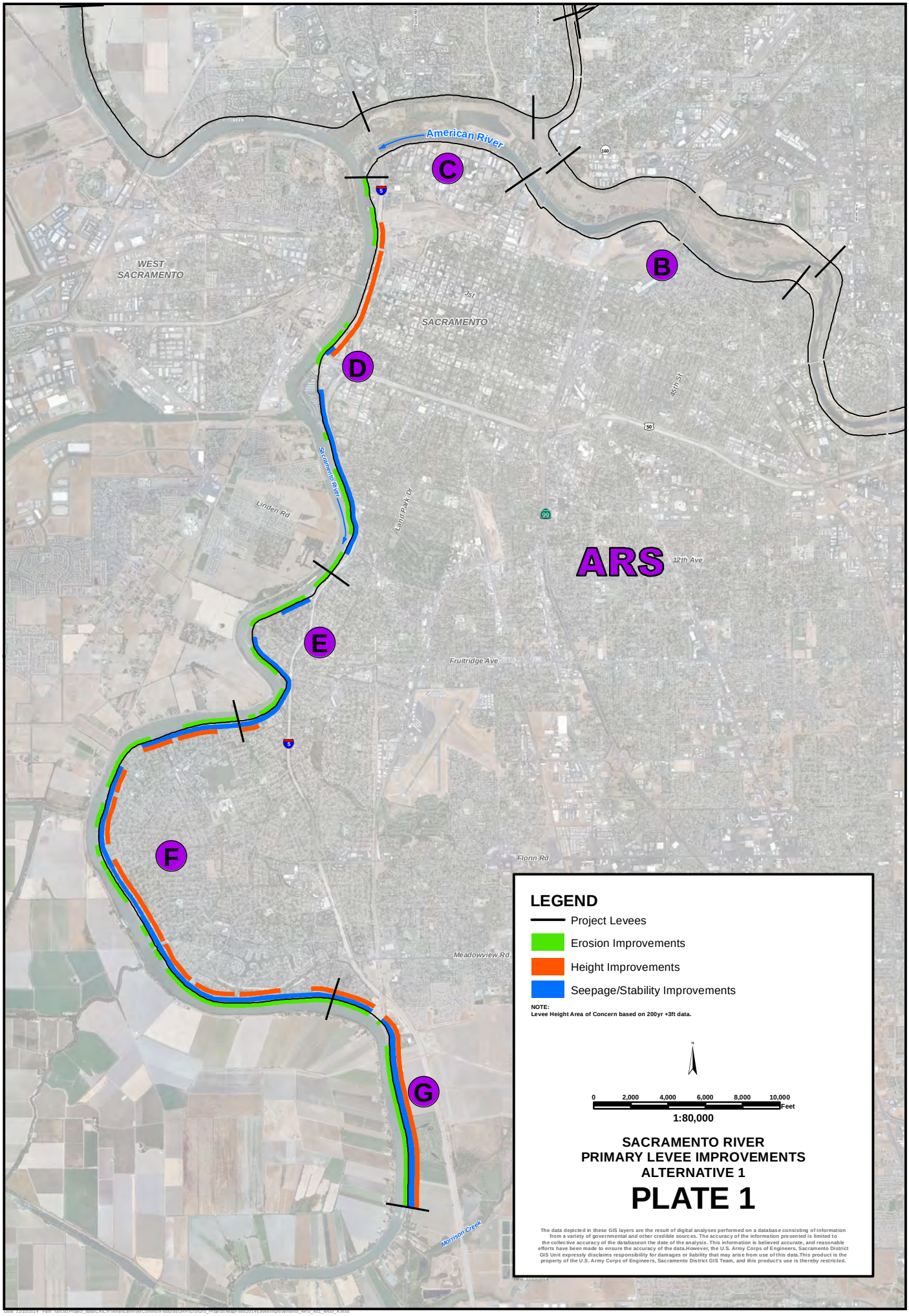
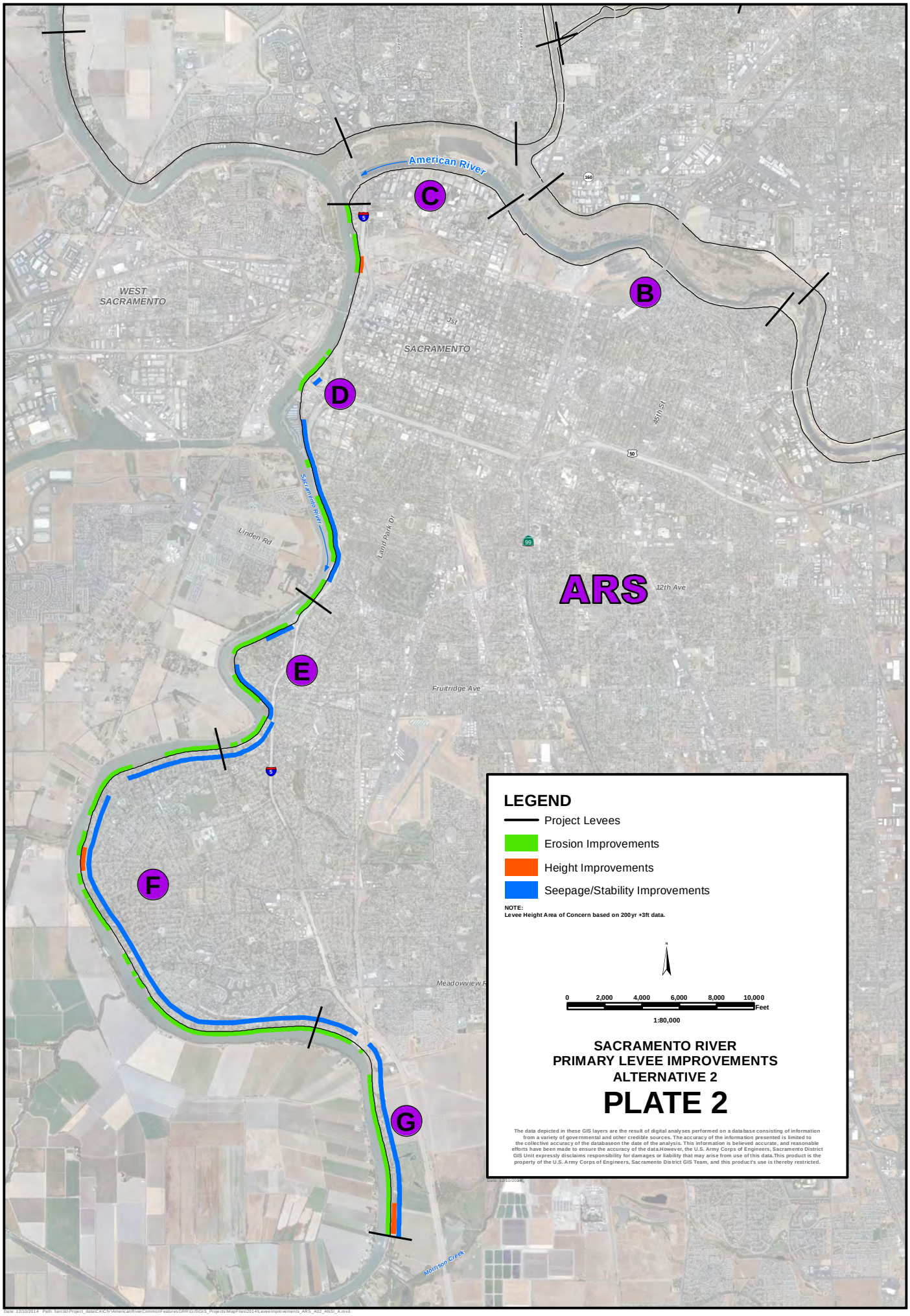
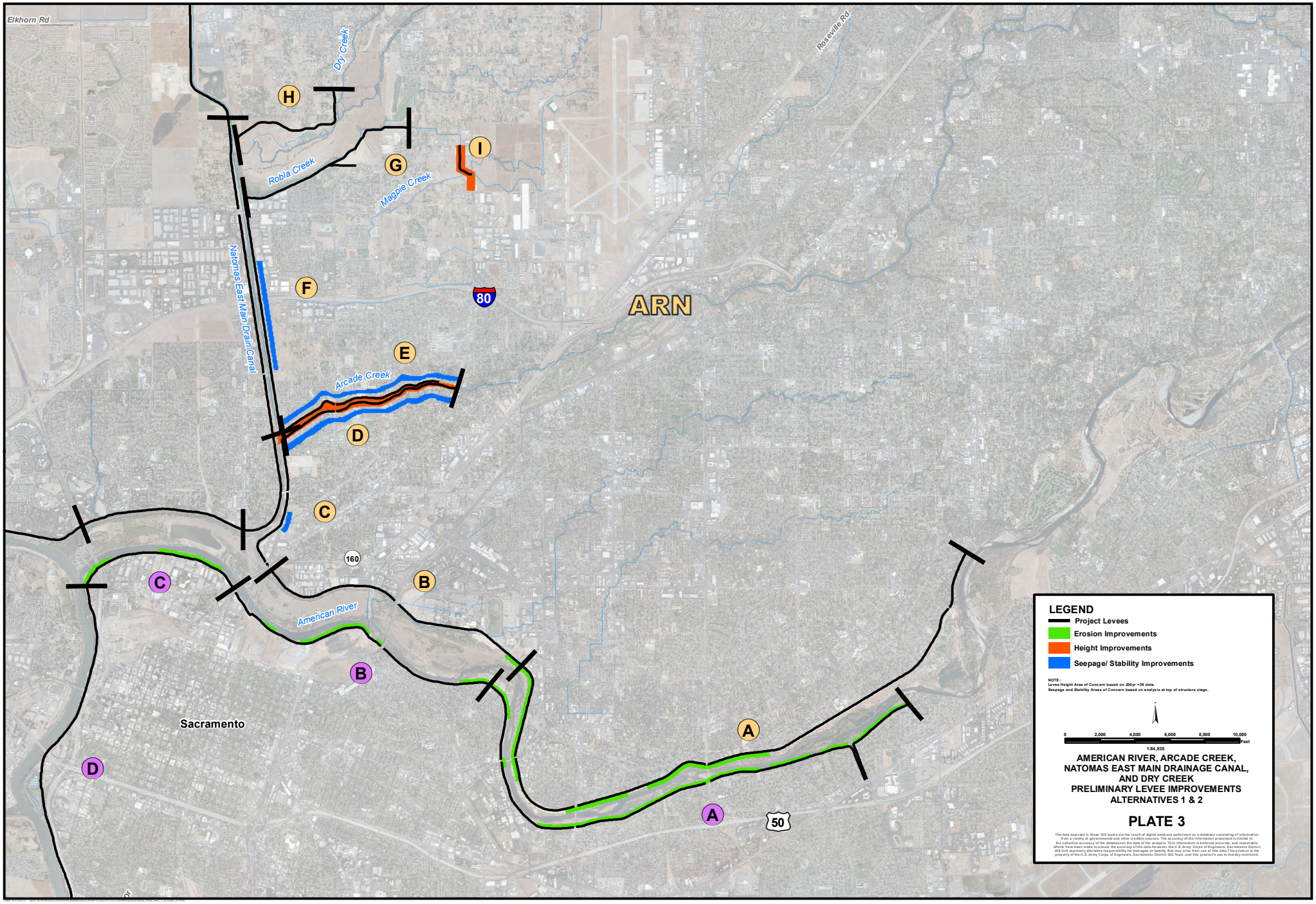
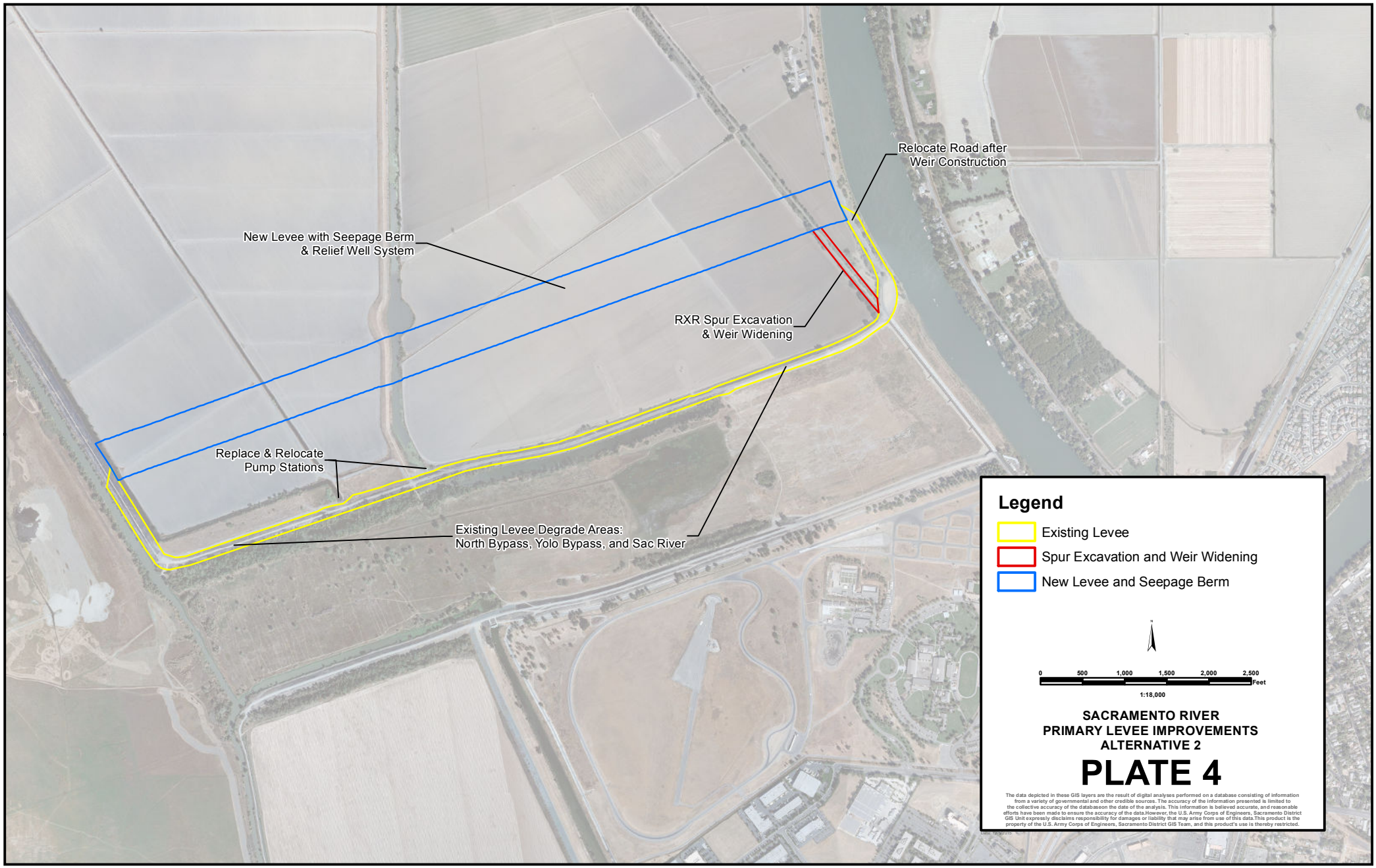

American River
C
B
D
E
F
G
ARS
WEST SACRAMENTO
SACRAMENTO
J St
45th St
Sacramento River
Linden Rd
Lenn Park Dr
12th Ave
Fruitridge Ave
Florin Rd
Meadowview Rd
Morrison Creek
LEGEND
Project Levees
Erosion Improvements
Height Improvements
Seepage/Stability Improvements
NOTE:
Levee Height Area of Concern based on 200yr +3ft data.
0 2,000 4,000 6,000 8,000 10,000 Feet
1:80,000
SACRAMENTO RIVER
PRIMARY LEVEE IMPROVEMENTS
ALTERNATIVE 1
PLATE 1
The data depicted in these GIS layers are the result of digital analyses performed on a database consisting of information from a variety of governmental and other credible sources. The accuracy of the information presented is limited to the collective accuracy of the databaseon the date of the analysis. This information is believed accurate, and reasonable efforts have been made to ensure the accuracy of the data.However, the U.S. Army Corps of Engineers, Sacramento District GIS Unit expressly disclaims responsibility for damages or liability that may arise from use of this data.This product is the property of the U.S. Army Corps of Engineers, Sacramento District GIS Team, and this product's use is thereby restricted.


American River
C
B
D
E
F
G
ARS
WEST SACRAMENTO
SACRAMENTO
J St
Sacramento River
Linden Rd
Land Park Dr
12th Ave
Fruitridge Ave
Meadowview R
Morrison Creek
LEGEND
Project Levees
Erosion Improvements
Height Improvements
Seepage/Stability Improvements
NOTE:
Levee Height Area of Concern based on 200yr +3ft data.
0 2,000 4,000 6,000 8,000 10,000
Feet
1:80,000
SACRAMENTO RIVER
PRIMARY LEVEE IMPROVEMENTS
ALTERNATIVE 2
PLATE 2
The data depicted in these GIS layers are the result of digital analyses performed on a database consisting of information from a variety of governmental and other credible sources. The accuracy of the information presented is limited to the collective accuracy of the databaseon the date of the analysis. This information is believed accurate, and reasonable efforts have been made to ensure the accuracy of the data.However, the U.S. Army Corps of Engineers, Sacramento District GIS Unit expressly disclaims responsibility for damages or liability that may arise from use of this data.This product is the property of the U.S. Army Corps of Engineers, Sacramento District GIS Team, and this product's use is thereby restricted.


Elkhorn Rd
Dry Creek
Roseville Rd
H
I
G
Robla Creek
Magpie Creek
Natomas East Main Drain Canal
F
80
ARN
E
Arcade Creek
D
C
160
B
American River
Sacramento
A
50
LEGEND
Project Levees
Erosion Improvements
Height Improvements
Seepage/ Stability Improvements
NOTE:
Levee Height Area of Concern based on 200yr +3ft data.
Seepage and Stability Areas of Concern based on analysis at top of structure stage.
0 2,000 4,000 6,000 8,000 10,000 Feet
1:84,835
AMERICAN RIVER, ARCADE CREEK,
NATOMAS EAST MAIN DRAINAGE CANAL,
AND DRY CREEK
PRELIMINARY LEVEE IMPROVEMENTS
ALTERNATIVES 1 & 2
PLATE 3


Relocate Road after
Weir Construction
New Levee with Seepage Berm
& Relief Well System
RXR Spur Excavation
& Weir Widening
Replace & Relocate
Pump Stations
Existing Levee Degrade Areas:
North Bypass, Yolo Bypass, and Sac River
Legend
Existing Levee
Spur Excavation and Weir Widening
New Levee and Seepage Berm
0
500
1,000
1,500
2,000
2,500
Feet
1:18,000
SACRAMENTO RIVER
PRIMARY LEVEE IMPROVEMENTS
ALTERNATIVE 2
PLATE 4
The data depicted in these GIS layers are the result of digital analyses performed on a database consisting of information from a variety of governmental and other credible sources. The accuracy of the information presented is limited to the collective accuracy of the databaseon the date of the analysis. This information is believed accurate, and reasonable efforts have been made to ensure the accuracy of the data.However, the U.S. Army Corps of Engineers, Sacramento District GIS Unit expressly disclaims responsibility for damages or liability that may arise from use of this data.This product is the property of the U.S. Army Corps of Engineers, Sacramento District GIS Team, and this product's use is thereby restricted.

ATTACHMENTS

Attachment A – Hydrology Executive Report (Under Separate Cover)

Attachment B – Hydraulic Appendix Executive Report (Under Separate Cover)

Attachment C – Geotechnical Report (Under Separate Cover)

Attachment D – Cost Engineering (Under Separate Cover)

Attachment E – Erosion Protection Report (Under Separate Cover)

American River Watershed

Common Features
General Reevaluation Report

Attachment A
Hydrology Report

December 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Attachment A
Hydrology Report

U.S. Army Corps of Engineers
Sacramento District

December 2015

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AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Appendix B Hydrology Report Contents

Hydrology Executive Summary

Appendix B1 – Synthetic Hydrology Technical Documentation

Appendix B2 – American River Hydrology and Folsom Dam Reservoir Operations

Appendix B3 – Dry and Arcade Creeks Flow Frequency Curves and Synthetic 8- Flood Series Hydrographs Upstream of Steelhead Creek

Common Features General Reevaluation Report
Hydrology Technical Documentation

EXECUTIVE SUMMARY

Scope. This Attachment (hydrology documentation) describes the development of the existing conditions synthetic hydrology for the greater Sacramento area, which includes the Lower American River and the Natomas Basin. The hydrology documentation includes Common Features General Reevaluation Report (GRR), Appendix B1, Synthetic Hydrology Technical Documentation, dated September 2008, Appendix B2, American River Hydrology and Folsom Dam Reservoir Operations, dated January 2009, and Appendix B3, Dry and Arcade Creeks Flow Frequency Curves and Synthetic 8-Flood Series Hydrographs Upstream of Steelhead Creek, dated January 2010. Documentation referenced here, but not included, is the Technical Studies Documentation, Appendices B and C, for the Sacramento and San Joaquin River Basins Comprehensive Study (Comp Study), dated December 2002.

Background. 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.

This appendix describes the development of the Folsom Dam discharge hydrographs for the floodplain delineation efforts and the hydrologic data inputs needed for the economic evaluations. The economic analysis will evaluate the extent of the damage caused by levee failures within the basin.

Comprehensive Study Methodology. The Common Features GRR is using existing conditions hydrology, which is anticipated to be adequate for determining exterior stages on all levee reaches surrounding the greater Sacramento area. The existing hydrology for the Common Features GRR is based upon the storm centering method described in the Comp Study Technical Studies Documentation, Appendices B and C: Appendix B of the Comp Study describes the development of unregulated synthetic hydrographs for specific flood frequencies at particular watershed locations; Appendix C of the Comp Study presents the transformation of the unregulated conditions synthetic hydrology to regulated conditions. The Comp Study synthetic hydrology represents the best available information for the large external sources of flooding for the greater Sacramento area and the associated hydrologic models were developed for use in regional, broad concept studies, such as the Common Features GRR.

Synthetic Flood Centerings. Three different flood centerings were investigated in the development of existing conditions hydrology for the Sacramento area: the Sacramento Mainstem at Latitude of Sacramento centering, the Shanghai Bend – Yuba River centering, and the American River centering. These centerings are described in Appendix B1, Synthetic Hydrology Technical Documentation. The American River centering hydrology is described in greater detail in Appendix B2, American River Hydrology and Folsom Dam Reservoir

Operations. This hydrology included analysis of local flooding contribution from the Natomas Cross Canal and Steelhead Creek, as discussed in Appendix B1 and B3.

Existing Conditions Hydrology for Common Features GRR. 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 study. The Comp Study data provides the majority of the input to the hydraulic model. The one exception is the data for the American River. Both the hydrology and routing tool for American River flows differ. For consistency, the same hydrology used in other American River studies, including output from the Excel-based reservoir routing model, was utilized for the Common Features GRR. See Appendix A of the Comp Study – Synthetic Hydrology Technical Documentation, for a discussion on the differences between the Comp Study and the American River studies unregulated hydrographs for the American River. With regard to reservoir outflow hydrographs, the HEC-ResSim reservoir simulation model built for the Comp Study simulates system-wide operation for multiple reservoirs on the Sacramento River along with those on its major tributaries, however the Folsom Dam Excel-based reservoir simulation model provides the means necessary to examine Folsom Dam project features in more detail and is used in this study.

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

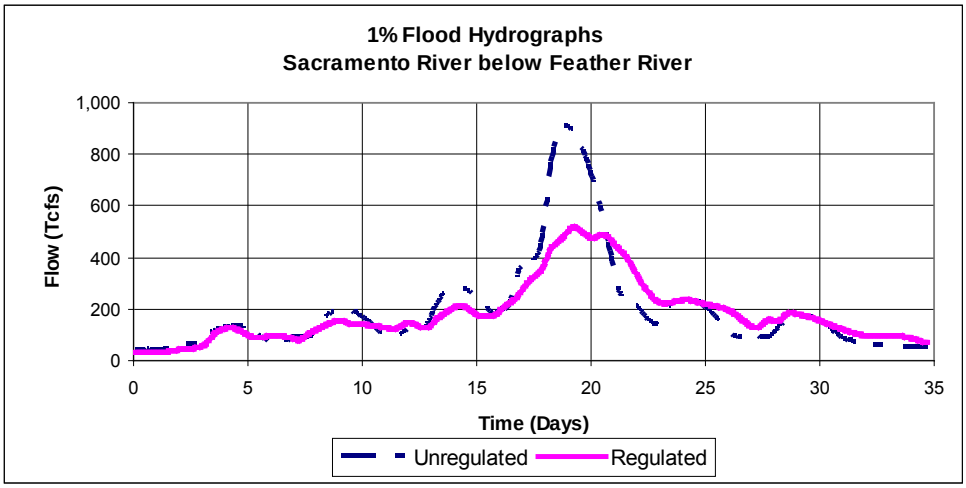
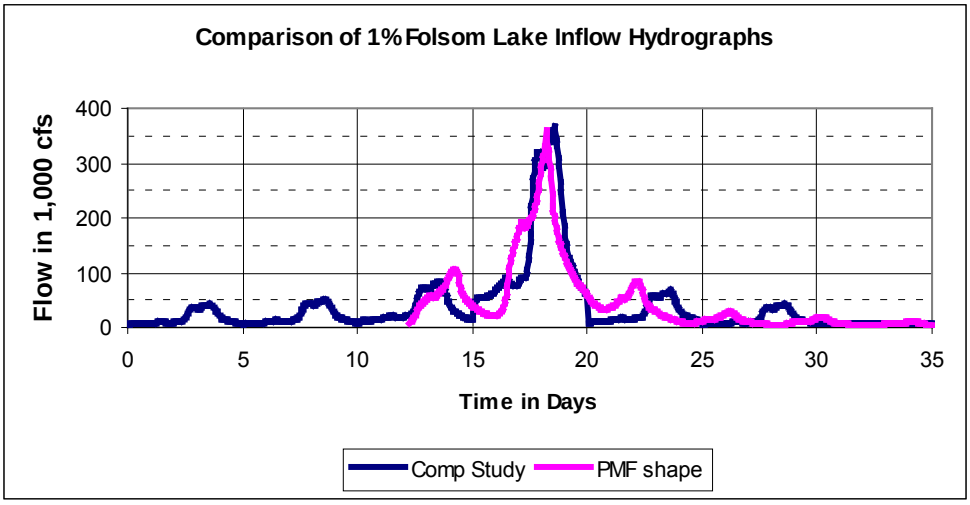


Figure 2



1.2 Shanghai Bend-Yuba River Centering. 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) 10% (Comprehensive Study) % Difference	101,000 113,000 12%	71,000 70,000 -1%	43,000 46,000 7%
4% (PMF Shape) 4% (Comprehensive Study) % Difference	156,000 174,000 10%	110,000 108,000 -2%	66,000 67,000 1%
2% (PMF Shape) 2% (Comprehensive Study) % Difference	207,000 229,000 10%	145,000 142,000 -2%	87,000 86,000 -1%
1% (PMF Shape) 1% (Comprehensive Study) % Difference	266,000 292,000 9%	187,000 181,000 -3%	112,000 107,000 -5%
0.5% (PMF Shape) 0.5% (Comprehensive Study) % Difference	334,000 363,000 8%	235,000 226,000 -4%	141,000 131,000 -8%
0.2% (PMF Shape) 0.2% (Comprehensive Study) % Difference	440,000 475,000 7%	309,000 300,000 -3%	185,000 169,000 -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

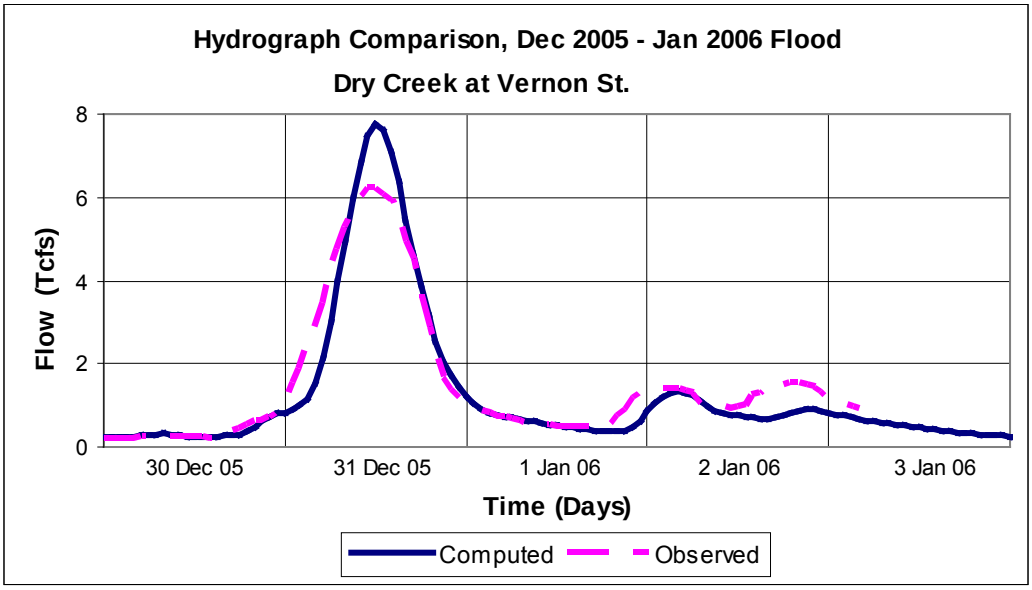


Table 7

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

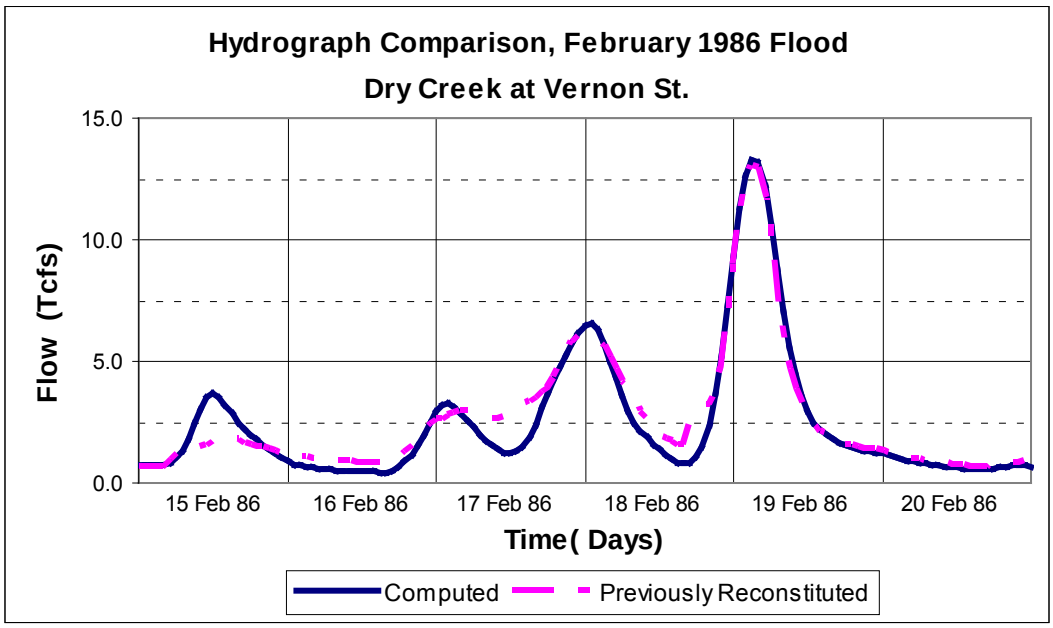


Table 8
15 – 19 February 1986 Flood Volume Comparison
Dry Creek at Roseville Gage

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

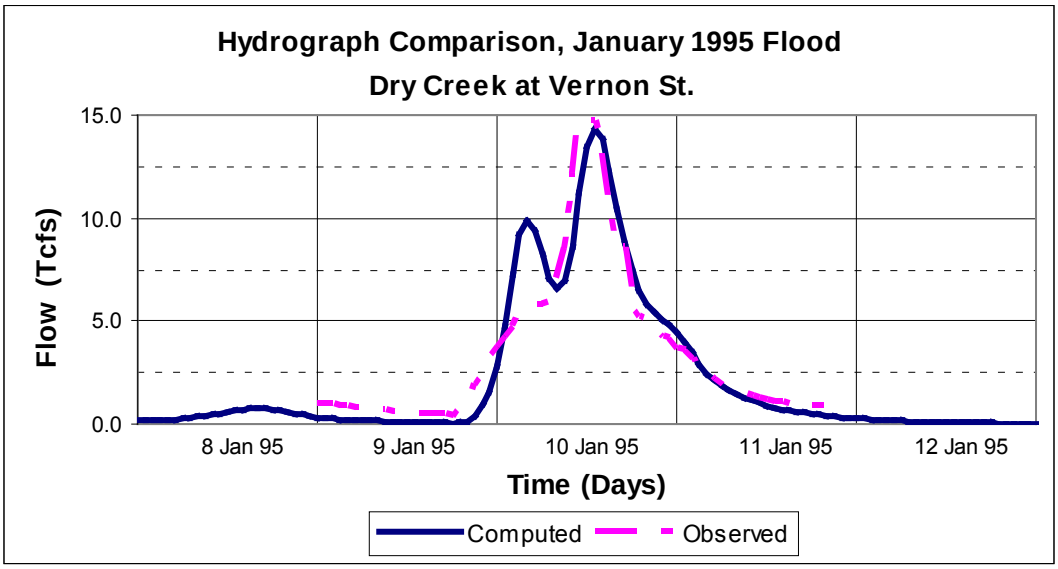


Table 9
8 – 12 January 1995 Flood Hydrograph Comparison
Dry Creek at Roseville Gage

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. 29 Dec 1996 – 3 Jan 1997 Flood. 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

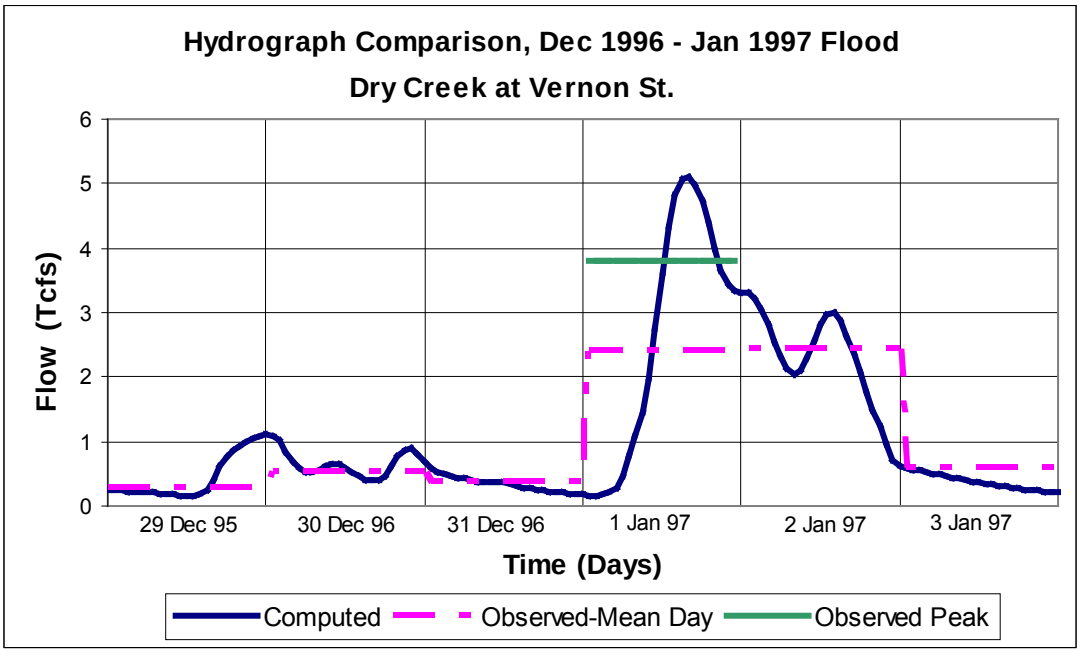


Figure 7

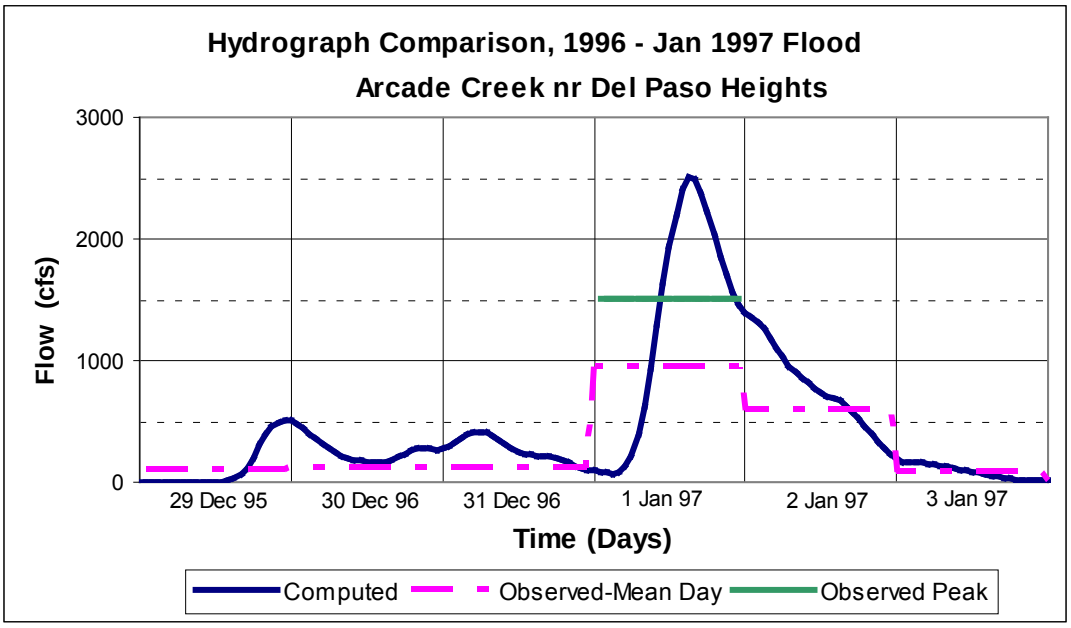


Table 10
29 December 1996 – 3 January 1997 Flood Volume Comparison
For Three Steelhead Creek Tributary Streamflow Gaging Stations

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

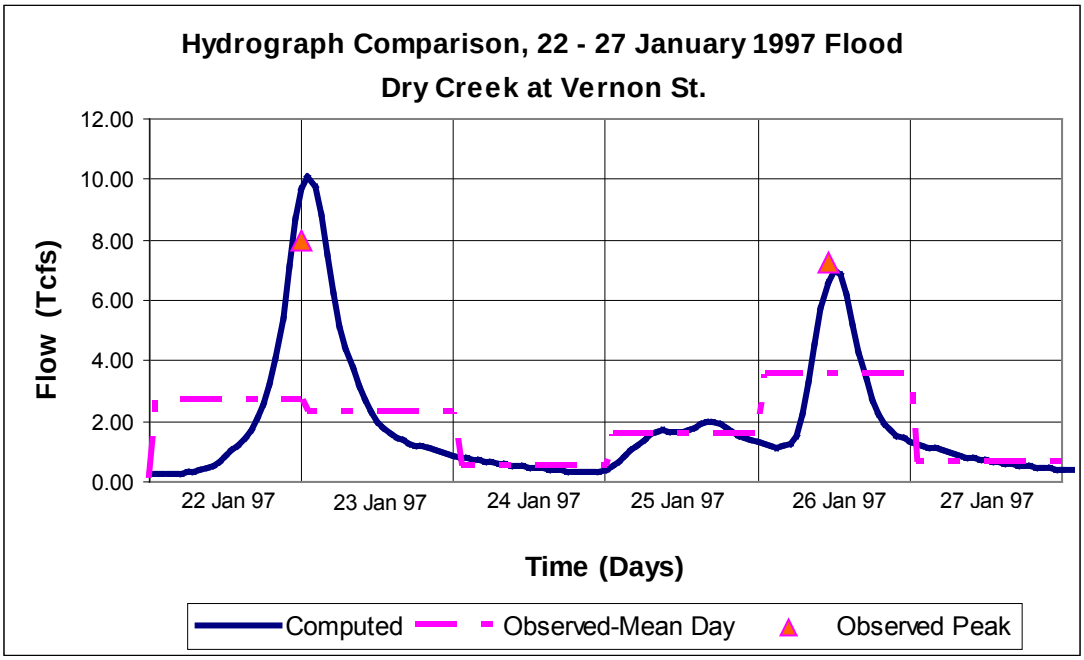


Table 11
22 - 26 January 1997 Flood Volume Comparison
For Three NEMDC Tributary Streamflow Gaging Stations

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

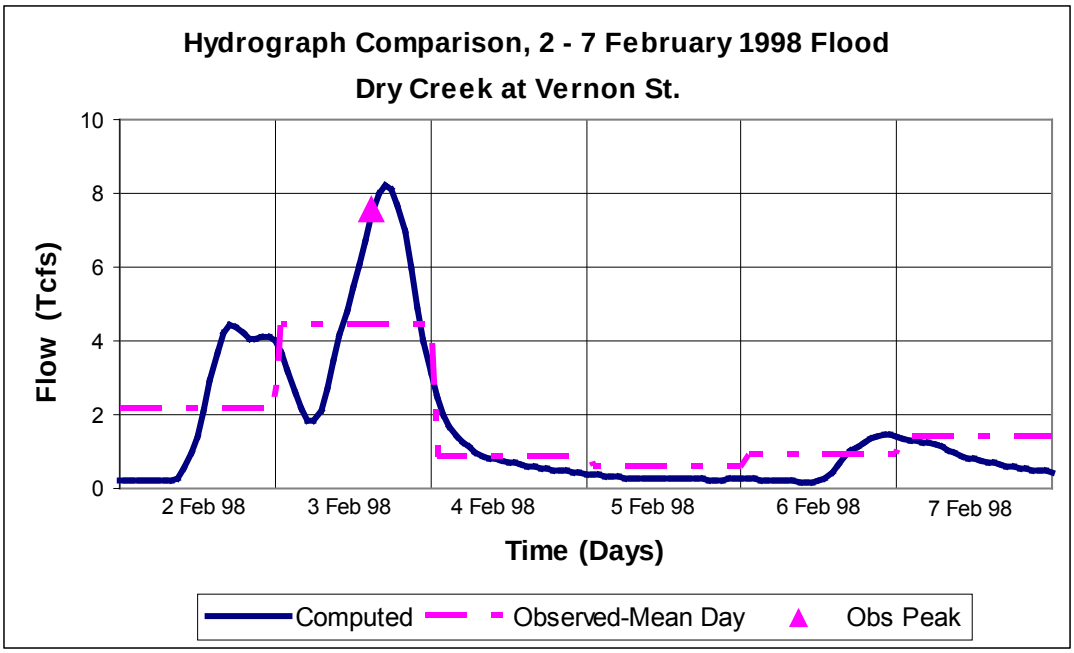


Table 12
2 - 6 February 1998 Flood Volume Comparison
For Two Steelhead Creek Tributary Streamflow Gaging Stations

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. <u>5-Day Volume Frequency Relationships</u>. **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 at Mouth	D.A. (sq.mi.)	8-Flood Series Five-Day Volumes (in Acre-Feet)							
		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

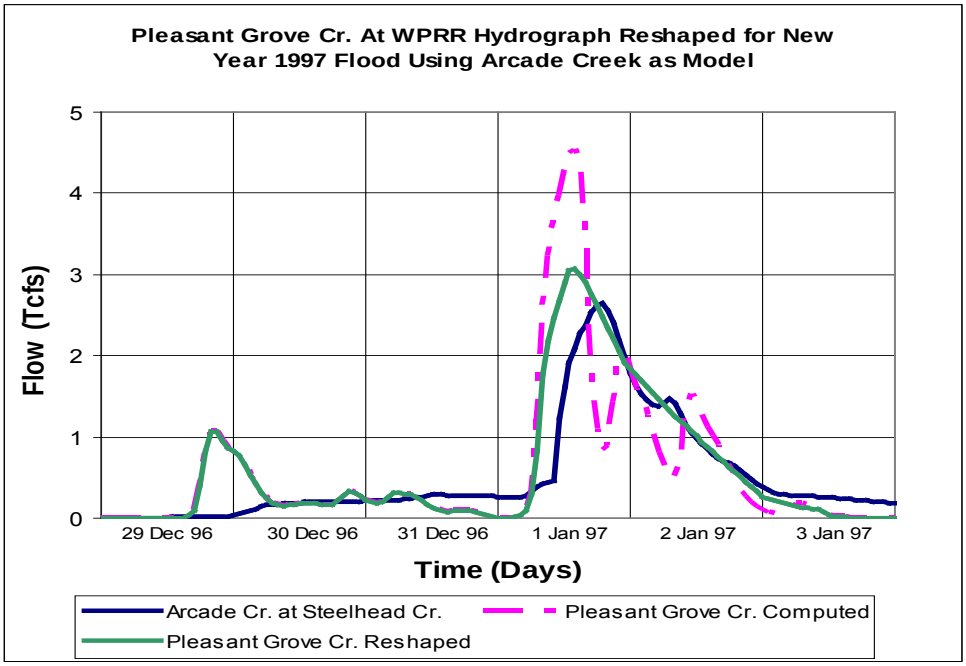
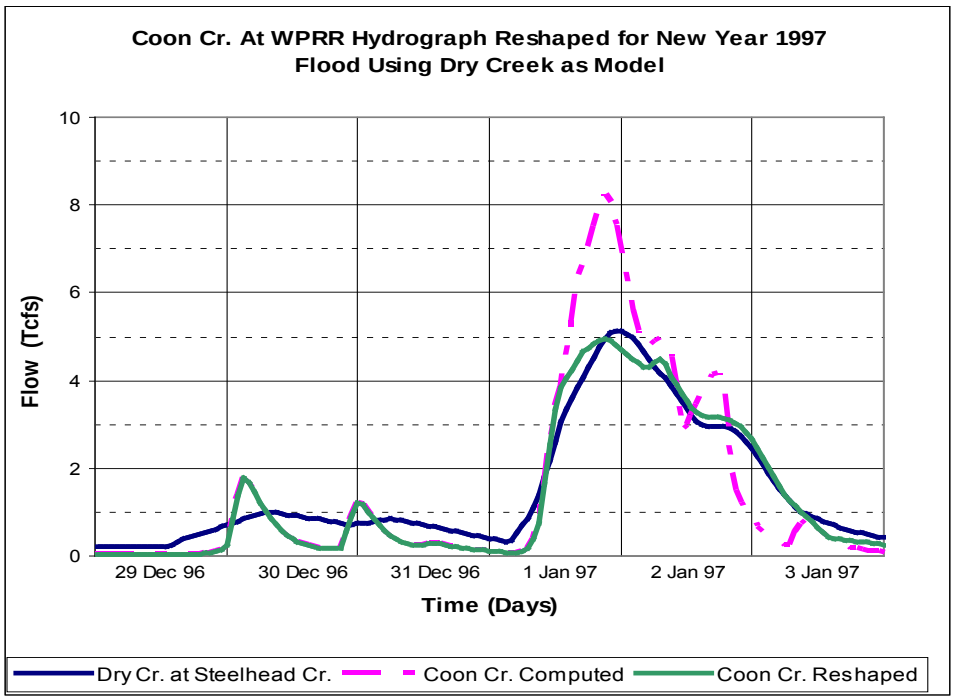
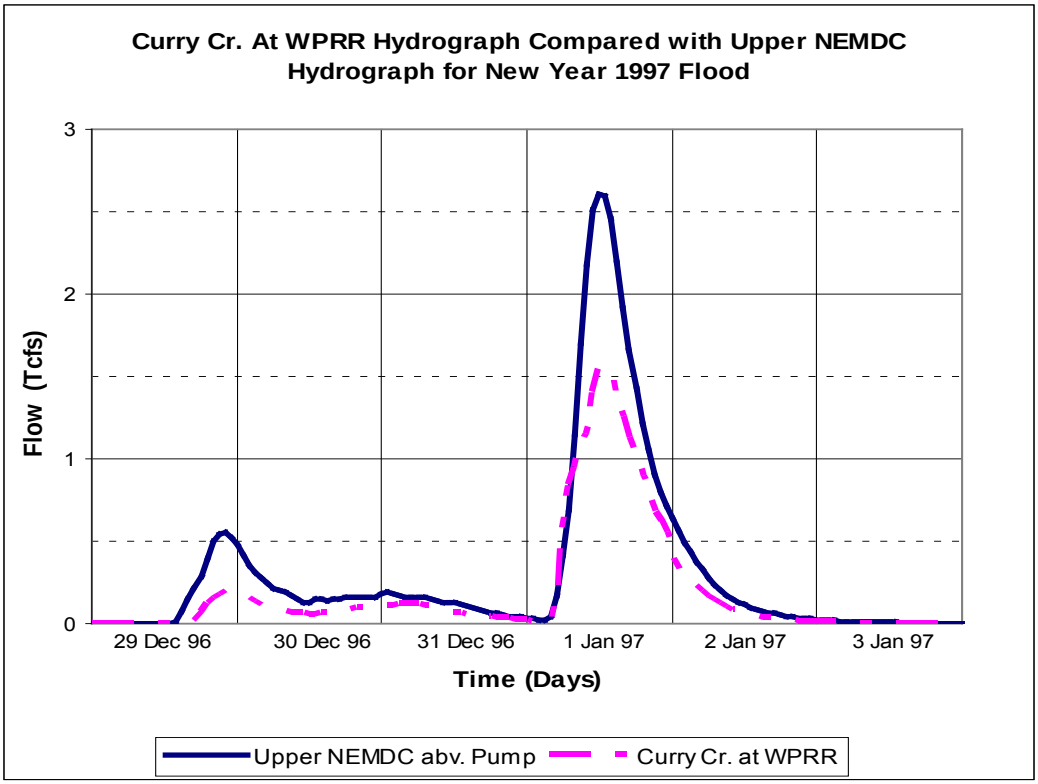


Figure 11



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 Use of Historical Flood Hydrographs on Natomas Tributaries. 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

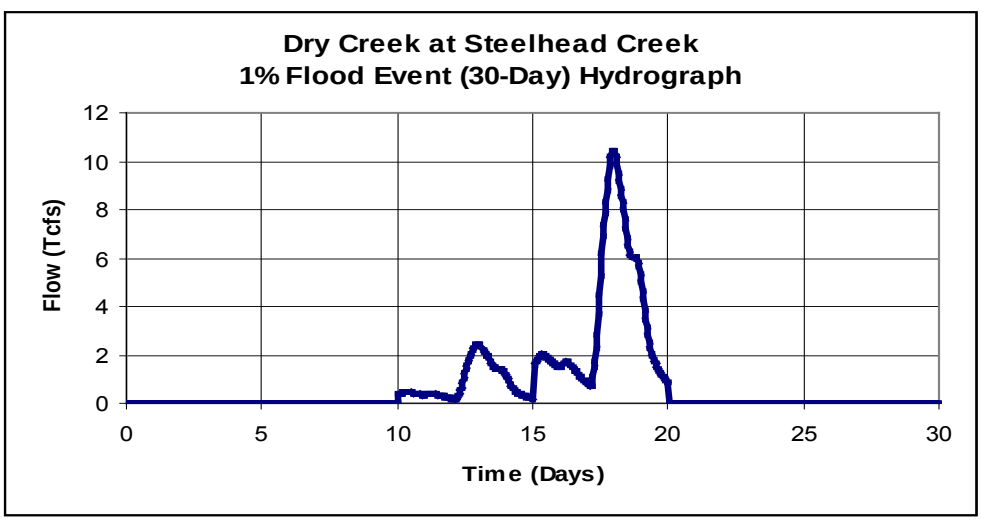
Stream at at Mouth	D.A. (sq.mi.)	8-Flood Series Five-Day Volumes (in Acre-Feet)							
		50%	20%	10%	4%	2%	1%	0.50%	0.20%
Steelhead Cr									
Dry Cr. at NEMDC	116.48	11,000	18,300	23,600	32,700	38,200	43,900	49,100	58,700
Upper NEMDC	27.13	2,400	3,840	4,920	6,400	7,510	8,700	9,760	11,500
OldMag at 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 Total Probability Theorem. 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

1. Sacramento and San Joaquin River Basins Comprehensive Study, Technical Studies Documentation. Appendix B: Synthetic Hydrology Technical Documentation. Appendix C: Reservoir Operations Modeling, Existing Design Operations and Reoperation Analyses. State of California Reclamation Board. U.S. Army Corps of Engineers, Sacramento District. December 2002.

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.

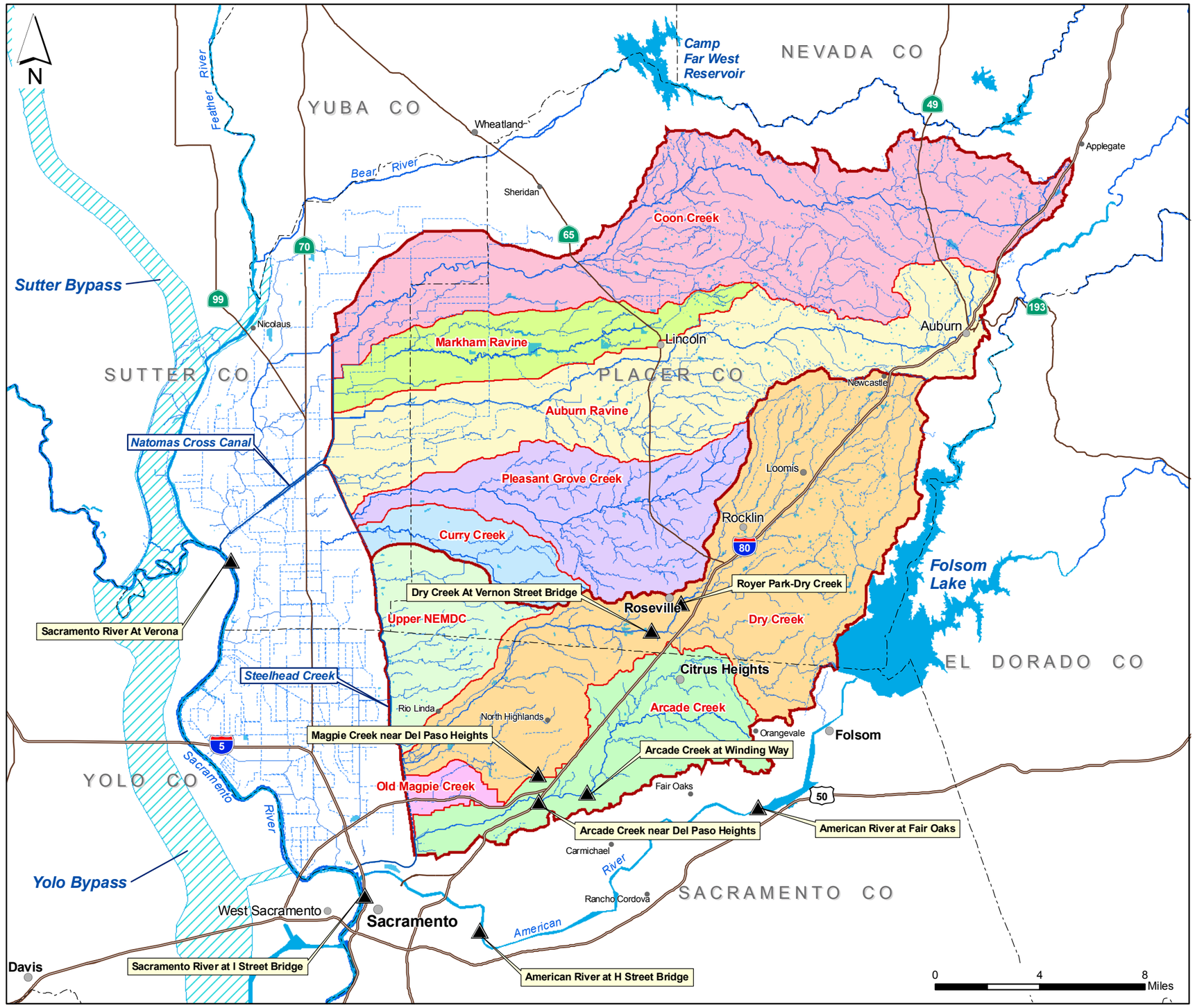
12. Memorandum: NCC/SHC Coincident-Frequency Study: Exposition of Analytical Procedures. Prepared by David Ford Consulting Engineers, Inc. September 10, 2008.

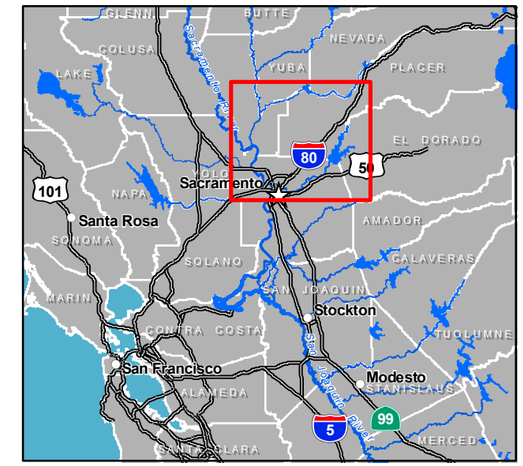
13. California Data Exchange Center (CDEC), the access point to the California Department of Water Resources' operation hydrologic data at: <http://cdec.water.ca.gov>.

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.





Legend

- Stream Gage
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- Canal or Ditch
- Freeway
- Highway
- County Boundary
- City or Town

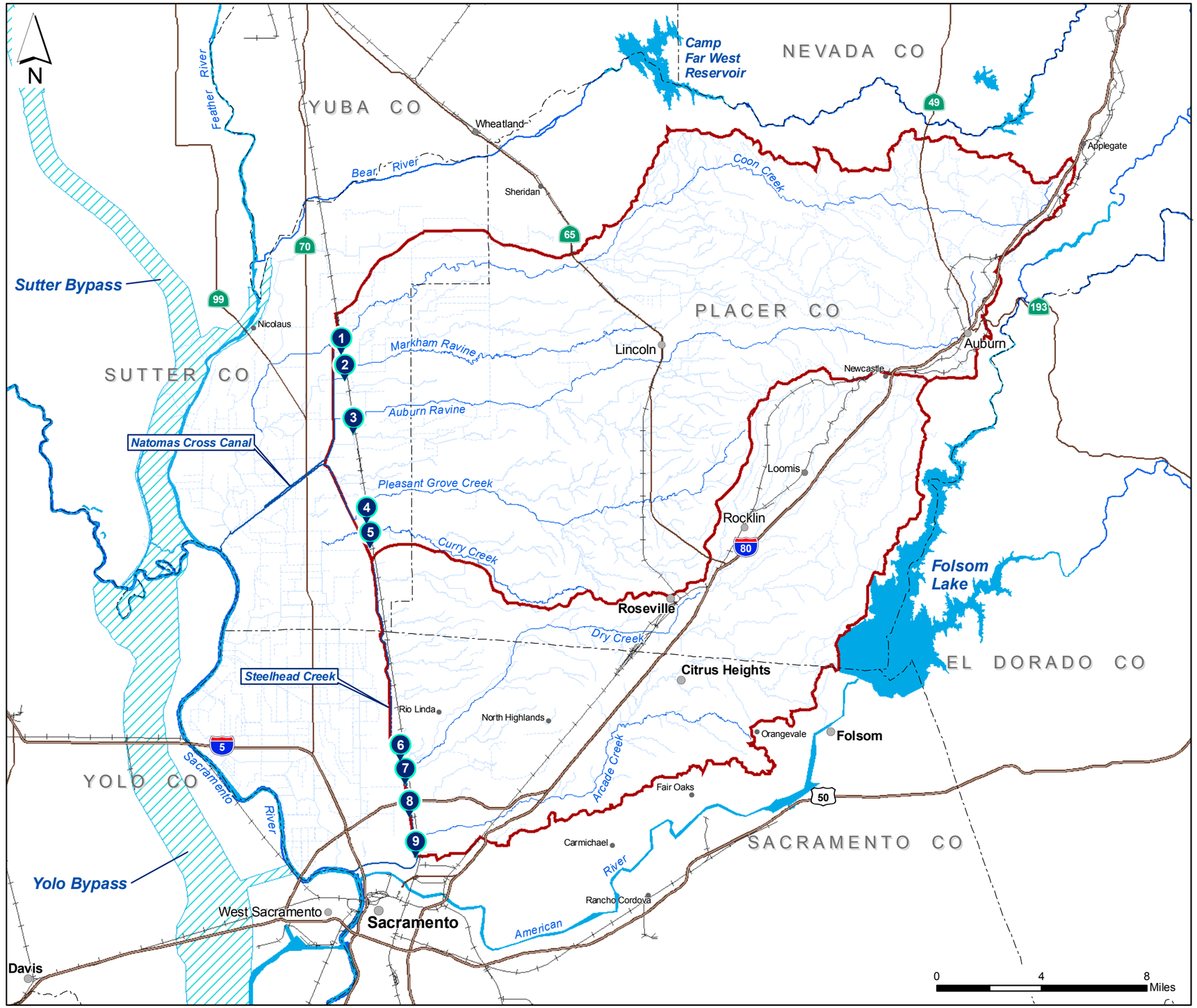
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

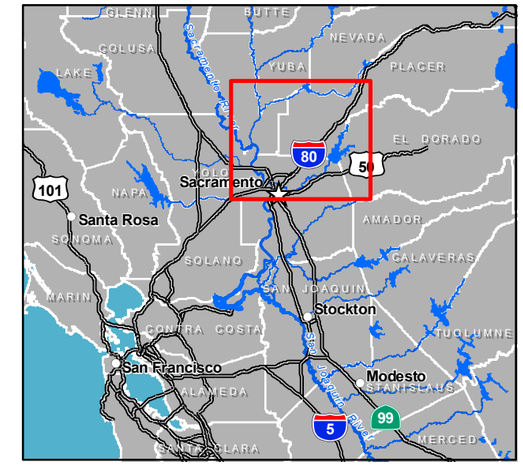
GENERAL MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 1





Legend

- Watershed
- Lake or Major River
- River or Stream
- Canal or Ditch
- City or Town
- Freeway
- Highway
- Railroad
- County Boundary

Input Sites

1. Coon Creek
2. Markham Ravine
3. Auburn Ravine
4. Pleasant Grove Creek
5. Curry Creek
6. Upper NEMDC Tribs
7. Dry Creek
8. Old Magpie Creek
9. Arcade Creek

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

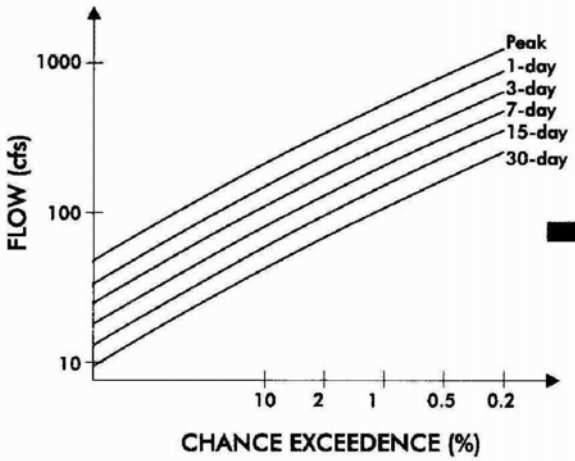
NATOMAS TRIBUTARY INPUT LOCATIONS FOR HYDRAULIC MODEL

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

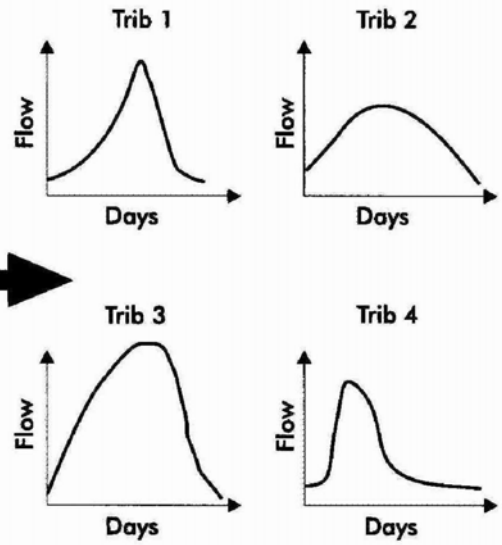
PLATE 2

Full Natural Flow



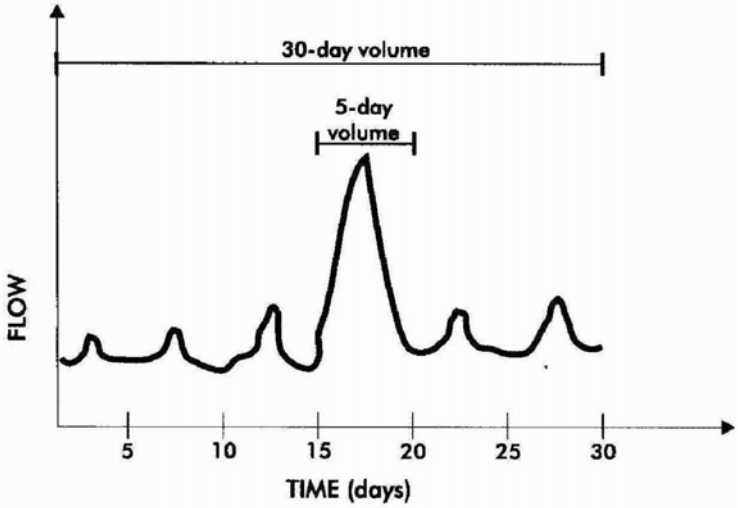
Full natural flow volumes were developed for each of 7 synthetic exceedence events on each tributary

Tributary-Specific Patterns



Tributary-specific hydrograph patterns were used to translate 5-day incremental volumes to flow patterns

Flow Patterns were combined to develop a 30-day period



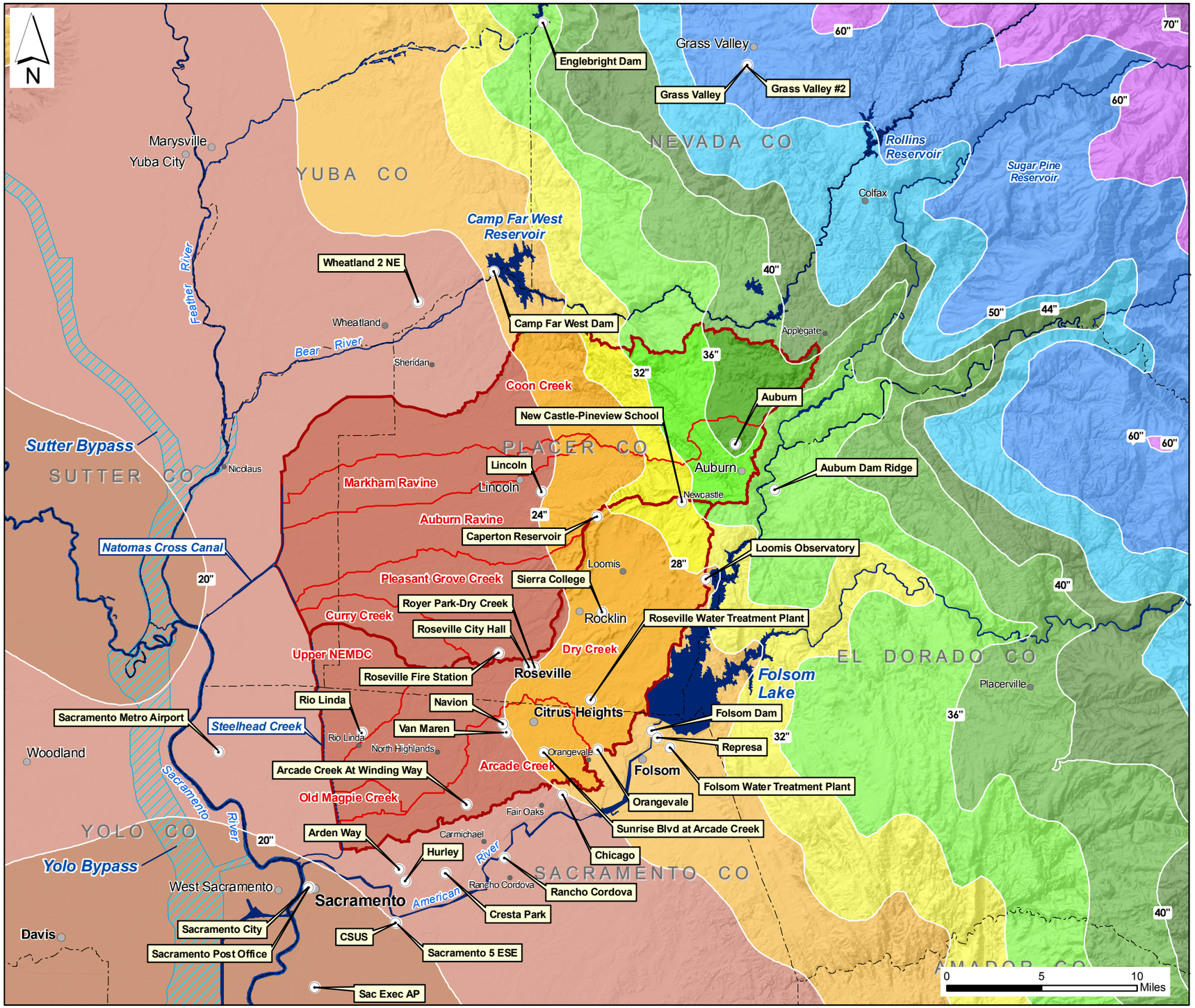
Resulting 30-day hydrographs for each of the 7 exceedence events on each tributary

Sacramento & San Joaquin River Basins Comprehensive Study

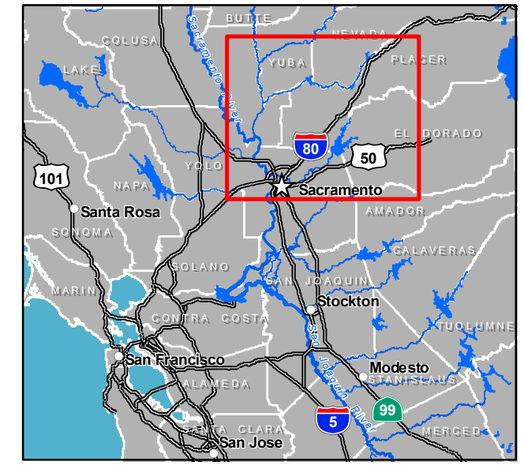
HYDROGRAPH CONSTRUCTION

U.S. Army Corps of Engineers
Reclamation Board, State of California

July 2002



Prepared by J.S.M



Legend

- Precipitation Gage
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- Canal or Ditch
- County Boundary
- City or Town

Average Annual Precipitation (Inches):

18 - 20	32 - 36	50 - 60
20 - 24	36 - 40	60 - 70
24 - 28	40 - 44	70 - 80
28 - 32	44 - 50	

Precipitation data from the PRISM Group at Oregon State University - ***UNITED STATES AVERAGE ANNUAL PRECIPITATION, 1971 - 2000***

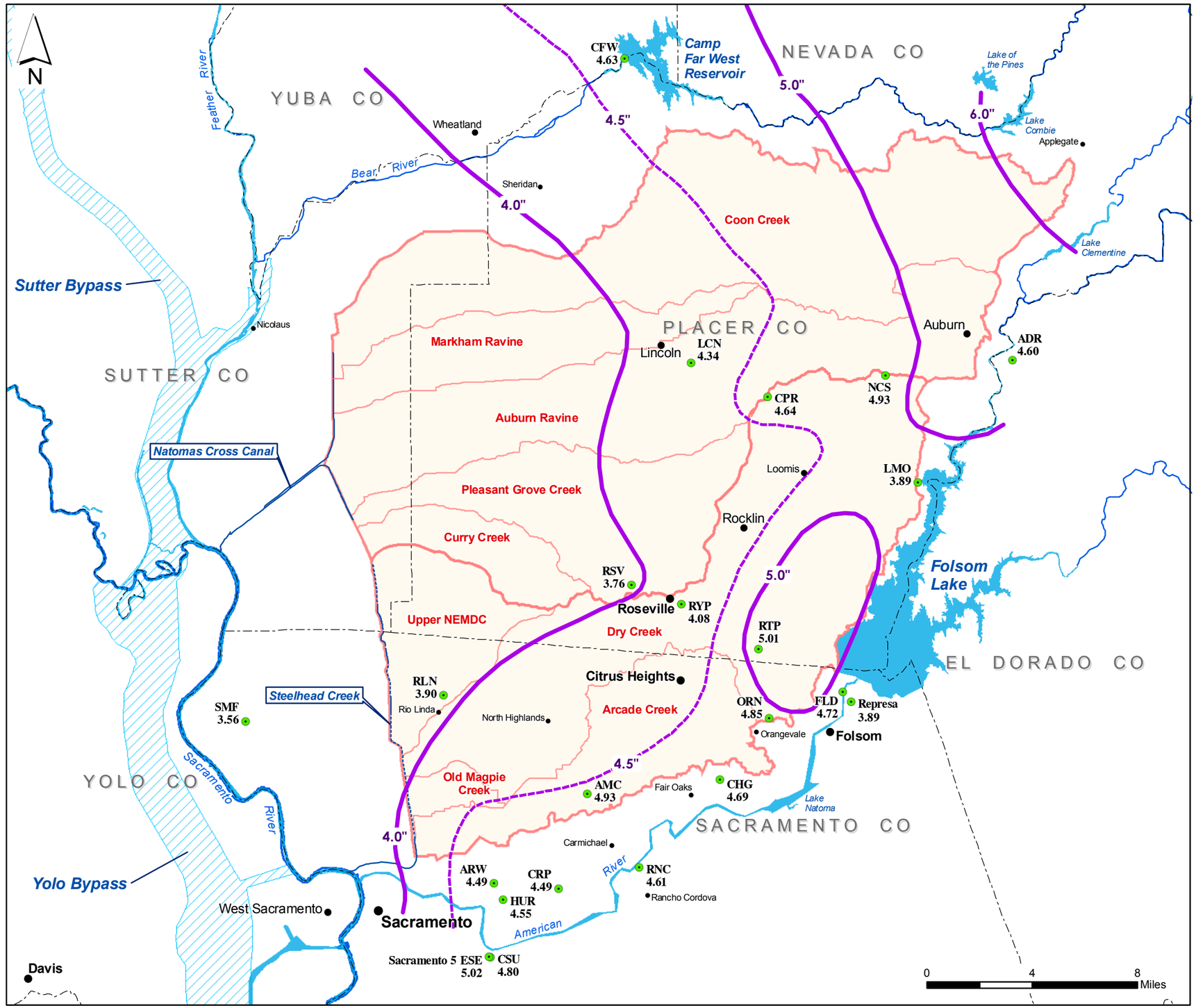
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

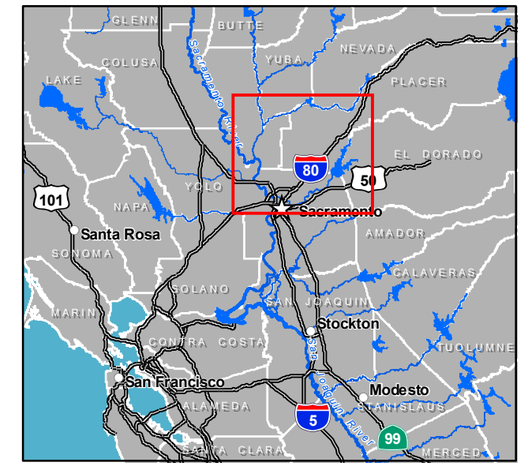
AVERAGE ANNUAL PRECIPITATION

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 4





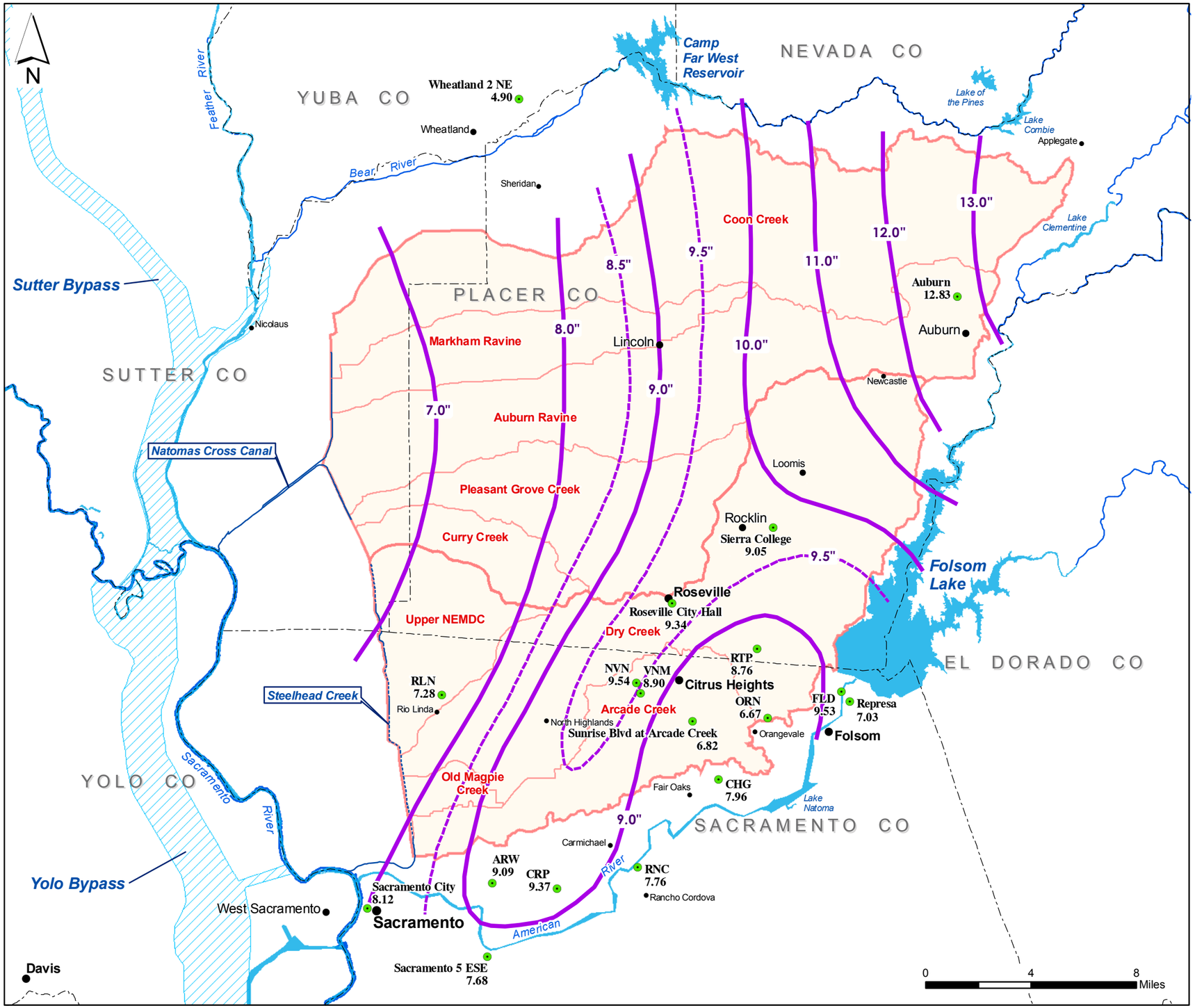
Legend

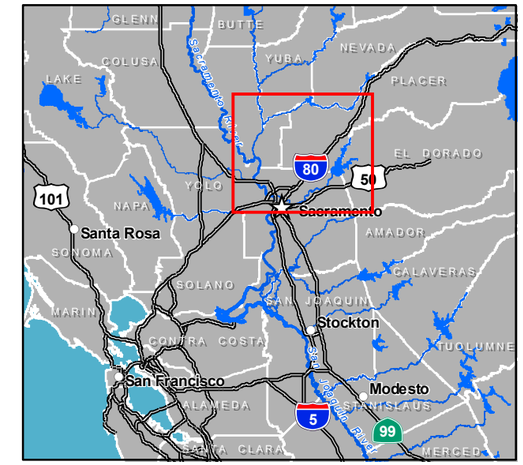
- Precip Gage (Event Total in inches)
- Isohyet
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- County Boundary
- City or Town

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





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

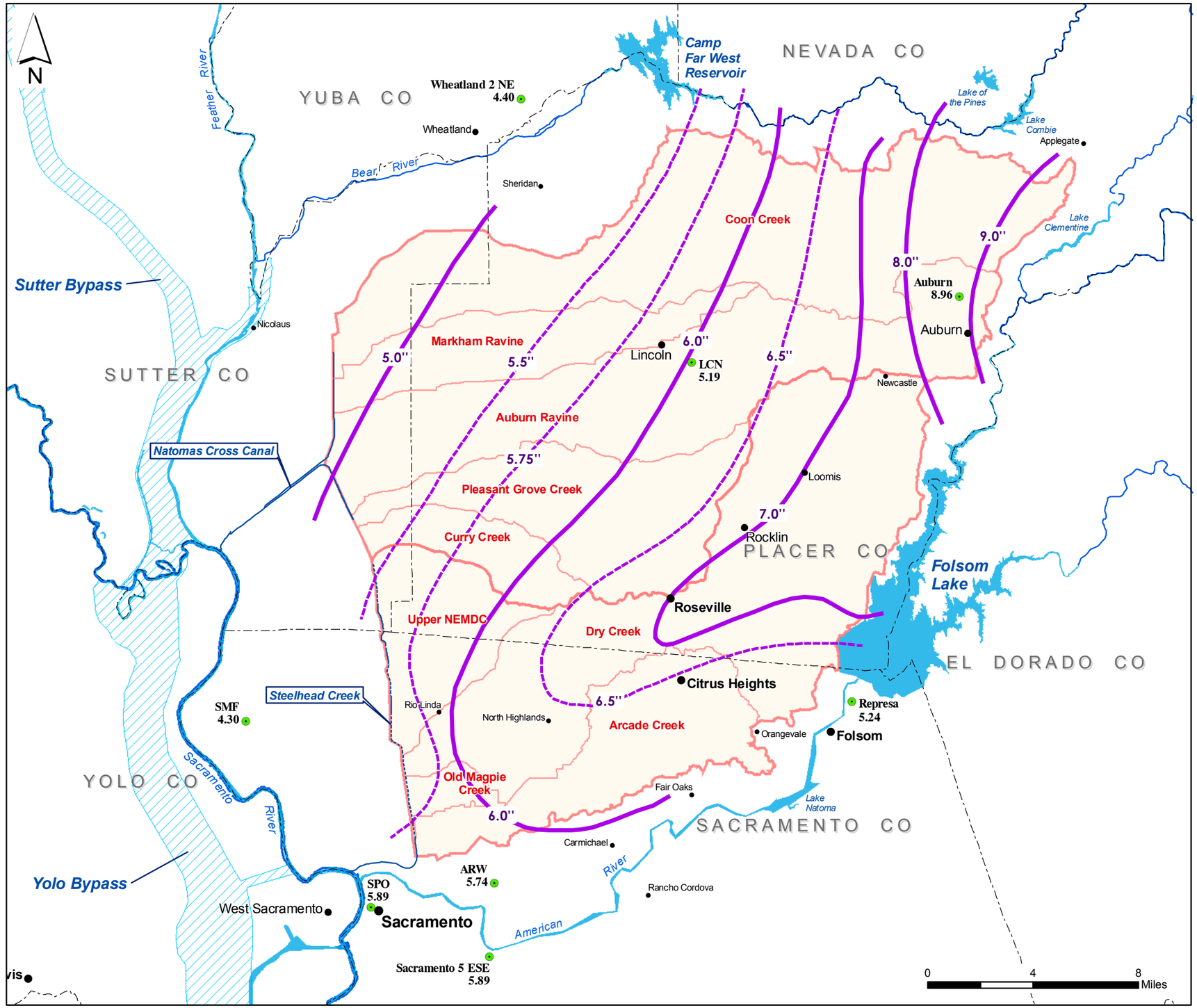
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

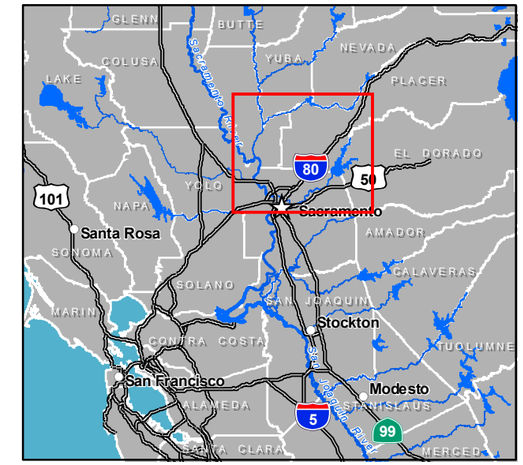
ISOHYETAL MAP FOR EVENT STORM
15 FEB - 19 FEB 1986

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 6





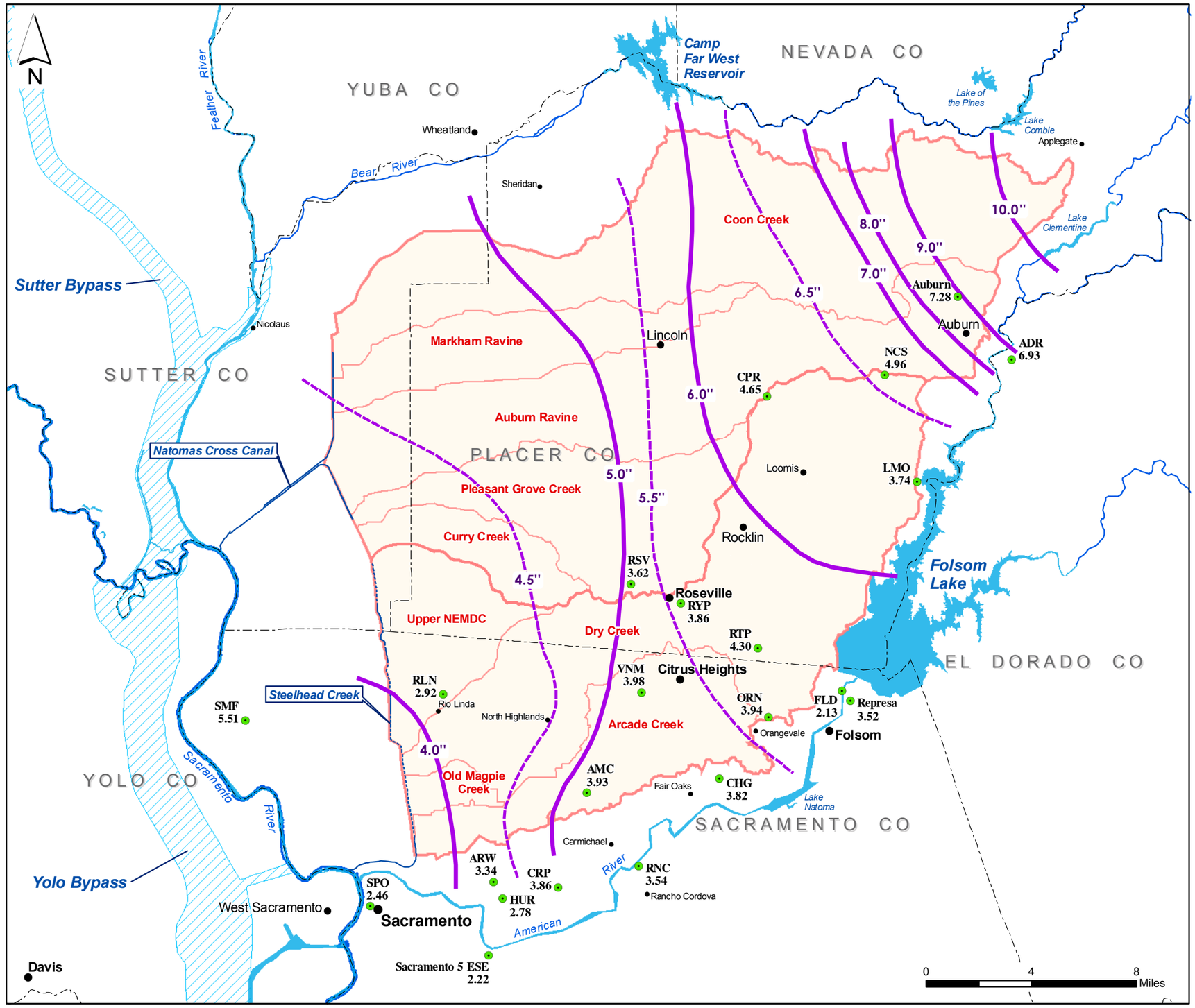
Legend

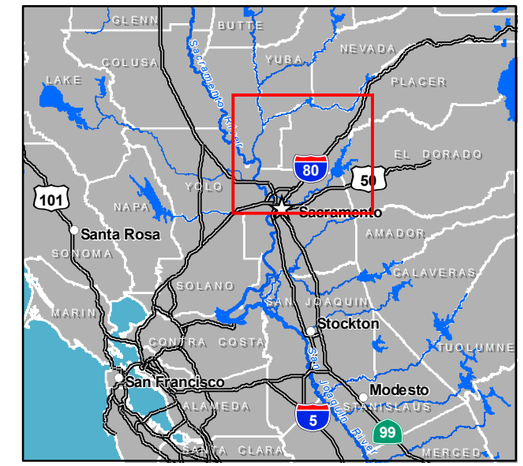
- Precip Gage (Event Total in inches)
- Isohyet
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- County Boundary
- City or Town

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





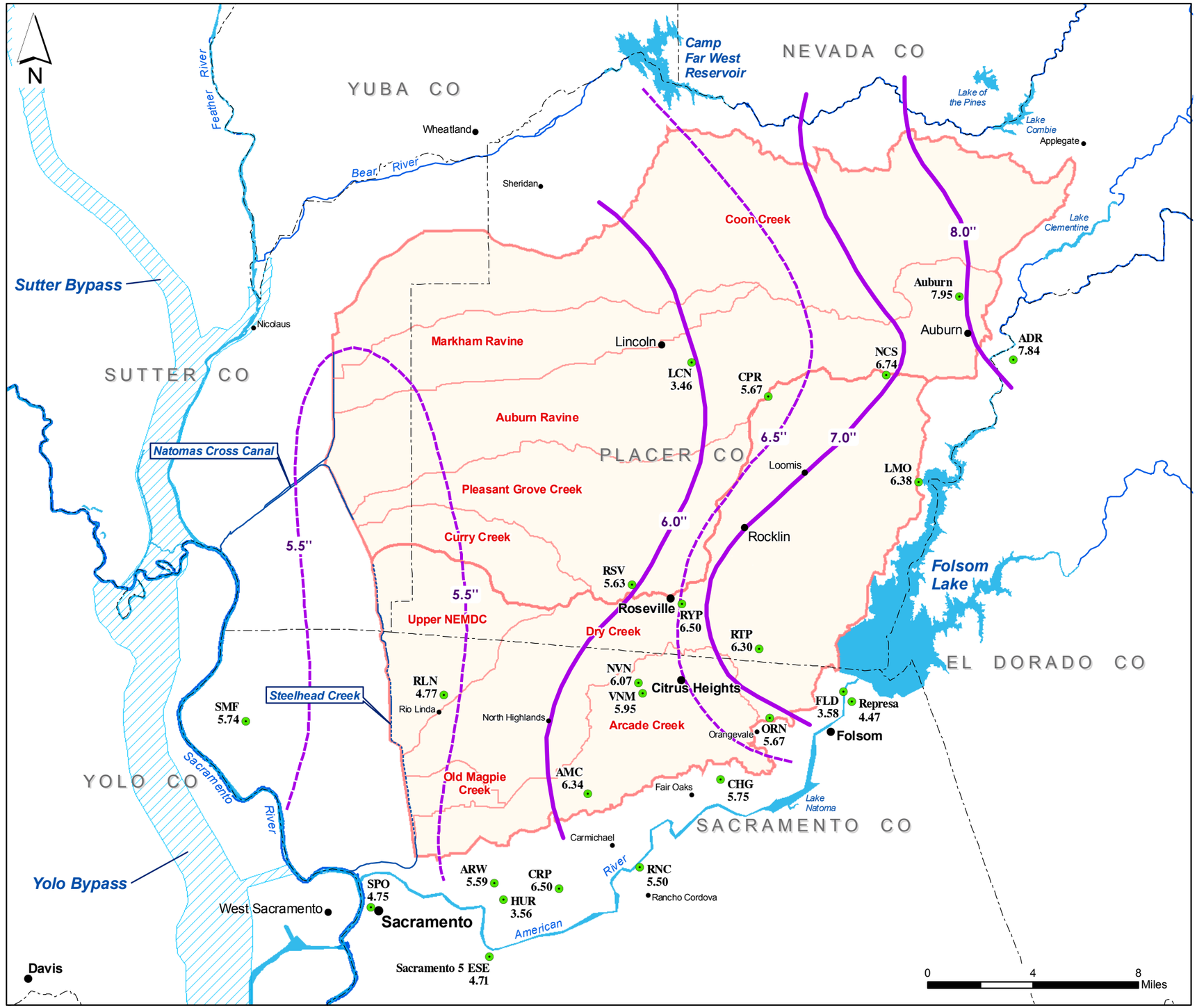
Legend

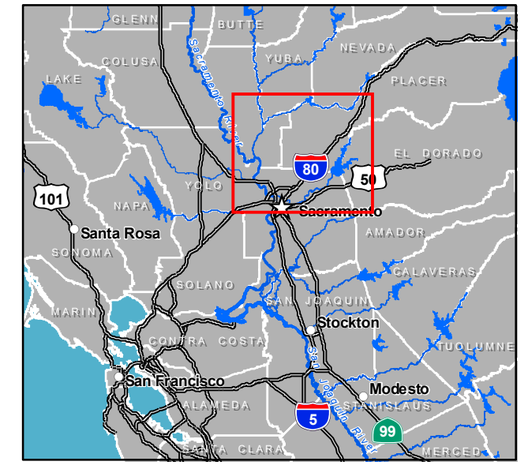
- Precip Gage (Event Total in inches)
- Isohyet
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- County Boundary
- City or Town

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





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

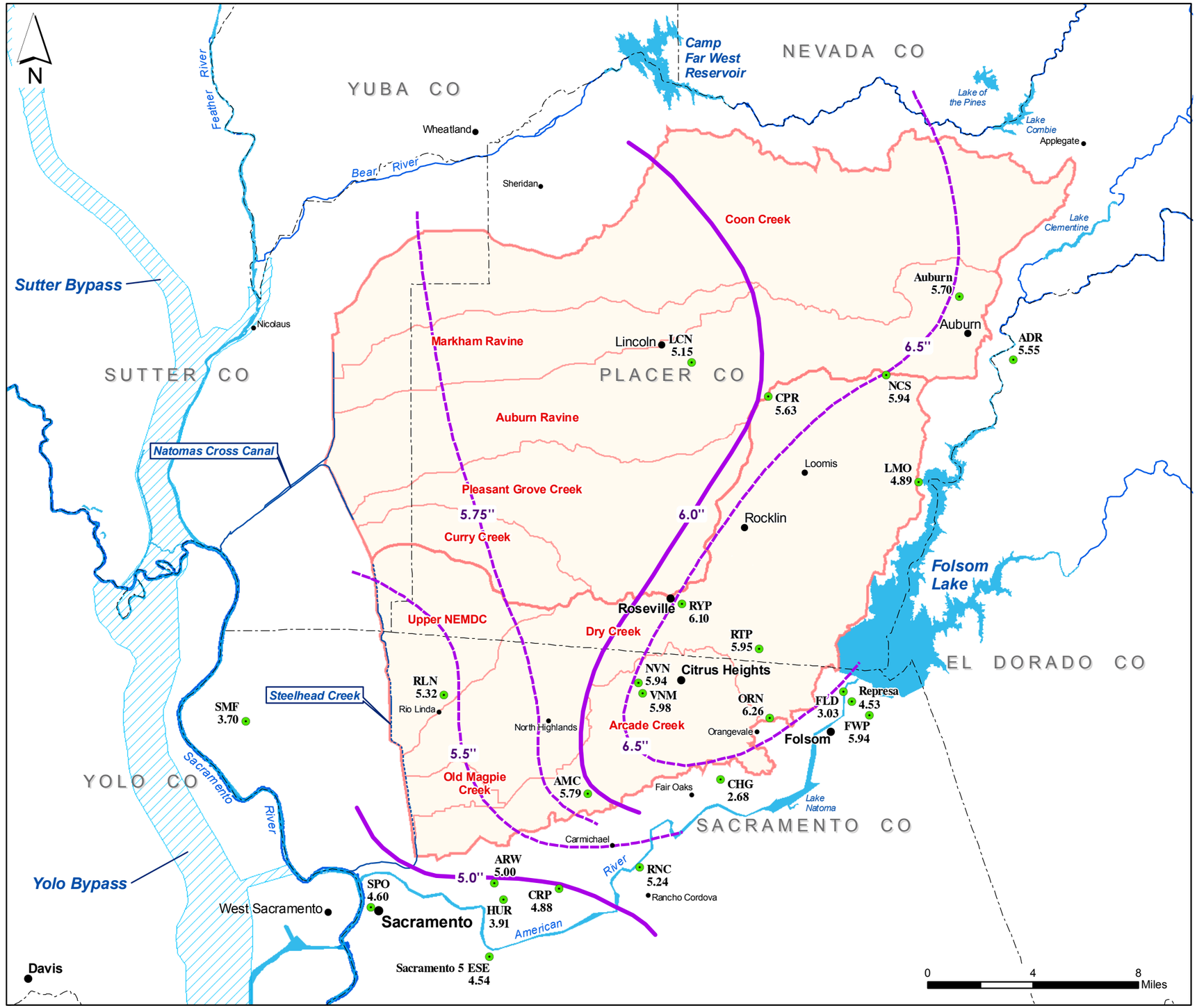
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

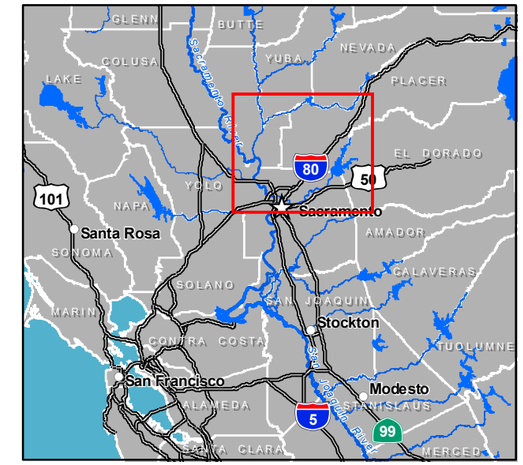
ISOHYETAL MAP FOR EVENT STORM
22 JAN - 26 JAN 1997

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

SEP 2008

PLATE 9





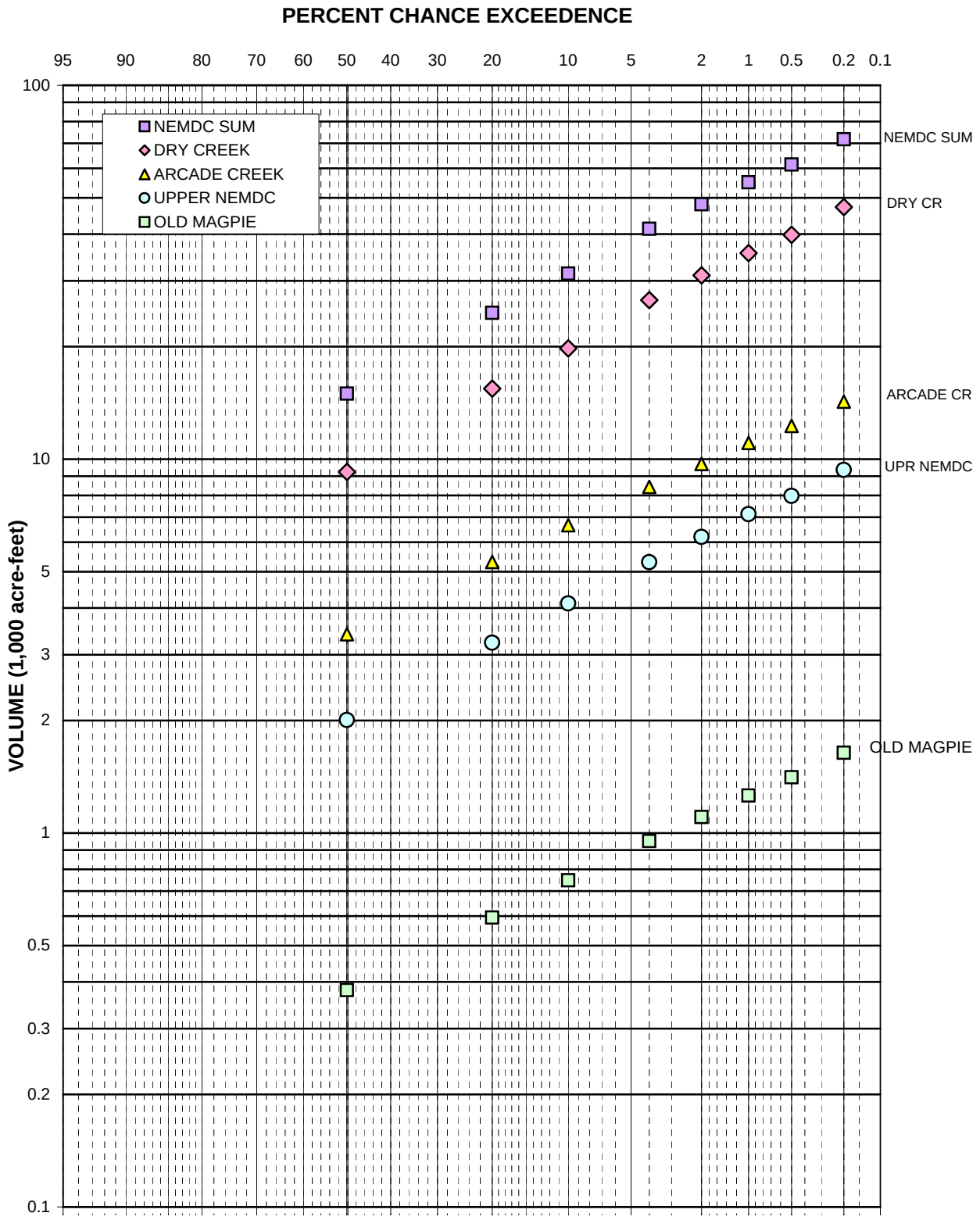
Legend

- Precip Gage (Event Total in inches)
- Isohyet
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- County Boundary
- City or Town

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



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.

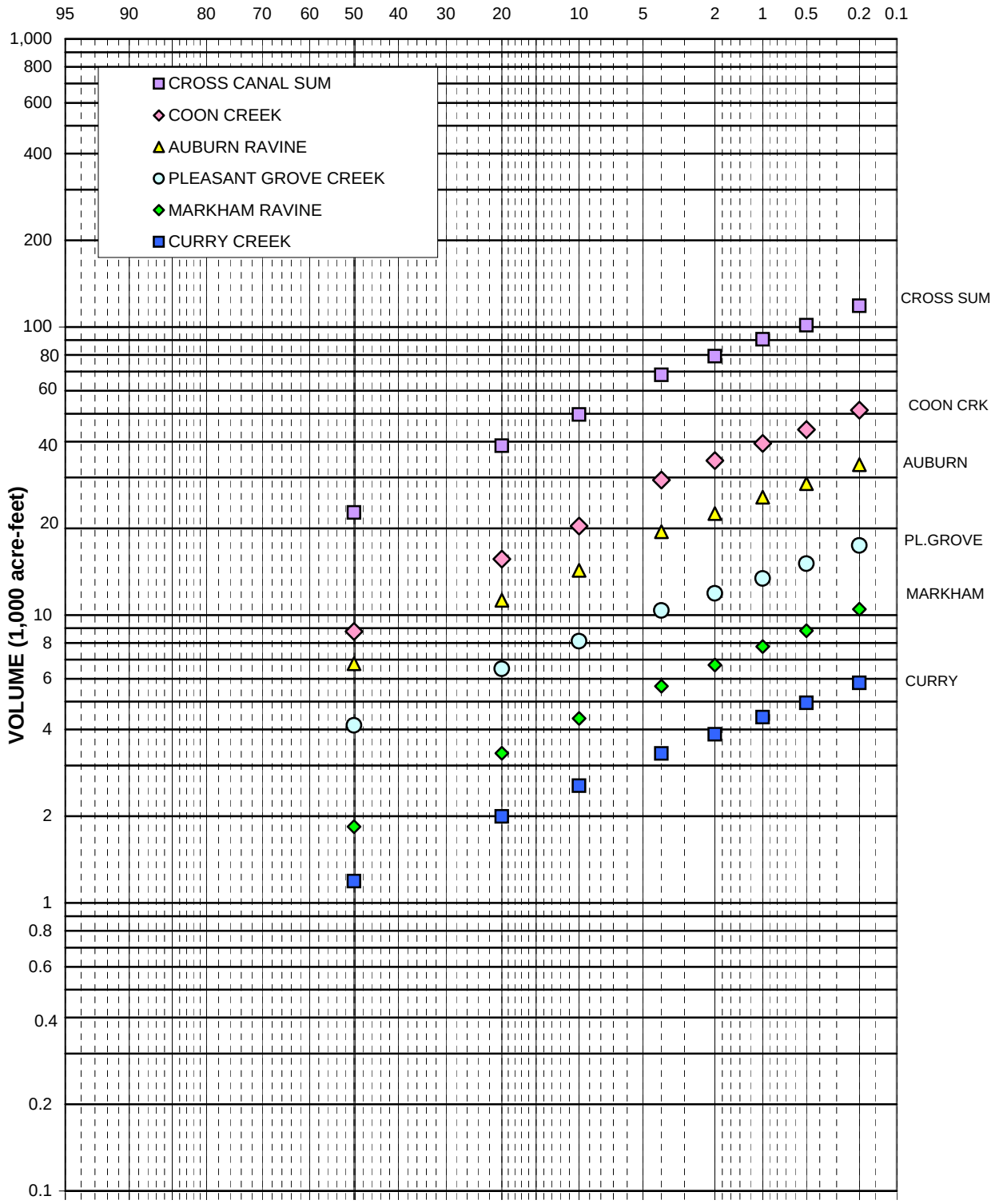
NEMDC Sum 188.32 sq. mi.

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

Developed by LLW and prepared by JLB



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.

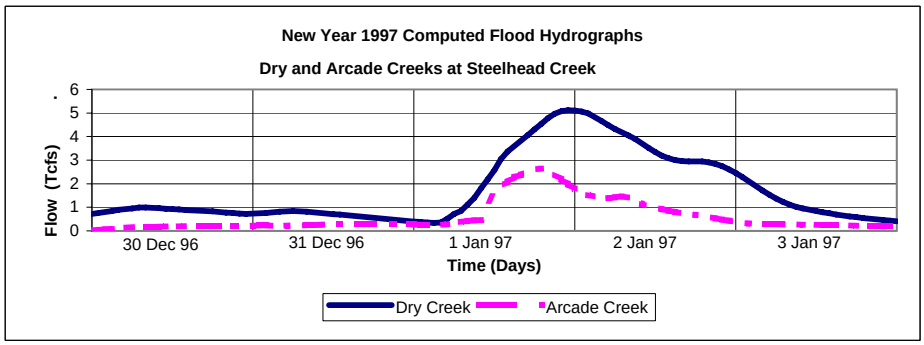
Cross Canal Sum 288.22 sq. mi.

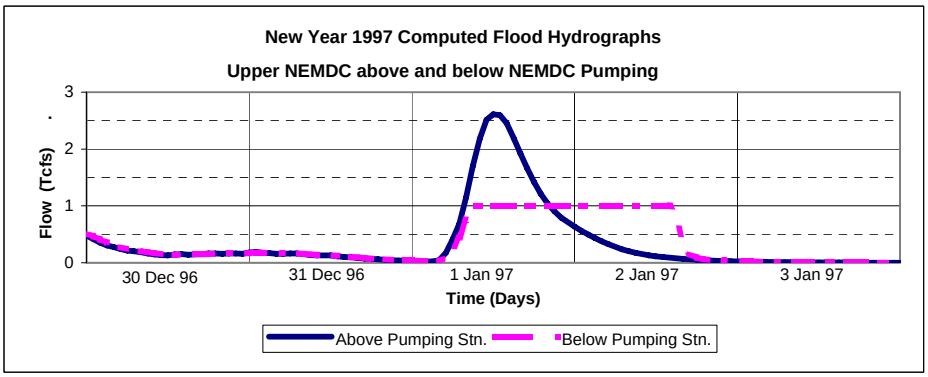
Developed by LLW and prepared by JLB

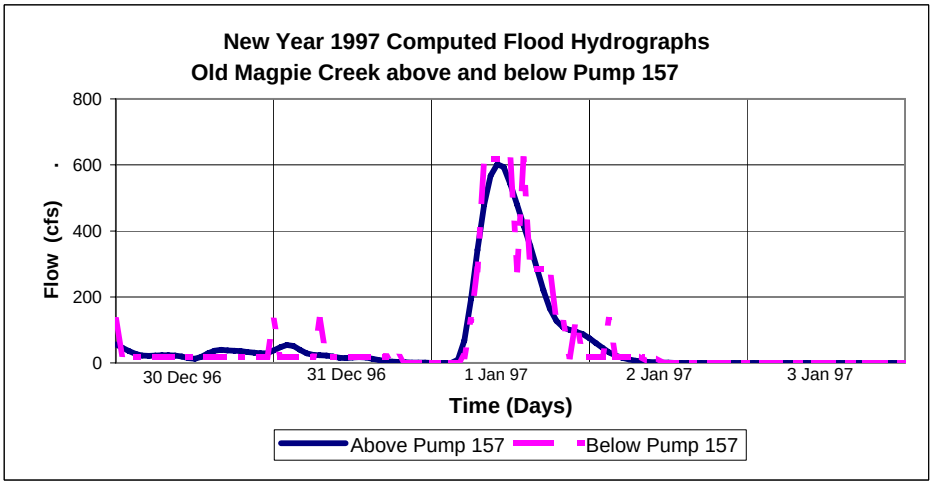
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

5-DAY VOLUME FREQUENCY CURVES CROSS CANAL TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



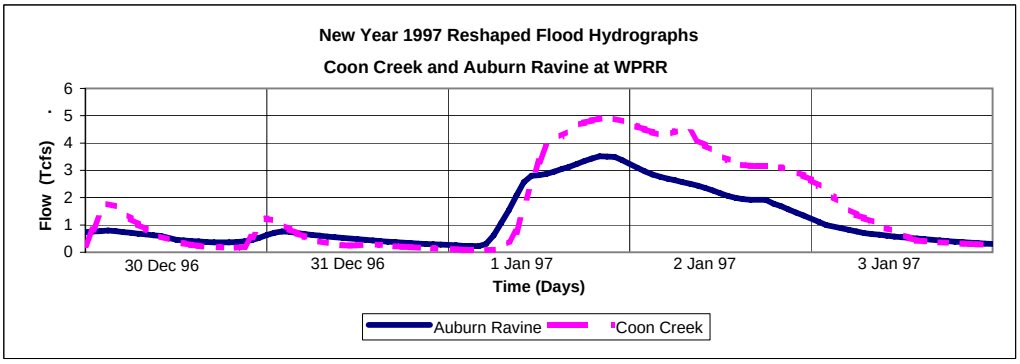


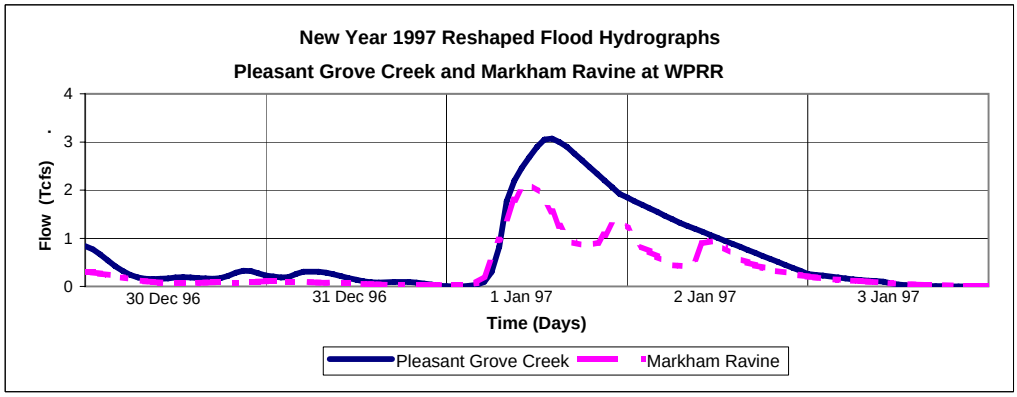


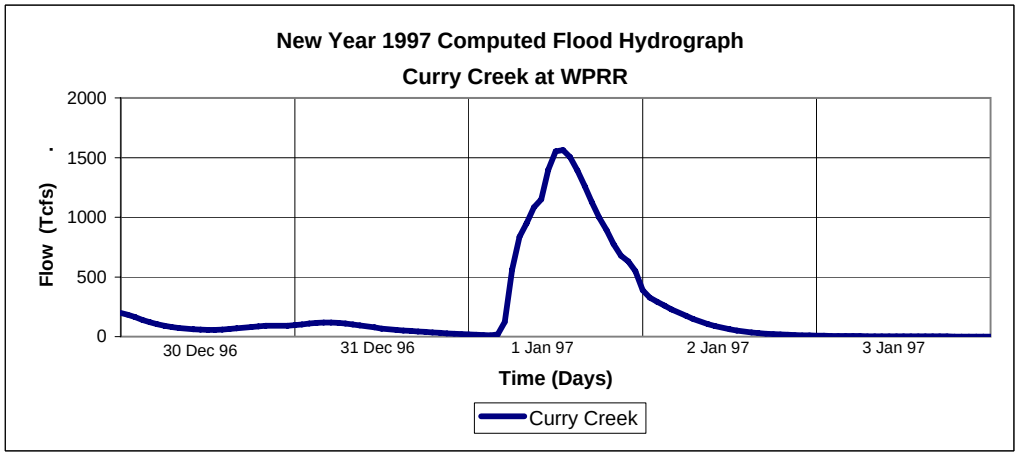
AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT STEELHEAD CREEK TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



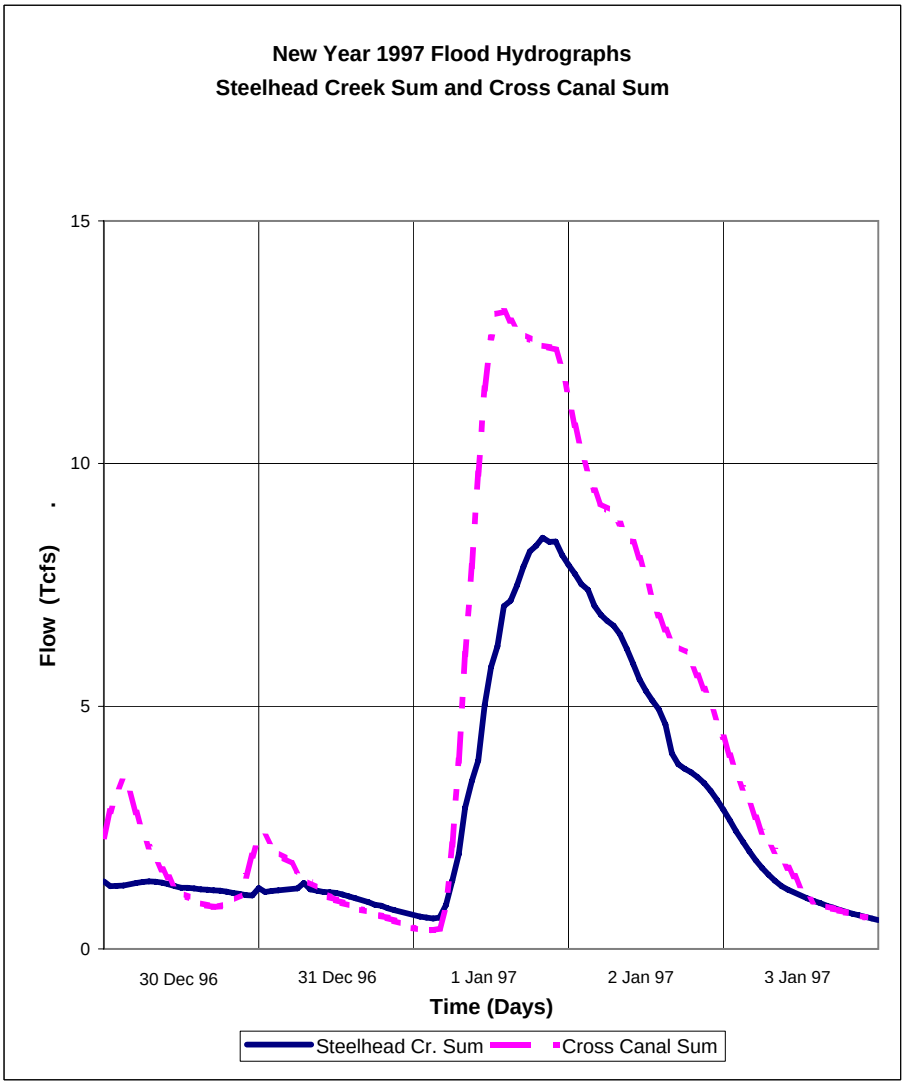




AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CALIFORNIA

COMPUTED AND RESHAPED HYDROGRAPHS FOR FOR NEW YEAR 1997 FLOOD EVENT NATOMAS CROSS CANAL TRIBUTARIES

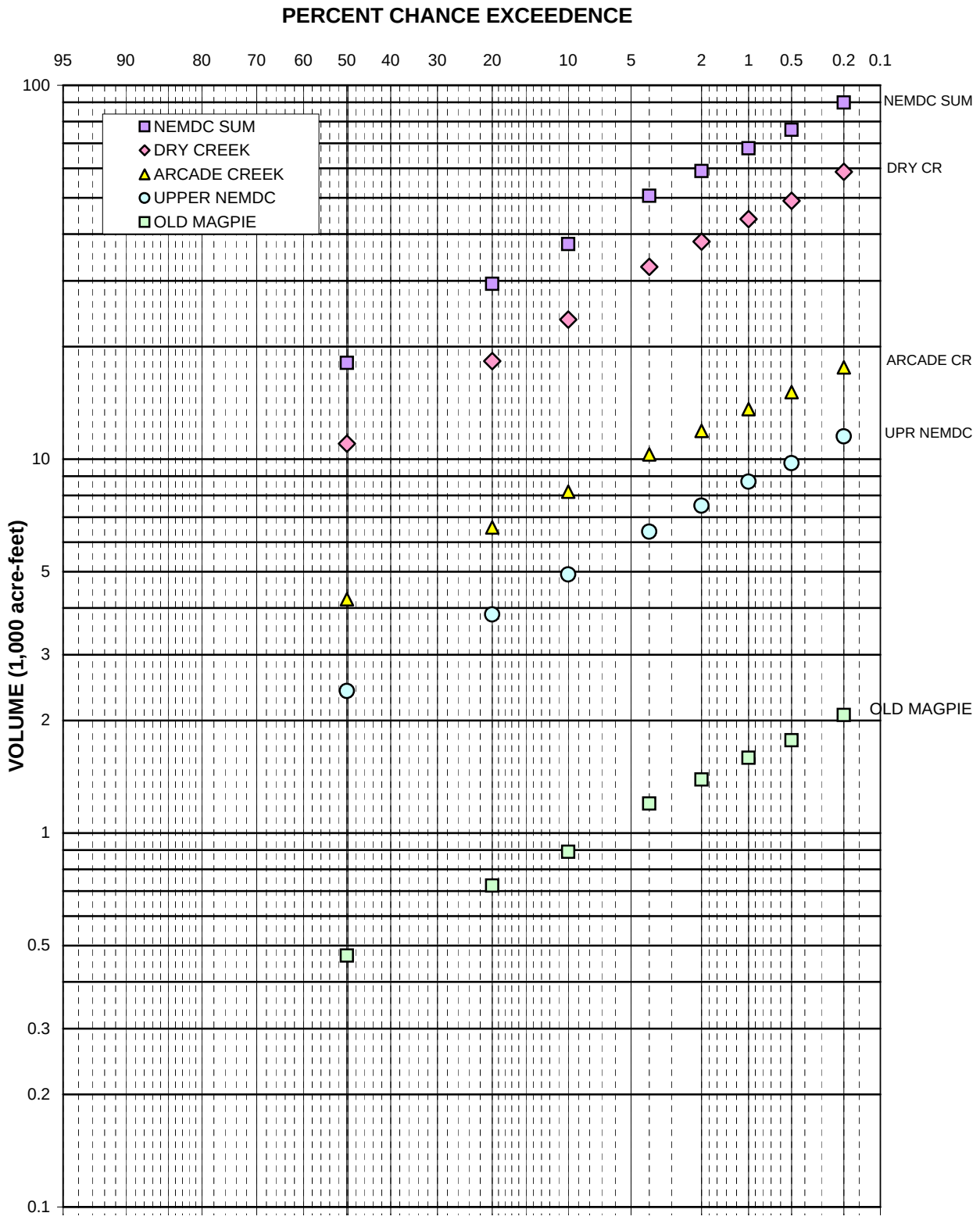
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



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.

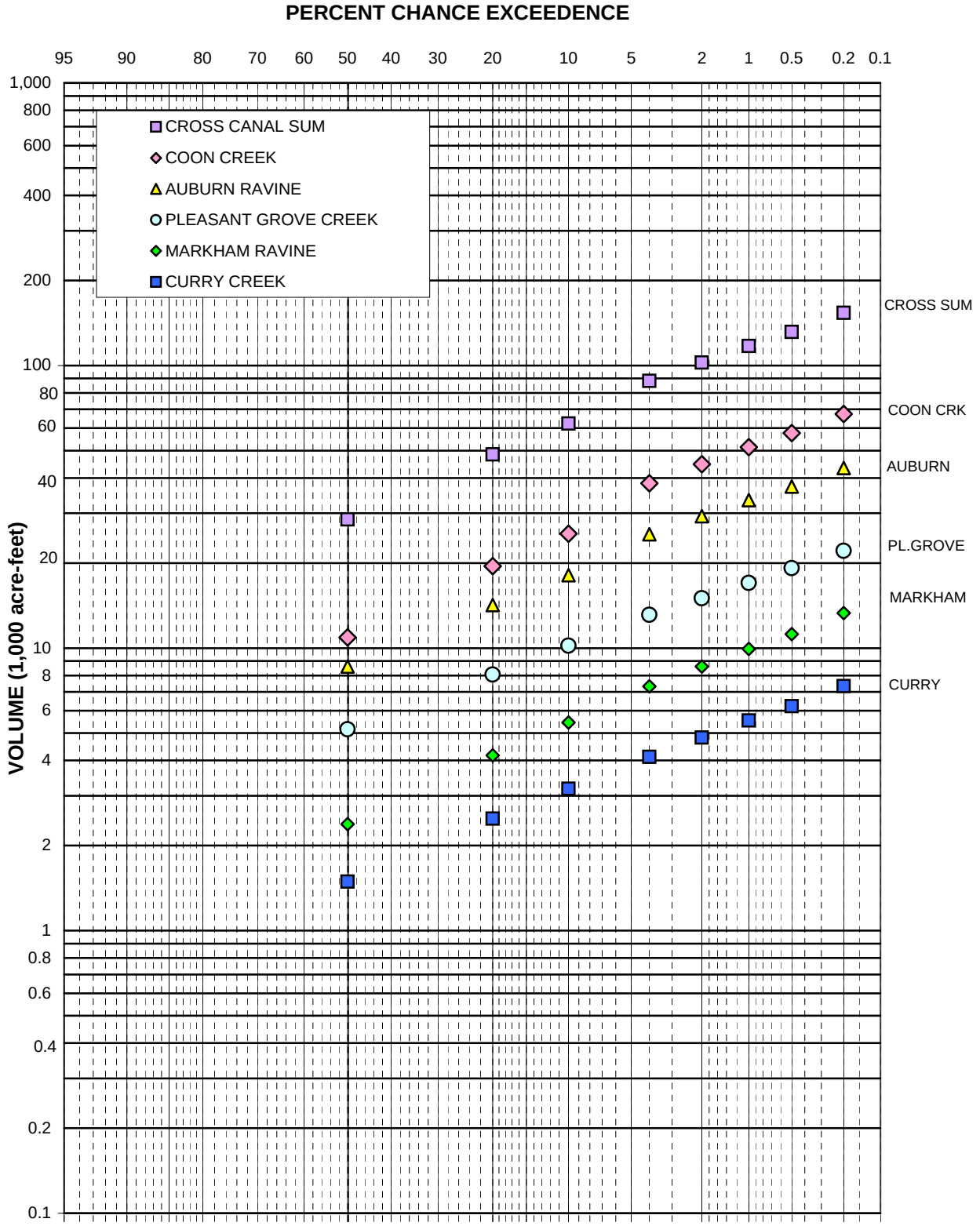
NEMDC Sum 188.32 sq. mi.

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

Developed by LLW and prepared by JLB



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Pleasant Grove Creek 46.69 sq. mi.

Markham Ravine 32.36 sq. mi.

Curry Creek 16.59 sq. mi.

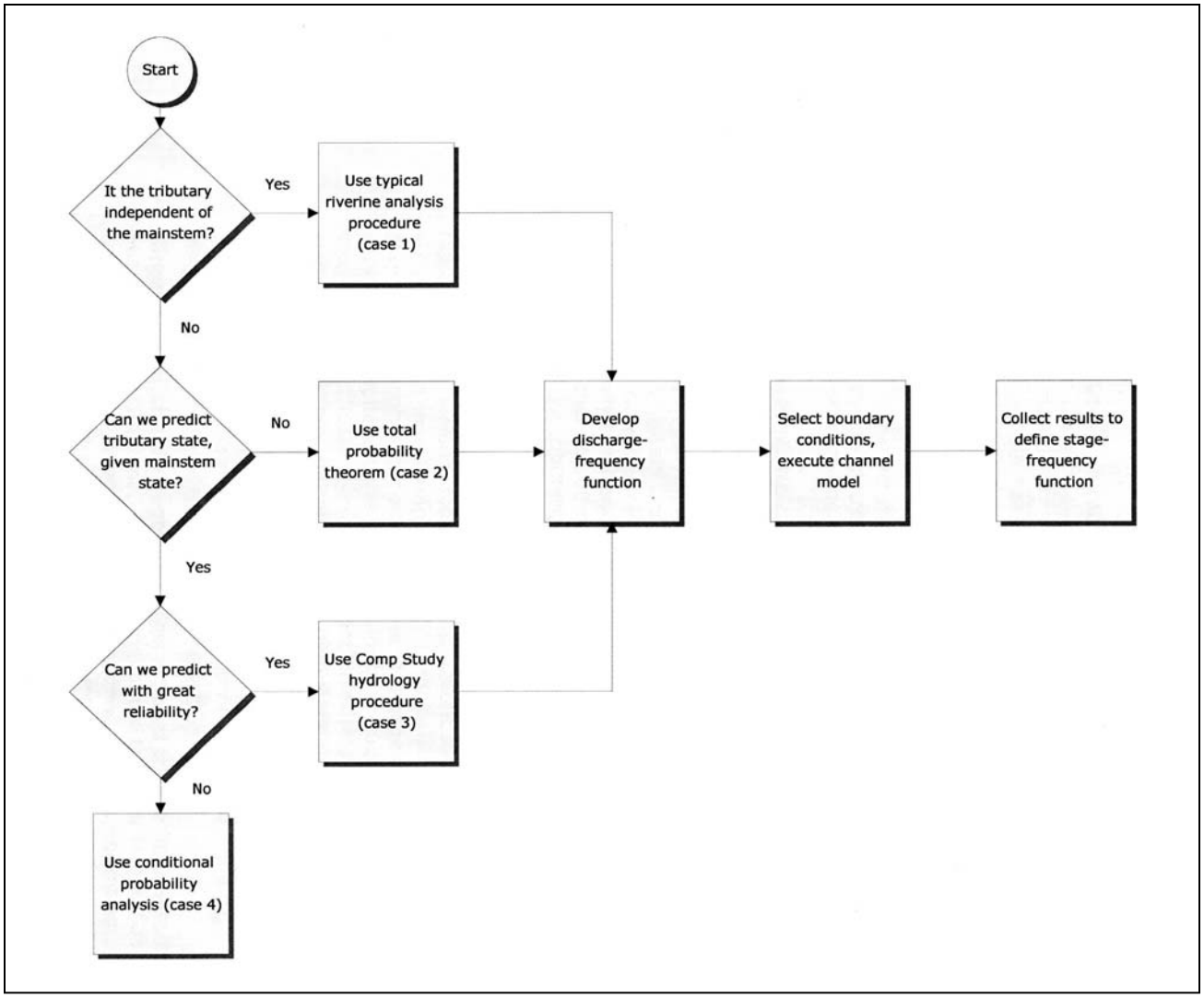
Cross Canal Sum 288.22 sq. mi.

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



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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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.

Longer duration hydrographs (more than 3-days) are utilized in the modeling because:

a) Atmospheric rivers tend to produce 3 - 5 day precipitation waves in this region
b) After a levee break, the large, flat floodplain areas in the Sacramento area may take more than 3 days to fill
c) More than 3 days must be simulated to account for timing between the larger Sacramento River and smaller American River.

Critical duration is the most challenging volume to the safe operation of the project to protect downstream. The maximum storage (filling of the reservoir) and maximum downstream discharge occurs during the maximum 3-day unregulated inflow, rather than after that period. While critical duration is described as the 3-day, the Folsom Dam inflow hydrographs are actually balanced to multiple durations (including the critical 3-day volume). The hydrograph is balanced to all durations shown in Table A-1 (page B2-4) which includes the peak, 1-, 3-, 7-, 15-, and 30-day durations.

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.

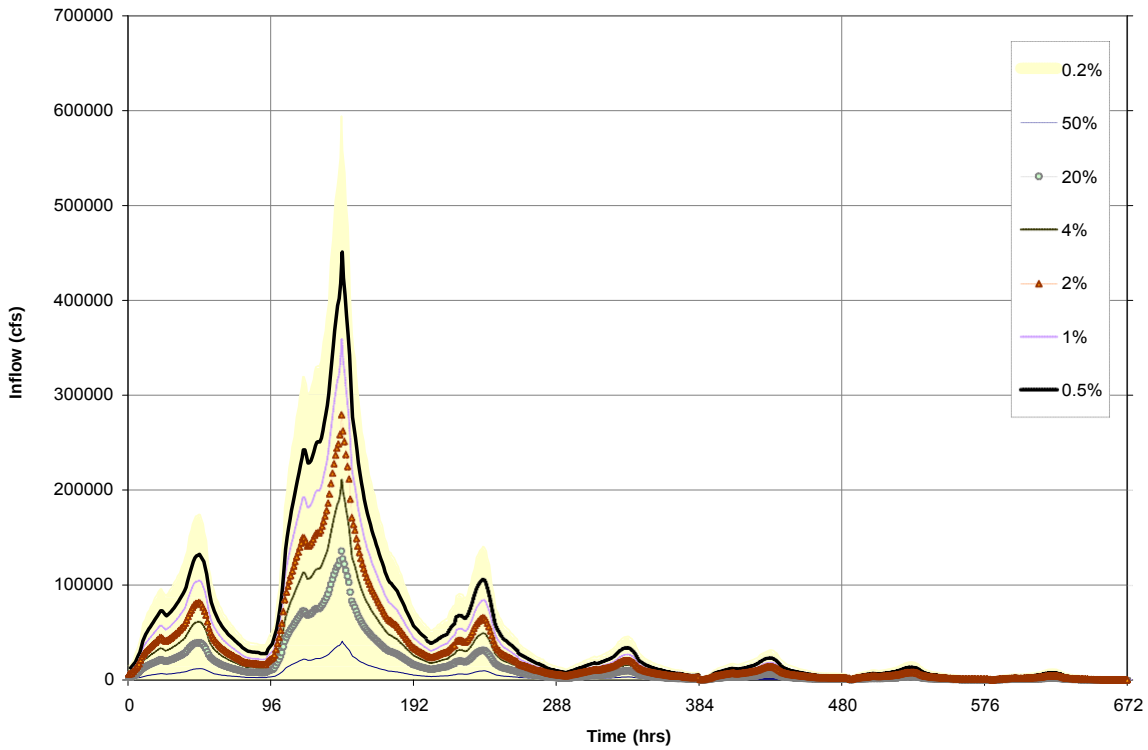

FIGURE A-1
FLOOD HYDROGRAPHS

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)**.

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. All together, 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 ŦŦ

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:

ŦŦ *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

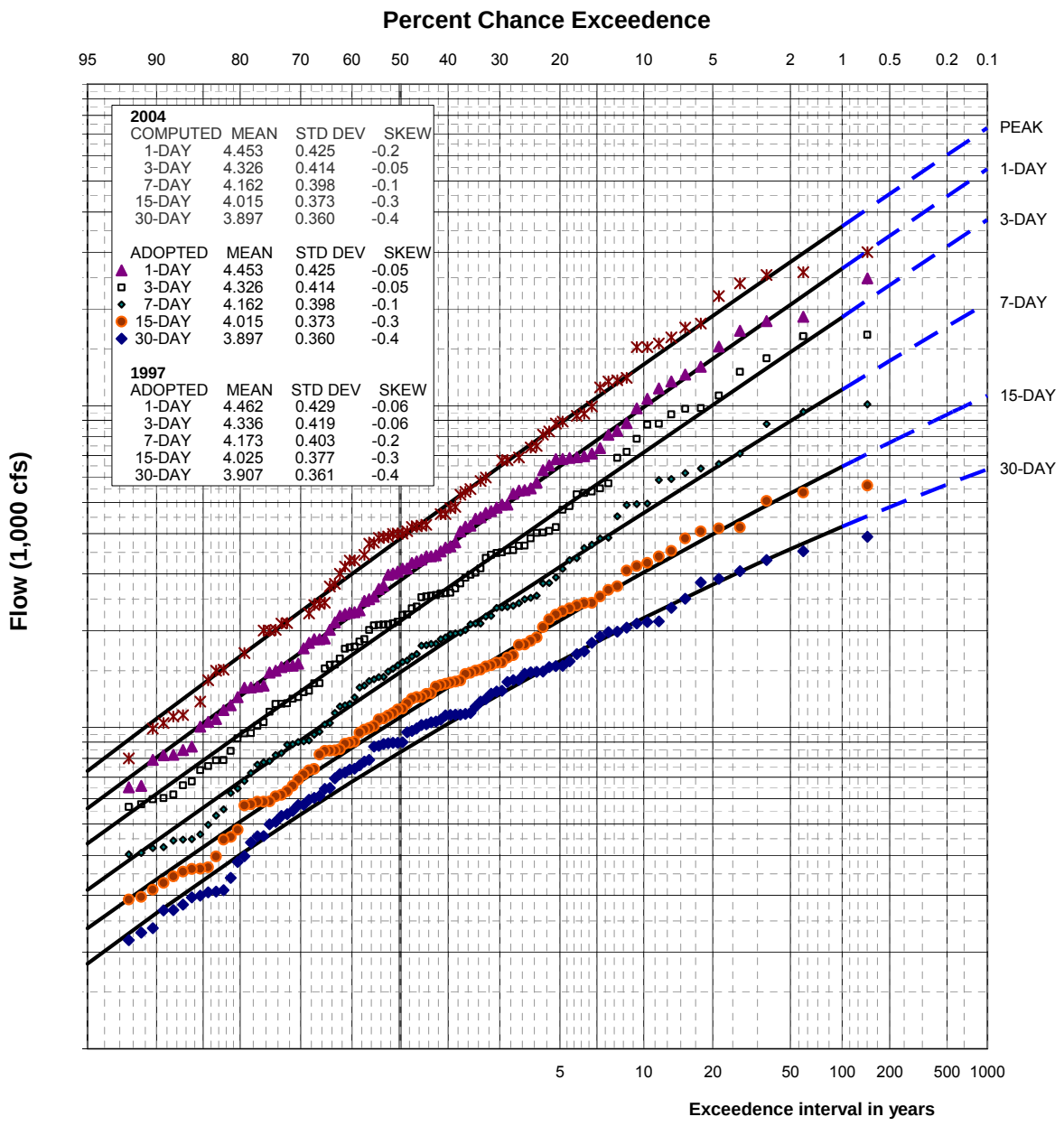
KEY
Cfs – cubic feet per second

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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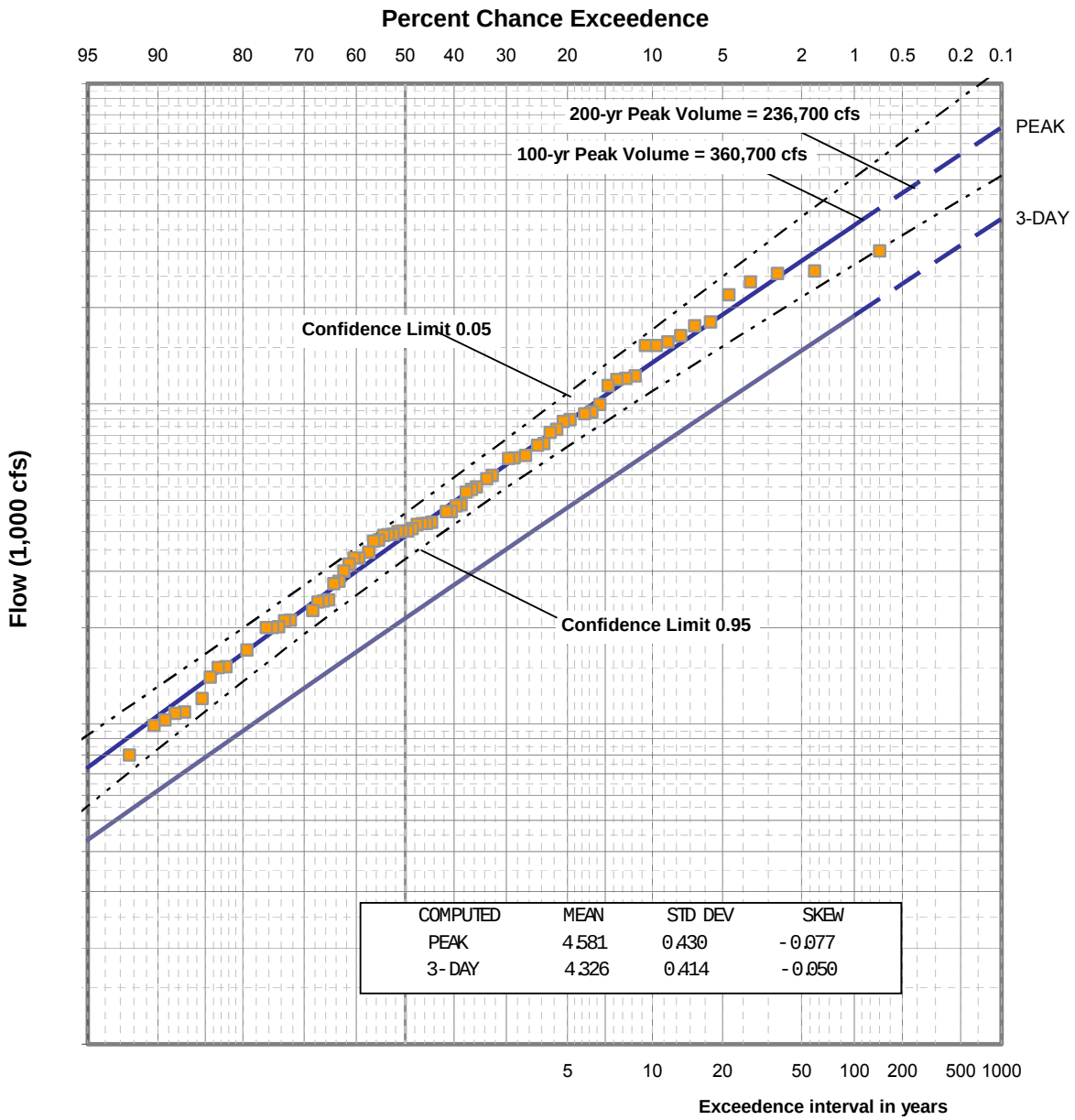

NOTES:

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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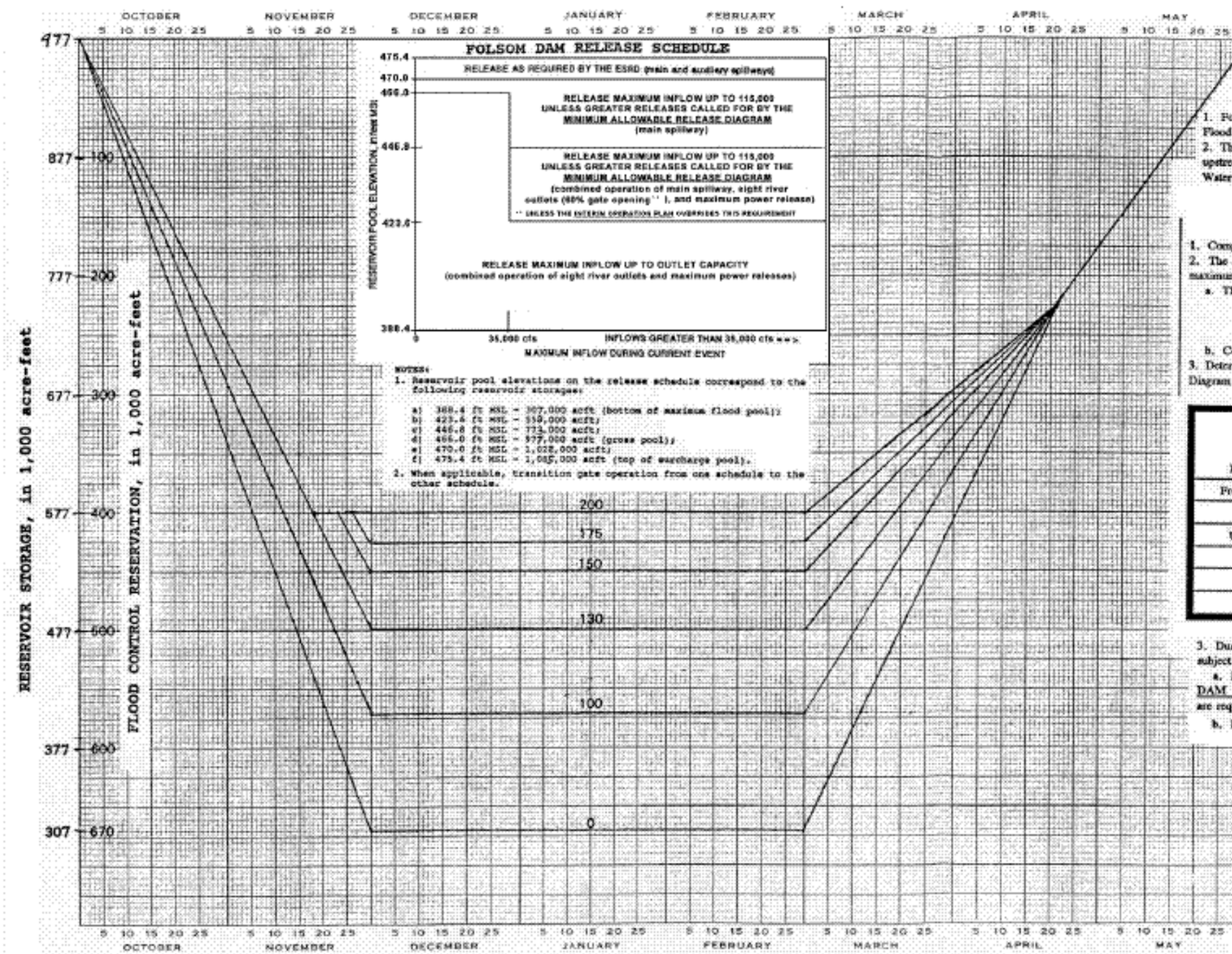

FLOOD CONTROL DIAGRAM FOR FOLSOM DAM AND LAKE

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 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 **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.

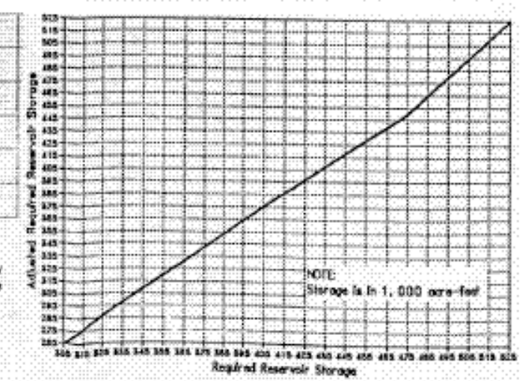

FIGURE A-4
WATER CONTROL DIAGRAM -- HISTORICAL
EXISTING CONDITION 400/670

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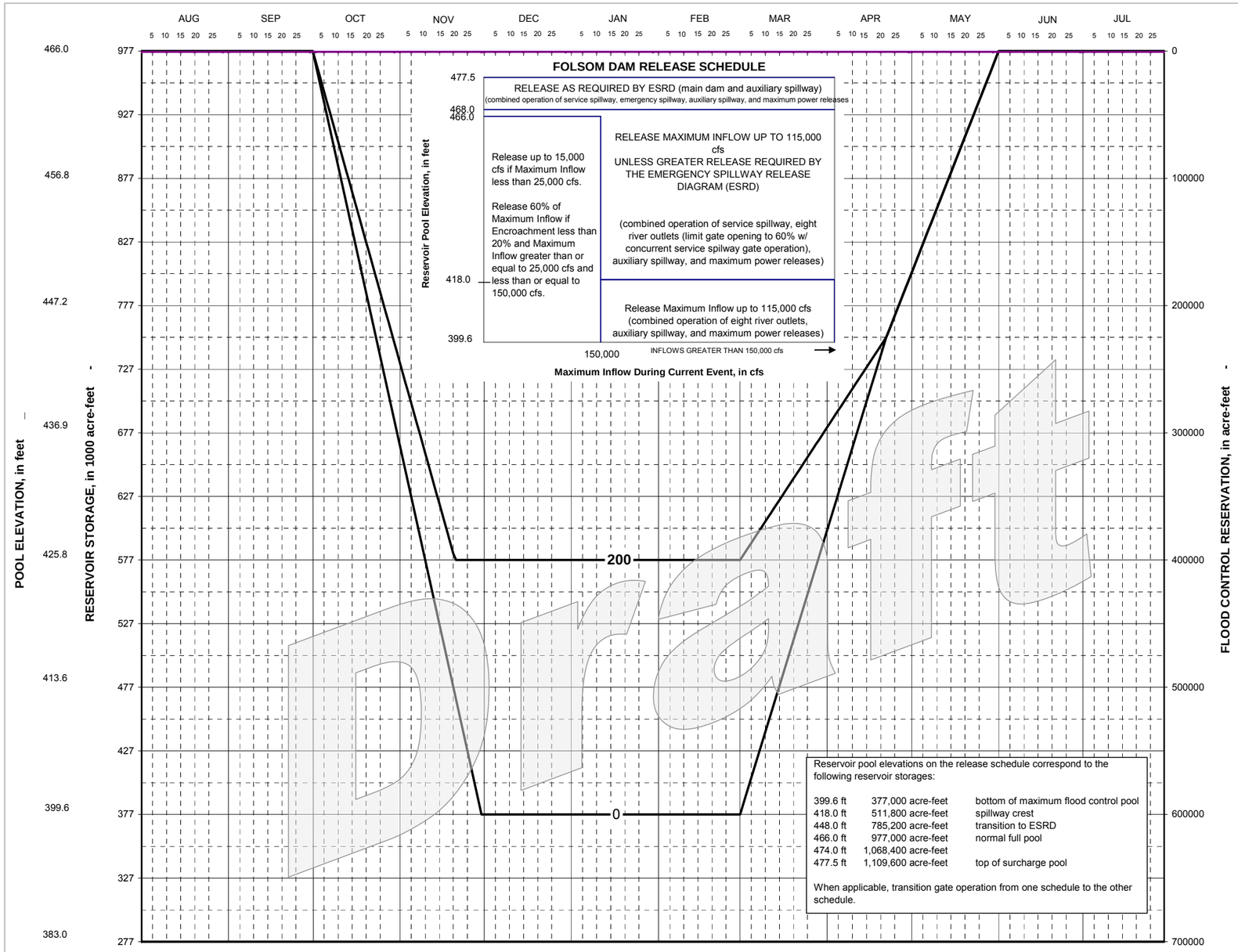

FLOOD CONTROL DIAGRAM

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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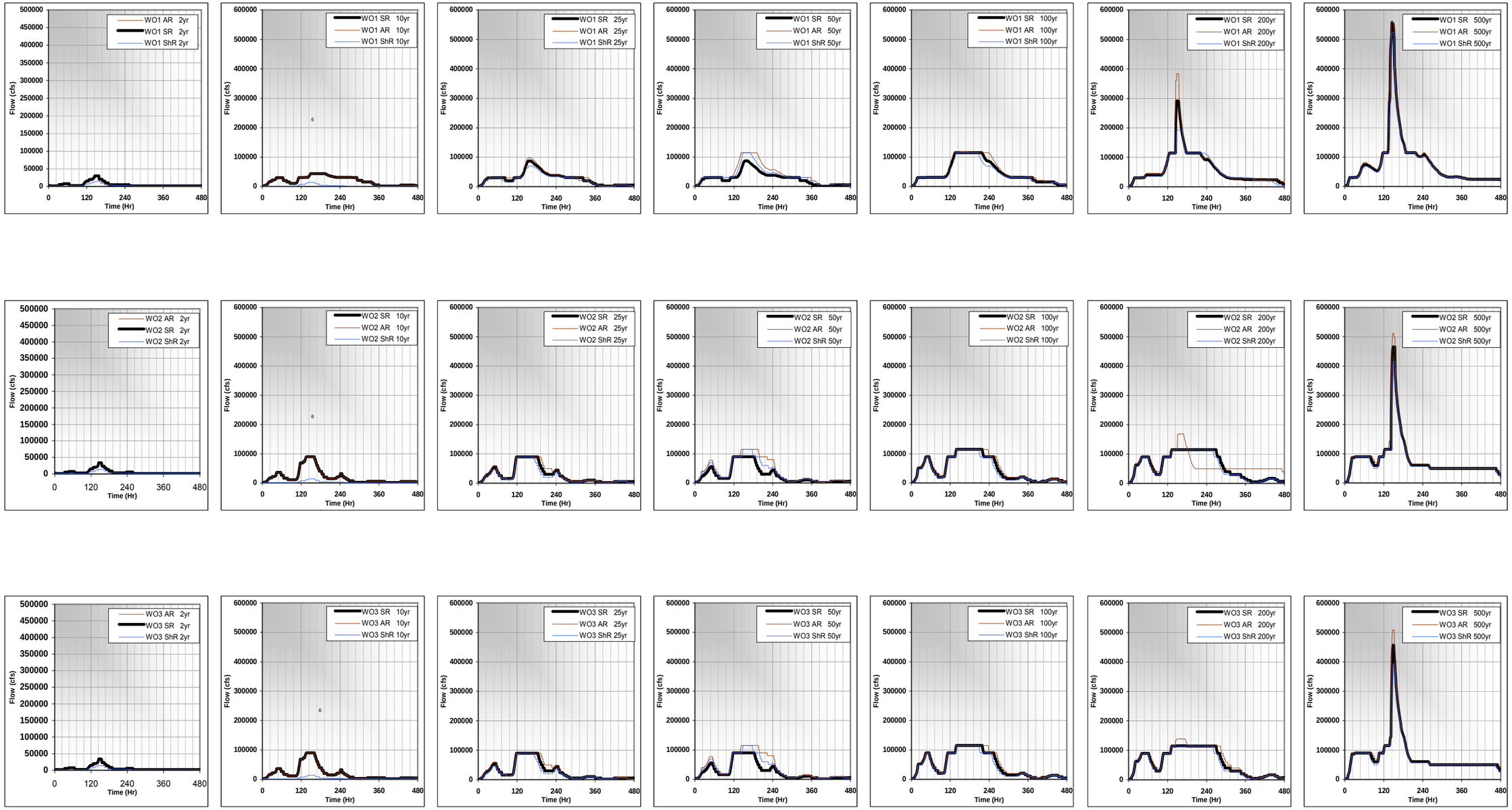

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-8: DISCHARGE HYDROGRAPHS – BASE – EXISTING CONDITION

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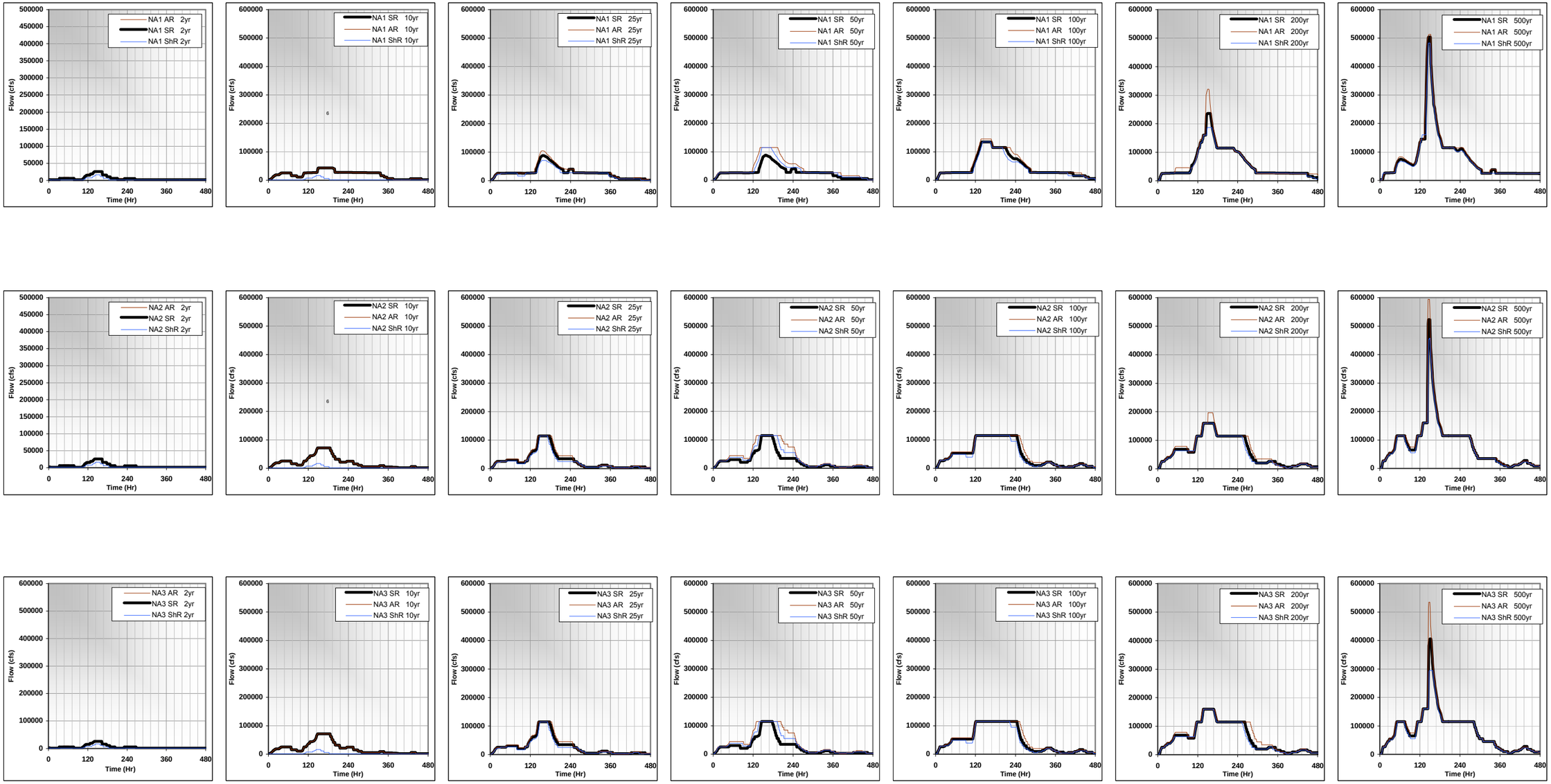

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-9: DISCHARGE HYDROGRAPHS – BASE – FUTURE WITHOUT-PROJECT (NO ACTION)

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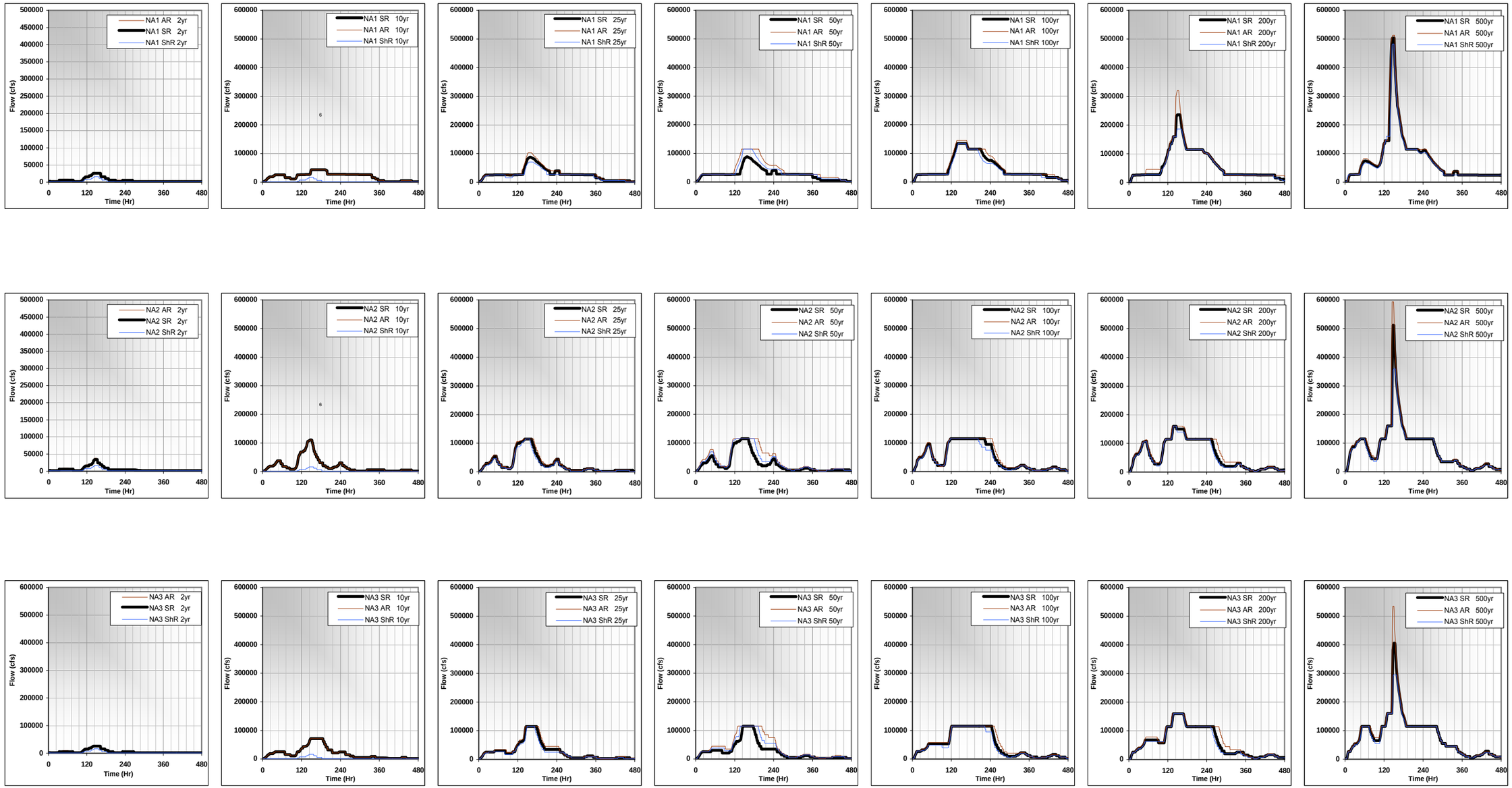

Key

SR Sacramento River
AR American River
ShR Shanghai River

FIGURE A-10: DISCHARGE HYDROGRAPHS – BASE – WITH-PROJECT

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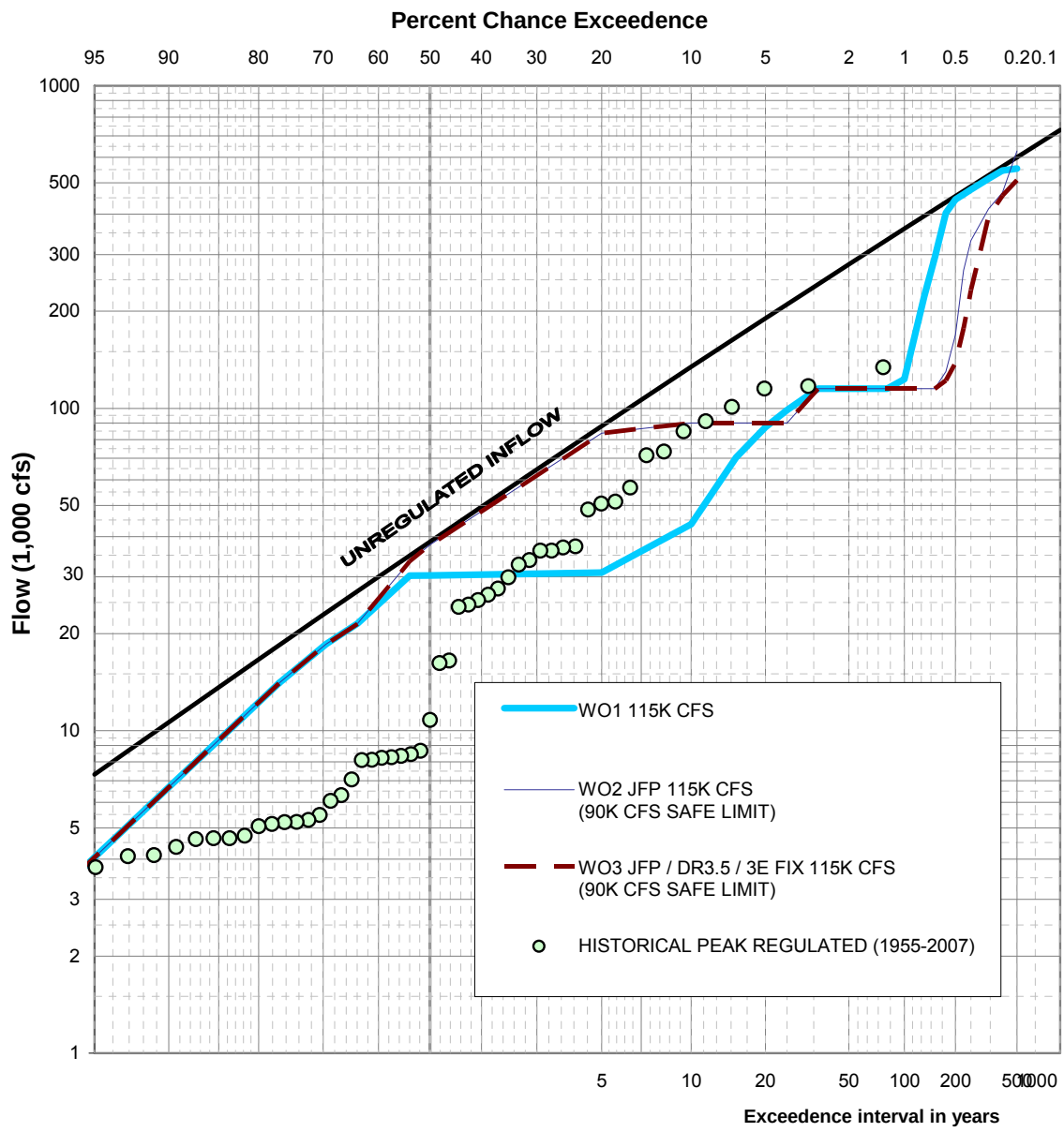

NOTES:

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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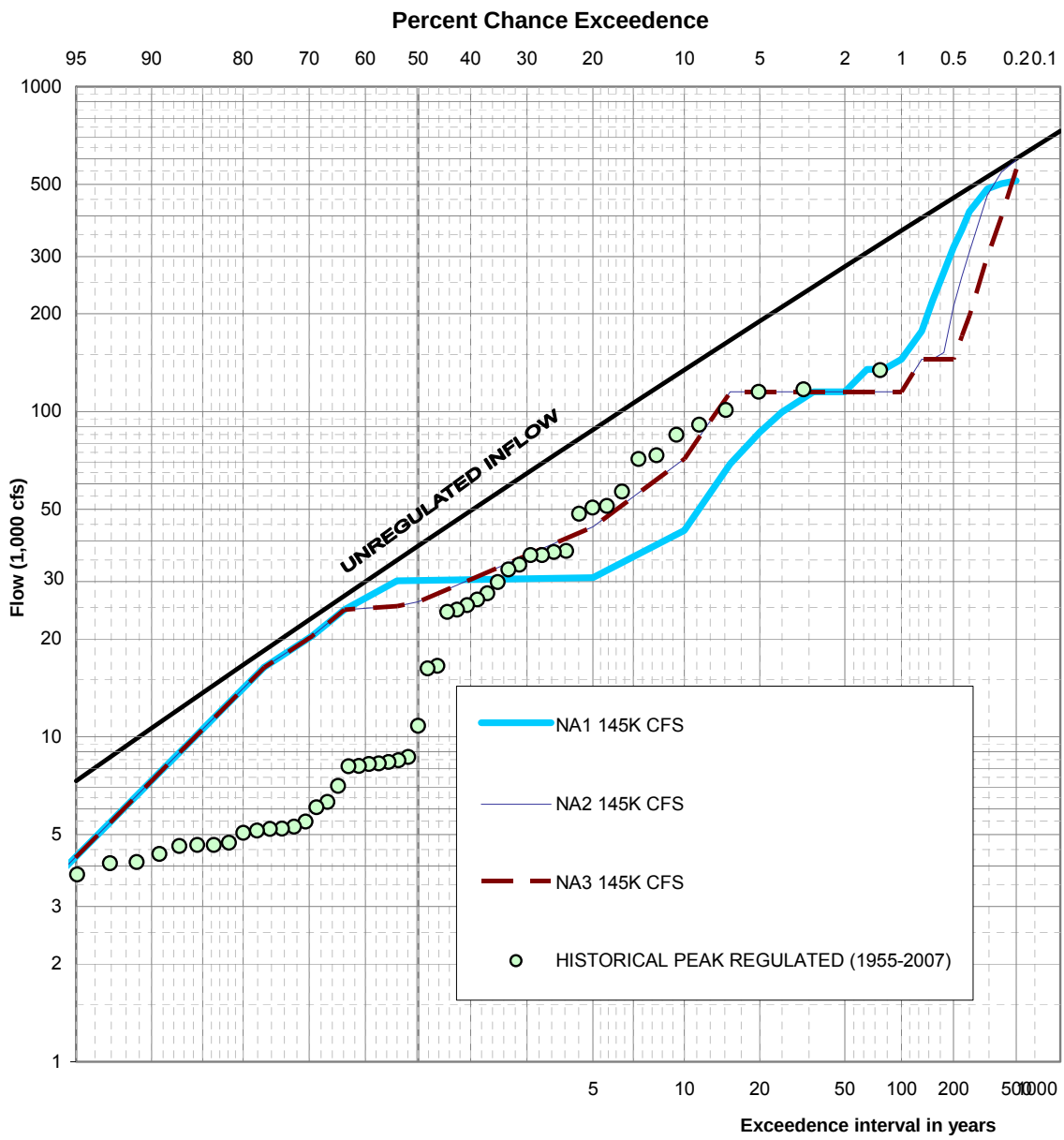

NOTES:

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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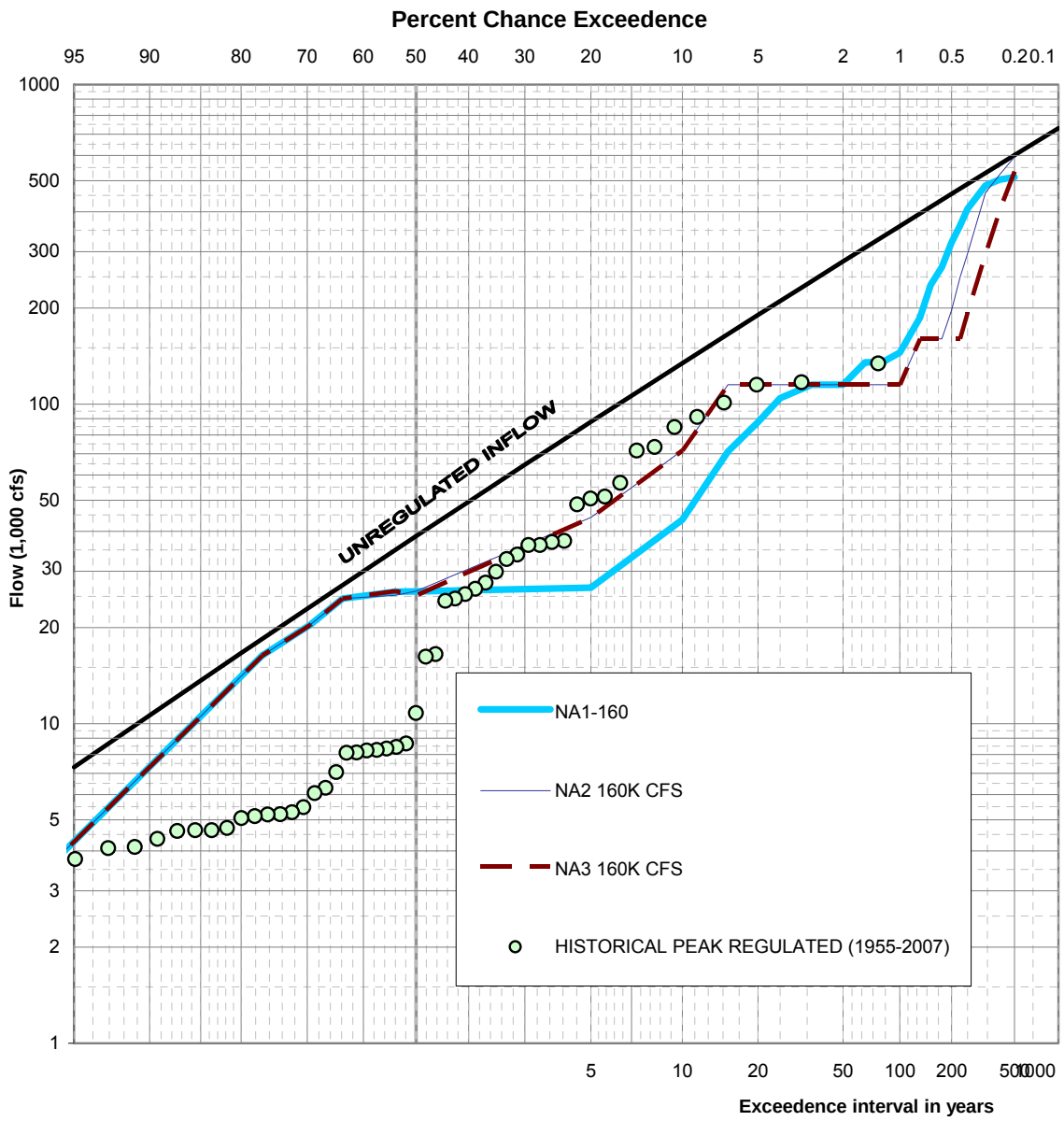

NOTES:

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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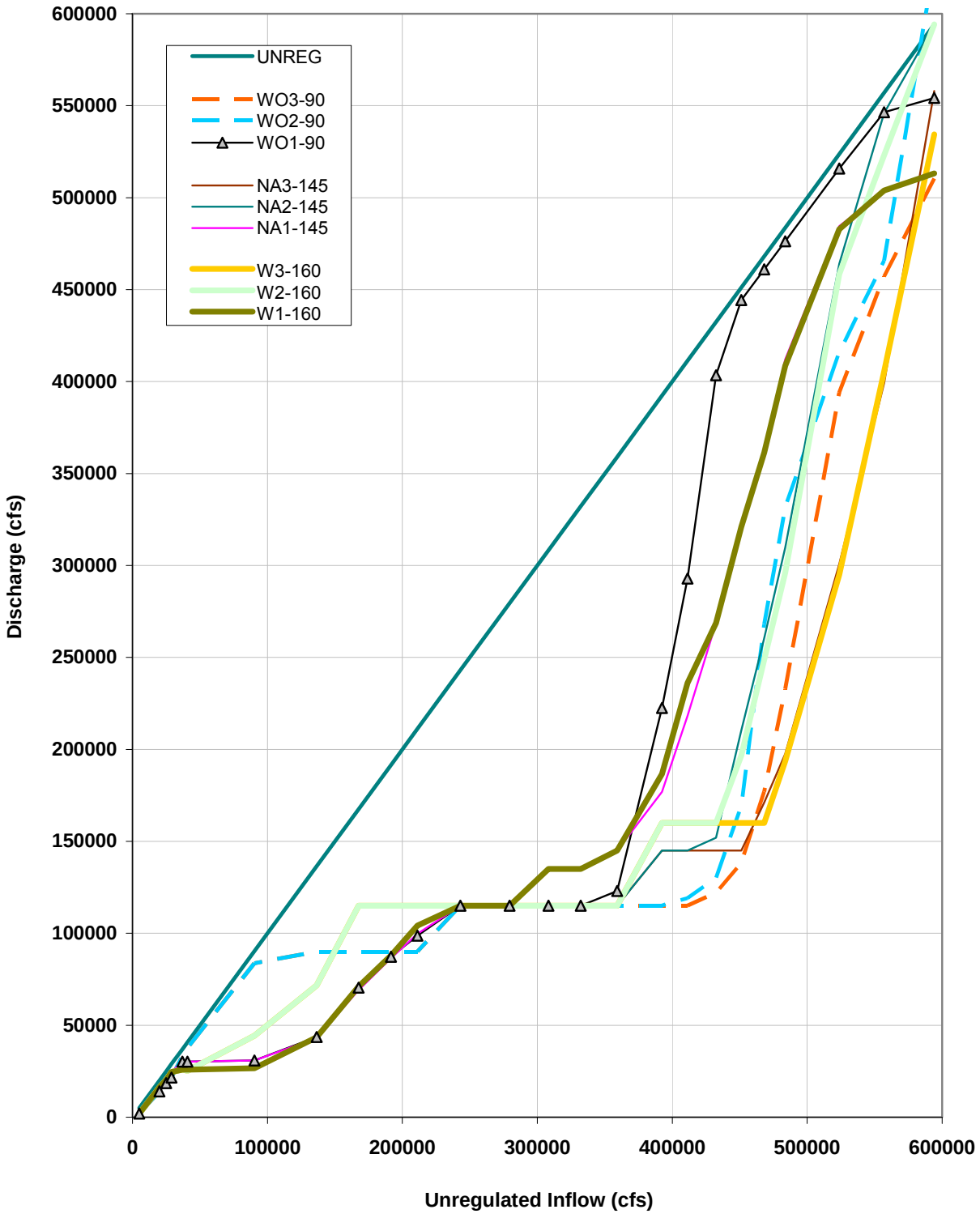

FIGURE A-14: INFLOW-OUTFLOW TRANSFORM – BASE – COMPARISON

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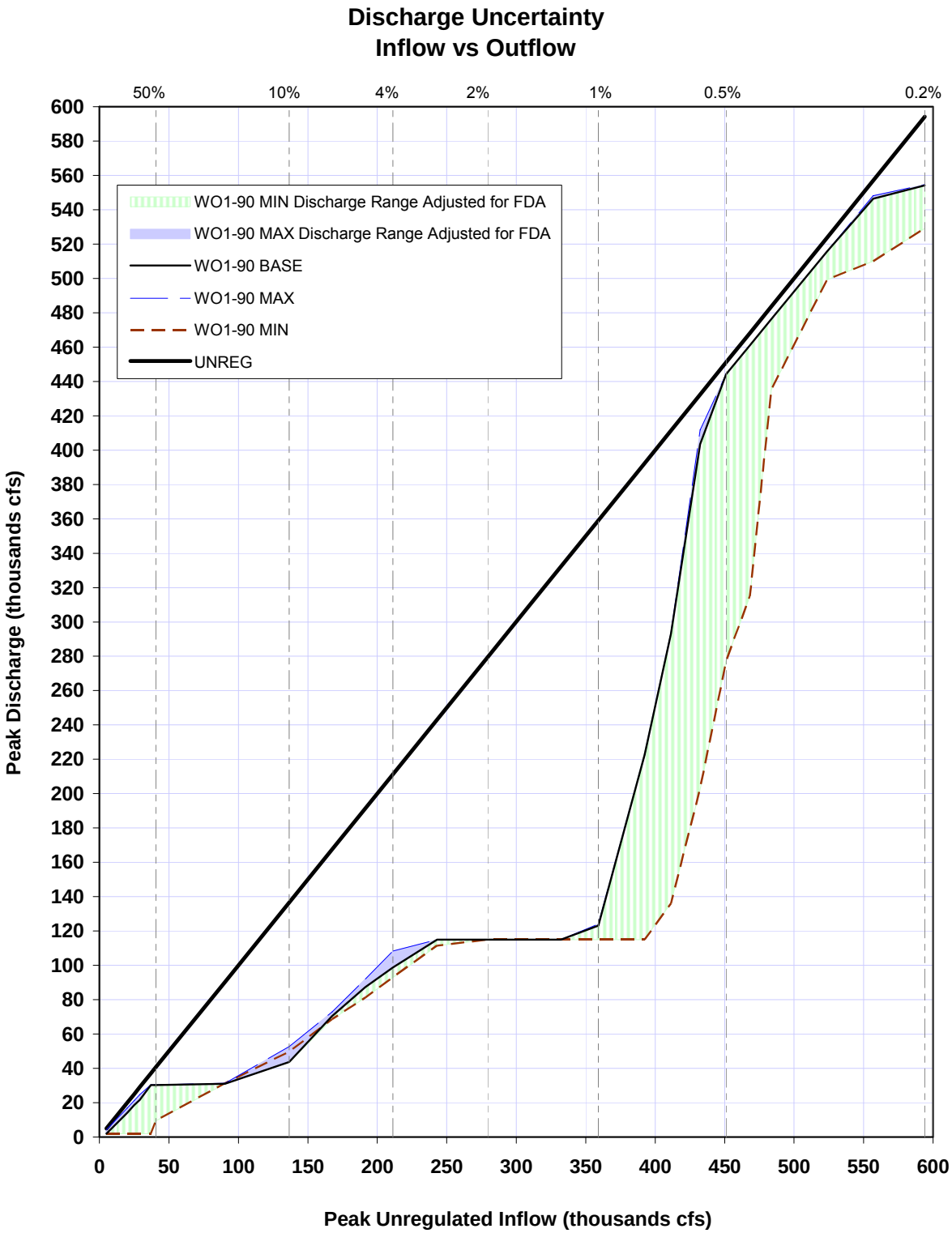

FIGURE A-15: DISCHARGE UNCERTAINTY – WO1 WITHOUT-PROJECT – 115,000 CFS

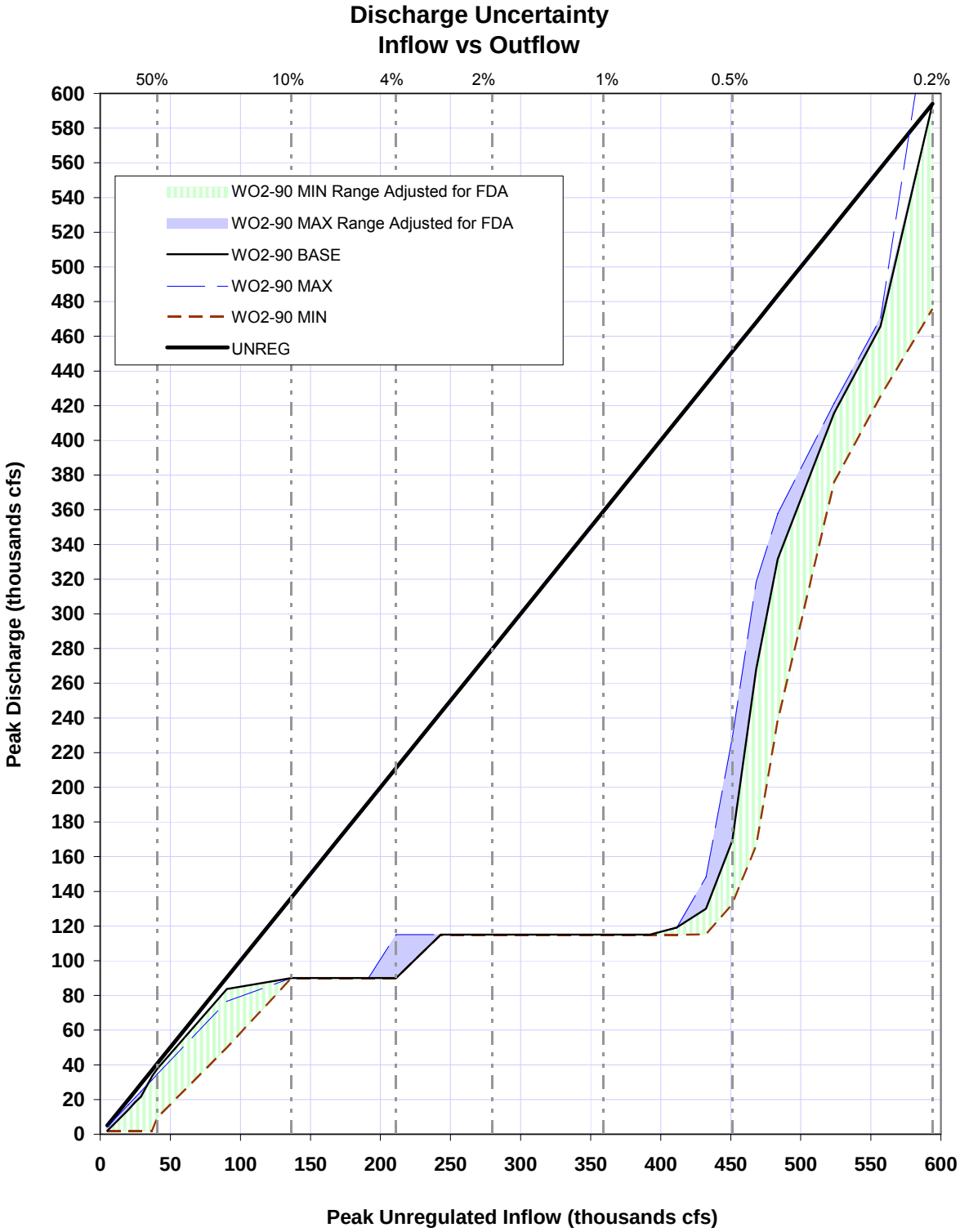

FIGURE A-16: DISCHARGE UNCERTAINTY – WO2 WITHOUT-PROJECT – 115,000 CFS

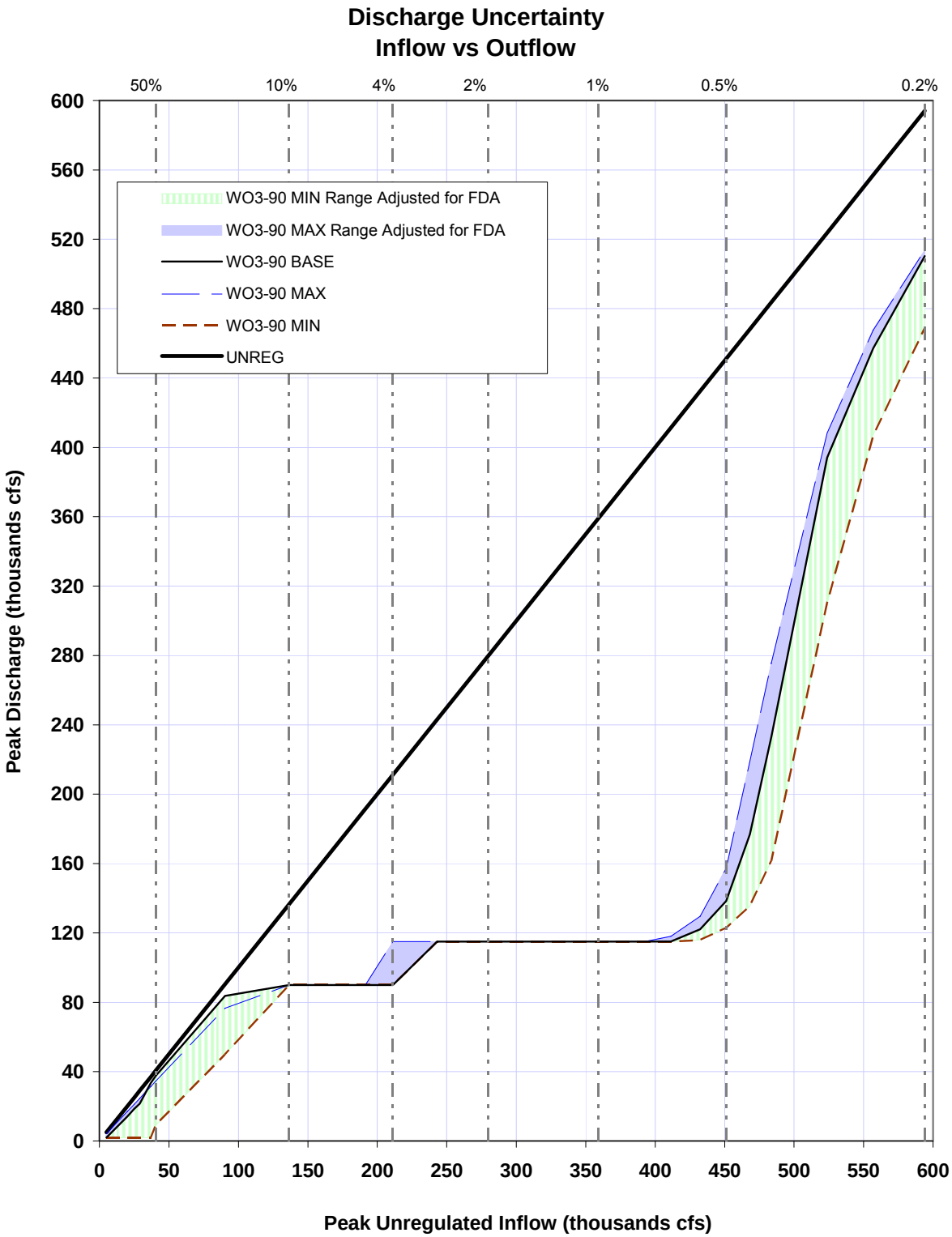

FIGURE A-17: DISCHARGE UNCERTAINTY – WO3 WITHOUT-PROJECT – 115,000 CFS

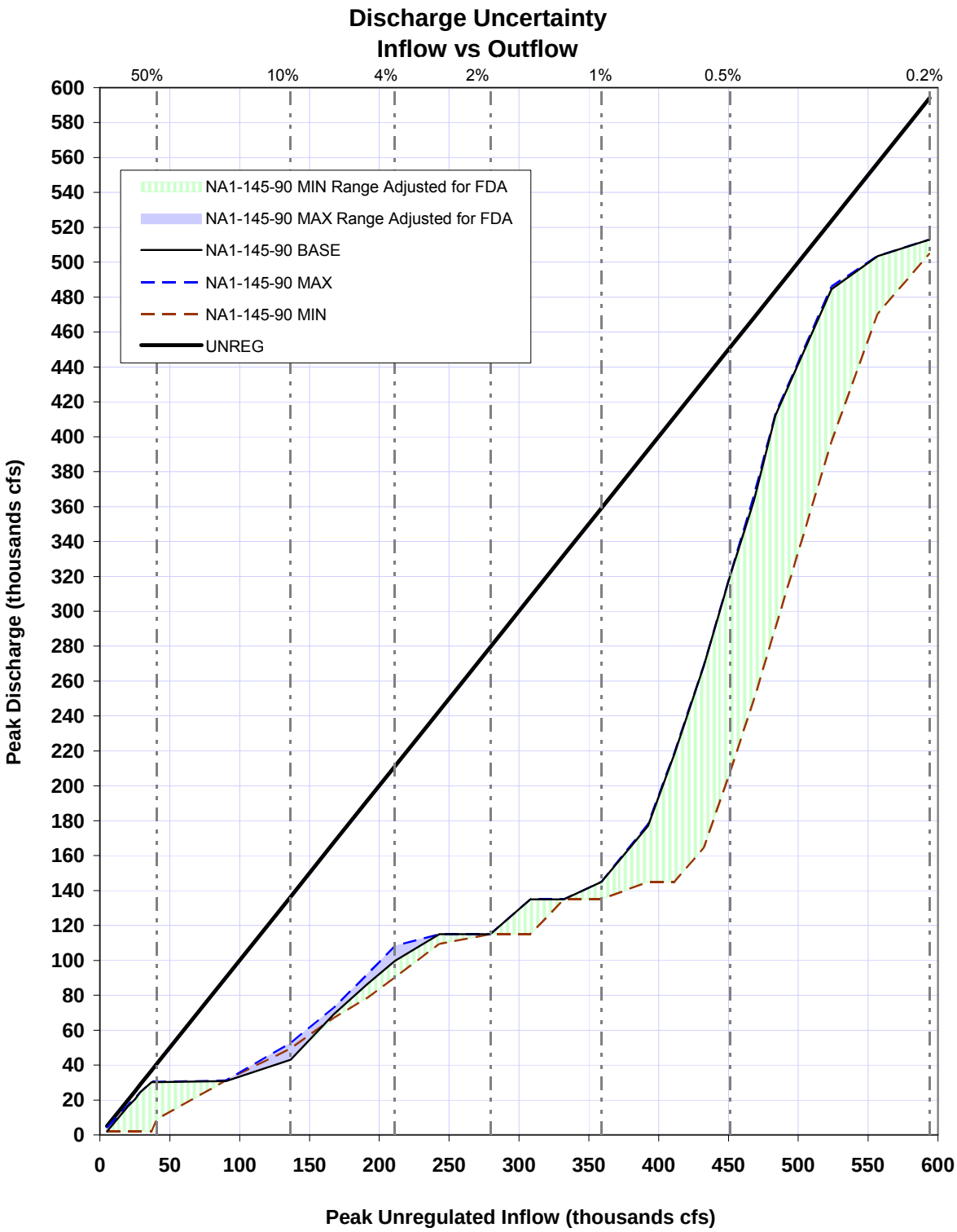

FIGURE A-18: DISCHARGE UNCERTAINTY – NA1 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

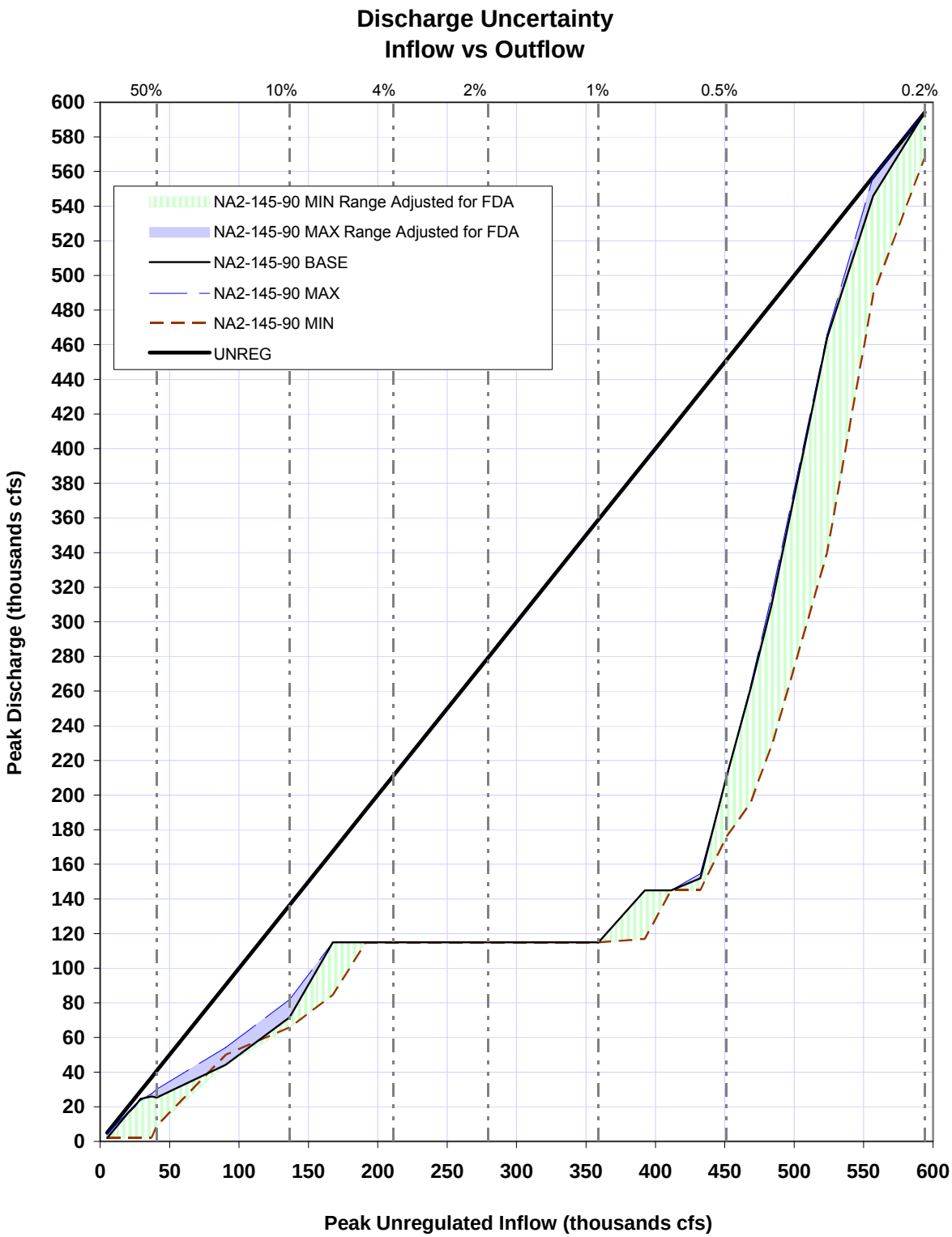

FIGURE A-19: DISCHARGE UNCERTAINTY – NA2 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

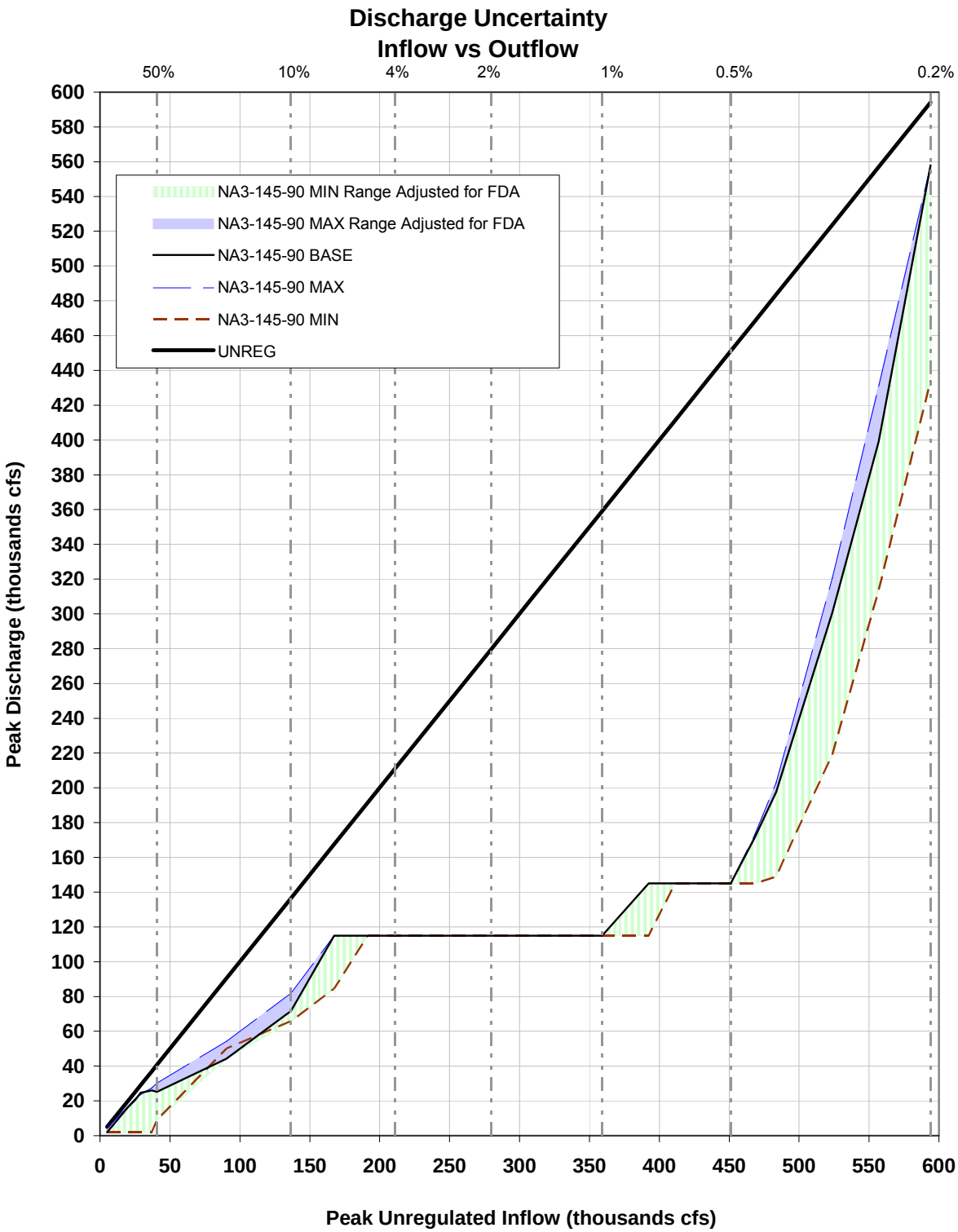

FIGURE A-20: DISCHARGE UNCERTAINTY – NA3 NO ACTION (FUTURE WITHOUT-PROJECT) – 145,000 CFS

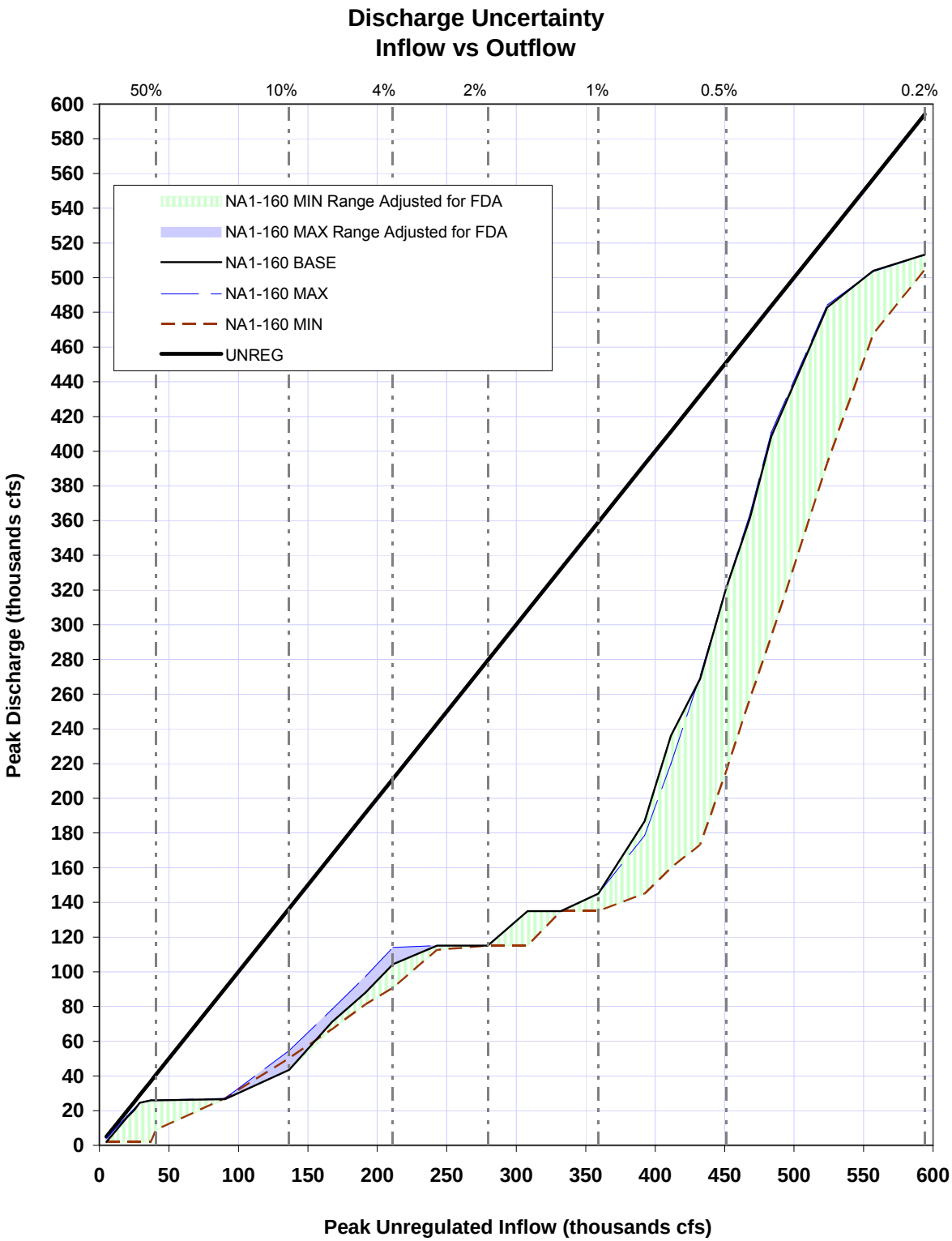

FIGURE A-21: DISCHARGE UNCERTAINTY – W1 WITH-PROJECT – 160,000 CFS

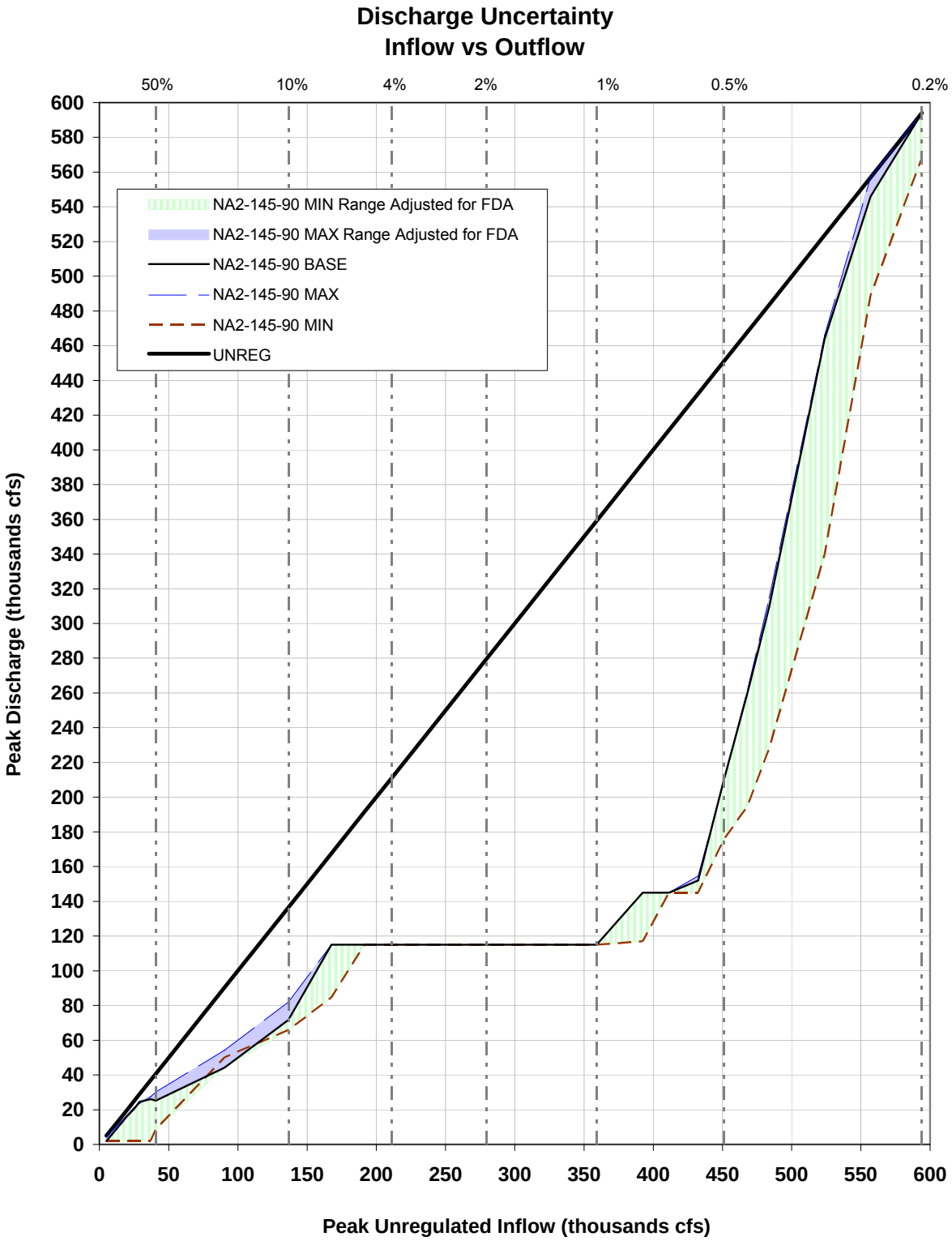

FIGURE A-22: DISCHARGE UNCERTAINTY – W2 WITH-PROJECT – 160,000 CFS

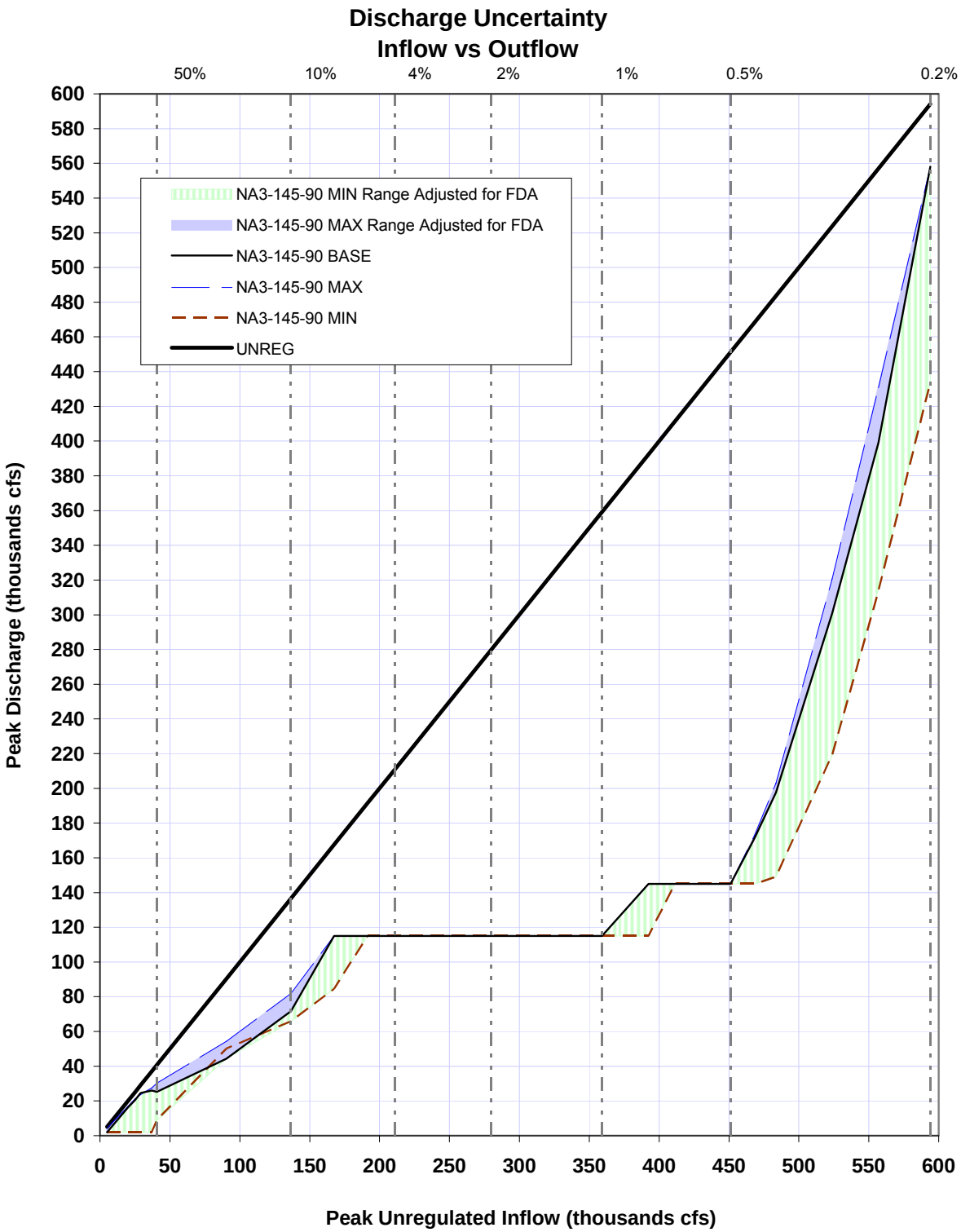

FIGURE A-23: DISCHARGE UNCERTAINTY – W3 WITH-PROJECT – 160,000 CFS

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

US Army Corps of Engineers
Sacramento District

American River Watershed
Common Features Project
Natomas Post-Authorization Change Report

Appendix B3

Dry and Arcade Creeks Flow Frequency Curves and Synthetic 8-Flood Series Hydrographs Upstream of Steelhead Creek

January 2010

AMERICAN RIVER WATERSHED COMMON FEATURES PROJECT
NATOMAS POST-AUTHORIZATION CHANGE REPORT

APPENDIX B3
DRY AND ARCADE CREEKS FLOW FREQUENCY CURVES AND SYNTHETIC 8-FLOOD SERIES HYDROGRAPHS UPSTREAM OF STEELHEAD CREEK

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Attachments

Peer Review Statement of Findings, dated November 13, 1996

Peer Review Cover Letter, dated May 22, 1996

Peer Review Appendix 3: Peak Flow Frequency Relationships for Dry Creek at Vernon Street and Arcade Creek at American River, 1996

Cover photo: Dry Creek upstream of the confluence of Magpie and Robla creeks

AMERICAN RIVER COMMON FEATURES, CALIFORNIA
GRR FEASIBILITY STUDY

APPENDIX B3
DRY AND ARCADE CREEKS FLOW FREQUENCY CURVES AND SYNTHETIC 8-FLOOD SERIES HYDROGRAPHS UPSTREAM OF STEELHEAD CREEK

1. STUDY BACKGROUND AND SCOPE

This report presents the hydrologic peak flow frequency analysis of flows on Dry and Arcade creeks for the synthetic 8-flood series hydrographs. The synthetic 8-flood series consists of the 50-, 20-, 10-, 4-, 2-, 1-, 0.5-, and 0.2% chance floods on Dry and Arcade creeks. The flow frequency analysis includes updating the peak flow record to 2009 as well as developing or revising flow frequency curves for the 1-, 3-, 5-, and 10-day durations.

This analysis is being conducted in response to questions raised about the influence high peak flows upstream on the Steelhead Creek tributaries would have on Steelhead Creek flood stages. (Steelhead Creek is also known as Natomas East Main Drainage Canal (NEMDC)). Included in the analysis is a revision of the synthetic 8-flood series hydrographs presented in the American River Common Features General Reevaluation Report (AR CF GRR) Appendix A, Synthetic Hydrology Technical Documentation (**Reference 1**). Future modeling for the AR CF GRR will include hydraulic modeling up the NEMDC tributaries, for Dry Creek upstream to the Placer-Sacramento County line, and for Arcade Creek upstream to the Sacramento County gage on Arcade Creek at Winding Way.

The revised synthetic 8-flood series hydrographs include balanced hydrographs with higher peaks for Dry Creek at Vernon Street (Roseville) and Arcade Creek at the "near Del Paso Heights" gage, based on the updated flow frequency curves for those locations. The total 8-flood series hydrographs for downstream locations on Dry and Arcade creeks also have higher peak flows, only because the Vernon Street and Del Paso Heights hydrographs have been revised. The 8-flood series hydrographs for downstream local flows on Dry and Arcade creeks, as well as the other NEMDC tributaries, were not revised: there were no stream gages to calibrate to for the higher flood flows. Also, the higher flood peaks on Dry and Arcade creeks are produced by greater and more intense rainfall on the higher eastside elevations of these watersheds, and not by more intense rainfall on the flat valley floor. **Plate 1**, the General Map, shows the locations of Steelhead Creek (NEMDC) and its tributaries, Dry Creek, Arcade Creek, Upper NEMDC, and Old Magpie Creek. **Plate 2** shows locations of the index points for Dry Creek and **Plate 3** those index points for Arcade Creek for which hydrographs were developed.

2. DRY CREEK HYDROLOGY/HYDRAULICS PEER REVIEW AND CONCENSUS EFFORT

2.1 Peer Review Background. An intense storm hit Sacramento and western Placer counties on the evening of January 9 through the early morning hours of January 10, 1995. Overflow from the streams in the area caused severe flooding in both counties. Peak flows on Dry and Arcade creeks for the January 1995 storm are the largest of record for those streams. Sacramento area government agencies initiated a post storm analysis, the Dry Creek Hydrology/Hydraulics Peer Review and Consensus Effort (Peer Review). Agencies and consulting engineering firms involved in the Peer Review included the U.S. Army Corps of Engineers; Sacramento County Water Resources Division; Sacramento Area Flood Control Agency (SAFCA); Placer County Flood Control & Water Conservation District; City of Sacramento Utilities Department; and the engineering firms of Ensign & Buckley Consulting Engineers; DC Consulting; Montgomery Watson Consulting Engineers; Borcalli & Associates; HYDMET, Incorporated; CH2M Hill; and Murray, Burns, & Keinlen. Appendix 3 (**Reference 2**) of the draft hydrology report presented an analysis of the peak flow frequency relationships for Dry Creek at Vernon Street, and Arcade Creek at American River. The Peer Review Statement of Findings, dated 6 November 1996 (**Reference 3**), includes a peak flow frequency curve for Dry Creek at Vernon Street in Roseville, California.

2.2 Dry Creek at Vernon Street Peak Flow Frequency Curve. The California State Department of Water Resources (DWR) operated a stream gage (gage A00040) on Dry Creek in Roseville upstream of the SPRR culverts for water years 1950 to 1966. The drainage area at this location is 78.2 square miles. In 1966 the gage was discontinued and relocated (as gage A00047) to upstream of Douglas Boulevard, with a drainage area of 57.9 square miles. Gage A00047 is referred to in the record as both "Dry Creek at Roseville above Douglas Boulevard" and "Dry Creek at Royer Park." This gage was discontinued in 1984 and moved to Vernon Street, about 1,500 feet upstream of the SPRR bridge. This gage, A00041, "Dry Creek below Roseville," with a drainage area of about 78 square miles, was damaged by the February 1986 flood and discontinued. Records for the three stream gages are incomplete. The City of Roseville established a gage at the Vernon Street location in 1987 (Sensor ID #1603) as part of the ALERT (Automated Local Evaluation in Real Time) system (**Reference 4**) to provide local stream and weather information during storm events. The City of Roseville also operates an ALERT gage at the Royer Park location (Sensor ID #1630).

As part of the Peer Review, a peak flow frequency curve was developed for the Dry Creek at Vernon Street location for water years 1950 to 1995 using peak flow records for the DWR gages A00040, A00041, and A00047. Peak flows for 1968 to 1975 and 1978 to 1981 were developed for the Vernon Street location based on a drainage area relationship between the Vernon Street gage and the upstream Royer Park gage. With so much missing data for the Vernon Street, SPRR culvert, and Royer Park locations, peak flows between 1950 and 1995 were also estimated from the mean daily flow record,

observed flow on Arcade Creek, storm precipitation, HEC-2 and HEC-RAS modeling, and high water marks in Roseville and downstream near Elverta Road in Sacramento County. See Peer Review Appendix 3, included as an appendix to this report, for additional information.

The 46-year record, using recorded and estimated peak flows, was used with the Corps of Engineers Flood Frequency Analysis program, HEC-FFA (**Reference 5**), to compute statistics for the peak flow frequency curve for Dry Creek at Vernon Street. The FFA program identified 1977 as a low outlier. The FFA final results statistics were almost the same as those for the final Dry Creek at Vernon Street peak flow frequency curve included in the Dry Creek Peer Review Statement of Findings, dated 6 November 1996 (**Reference 3**).

The final Peer Review peak flow frequency curve for Vernon Street includes tabulations for two sets of n-flood series peak flows. One set is for the flow frequency curve, with flows based on the adjusted gage measurements. These flows are very similar to the peak flows computed in the HEC-FFA run. The other n-flood peak flow tabulation is for flood flows from an HEC-1 calibration to the January 1995 flood. **Table 1** lists the n-flood peaks for the HEC-FFA run, the adjusted gage measurements, and the HEC-1 calibration. Part of the process in developing the balanced flood hydrographs was a decision as to which set of n-flood peaks to use for the balanced hydrographs for Dry Creek at Vernon Street.

Files associated with the Peer Review analysis include hydrographs from the HEC-1 calibration for Dry Creek, with n-flood series hydrographs (10-, 2-, 1-, 0.5-, and 0.2%) for various locations on the NEMDC tributaries. These are compiled in a single spreadsheet file referred to elsewhere in this report as "Excel spreadsheet" with n-flood series hydrographs (10-, 2-, 1-, 0.5-, and 0.2% floods) for various locations on the NEMDC tributaries. These hydrographs are from the Peer Review HEC-1 Calibration for Dry Creek. **Table 1** also lists the peak flows for Dry Creek routed to NEMDC from the HEC-1 Calibration.

Table 1
Dry Creek Peak Flow Comparison for Synthetic 8-Flood Series Hydrographs
Peer Review HEC-1 Model and FFA Program

	Flood Event and Peak Flows (cfs)				
Dry Cr. at Vernon St. (78.12 sq mi)	10% 2%		1%	0.50%	0.20%
HEC-1 Calibration	7,300	13,000	15,900	18,700	23,600
Adjusted Gage Measurement	5,640	11,200	14,400	18,300	24,500
HEC-FFA Run	5,620	11,100	14,300	18,200	24,400
	Flood Event and Peak Flows (cfs)				
Dry Cr. at NEMDC (115.8 sq mi)	10%	2% 1%		0.50%	0.20%
HEC-1 Calibration	6,860	12,300	13,900	16,440	21,500

2.3 Arcade Creek Peak Flow Frequency Curve. The USGS operated a stream gage (ID 11447360), Arcade Creek near Del Paso Heights, for water years 1964 to 1978, when the gage was discontinued. This gage was located just upstream of Watt Avenue, with a drainage area of 31.8 square miles. The County of Sacramento has operated a gage, Arcade Creek at Winding Way (Sensor ID 298), from 1961 to present, with some missing years. This gage, also known as the American River College gage, has a drainage area of 28.4 square miles. It is currently part of the ALERT (Automated Local Evaluation in Real Time) system.

As part of the Peer Review, a peak flow frequency curve for water years 1962 to 1995 was computed for Arcade Creek using flow records for the USGS gage combined with the Sacramento County gage. The difference in drainage area between the USGS gage and the upstream Sacramento County gage is only 3.4 square miles. Data for the missing years (1979 to 1981 and 1985) were estimated using peak flows for Dry Creek at Vernon Street.

The 34-year record for the combined gages, including estimated flows, was used with the Corps of Engineers' Flood Frequency Analysis program, HEC-FFA, to compute statistics for the peak flow frequency curve for Arcade Creek at Winding Way/Del Paso Heights. See Peer Review Appendix 3, included as an appendix to this report, for additional information.

Additional files associated with the Peer Review analysis include "HEC-1 flood runs" for the NEMDC tributaries only for the 2- and 1% event storms for the HEC-1 Calibration. The modeling includes hydrographs for Arcade Creek at Winding Way, at the "near Del Paso Heights gage," and at NEMDC. **Table 2** lists the peak flows for these three locations for the 2- and 1% floods, as well as the n-flood series peak flows from the HEC-FFA program. The difference between peak flows at Winding Way and at the downstream Del Paso Heights gage is less than 1%.

Table 2

Arcade Creek Peak Flow Comparison

Peer Review HEC-1 Model and FFA Program

Peer Review HEC-1 Model Results					
	Flood Event and Flows (cfs)				
10%		2%	1%	0.50%	0.20%
Arcade Cr. - Winding Way (28.4 sq mi) Peak (cfs)	N/A	3,960	4,500	N/A	N/A
Arcade Cr. - Del Paso gage (31.8 sq mi) Peak (cfs)	N/A	3,950	4,470	N/A	N/A
Arcade Cr. - NEMDC (40.1 sq mi) Peak (cfs)	N/A	3,860	4,440	N/A	N/A
Peer Review FFA Program Results					
Arcade Creek for Winding Way/ Del Paso Heights gage	3,010	4,260	4,770	5,260	5,900

Note: N/A = flows not available

3. UPDATED PEAK FLOW RECORDS FOR DRY AND ARCADE CREEKS

3.1 Dry Creek at Vernon Street Gage. In 1996, the USGS established a gage (USGS ID 11447293, Dry Creek at Vernon Street Bridge at Roseville, CA) at the Vernon Street location. Only a few days of data were recorded for each of the water years 1997 through 1999. The USGS gage has annual peak flows for 1997 and for 2000 to 2009. The City of Roseville provided peak and mean day flow data for the Vernon Street ALERT gage for 1996, 1998 and 1999. With this information, the peak flow record for the Vernon Street gage was updated from 1995 to 2009.

The annual peak flow record for 60 years, for 1950 to 2009, for Dry Creek at Vernon Street gage, was created using observed and estimated flows based on stage records and high water marks at three DWR gages, a USGS gage, and an ALERT gage. The drainage areas for the DWR gages, A00040 and A00041, the USGS gage, and the ALERT gage are all around 78 square miles. Peak flows observed or estimated for the DWR Royer Park gage and stages downstream at Elverta Road were areally adjusted to the Vernon Street drainage area. The annual peak flows for 1950 to 2009 were used with the HEC-FFA program to compute statistics for the updated record for Dry Creek at Vernon Street. 1977 was identified as a low outlier year. **Table 3** compares the peak flow statistics for Dry Creek at Vernon Street.

Table 3
Dry Creek at Vernon Street
Comparison of Peak Flow Frequency Statistics

	Mean	Standard Deviation	Skew	Years of Record
Peer Review FFA	3.3184	0.3294	0.3	46 (1950 - 1995)
Peer Review Findings Adjusted Gage Measurement	3.3189	0.3301	0.3	46 (1950 - 1995)
Updated Record FFA	3.3367	0.3213	0.4	60 (1950 - 2009)

3.2 Arcade Creek: Winding Way and Del Paso Heights Gages. The peak flow records for Arcade Creek near Del Paso Heights were updated using records from the USGS stream gage, which was reestablished in water year 1996. The annual peak flow record for Arcade Creek includes peak flows from the "near Del Paso Heights" gage for 1964 to 1978 and 1996 to 2008; peak flows for the Sacramento County gage at Winding Way for 1962 and 1963, 1982 to 1984, and 1986 to 1995; and recorded or estimated flows on Dry Creek for 1979 to 1981 and 1985. The 47 years of annual peak flows (1962 to 2008) for Arcade Creek were used with the HEC-FFA program to compute statistics for the updated record. 1976 was identified as a low outlier year. **Table 4** presents a comparison of the peak flow statistics for Arcade Creek.

Table 4
Arcade Creek at Winding Way/Del Paso Heights Gage
Comparison of Peak Flow Frequency Statistics

	Mean	Std. Dev.	Skew	Years of Record
Peer Review FFA	3.1699	0.2504	-0.4	34 (1962 - 1995)
Updated Record FFA	3.1777	0.2326	-0.4	47 (1962 - 2008)

4. MEAN DAILY FLOWS FOR DRY AND ARCADE CREEKS

Flow frequency curves for longer durations for Dry and Arcade creeks are needed in order to develop balanced synthetic 8-flood series hydrographs on those watersheds. The 1996 Peer Review was concerned with computation of the peak flow frequency curves, not the longer duration curves. **Table 5** lists the one-day flows associated with the n-flood peak flows for Dry Creek at Vernon Street and at NEMDC. These one-day flows were computed from the n-flood hydrographs in the Peer Review "Excel spreadsheet" file. **Table 5** also lists the one-day flows associated with the Arcade Creek peak flows in the HEC-1 model for the 2- and 1% storm events.

Table 5

Dry and Arcade Creeks

One-Day Flows Associated with Synthetic 8-Flood Peak Flows

Stream and Index Location	Flood Event and One-Day Flows (avg. cfs)				
	10%	2%	1%	0.50%	0.20%
Dry Cr. at Vernon St. (78.12 sq.mi.)	3,050	5,520	6,770	8,110	10,720
Dry Cr. at NEMDC (115.8 sq.mi.)	3,920	7,120	8,630	10,560	14,790
Arcade Cr. at Winding Way (28.4 sq.mi.)	N/A	1,690	1,960	N/A	N/A
Arcade Cr. at Del Paso Heights gage (31.8 sq.mi.)	N/A	1,700	1,970	N/A	N/A
Arcade Cr. at NEMDC (40.1 sq.mi.)	N/A	1,520	1,850	N/A	N/A

Note: N/A = data not available.

4.1 Dry Creek Flow Duration Data. Much of the Dry Creek daily flow record is missing for periods when flows were very high. For the Corps of Engineers' Dry Creek Hydrology Office Report, revised July 1987 (**Reference 6**), the annual Dry Creek peak and associated one-day flows were either observed or estimated for the DWR stream gage A00040, upstream of the SPRR culvert, near Vernon Street in Roseville. The peak and one-day flows for 1951 to 1966 are based on the gage at this location. Peak and one-day flows for gage A00040 for 1967 to 1982 were based on a drainage area relationship with DWR gage A00047 upstream of Douglas Boulevard in Roseville. The estimated one-day flows for A00040 were not used for every year, but were used for 23 years between 1952 and 1981. **Table 6** lists the estimated peak flows and associated one-day flows used in the revised flow frequency for Dry Creek at Vernon Street. **Table 6** includes a tabulation of the recorded peak, 1-, 3-, 5-, and 10-day annual flows for water years 2000 through 2009 for the USGS gage at Vernon Street.

4.2 Arcade Creek Flow Duration Data. Flow duration data for Arcade Creek at the Del Paso Heights USGS gage are available for water years 1964 to 1978 and 1996 to 2009. Observed and estimated peak flows for Arcade Creek at the Winding Way location (Sacramento County gage) are available for water years 1962 to 1963 and 1979 to 1995. No flow duration data are available for the Winding Way location.

Table 6
Dry Creek at Vernon Street Gage in Roseville
Annual Flow Duration Data

Water Year	Flow Duration and Average Flow (cfs)				
	Peak	1-Day	3-Day	5-Day	10-Day
1950	1,260	N/A	N/A	N/A	N/A
1951	1,980	N/A	N/A	N/A	N/A
1952	2,000	1,350	N/A	N/A	N/A
1953	2,839	2,060	N/A	N/A	N/A
1954	1,095	700	N/A	N/A	N/A
1955	1,230	674	N/A	N/A	N/A
1956	4,000	2,900	N/A	N/A	N/A
1957	1,130	868	N/A	N/A	N/A
1958	4,190	2,010	N/A	N/A	N/A
1959	748	582	N/A	N/A	N/A
1960	2,240	1,300	N/A	N/A	N/A
1961	1,212	800	N/A	N/A	N/A
1962	3,900	3,080	N/A	N/A	N/A
1963	5,800	N/A	N/A	N/A	N/A
1964	2,800	N/A	N/A	N/A	N/A
1965	3,800	2,100	N/A	N/A	N/A
1966	989	682	N/A	N/A	N/A
1967	4,800	N/A	N/A	N/A	N/A
1968	1,087	673	N/A	N/A	N/A
1969	3,700	N/A	N/A	N/A	N/A
1970	1,947	1,361	N/A	N/A	N/A
1971	2,200	N/A	N/A	N/A	N/A
1972	1,049	884	N/A	N/A	N/A
1973	3,000	N/A	N/A	N/A	N/A
1974	2,000	1,290	N/A	N/A	N/A
1975	1,541	1,181	N/A	N/A	N/A
1976	282	78	N/A	N/A	N/A
1977	131	N/A	N/A	N/A	N/A
1978	3,295	2,260	N/A	N/A	N/A
1979	1,392	938	N/A	N/A	N/A
1980	3,894	2,870	N/A	N/A	N/A
1981	1,243	790	N/A	N/A	N/A
1982	6,000	N/A	N/A	N/A	N/A
1983	7,000	N/A	N/A	N/A	N/A
1984	952	N/A	N/A	N/A	N/A
1985	1,300	N/A	N/A	N/A	N/A
1986	13,000	5,930	N/A	N/A	N/A
1987	1,600	N/A	N/A	N/A	N/A
1988	1,446	N/A	N/A	N/A	N/A
1989	1,720	N/A	N/A	N/A	N/A
1990	1,739	N/A	N/A	N/A	N/A
1991	2,128	N/A	N/A	N/A	N/A
1992	2,290	N/A	N/A	N/A	N/A

Water	Flow Duration and Average Flow (cfs)				
Year	Peak	1-Day	3-Day	5-Day	10-Day
1993	2,133	N/A	N/A	N/A	N/A
1994	787	N/A	N/A	N/A	N/A
1995	15,000	7,580	N/A	N/A	N/A
1996	2,215	1,417	N/A	N/A	N/A
1997	7,950	3,550	N/A	N/A	N/A
1998	7,521	4,434	N/A	N/A	N/A
1999	1,771	1,182	N/A	N/A	N/A
2000	4,010	3,020	1,740	1,339	893
2001	983	636	411	317	239
2002	1,120	817	533	464	371
2003	1,730	1,060	586	445	335
2004	1,910	1,220	718	505	437
2005	1,750	1,290	1,010	803	526
2006	7,200	4,200	2,067	1,424	966
2007	2,230	1,140	676	498	297
2008	2,620	1,200	765	530	322
2009	1,268	781	585	438	373

N/A = data not available or not estimated
One-day flows for 1986 and 1995 based on rainfall-runoff modeling for these two flood events. Peaks for 1950 to 1995 developed as detailed in Reference 2, Appendix 3 for Peer Review. One-day flows between 1968 and 1981 developed as described in Section 4.1 of this report.

The peak flow frequency curve developed for the Peer Review used data for the Winding Way and Del Paso Heights locations as if the locations were interchangeable. **Tables 2** and **5** list the 2- and 1% flood peak and associated one-day flow data for Arcade Creek at Winding Way and at the Del Paso Heights gage; the differences in magnitude are less than 1%. For this study, the differences in flow between upstream and downstream location are treated as negligible. **Table 7** tabulates the annual peak and flow duration data for Arcade Creek at Winding Way/Del Paso Heights gage used for the flow frequency analysis presented in this study.

5. DRY CREEK AT VERNON STREET FLOW FREQUENCY ANALYSIS

5.1 Regional Frequency Computation for Dry Creek. The annual peak flows for 60 years of recorded and estimated values for Dry Creek at Vernon Street, Roseville, gage are plotted on **Plate 5**, the annual rainflood frequency curves for Dry Creek at Vernon Street. Considering the lack of annual duration data in the record for Dry Creek, an approach was needed to determine the plotting positions of the previously recorded and estimated annual 1-day flow data in relation to the peak flows. The HEC program, REGFQ (Regional Frequency Computation (**Reference 7**)) was used to develop a reasonable estimate of the plotting positions for those one-day flows. The flows listed in **Table 6** were used as input to the REGFQ computer program. Output from the program is shown on **Plate 4** with the one-day flows from **Table 6** plotted using median plotting positions. The missing one-day flows are indicated as gaps where the REGFQ program made estimates of their magnitudes.

Table 7
Arcade Creek at Winding Way/Del Paso Heights Gage
Flow Duration Data

Water Year	Flow Duration and Average Flow (cfs)				
	Peak	1-Day	3-Day	5-Day	10-Day
1962	2,450	N/A	N/A	N/A	N/A
1963	2,500	N/A	N/A	N/A	N/A
1964	1,400	772	431.7	266.5	134.8
1965	1,450	897	593.3	419.8	250.3
1966	625	360	155.7	103.8	65.4
1967	2,000	1,020	574.7	471.4	360.8
1968	568	289	162.3	112.4	63.5
1969	1,570	1,280	937.0	664.0	517.9
1970	1,600	879	455.3	313.0	247.4
1971	1,630	1,090	537.7	413.6	288.9
1972	590	408	228.0	178.0	115.6
1973	2,170	771	508.7	412.8	363.7
1974	2,050	807	317.0	241.0	197.7
1975	1,300	829	449.7	311.2	206.7
1976	200	153	56.0	51.7	27.2
1977	345	281	69.5	49.4	25.7
1978	2,390	1,270	811.0	599.0	346.3
1979	1,200	N/A	N/A	N/A	N/A
1980	1,700	N/A	N/A	N/A	N/A
1981	800	N/A	N/A	N/A	N/A
1982	3,300	N/A	N/A	N/A	N/A
1983	2,900	N/A	N/A	N/A	N/A
1984	1,650	N/A	N/A	N/A	N/A
1985	700	N/A	N/A	N/A	N/A
1986	3,800	N/A	N/A	N/A	N/A
1987	1,500	N/A	N/A	N/A	N/A
1988	1,180	N/A	N/A	N/A	N/A
1989	1,550	N/A	N/A	N/A	N/A
1990	1,080	N/A	N/A	N/A	N/A
1991	1,650	N/A	N/A	N/A	N/A
1992	2,100	N/A	N/A	N/A	N/A
1993	2,300	N/A	N/A	N/A	N/A
1994	1,250	N/A	N/A	N/A	N/A
1995	4,100	N/A	N/A	N/A	N/A
1996	1,700	1100	589.7	358.6	212.5
1997	2,270	1090	591.3	678.6	381.7
1998	3,320	1910	1,069.3	714.8	462.5
1999	1,040	527	350.0	218.6	133.5
2000	2,430	1790	740.3	549.2	309.0
2001	1,030	281	181.7	141.0	73.8
2002	1,030	543	229.7	213.4	147.7
2003	1,150	578	340.0	250.8	173.7
2004	1,340	492	224.7	149.1	108.9

Water	Flow Duration and Average Flow (cfs)				
Year	Peak	1-Day	3-Day	5-Day	10-Day
2005	1,000	661	420.3	322.4	191.7
2006	3,460	1890	835.3	538.2	373.9
2007	1,030	438	300.7	192.2	100.1
2008	1,700	745	373.0	242.4	133.4
2009	N/A	388	208.0	140.4	125.8

Note: N/A = data not available
Peak flows for 1962, 1963, 1982 to 1984, 1986 to 1995 from the Sacramento County Winding Way gage. Peak flows for 1972 to 1981 and 1985 estimated based on Dry Creek at Vernon gage.

5.2 Updated Dry Creek Peak Flow Frequency Curve. **Table 3** lists the statistics for the peak flow frequency curve, for the Peer Review analysis and the FFA statistics for 60 years of estimated and observed peak flows. The peak flow frequency statistics did not change by much with the addition of 14 years of data. The decision was made not to change the peak flow frequency curve statistics used with the Peer Review adjusted gage measurement record for several reasons. The peak flow record includes many estimated peak flows. Also, the flow frequency curve for the adjusted gage measurement record was developed based on analysis by engineers from several government agencies and engineering firms. Further analysis should be done before making the decision to change the statistics.

5.3 Dry Creek One-Day Flow Frequency Curve. The previously recorded and estimated annual one-day flows for Dry Creek at Vernon Street listed in **Table 6** were plotted on **Plate 4** using the plotting positions estimated from the REGFQ run. Statistics were tested to develop a one-day flow frequency curve that was representative of the plotted one-day data points above the 50% chance exceedence on **Plate 4**. Guidance for the upper end of the frequency curve came from the "Excel spreadsheet" with the one-day flows associated with the 2-, 1-, 0.5-, and 0.2% flood hydrographs for Dry Creek at Vernon Street. These "Excel spreadsheet" one-day flows for Vernon Street are listed in **Table 5.** While the Peer Review peak flow frequency curve has a positive skew, the volume frequency curves developed for the current analysis have zero or negative skews, more typical of flow frequency curves for the region. A zero skew is used for the one-day flow frequency curve. The mean and standard deviation selected for the straight line curve produce a one-day flow frequency curve that fits very well to the observed and estimated one-day flows plotted on **Plate 4** as well as to the "Excel spreadsheet" one-day flows listed in **Table 5.** The final statistics selected for the one-day flow frequency curve are listed on **Plate 4**.

5.4 Dry Creek Five- and Ten-Day Flow Frequency Curves. As discussed in Section 7 below, the synthetic 8-flood series hydrographs for Dry Creek at NEMDC were developed as part of the AR CF GRR. The preliminary 8-flood series hydrographs for Dry Creek at NEMDC were flood runoff from 10-day storms using methodology in the Sacramento City/County Drainage Manual, **Reference 8**. Development of these hydrographs is discussed in the Natomas General Reevaluation Report Hydrology

Appendix, **Reference 9**. The 10-day flood hydrographs were later reshaped into a main 5-day wave preceded by a smaller 5-day wave, as discussed in the AR CF GRR Synthetic Hydrology Technical Documentation Appendix (**Reference 1**). The flood hydrographs were reshaped to conform to the valley-wide flood hydrographs developed for the Sacramento and San Joaquin River Basins Comprehensive Study (**Reference 10**). While the flood hydrograph shapes changed, the 5- and 10-day flood volumes for Dry Creek at NEMDC did not. **Tables 13** and **17** in **Reference 1** list the 5- and 10-day volumes, respectively, of the synthetic 8-flood series hydrographs for Dry Creek at NEMDC**.** **Table 8** below lists these flood volumes in acre feet. Flood volumes listed in other tables in this report are in average day cfs.

Computer modeling was used to develop a flood reproduction of the New Year January 1997 (NY '97), 29 December 1996 to 3 January 1997) storm and flood event for Dry and Arcade creeks as part of the AR CF GRR Synthetic Hydrology Technical Documentation (**Reference 1**). The reshaped 8-flood series 10-day flood hydrographs for Dry Creek, with the main 5-day wave and smaller 5-day wave, are based on the shape of the NY '97 5-day flood reproduction hydrographs for Dry Creek. The computer model for the NY '97 flood reproduction computed a flood hydrograph for each Dry Creek subbasin and index point. **Figure 1** displays the NY '97 flood hydrograph computed for Dry Creek at Vernon Street. The 5-day volume for the NY '97 flood hydrograph for Dry Creek at Vernon Street is 12,459 ac-ft, and the corresponding 5-day flood hydrograph for Dry Creek down at NEMDC is 17,387 ac-ft.

Each of the 8-flood series 5-day volumes for Dry Creek at Vernon Street is computed by multiplying the 8-flood series 5-day flood volume for Dry Creek at NEMDC in **Table 8** by the ratio of the NY '97 5-day flood volume at Vernon Street to the NY '97 5-day flood volume at NEMDC. For example, the 50% 5-day flood volume for Dry Creek at Vernon Street is computed by multiplying the 50% flood 5-day volume at NEMDC (9,250 ac-ft in **Table 8**) by the ratio 0.717 (12,460 ac-ft divided by 17,400 ac-ft). The 50% 5-day flood volume for Dry Creek at Vernon Street is about 6,628 ac-ft or 668 average cfs. Each of the 8-flood series 5-day volumes was computed the same way.

The 8-flood series 10-day volumes for Dry Creek at Vernon Street are computed by multiplying the 8-flood series 10-day flood volume for Dry Creek at NEMDC in **Table 8** by the same ratio as above. For example, the 50% 10-day flood volume for Dry Creek at Vernon Street is computed by multiplying the 50% 10-day flood volume at NEMDC (11,000 ac-ft in **Table 8**) by the ratio 0.717. The 50% 10-day flood volume for Dry Creek at Vernon Street is about 7,882 ac-ft or 397 average cfs. Each of the 8-flood series 10-day volumes was computed the same way.

Table 8

Five- and Ten-Day Flood Volumes for Synthetic 8-Flood Series

8-Flood Series Five-Day Volumes (ac-ft)								
	50%	20%	10%	4%	2%	1%	0.50%	0.20%
Dry Cr. at NEMDC	9,250	15,450	19,800	26,600	31,000	35,600	39,800	47,200
Arcade Cr. at NEMDC	3,400	5,310	6,650	8,430	9,710	11,050	12,300	14,260
8-Flood Series Ten-Day Volumes (ac-ft)								
	50%	20%	10%	4%	2%	1%	0.50%	0.20%
Dry Cr. at NEMDC	11,000	18,300	23,600	32,700	38,200	43,900	49,100	58,700
Arcade Cr. at NEMDC	4,220	6,570	8,190	10,300	11,900	13,600	15,100	17,600

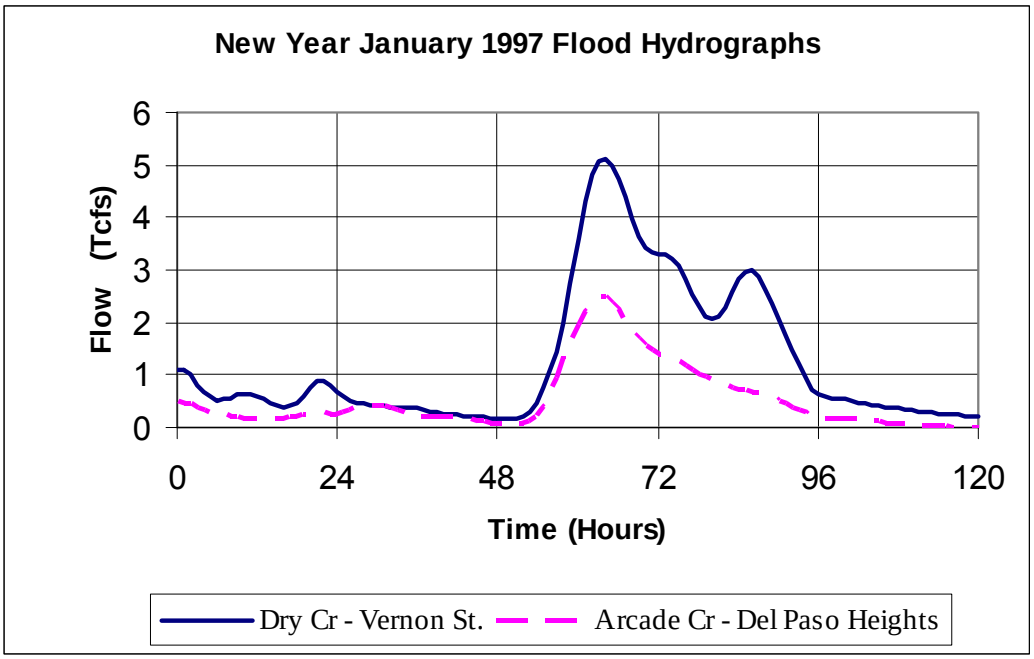

Figure 1. New Year January 1997 Flood Hydrographs Modeled for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights Gage

The synthetic 8-flood series hydrographs for Dry Creek at Vernon Street, Roseville, were rebalanced to produce higher peak flows. The 8-flood series 5- and 10-day hydrograph volumes remain unchanged. The 8-flood series 5- and 10-day flood volumes, computed as described in the above paragraphs, were plotted as average flows in cfs on **Plate 4**, the flow frequency curves for Dry Creek at Vernon Street. Statistics were tested to develop flow frequency curves that passed smoothly through these flood volumes. The final statistics and flow frequency curves for the 5- and 10-day flood volumes are displayed on **Plate 4**. There are only ten years (2000 – 2009) of observed annual 5- and 10-day flows for the Vernon Street gage. This time period is insufficient to

plot the observed flows on **Plate 4**. The ten annual data points for 5- and 10-day flows, as distributed by the REGFQ program, do not match the 5- and 10-day flow frequency curves and are not shown on **Plate 4**.

5.5 Dry Creek Three-Day Flow Frequency Curve. There are only ten years of recorded data for Dry Creek at Vernon Street for which annual 3-day flows could be computed. This is not a long enough record on which to base a flow frequency curve. The statistics for the 3-day flow frequency curve needed to be somewhere in-between the statistics for the 1-day and the 5-day flow frequency curves, in order for develop reasonable 3-day flood volumes that would not be too difficult to balance as part of the 5-day flood waves for the 8-flood synthetic series at Vernon Street. A preliminary set of statistics for the 3-day flow frequency curve was selected such that the mean peak flow, standard deviation, and skew were between those for the 1-day and 5-day statistics. During the process of balancing the 8-flood series hydrographs, the 3-day volumes needed to be changed by minor amounts to create realistically shaped hydrographs. The 3-day flow frequency statistics on **Plate 4** are those used for the 3-day volumes of the final balanced hydrographs. By coincidence, the plotting positions from the REGFQ program for the ten annual 3-day flows fit along the 3-day frequency curve pretty well and are included on **Plate 4**.

6. ARCADE CREEK AT WINDING WAY/DEL PASO HEIGHTS FLOW FREQUENCY ANALYSIS

6.1 Regional Frequency Computation for Arcade Creek. The annual peak flows for 47 years of record for Arcade Creek at Winding Way/Del Paso Heights are plotted on **Plate 5**, the rainflood frequency curves for Arcade Creek. While more annual duration data are available for Arcade Creek than for Dry Creek, 19 years of duration data are missing for the years that the USGS gage at Del Paso Heights was not in operation. The REGFQ program (**Reference 7**) was also used to develop reasonable estimates of the annual 1-, 3-, 5-, and 10-day flows for the missing years. The annual flows listed in **Table 7** for Arcade Creek were used as input to the Regional Frequency Computation program. **Plate 5** shows the median plotting positions for the annual duration data listed in **Table 7**. Estimates for duration data for the missing years are indicated as gaps between the recorded data points.

6.2 Updated Arcade Creek Peak Flow Frequency Curve. **Table 4** lists the statistics for the Arcade Creek peak flow frequency curve, for the Peer Review analysis and the FFA statistics for 47 years of peak flows. Most of the peak flows were recorded at the Del Paso Heights gage, some were recorded at the Sacramento County gage at Winding Way, and a few were estimated. Updating the peak flow record with 13 more years of data at the Del Paso Heights gage did not make much difference in the frequency curve. It was decided to use the Peer Review statistics, from the FFA analysis for 34 years of record. The statistics are based on the hydrologic data set from 1962 to 1995, rather than updated statistics based on data from 1950 - 2009. The reasoning to use the 1996 analysis are as follows: a) the curve did not change significantly; and b) multiple agencies had worked together to analyze the data and results for the Peer Review Study which gave it importance.

6.3 Arcade Creek 1-Day Flow Frequency Curve. An FFA analysis could not be performed for the one-day flow duration with 19 years missing from the record. The FFA analysis for the Arcade Creek peak flow record showed that 1976 was a low outlier. The REGFQ program was used for the Arcade Creek peak and 1-day flow data with low outlier 1976 removed. The adjusted frequency statistics for the one-day duration matched the plotted data points and were used for the one-day flow frequency curve. The flow frequency statistics, one-day flow frequency curve, and recorded one-day flows for Arcade Creek at the Del Paso Heights gage are shown on **Plate 5**.

6.4 Arcade Creek Five- and Ten-Day Flow Frequency Curves. The frequency curves for the 5- and 10-day volumes for Arcade Creek at Winding Way/Del Paso Heights gage were developed in the same manner as the 5- and 10-day frequency curves for Dry Creek at Vernon Street, Roseville. **Table 8** lists the synthetic 8-flood series 5- and 10-day flood volumes for Arcade Creek at NEMDC, which were developed for the Natomas GRR Hydrology Appendix, **Reference 9**. These flood volumes are still used for the present analysis.

The computer model for the NEMDC tributaries was used to develop a flood reproduction of the NY '97 flood hydrograph for Arcade Creek as well as for Dry Creek (in **Reference 1**). The computer model developed a flood hydrograph for each Arcade Creek subbasin and index point. **Figure 1** displays the NY '97 flood hydrograph computer for Arcade Creek at the Del Paso Heights gage location. The 5-day volume for the NY '97 flood hydrograph for Arcade Creek at the Del Paso Heights gage is 5,300 ac-ft, and the corresponding 5-day flood hydrograph for Arcade Creek down at NEMDC is 6,098 ac-ft.

Each of the 8-flood series 5-day volumes for Arcade Creek at Del Paso Heights gage is computed by multiplying the 8-flood series 5-day flood volume for Arcade Creek at NEMDC in **Table 8** by the ratio of the NY '97 5-dayflood volume at Del Paso Heights gage to the NY '97 5-day flood volume at NEMDC. For example, the 50% 5-day flood volume for Arcade Creek at Del Paso Heights gage is computed by multiplying the 50% 5-day volume at NEMDC (3,400 ac-ft in **Table 8**) by the ratio 0.869 (5,300 ac-ft divided by 6,098 ac-ft). The 50% 5-day flood volume for Arcade Creek at Del Paso Heights gage is about 5,300 ac-ft or 300 average cfs. Each of the 8-flood series 5-day volumes was computed the same way.

The 8-flood series 10-day volumes for Arcade Creek at Del Paso Heights gage are computed by multiplying the 8-flood series 10-day flood volume for Arcade Creek at NEMDC in **Table 8** by the same ratio as above. For example, the 50% 10-day flood volume for Arcade Creek at Del Paso Heights gage is computed by multiplying the 50% 10-day flood volume at NEMDC (4,220 ac-ft in **Table 8**) by the ratio 0.869. The 50% 10-day flood volume for Arcade Creek at Del Paso Heights gage is about 3,667 ac-ft or 185 average cfs. Each of the 8-flood series 10-day volumes was computed the same way.

The synthetic 8-flood series hydrographs for the Del Paso Heights gage location were rebalanced to produce higher peak flows, but the 5- and 10-day hydrograph volumes

were not changed in the process. The 8-flood series 5- and 10-day flood volumes, computed as described in the above paragraphs, were plotted as average flows in cfs on **Plate 5,** the flow frequency curves for Arcade Creek at Winding Way/Del Paso Heights. Statistics were tested to develop flow frequency curves that passed smoothly through these flood volumes. The final statistics, 5- and 10-day flow frequency curves, and recorded 5- and 10-day flows for Arcade Creek at the Del Paso Heights gage are shown on **Plate 5.**

The annual 5-day duration data observed for Arcade Creek fit along the 5-day flow frequency curve on **Plate 5**. The observed annual 10-day volumes for Arcade Creek at Del Paso Heights gage are slightly higher than the 10-day flow frequency curve. The 10-day volumes for the synthetic 8-flood series hydrographs were based on rainfall-runoff modeling of a series of 10-day storms for the NEMDC tributaries, not on analysis of flow frequency data for Arcade Creek. The 10-day storms were based on criteria in the Sacramento City/County Drainage Manual, Volume 2, Hydrology Standards (**Reference 8**). The development of the 10-day storms and runoff hydrograph volumes was presented in the Natomas General Reevaluation Report Hydrology Appendix (**Reference 9**).

6.5 Arcade Creek Three-Day Flow Frequency Curves. The recorded annual 3-day volumes for Arcade Creek at Del Paso Heights gage were plotted on **Plate 5** using the plotting positions output from the REGFQ program. The statistics for the flow frequency curve needed to be somewhere in-between the statistics for the 1-day and the 5-day flow frequency curves, in order to develop reasonable 3-day flood volumes that would not be too difficult to balance as part of the 5-day flood waves for the 8-flood synthetic series at the Del Paso Heights gage. A preliminary set of statistics for the 3-day flow frequency curve was selected such that the mean peak flow, standard deviation, and skew were between those for the 1-day and 5-day statistics and were representative of the plotted annual data points. During the process of balancing the 8-flood series hydrographs, the 3-day volumes needed to be changed by minor amounts to create realistically shaped hydrographs. The 3-day flow frequency statistics on **Plate 5** are those used for the 3-day volumes of the final balanced hydrographs.

7. BALANCED HYDROGRAPH DEVELOPMENT FOR DRY AND ARCADE CREEKS

This section discusses development of the balanced hydrographs to the flow frequency curves displayed on **Plates 4 and 5** for the synthetic 8-flood series at Dry Creek at Vernon Street and at Arcade Creek at the Del Paso Heights gage. For consistency with the Comprehensive Study, the computed New Year January 1997 flood hydrographs for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights gage were used as the pattern hydrographs for the synthetic 8-Flood Series.

7.1 Peak Flows. The balanced flood hydrographs include the peak flows listed below in **Tables 9 and 10**. The peak flows for Dry Creek (**Table 9**) are the same as the Adjusted Gage Measurement peak flows on **Table 1** and the same as those on the flow

frequency curve defined by the Adjusted Gage Measurement flow frequency statistics on **Table 3**. The peak flows for Arcade Creek (**Table 10**) are the same as the Peer Review FFA Program Results on **Table 2** and those on the flow frequency curve defined by the Peer Review FFA Statistics on **Table 4**. Hydrographs and peak flows for the downstream tributaries and local subbasins on Dry and Arcade creeks were not changed from those previously provided to Hydraulic Design Section.

Table 9

Peak and Volume Tabulation for Synthetic 8-Flood Series

Balanced Hydrographs for Dry Creek at Vernon Street (Roseville)

8-Flood Event	**Peak** (cfs)	**24-Hour** (avg cfs)	**3-Day** (avg cfs)	**5-Day** (avg cfs)	**10-Day** (avg cfs)
50%	2,010	1,360	843	665	407
20%	3,900	2,500	1,420	1,080	659
10%	5,640	3,500	1,880	1,400	854
4%	8,500	4,900	2,560	1,860	1,130
2%	11,200	6,340	3,110	2,220	1,350
1%	14,400	7,390	3,720	2,590	1,560
0.50%	18,300	8,620	4,340	2,970	1,790
0.20%	24,500	11,300	5,260	3,530	2,120

Table 10

Peak and Volume Tabulation for Synthetic 8-Flood Series

Balanced Hydrographs for Arcade Creek at Del Paso Heights Gage

8-Flood Event	**Peak** (cfs)	**24-Hour** (avg cfs)	**3-Day** (avg cfs)	**5-Day** (avg cfs)	**10-Day** (avg cfs)
50%	1,540	945	425	304	187
20%	2,420	1,460	677	491	302
10%	3,010	1,790	842	613	377
4%	3,730	2,200	1,050	771	474
2%	4,260	2,490	1,200	884	544
1%	4,770	2,780	1,350	995	613
0.50%	5,260	3,050	1,500	1,110	685
0.20%	5,900	3,410	1,680	1,250	769

7.2 Balancing to 1-, 3-, and 5-Day Durations. A spreadsheet was developed to balance the synthetic flood hydrographs to the 1-, 3-, and 5-day durations from the flow frequency curves, **Plates 4 and 5**. The synthetic hydrographs were balanced using the New Year 1997 flood hydrographs on **Figure 1**, for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights gage. A different flood hydrograph pattern was used for Dry Creek at Vernon Street for the 1-, 0.5-, and 0.2% floods; it is discussed in **Section 7.3** below.

a. 24-Hour Flow. The 1-day flow frequency curve is for the annual maximum 1-day volume, measured at the gage from midnight to midnight. The maximum 24-hour flow for the same event is almost always higher than the 1-day flow, because the maximum 24-hour flow does not normally occur exactly between midnight one day and midnight the next. 24-hour volumes were used to balance the hydrographs to prevent the peak flow from appearing too peaked with respect to the one-day volume. For the balanced hydrographs, the ratio used for 24-hour flow to maximum 1-day flow is less than 1.15. Historically, the ratio of 24-hour flow to 1-day flow is not known for Dry and Arcade creeks, because only 1-day flows were available for most flood events. The 24-hour flows used to balance the synthetic 8-flood series hydrographs are listed on **Tables 9 and 10**.

b. Three Day Flow. In the process of balancing the hydrographs at the upstream gaging stations to the 3-day volumes, the 3-day volumes were slightly modified from those volumes represented by the 3-day flow frequency curves. Except for the 50% flood hydrograph for Dry Creek at Vernon Street, the 3-day volumes listed in **Tables 9 and 10** are within 2% of the 3-day volumes for the flow frequency curves for Dry and Arcade creeks.

c. Five Day Flow. In the process of balancing the hydrographs at the Dry Creek at Vernon Street to the 5-day volumes, the 5-day volumes were slightly modified from those volumes represented by the 5-day flow frequency curves. The 5-day volumes listed in **Table 9** are between 0- and 3% of the flow frequency curve volumes. The 5-day volumes listed in **Table 10** for Arcade Creek at Del Paso Heights are the same as those represented by the 5-day flow frequency curves.

7.3 Dry Creek at Vernon Street Pattern for 1-, 0.5-, and 0.2% Event Floods. The New Year January 1997 flood hydrograph modeled for Dry Creek at Vernon Street, shown on **Figure 1** in Section 5.4 and **Figure 2** below, has a double peak. Not only is the double-peak pattern more difficult to balance, especially for the 1-, 0.5-, and 0.2% flood events, but the New Year January 1997 flood was only about a 12% chance event for Vernon Street. A flood hydrograph pattern needed to be developed that would be easier to balance for the rarer floods yet still be representative of the Dry Creek watershed.

Figure 2 shows how the composite flood hydrograph pattern was developed based on the NY ’97 flood hydrograph as well as the observed or computed flood hydrographs for the two largest floods at Vernon Street. **Figure 2** shows the NY ’97 flood hydrograph for Dry Creek at Vernon Street as well as the flood hydrographs for the February 1986 and January 1995 events. The peak flows for the three hydrographs were

lined up to coincide. Using portions of the three existing flood hydrographs, the composite flood hydrograph was developed to have a reasonable shape for a single peak and recession. The composite flood hydrograph pattern displayed below balanced very well to the 1-, 0.5-, and 0.2% flood volumes.

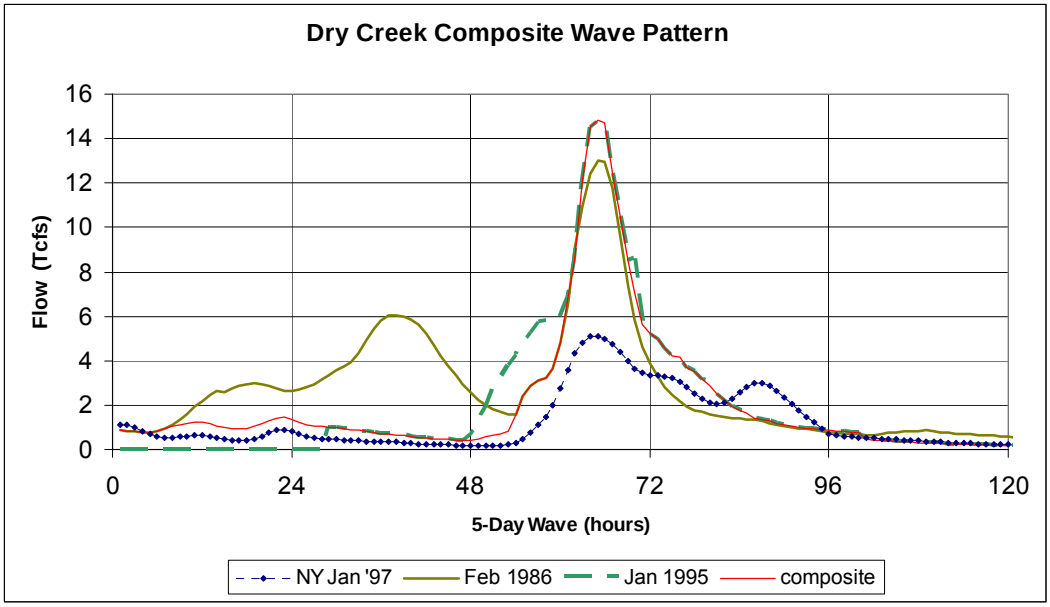

Figure 2. Development of Composite 5-Day Wave Pattern Hydrograph for Dry Creek at Vernon Street, for the 1-, 0.5-, and 0.2% Balanced Flood Hydrographs

7.4 Ten- and Thirty-Day Flood Hydrographs. For the Comprehensive Study, the basic pattern of all synthetic flood hydrographs was a 30-day hourly time series consisting of 6 waves, each 5 days in duration. 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 volume of the fourth, or main, wave for each n-flood hydrograph at NEMDC is that listed for the 5-day volume in **Table 8**. For the hydrographs at upstream index points Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights gage, the 5-day main wave volumes are those listed in **Tables 9 and 10**, based on the flow frequency curves on **Plates 4 and 5**. The 5-day wave hydrographs are patterned after the modeled New Year 1997 floods, except for the Dry Creek 1-, 0.5-, and 0.2% floods. Those floods use the composite pattern shown on **Figure 2**. The volume for the second highest wave for each n-flood hydrograph is the difference between the 5-day volume and corresponding 10-day volume in **Tables 9 and 10**.

Flows on the NEMDC 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 NEMDC tributary flows for the four smaller waves, waves 1 and 2, 5 and 6, would be so minor that zero runoff is assumed for the 30-day hydrographs, except for the middle 10 days (Waves 3 and 4). **Figure 3** displays the 6-wave 30-day pattern balanced

hydrographs for the 1% floods for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights gage.

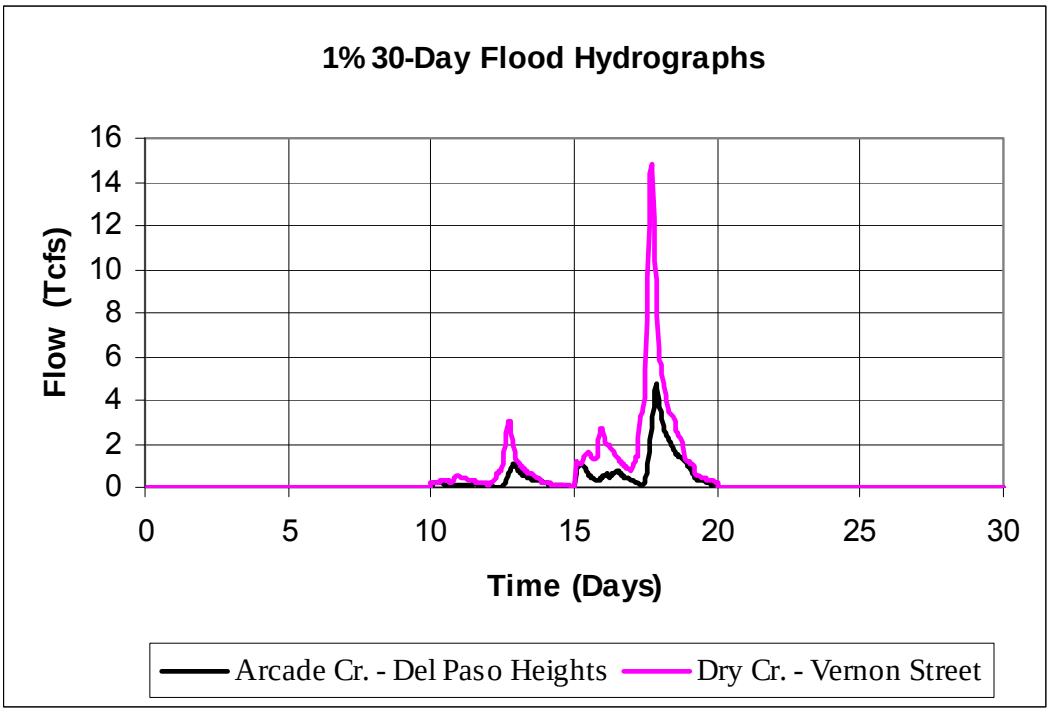

Figure 3. Synthetic 1% Flood 30-Day Wave Hydrographs for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights Gage

7.5 Routing Balanced Flood Hydrographs to NEMDC. The HEC-1 model was used to route the balanced 30-day synthetic flood hydrographs for Dry Creek at Vernon Street and Arcade Creek downstream to the NEMDC index points, combined with the local flow hydrographs along the way. The 8-flood volumes for Dry and Arcade creeks at NEMDC closely match the 5- and 10-day volumes listed on **Table 8**. The peaks and flood volumes for the flood hydrographs for Dry and Arcade creeks at NEMDC are listed on **Tables 11 and 12** below.

Table 11

Peak and Volume Tabulation for Synthetic 8-Flood Series

Dry Creek at NEMDC from Upstream Balanced Hydrographs

8-Flood Event	**Peak** (cfs)	**24-Hour** (avg cfs)	**3-Day** (avg cfs)	**5-Day** (avg cfs)	**10-Day** (avg cfs)
50%	2,170	1,840	1,170	949	543
20%	3,980	3,330	1,990	1,520	887
10%	5,330	4,520	2,620	1,960	1,150
4%	7,280	6,240	3,560	2,580	1,540
2%	8,900	7,670	4,290	3,060	1,830
1%	11,500	9,230	5,050	3,530	2,110
0.50%	14,000	10,700	5,820	4,010	2,410
0.20%	18,800	13,500	7,020	4,760	2,860

Table 12

Peak and Volume Tabulation for Synthetic 8-Flood Series

Arcade Creek at NEMDC from Upstream Balanced Hydrographs

8-Flood Event	**Peak** (cfs)	**24-Hour** (avg cfs)	**3-Day** (avg cfs)	**5-Day** (avg cfs)	**10-Day** (avg cfs)
50%	1,810	938	477	321	213
20%	2,380	1550	777	525	341
10%	2,930	1900	982	662	426
4%	3,600	2350	1230	837	535
2%	4,100	2690	1410	964	614
1%	4,620	3010	1580	1090	692
0.50%	4,970	3320	1750	1220	772
0.20%	5,570	3740	1970	1380	872

7.6 Peak Flow Attenuation. The balanced flood hydrographs with higher peaks at the upstream gaging stations on Dry and Arcade creeks do generate higher peak flows downstream at their confluences with NEMDC. With the routing process and addition of local flows, peak flows for the 50- and 20% flood events may increase in magnitude down at NEMDC. For the 10% and rarer floods, peak flows on Arcade Creek may attenuate somewhat as they travel down to NEMDC. In the modeling process, the peak flows for Dry Creek at Vernon Street for the 10% and rarer events appear to attenuate

more in proportion to their magnitude. In the HEC-1 model, the 0.2% flood peak for Arcade Creek at NEMDC is 94% of the peak flow at the Paso Heights gage (5,570 cfs compared with 5,900 cfs upstream), while the Dry Creek peak flow at NEMDC is 77% of the peak flow at Vernon Street (18,800 cfs compared with 24,500 cfs upstream).

For the prior hydrology analysis of the NEMDC tributaries (**Reference 1**), peak flows for Arcade Creek at the "near Del Paso Heights" gage increased slightly downstream at NEMDC. Peak flows for Dry Creek at Vernon Street were attenuated downstream at NEMDC, but by no more than 8%, not by greater than 20%. All of the subbasin hydrographs for Dry and Arcade creeks were ratios of the computed HEC-1 subbasin flows for the modeled NY '97 historical flood. The hydrographs for Dry Creek at Vernon Street and Arcade Creek at Del Paso Heights gage were not balanced, nor were the peak flows adjusted to match existing flow frequency curves.

8. RESULTS

The Dry and Arcade creeks 30-day hydrographs for the synthetic 8-Flood Series were provided to Hydraulic Design Section. The hydrographs for the Dry Creek/Vernon Street and Arcade Creek/Del Paso Heights index points have higher peaks but the same volumes as the 8-flood series hydrographs documented in **Reference 1**. These hydrographs will be used in a hydraulic stage frequency analysis for NEMDC. They will also be used for additional hydraulic routing to upstream index points on Dry and Arcade creeks.

The synthetic 8-flood series hydrographs provided to Hydraulic Design Section are for the locations listed in **Table 13**. These locations are also shown on **Plates 2 and 3** for Dry and Arcade creeks.

Table 13

List of Locations for Balanced Synthetic 8-Flood Series Hydrographs
Provided to Hydraulic Design Section

Subbasin #	Subbasin or Index Pt. Location	D.A. (sq mi)
Dry Creek:		
511140	Dry Cr. At Sacramento-Placer County Line	88.58
512320	Sierra Cr. At Mouth	3.00
512110	Dry Cr. Local at Q Street	5.74
591010	Robla Cr. At Mouth	5.70
591011	Magpie Div. above Robla Cr.	8.90
510930	Dry Cr. Local at Rio Linda Blvd.	2.59
590620	Dry Cr. Local at NEMDC	1.97
590620	Dry Cr. Total Flow at NEMDC	116.48
Arcade Creek:		
HC15	Arcade Cr nr Del Paso Heights Gage	31.83
40	Del Paso Park Subbasin	1.91
50	North Town & Country Subbas	1.81
60	Interior Drainage above Pump 103	1.51
64	Water from Pump 103	1.51
70	Interior Drainage above Pump 159	1.22
72	Water from Pump 159	1.22
80	Interior Drainage above Pump 158	0.78
82	Water from Pump 158	0.78
90	Interior Drainage above Pump 154	1.08
92	Water from Pump 154	1.08
92C	Arcade Cr. Total Flow at NEMDC	40.14

9. LIST OF REFERENCES

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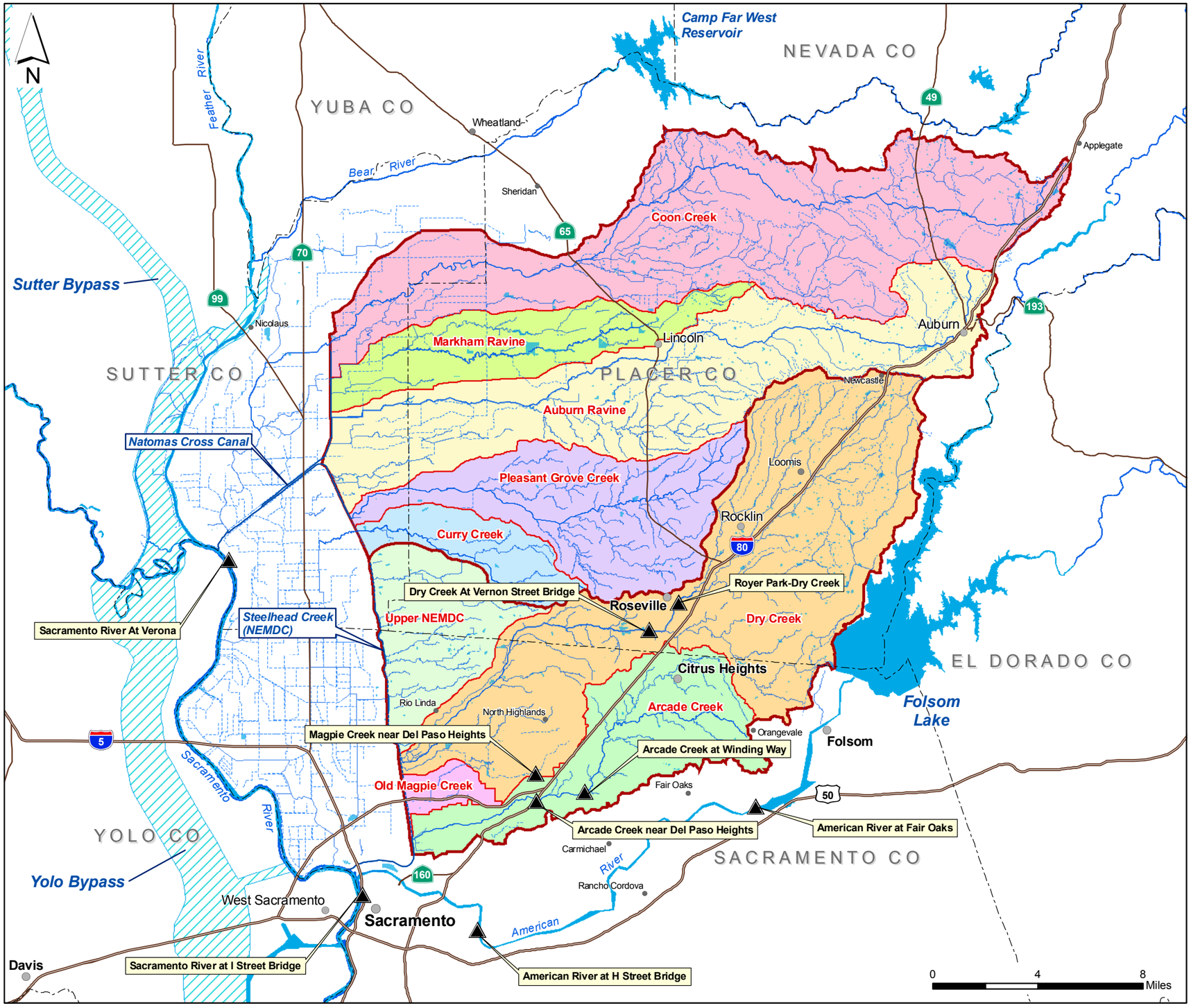

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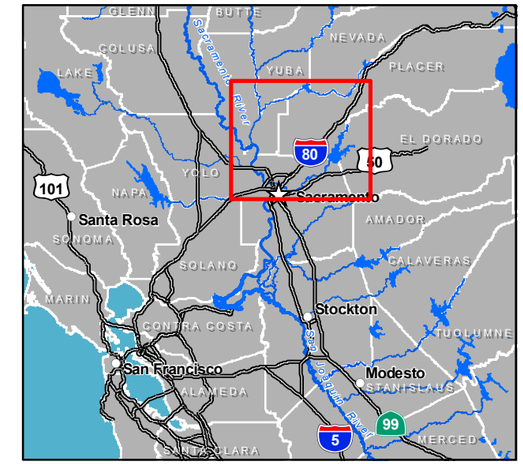


Legend

- Stream Gage
- Watershed
- Sub-Watershed
- Lake or Major River
- River or Stream
- Canal or Ditch
- Freeway
- Highway
- County Boundary
- City or Town

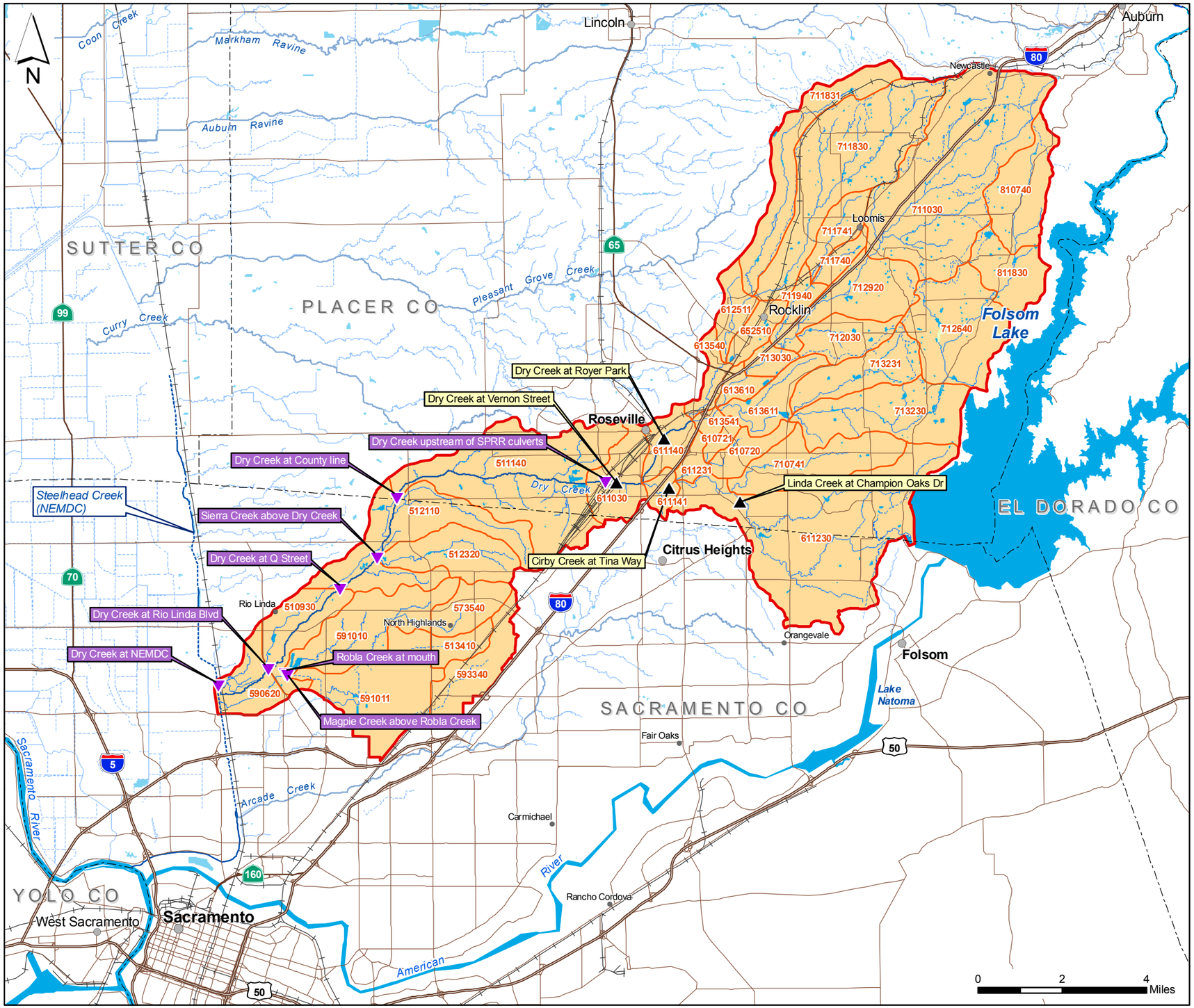
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

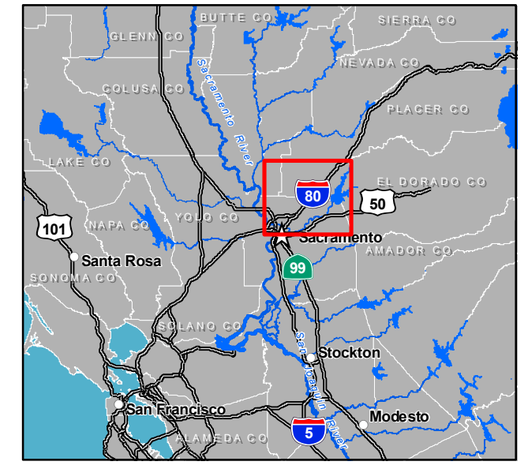
GENERAL MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2009

PLATE 1





Legend

- Stream Gage
- Model Index Point
- Watershed
- Subbasin
- Waterbody
- River or Stream
- Canal or Ditch
- Freeway
- Highway
- Major Street or Road
- Railroad
- County Boundary
- City or Town

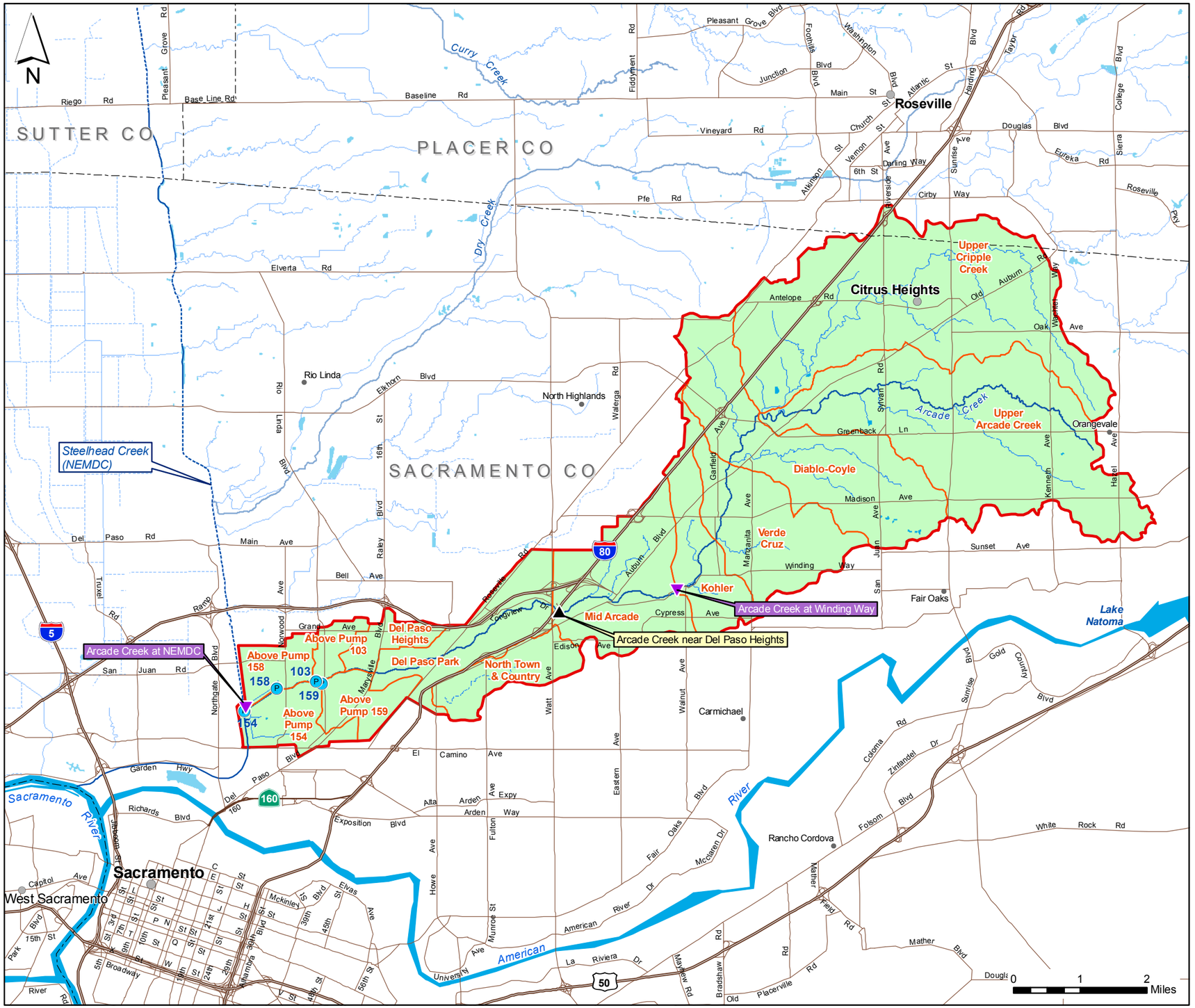
American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

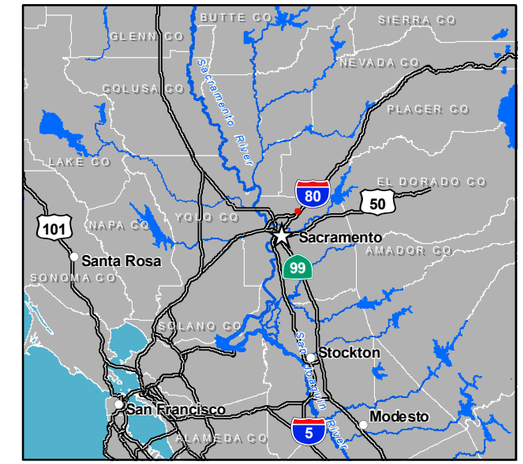
DRY CREEK WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2009

PLATE 2





Legend

- Stream Gage
- Model Index Point
- Pump Station
- Watershed
- Subbasin
- Waterbody
- River or Stream
- Canal or Ditch
- Freeway
- Highway
- Major Road
- County Boundary
- City or Town

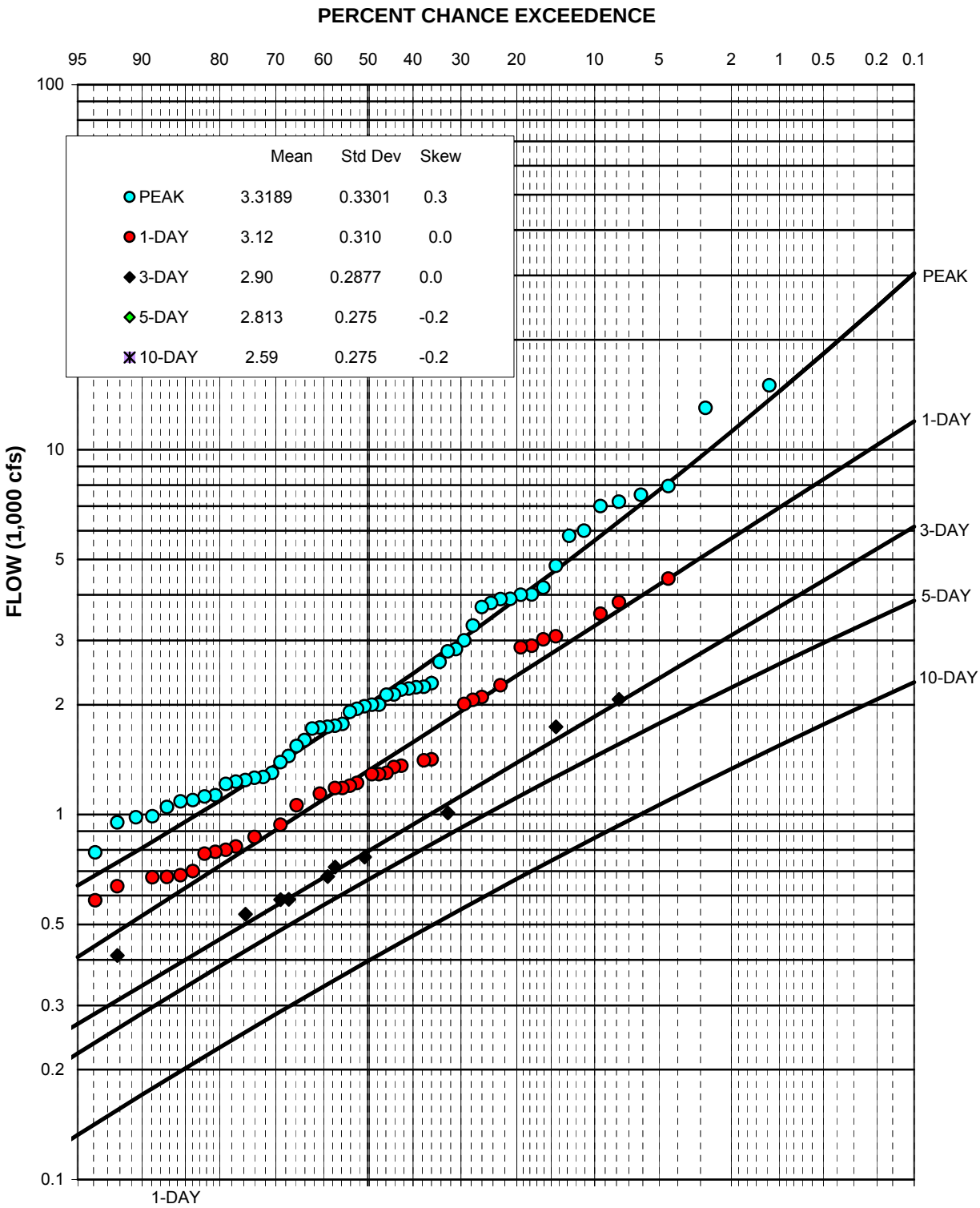
Prepared by J.S.M

American River Common Features GRR
Placer, Sacramento, Sutter Counties, California

ARCADE CREEK WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

NOV 2009



NOTES:

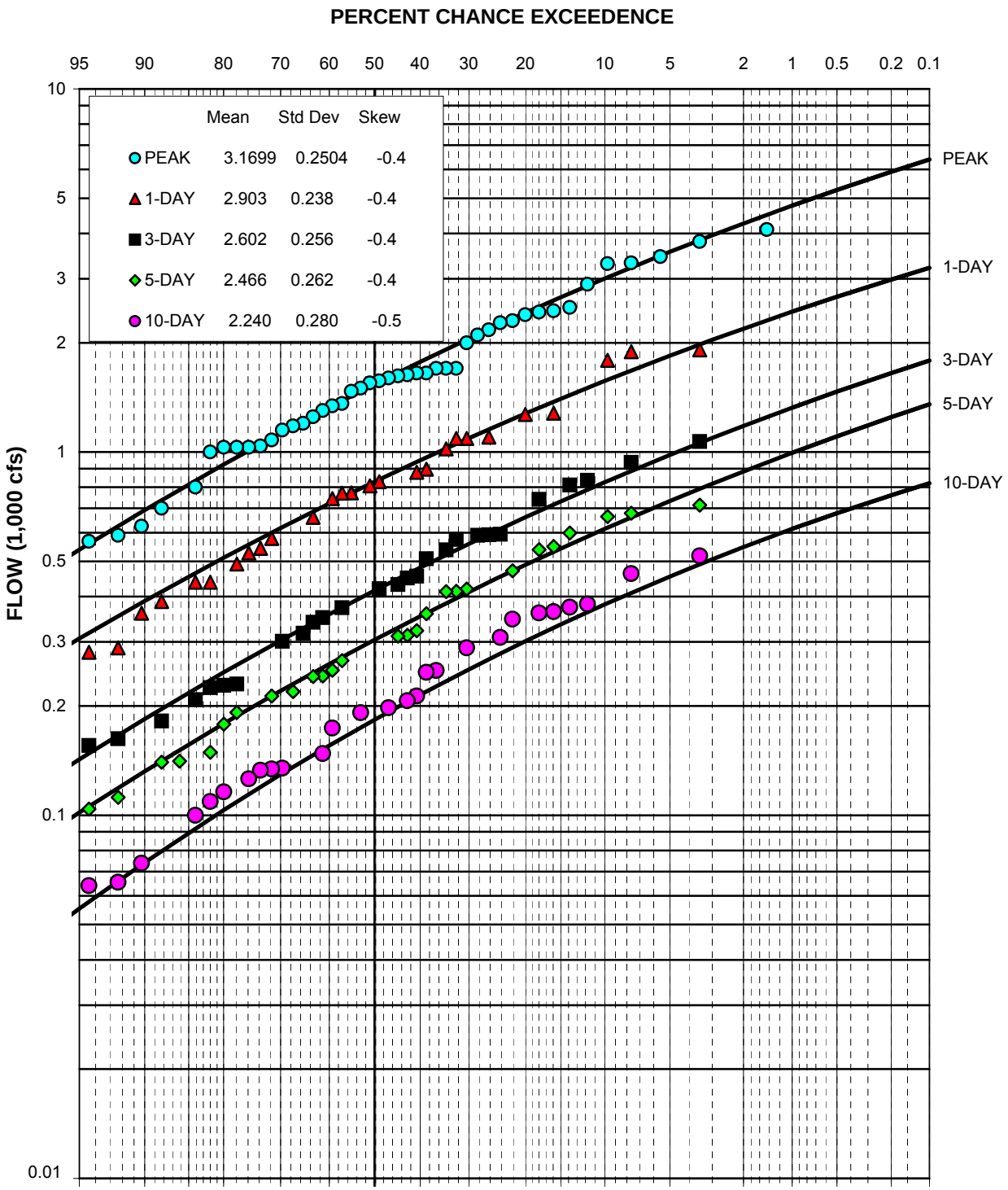
1. Drainage area 78.20 sq. mi.
2. Median plotting positions, 60 years record.
3. Peak and 1-day plotting positions for WY 1950 to 2009, observed and estimated flows.
4. 1977 identified as low outlier peak.

Developed by LLW and prepared by JLB

AMERICAN RVR COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CA

RAINFLOOD FREQUENCY CURVES
DRY CREEK AT VERNON ST., ROSEVILLE
USGS STATION 11447293
WATER YEARS 1950 TO 2009

U.S. ARMY CORPS OF ENGINEERS
WATER CONSERVATION DISTRICT



NOTES:

1. Drainage area 31.5 sq. mi.
2. Median plotting positions, 48 yrs record.
3. Period of record WY 1964-1978, 1996-2009 for 1-day to 10-day flows.
4. FFA peak flow record for 1962 to 2008.
5. 1976 identified as low outlier peak.

Developed by LLW and prepared by JLB

AMERICAN RIVER COMMON FEATURES GRR
PLACER, SACRAMENTO, SUTTER COUNTIES, CA

RAINFLOOD FREQUENCY CURVES
ARCADE CREEK NR DEL PASO HEIGHTS
USGS STATION 11447360
WATER YEARS 1962-2009

U.S. ARMY CORPS OF ENGINEERS
WATER CONSERVATION DISTRICT

WATER MANAGEMENT SECTION
CERTIFICATION FOR AGENCY TECHNICAL REVIEW

American River Common Features Project General Reevaluation Report
Placer, Sacramento, Sutter Counties, California
Synthetic Hydrology Technical Documentation, Sacramento District
September 2008, Revised January 2009

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 agency 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 American River Common Features Project General Reevaluation.

Laurine L. White — 26 Jan 2009
Laurine L. White
Hydrologist, SPK
Date

James Chieh — 1-26-2009
James Chieh
Independent Technical Reviewer
Date

John M. High — 1-26-2009
John M. High
Chief, Water Management Section, SPK
Date

HYDROLOGY SECTION
CERTIFICATION FOR AGENCY TECHNICAL REVIEW

American River Common Features Project General Reevaluation Report
Appendix B, Dry and Arcade Creeks Flow Frequency Curves
And Synthetic 8-Flood Series Hydrographs
Upstream of Steelhead Creek, Sacramento District
November 2009, Revised January 2010

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 agency 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 American River Common Features Project General Reevaluation.

Laurine L. White — 19 January 2010
Laurine L. White
Hydrologist, SPK
Date

James Chieh — 20 January 2010
James Chieh
Independent Technical Reviewer
Date

John M. High — 19 JANUARY 2010
John M. High
Chief, Hydrology Section, SPK
Date

HYDROLOGY SECTION

CERTIFICATION FOR AGENCY TECHNICAL REVIEW

West Sacramento General Reevaluation Report
Yolo County, California
Hydrologic Study

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 U.S. Army Corps of Engineers criteria and policy.

In accordance with CESPD R 1110-1-8, 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 West Sacramento General Reevaluation.

This quality control certification includes the 50% through 0.2% chance flood hydrographs on the Sacramento River and Yolo Bypass in the vicinity of West Sacramento, which is based on the Comprehensive Study Latitude of Sacramento flood centering. The concurrent American River flows in this centering 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.

I certify that an independent technical review of the project indicated above has been completed and that all technical issues have been identified and resolved. I recommend certification that the quality control process has been completed.

John M. High, Section Chief
Hydrology Section, SPK

10/19/2010
Date

Gregory A. Kukas, Branch Chief
Hydrology & Hydraulics Branch, SPK

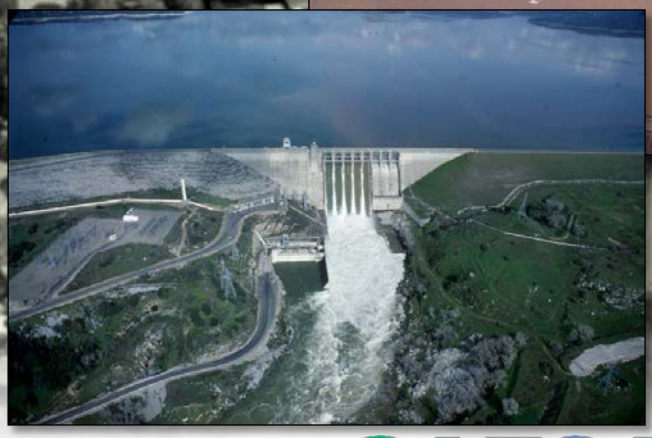
10/19/2010
Date

American River Watershed

Common Features
General Reevaluation Report

Attachment B
Hydraulic Report

December 2015



SAFCA
Sacramento Area Flood Control Agency

CENTRAL VALLEY FLOOD PROTECTION BOARD
PUBLIC SAFETY
WITH FLOOD PROTECTION
STATE OF CALIFORNIA

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Attachment B
Hydraulic Report

U.S. Army Corps of Engineers
Sacramento District

December 2015

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AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

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Technical Memorandums Supporting this Executive Summary Report

Memorandums are referred to in the text by the numbers shown below but are not included in this report. Copies are available on request.

1. Sacramento Basin HEC-RAS Phase I Model Development
2. Sacramento Basin HEC-RAS Phase II Model Development
3. Sutter Basin HEC-RAS Model Conversion
4. Datum Conversion of Hydraulic Models to NAVD88 Values
5. Downstream Boundary Conditions
6. Gages
7. Hydrologic Inputs (DSS files)
8. High-Water Marks
9. Hydraulic Uncertainty
10. FLO-2D Floodplain Mapping Documentation
11. Levee Breach Sensitivity
12. Climate Change Memo
13. Systems Risk and Uncertainty
14. Interior Drainage
15. Upstream Alternative Analysis
16. Calibration
17. TSP Comparison
18. Historic Upstream Levee Failure

1 STUDY DESCRIPTION

1.1 Introduction

This Hydraulic Report summarizes a collection of technical memorandums documenting the hydraulic analysis performed to support the ARCF GRR and has been prepared to meet the intention of the new USACE SMART Planning process – Specific, Measurable, Attainable, Risk-informed and Timely. A complete list of the memorandums cited in this document follows the Table of Contents and are also located in the References section. To support streamlined documentation as part of SMART Planning, the memorandums are referenced but not included with this report. They can be provided on request.

Several significant factors justify a reevaluation of the American River Common Features Project at this time:

1. Since the last authorization of the American River Common Features Project, the scope and cost of levee improvements for the Natomas Basin have increased.
2. New hydraulic modeling and geotechnical studies suggest potential issues with the Sacramento River east levee downstream of the American River. Specifically, the levees have shown evidence of through-seepage and underseepage that could lead to a failure. Such a failure could cause major flooding in the city of Sacramento.
3. There are also additional erosion issues on the American River that will need to be addressed to ensure that the American River can pass 160,000 cubic feet per second (cfs) with some degree of certainty.

Based on these factors, the city of Sacramento may continue to have a high risk of flooding, even with the completion of all authorized improvements in the Natomas Basin, along the Lower American River, and at Folsom Dam.

Previous study efforts of the Natomas Basin under the Natomas GRR were folded into a more broadly scoped American River Common Features General Reevaluation Report. That report considered all the aforementioned issues from a system approach in order to reduce the flood risk in the entire city of Sacramento.

1.2 Location

The project area reflects the area for which alternatives were formulated to meet the planning objectives. The study area is a broader area where the benefits (or impacts) of the alternatives was evaluated. The project area is divided into three basins – Natomas, American River North, and American River South – and has an upstream boundary at Verona and a downstream boundary at Freeport on the Sacramento River (see Plate 4 for the location of these basins). It also includes the leveed portions of the American River, the Natomas Cross Canal, the Natomas East Main Drain Canal (NEMDC), the Pleasant Grove Creek Canal, Magpie Creek, and the leveed portions of Dry and Arcade creeks. The study area for the ARCF GRR includes the above project area and extends beyond it both upstream and downstream. See Plates 1 and 2 for a watershed and a general topographic map, respectively.

Flood control channels and other features in the Sacramento area are part of a much larger flood control system known as the Sacramento River Flood Control Project (SRFCP). The SRFCP in the

Sacramento Valley consists of a series of levees and bypasses, placed to protect urban and agricultural areas and take advantage of several natural overflow basins. See Plate 3 for a graphic depiction of the system layout. The SRFCP system includes levees along the Sacramento River south of Ord Ferry; levees along the lower portion of the Feather, Bear, and Yuba Rivers; and levees along the American River. The system includes the Sutter, and Yolo bypass channels. These bypass channels run parallel to the Sacramento River and receive excess flows from the Sacramento, Feather, and American rivers via overflow channels and constructed weirs. During floods, the flood control system is one continuous waterway.

1.3 Topographic Data

Existing topography and bathymetry were used for most of the study's hydraulic modeling efforts. There were several areas with updates, including the Natomas east side tributaries area for the HEC-RAS model where new surveyed cross sections were developed.

The topography for the HEC-RAS model was previously collected for the Sacramento River Bank Protection Project and the Sacramento San Joaquin Comprehensive Study (Comp Study) UNET model. More detailed descriptions of the hydrographic and topographic surveys completed are in documentation provided by Ayres Associates in support of the Comprehensive Study (References 31, 32).

The geospatial survey data used in the development of the FLO-2D models were obtained from both Sacramento County and the United States Geological Survey (USGS). The Sacramento County information included LiDAR data for the urban area of the county and is dated 2004. The USGS information included publicly available 30-meter USGS Digital Elevation Models (DEMs) which were obtained from http://www.GISdatadepot.com.

All topographic data references the North American Vertical Datum of 1988 (NAVD88) and the North American Datum of 1983 (NAD83), projected in California State Plane Zone 2. The units are in feet. Several of the topographic datasets were created in different vertical datums and significant effort has been made to convert the topographic datasets and hydraulic models into the current standard vertical datum, NAVD88. See both the Technical Memorandum (USACE May2013c) on model datum conversion and the reference on the Comprehensive Study topography conversion (HJW Geospatial, 2010).

1.4 Study Approach

The three basins that are the focus of this GRR – American River North, American River South and Natomas (described in more detail in Chapter 3) are susceptible to flooding from both the American River and Sacramento River. Within the study area, the American and Sacramento rivers were divided into more than 25 river reaches according to the geotechnical similarity of their levees. The number was reduced to five representative reaches that would adequately describe the flood risk within the study area during the plan formulation process.

HEC-RAS (1-dimensional channel model) and FLO-2D (2-dimensional gridded model) hydraulic models were used to produce necessary outputs for the economic evaluation of the future without-project conditions and alternatives. The ARCF GRR used the same basic models that were developed and refined for the existing conditions (F3, March 2009) analyses and the Natomas Post Authorization Change Document (NPAC, 2010). HEC-RAS was used to model the main flood control channels of the

system to determine the water surface profiles assuming no levee failure. The model was also used to simulate levee failure scenarios and simulate flood hydrographs into the floodplain areas. This HEC-RAS model includes the major river reaches within the lower portion of the Sacramento River Watershed. This was done to capture upstream and downstream influences to the project area as well as to eventually determine the potential project impacts to areas outside the project area.

Flood hydrographs generated in HEC-RAS from a levee break were input into FLO-2D for delineation of the floodplain in each basin. In order to generate flood damages for economic evaluations, floodplains were delineated for the 50% (1/2), 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5% (1/200-Yr) and 0.2% (1/500) annual chance exceedance events. The analysis was limited to flooding within the basin from levee breaches and does not include localized flooding from rainfall-runoff and smaller streams and drainages.

Floodplain delineations presented in this study are based on a single levee break within a levee reach. The levee break location was determined by the most significant geotechnical concerns along that reach and by any overriding hydraulic concerns, such as low levee elevations or locations where a large amount of water could travel through the levee break and out into the floodplain. The resultant flood depths from FLO-2D and the stage-discharge-frequency curves derived from HEC-RAS outputs were used to perform the risk analysis for the without-project condition and the alternatives.

This report presents a very specific and detailed analysis of the with- and without-project conditions for the general Sacramento metropolitan area. Based on an evaluation of study risks, some analyses typically found in a hydraulic appendix have been reduced to a sensitivity analysis, have not been done, or have been postponed to a later date and will likely be completed during design. These efforts are summarized below:

Efforts analyzed using sensitivity:

- Climate change
- Sea level rise
- Interior flooding

Efforts not expected to be completed at this time or in design:

- FEMA accreditation/certification
- Safe overtopping locations and evacuation plans
- Boat wave erosion

Efforts recommended for design or during refinement of selected plan:

- Sedimentation engineering, fluvial geomorphology
- Channel stability, channel stabilization, bridge scour
- Bank projection, vegetation analysis (tree scour)
- Operation and maintenance

The key assumptions for each analysis are listed in Table 1-1.

Table 1-1. ARCF Hydraulic Analyses and Key Assumptions	
ARCF Hydraulic Deliverables	Key Assumptions
Future without-project condition analysis (HEC-RAS, Flo-2D)	The project area is adequately represented by index points at 5 key locations, reduced from over 25.
Evaluation of final alternatives for evaluation (HEC-RAS)	For alternative analysis, large cost measures screened out qualitatively. Many features reduced and combined into final array of alternatives.
With-project floodplain analysis (Flo-2D)	Used without-project floodplains and adjusted frequency of floodplain based on peak stage and volume.
Potential Hydraulic impacts (HEC-RAS)	The baseline for potential hydraulic impacts at Folsom is the future without project condition with the Folsom features(JFP Spillway, Dam Raise) in place.
Residual risk (HEC-RAS, Flo-2D)	Overtopping of American River upstream of leveed reach and Sankey Gap will not be modified by a future project.
Interior drainage	Existing FEMA interior floodplains used in place of full interior drainage analysis.
Systems risk and uncertainty	HEC methodology used based on Reference 5.
Climate change	Sutter methodology used, sensitivity analysis only.
Sea level rise	Used Information from recent study in the Delta and existing sensitivity analysis.
Coincident flow frequency	Based on direction from Hydrology Section Chief, using the n-year event for coincident flows on the Eastside Tributaries and the American River until design, then refinement likely needed.
Superiority	No analysis was performed. Instead, ETL 1110-2-299 was used with bypasses serving as the overtopping locations along with using congressional legislation assumptions specifically for the American River.
Erosion (including riverine/bank, wind-wave, and channel stability)	Limited analysis conducted, coordinating with ongoing design efforts that are not yet complete. Erosion repair for the American River is identical to all alternatives.
Vegetation variance	Vegetation Variance Deferred to PED, Hydraulic efforts will be part of erosion scoping, likely a HEC-18 analysis for tree scour.

1.5 Basis of Design

The following is a partial list of USACE guidance used in the hydraulic analysis:

ER 1110-2-1150	Engineering and Design for Civil Works Projects
EC 1110-2-281	Requirements of River Hydraulics Studies
ER 1110-2-8153	Sedimentation Investigations
ER 1110-2-1405	Hydraulic Design for Local Flood Protection Projects
EC 1165-2-201	Ecosystem Restoration in the Civil Works Program
EM 1110-2-1416	River Hydraulics
EM 1110-2-1619	Risk-Based Analysis for Flood Damage Reduction Studies
EM 1110-2-4000	Sediment Investigations of Rivers and Reservoirs
EM 1110-2-1205	Environmental Engineering for Local Flood Control Channels
EM 1110-2-1601	Hydraulic Design of Flood Control Channels
ERDC/CHL TR-01-28	Hydraulic Design of Stream Restoration Projects
ETL 1110-2-299	Design of Overtopping of Levee
EC 1110-2-6067	USACE Levee Certification Guidance

2 PROJECT DESCRIPTION

2.1 Project Area Limits

The project limits for the floodplain north of the American River cover approximately 124 square miles of Sacramento County (see Plate 5). The American River North basin includes the area north of the American River and east of the Natomas East Main Drain Canal (NEMDC). It is separated from the Natomas Basin by the NEMDC. The American River North Basin is bounded on two sides by levees and high ground on the remainder as follows:

- Southern boundary: American River levees from Hazel Avenue to the NEMDC
- Western boundary: NEMDC levees
- Northern boundary: High ground and Elverta Road
- Eastern boundary: High ground

The American River South basin includes the area south of the American River and east of the Sacramento River (see Plate 6). For this effort, it does not include the Morrison Creek Stream Group. The study limits for the floodplain south of the American River cover approximately 254 square miles of Sacramento County and are defined as follows:

- Southern boundary: Morrison Creek Stream Group levees
- Western boundary: Sacramento River levees
- Northern boundary: American River levees from Hazel Avenue to confluence with Sacramento River
- Eastern boundary: High ground

The Natomas Basin is almost completely enclosed by levees and has significant interior drainage works (see Plate 7). The Natomas basin includes the reach of the Sacramento River from the Natomas Cross

Canal to the American River, the Pleasant Grove Creek Canal (PGCC), and the NEMDC. The Natomas basin is bounded as follows:

- Southern boundary: American River levees from the NEMDC to the confluence of the American and Sacramento Rivers
- Western boundary: Sacramento River levees from the Natomas Cross Canal to the confluence of the American and Sacramento Rivers
- Northern boundary: Cross Canal levees
- Eastern boundary: The NEMDC levees to the southern two-thirds of the eastern boundary and levees for a drainage canal connecting to the Cross Canal for the northern one-third of the eastern boundary

There is one location that is not leveed in the Natomas Basin, where the NEMDC and the drainage canal on the eastern boundary meet. This opening is less than a quarter mile in length near Sankey Road, and is commonly referred to as the Sankey Gap.

2.2 Future Without-Project Condition

The Sacramento River system configuration as it generally exists now (between years 2006 and 2014) was used for the future without-project condition with the exception of changes on the American River.

The ARCF GRR study assumes that the work identified in the Natomas PACR Chief's Report has been completed.

This study also assumes that all previously authorized constructed and unconstructed work on the American River, the new spillway being constructed at Folsom Dam, and the future planned raise of Folsom Dam. The Folsom Dam and Spillway were assumed to be operated as described in Appendix B2: American River Hydrology and Folsom Dam Reservoir Operations of the Hydrology Appendix.

As part of the March 2009 Existing Conditions Conference (F3), multiple scenarios were proposed and analyzed for the without-project and future without-project conditions for the American River. Much of the Sacramento River system was expected to be the same under the future without-project condition with the exception of the following:

- Changing operations at Folsom Dam because of the Joint Federal Project Spillway (JFP),
- Levee repairs as described in the "Natomas Post Authorization Change Report"
- Levee repairs as described in the "Authorized American River WRDA 96/99 Sites"

The Project Delivery Team (PDT) decided to analyze conditions needed to justify only the current work proposed by the ARCF GRR document. This decision considered the significant effort already expended and additional effort still needed to answer the question of incrementally justifying projects on the American River. Based on this information as well as profile comparisons, it was determined that it is not necessary to consider the multiple without-project conditions as previously studied.

For the ARCF GRR document, only a single without-project condition was analyzed. This condition was known as the NA3 condition in the CF GRR F3 documentation. Because previous nomenclature used was confusing, a new naming system was developed. The NA3 condition is now known as the Authorized Common Features + Joint Federal Plan + Dam Mini-Raise (ACF + JFP + Dam Mini-Raise). This

plan includes all previously authorized constructed and unconstructed work on the American River, the new spillway being constructed at Folsom Dam, and the future planned raise of Folsom Dam.

All this is considered to be part of the without-project condition. Any work beyond the without-project condition, proposed under the ARCF, is considered part of the with-project condition.

3 CHANNEL HYDRAULICS

3.1 Background

This chapter documents the HEC-RAS model development and calibration for the Sacramento River Basin river system in support of the ARCF GRR. HEC-RAS is a 1-D hydraulic model that can be run in steady or unsteady mode. The model for the Sacramento River Basin was generated from a combination of several previous modeling efforts, many of which modeled a portion of the Sacramento Basin. Previous modeling was supplemented with new modeling for some reaches.

A basin-wide UNET model was previously developed for the Sacramento Basin as part of the Sacramento and San Joaquin River Basins Comprehensive Study (Comp Study. As part of the F3, the entire model was converted from UNET to HEC-RAS, with the exception of the Butte Basin and the Sacramento River north of Colusa. All modeling is currently being done using HEC-RAS. Handoffs from the UNET model in the form of flow hydrographs were used as upstream boundary conditions for the HEC-RAS model. Details regarding development of the HEC-RAS model are contained in the Sacramento Basin HEC-RAS Phase I Development Technical Memorandum (USACE May 2013i).

Modeling of the study area was done in different phases in order to avoid delays to the major milestones of the ARCF GRR schedule. Phase 1(USACE May 2013i) of the model development was completed previously and supported the Natomas Post Authorization Change Document (Natomas PAC) in 2010 (the Natomas PAC is a portion of the overall ARCF GRR study). Phase 1 documents the generation of the main geometry files with pertinent features, including representation of major flood control levees in the system. During this phase of model development, the model was calibrated to the 1997 flood event. The model developed under Phase 1 was used to run *n*-year synthetic events, [50% (1/2), 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5% (1/200-Yr) and 0.2% (1/500)] for without-project conditions to determine economic damages and to screen alternatives for the Natomas PAC study. This model was based on the NGVD1929 vertical datum.

For Phase 2 of model development, the model was converted to the NAVD1988 vertical datum (USACE, May 2013c). Additional reaches were added to the model, in particular the Natomas east side tributaries (WEST July 2010). Though the model does cover a large portion of the lower Sacramento watershed, its main purpose is not to provide detailed hydraulics for all reaches in the system, but rather to support the ARCF GRR, which is for flood damage reduction efforts in and around Sacramento. Other Corps studies within the Sacramento Basin system, in particular the Sutter County Feasibility Study and the West Sacramento GRR studies, also use the same “base” Phase 2 model, but include refinements pertinent to their particular study reaches. More information on Phase 2 development can be found in the Draft Sacramento Basin HEC-RAS Phase II Development Technical Memorandum (USACE, May2013j).

3.2 Hydrology

Inflow hydrographs to the hydraulic models presented in this report are described in the hydrology report. Hydraulic model simulations were performed for flood frequencies ranging from 50% (1/2) through the 1.2% (1/500) ACE events. The hydrology report includes minor updates were made to the hydrology used in the Natomas Post Authorization Change Report. This includes greater detail and refinement of the tributary streams on the east side of the Natomas Basin and an update on timing of the American River outflows. For a revised map showing locations of boundary conditions, see Plate 57.

3.3 Model Calibration

The model was calibrated to flood events that occurred in 1997 and 2006. The Calibration Technical Memorandum (USACE, May 2013a) includes additional information on the calibration efforts. The 1986, 1997, and 2006 flood events were considered for model validation. The 1986 flood could not be used for validation, however, because it lacked a complete set of data. The 1997 event was selected for calibration because a significant amount of calibration data was collected for the 1997 event. However, this event was complicated by the challenges of accurately representing breach flow through two levee failures. The 2006 event was initially selected for model validation for two reasons: (1) there were no levee failures, even though it produced high stages within the Sacramento Flood Control System, and (2) results of the 2006 event, when compared to high-water mark data and gage data gathered at that time, could be used to test the results of the 1997 calibration. The 2006 was used first to validate the hydraulic model results and then it was also used as a second calibration because there were refinements mostly in terms of weir coefficients. This second calibration effort removes the independence of the model validation and there is not an additional flood event with enough hydrologic information to continue the model validation. However, the 2006 event has been reasonably reproduced and demonstrates the model's ability to reproduce results from multiple events.

Insomuch that calibration was done to both the 1997 and 2006 flood events, two separate model geometries had to be created to account for geometric changes that occurred between 1997 and 2006 that could impact the hydraulics. The first geometry represents the state of the system leading up to the 1997 flood event. The second geometry represents the state of the system leading up to the 2006 flood event. The 2006 geometry is different because it includes the following physical features that were constructed after the 1997 flood event:

1) *Pump Station at the Natomas East Main Drain Canal (NEMDC) / Dry Creek Confluence*
2) *Setback levee at Shanghai Bend on the Feather River*
3) *Setback levee on the Bear River as it meets the Feather River*

Model result hydrographs were compared to gage records and peak stage data, where available, for the 1997 and 2006 flood events. The HEC-RAS model parameters for Manning's *n*, weir coefficients, and levee breaches were then adjusted as needed in an iterative procedure to modify the model results to more closely match the calibration data. The final modeled water surface profiles matched highwater marks, hydrograph peak stages and flows, and hydrograph shapes at numerous gages throughout the system reasonably well.

3.4 Water Surface Profiles

The HEC-RAS model was used to develop water surface profiles for all reaches surrounding the three basins. A suite of seven *n*-year frequency profiles [50% (1/2), 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5% (1/200-Yr) and 0.2% (1/500)] is shown in Plates 12–24 for the future without-project condition (FWOP). The FWOP will serve as the baseline for alternative comparison. This suite of model runs included raising the levees along the project reaches high enough to contain all of the flow up to and including the 0.2% (1/500) ACE event through that reach. This approach supported an economic analysis of levee raises at multiple heights above the existing top of levee. The baseline to determine if a levee needs to be raised was set at the median 0.5% (1/200) Annual Chance Exceedance (ACE) plus 3 feet. This assumption is based on both the local sponsor's Urban Levee Design Criteria (DWR 2012) and the intent of the Folsom JFP to control releases up to 160,000 CFS which is currently estimated to be a 0.5% (1/200) ACE event.

This top of levee design of 3 feet above the median 0.5% (1/200) ACE was used on all reaches except the American River where there was already a design water surface profile from the WRDA 1996/1999 Design efforts. The American River top of levee was set at 3 feet above the design flow of 160,000 cfs (currently a median 0.5% (1/200) ACE) at a single index point but this would need to be evaluated in PED for the entire reach for levees on both sides.

There are two unique features on the water surface profiles on Plates 12-24. First, on the NEMDC right bank levee (Plate 19), there is a pump station at RM 6.3 that also acts as a barrier to rising American River backwater flowing up the channel. This is shown by a lower water surface profile upstream of the NEMDC Pump station than on the downstream side. Secondly, during large flood events, water from the American River flows upstream on the Sacramento River to the Sacramento Weir, where it discharges into the Sacramento Bypass (which connects to the Yolo Bypass). This creates a flat or increasing water surface profile downstream of the Sacramento Weir, which can be seen in the profile plates noted above.

3.5 Levee Breach Assumptions

Levee breach model results are needed for input into the 2D floodplain routing model (FLO-2D) to delineate the corresponding floodplains. Several key levee breach assumptions are listed below:

- A levee breach width of 500 feet was used consistently in the models that support the ARCF GRR. Historical precedent shows that 1,000 feet (which the Corps has used on other studies in the Sacramento Basin) is an achievable breach width, but it is on the high end of all known widths. The 500-foot width was chosen as a more reasonable or average value.

- For each model run with a levee break, the trigger elevation for a levee break was set to 0.5 feet below the max water surface of the simulated event at the failure location.

- If the maximum water surface did not reach the toe of levee, it was assumed that the levee did not fail and a breach simulation was not performed.

- The time for the breach to develop was set at 1 hour.

Several of these assumptions were evaluated with a sensitivity analysis and confirmed to not significantly impact the hydraulic results. The sensitivity analysis is discussed further in section 5.2 and the Levee Breach Sensitivity Technical Memorandum (USACE, May 2013h).

4 ALTERNATIVE DEVELOPMENT

4.1 Evaluation of Measures

A wide range of features were evaluated to reduce flood risk in the project area. There are two main strategies to reduce this risk:

- Reduce the consequences of flooding by moving communities to higher ground out of the floodplain, flood proofing, land use changes, and/or other non-structural alternatives.

- Reduce the probability of inundation of structures. This is generally done in one of two ways:
    - Reduce the amount of flood water getting to and through the project area
    - Fortify and improve the current flood defense system

Reducing the consequences of flooding is addressed in the main feasibility report and the economic appendix. Reducing the probability of inundation is addressed starting here in Chapter 4, with additional information found in Chapters 5-7. Measures to reduce the probability of inundation by strengthening or improving the existing flood risk management system are described below, with additional information found in the engineering appendix and its geotechnical attachment.

From a hydraulic perspective, measures to reduce the probability of inundation generally fall into four categories: levee improvements, upstream transitory storage, diversions, and combinations of these features. Of these features, it was determined that the first increment would be some amount of levee improvement and this is the base for combining additional measures to become the alternatives. Based on preliminary analyses, the other measures did not show significant reductions in stage or flow, had the potential to create hydraulic impacts, or had very large real estate requirements (USACE, May 2013m). Even with some of these additional measures, the stages and flows were not reduced enough to eliminate the need for levee improvements. For purposes of the current study, the following measures were therefore removed from further consideration:

- Upstream transitory storage at various locations
- Wicket gates at several location along the Sacramento River upstream of the American River confluence
- Pocket bypass
- Yolo Bypass widening
- I Street Diversion Structure
- Adjacent levee – seen as a design refinement to use where possible

Below is a list of alternatives developed by combining measures that were carried forward; these are described in greater detail in the following sections (4.2 - 4.3).

- Strengthen levees in place
- Strengthen levees in place with the Sacramento Bypass widening

The alternative including upstream storage on the American River was carried forward for planning purposes and existing information was used for this study.

4.2 Alternative 1: Strengthen Levees in Place

Due to the urban nature and proximity of existing development to the levees within the American River North and South basins, Alternative 1 proposes strengthen-in-place levee remediation. The stated purpose of this alternative is to improve the flood damage reduction system to safely convey flows up to a level that maximizes net benefits including the potential for a levee raise.

Alternative 1 primarily calls for landside strengthening of levees that do not change in-channel geometry or characteristics. These levee fixes involve the construction of levee remediation measures to address concerns such as seepage, slope instability, potential overtopping, erosion, lack of vegetation compliance, and lack of O&M access along the following streams: the American and Sacramento Rivers; the Natomas East Main Drainage Canal (NEMDC); Arcade, Dry, and Robla Creeks; Magpie Creek; the Pleasant Grove Creek Canal (PGCC); and the Natomas Cross Canal (NCC). This alternative combines construction of levee improvement measures while maintaining the present levee alignment in its existing location (aka, strengthen levees in place).

The Natomas Post Authorization Change Report (PACR) proposed levee improvements for the Natomas Basin that consisted of a combination of strengthen in place, adjacent levee, seepage cutoff walls, and seepage berms. The ARCF GRR study assumes that the work identified in the PACR will be completed as stated and proposes that levee raises are all that remain to be evaluated in the Natomas Basin. The levee raise is expected to be constructed within the existing or now expanded levee footprint. There may need to be some additional real estate considerations along the Natomas East Main Drain Canal downstream of the Pump Station (~RM 6.5). The levee would potentially expand on the landside to minimize any hydraulic impacts. See the Engineering Appendix for more information on the footprints of the alternatives.

A crest elevation of the future without-project mean 0.5% (1/200) ACE event plus 3 feet levee profile was compared the current top of levee. Levee raising (except for the Sankey Gap) was identified when the current top of levee fell below this profile. The typical amount of height increases needed is 1 to 2 feet. Plates 31-56 show the water surface elevations for the alternatives, the future without-project condition for both the 10-year and the 200-year events respectively. Plates 9–11 show the locations of levee raising along with erosion protection (Erosion is discussed in Section 8). Table 4-1 shows the extent (length) of levee raising needed per reach.

One reach in the American River North Basin, Magpie Creek, will require more than just strengthen levees in place to reduce the probability of inundation. Additional features for Magpie Creek may include a detention basin, a new reach of levee, and bridge improvements and are called out in Corps' Section 205 Continuing Authorities Program Basis of Design Report (MWH/CH2M Hill, 1999), and refined by the Draft Supplemental Report to the Section 205 Final Detailed Project Report and Environmental Assessment on Magpie Creek (USACE May 2003). These features will be refined during the Preconstruction, Engineering and Design (PED) Phase.

After the analysis was complete and in response to the increasing concerns about USACE projects encouraging development in floodplains (EO 11988), all proposed levee improvements proposed as part

of this report for the Natomas Basin have been removed from all of the final alternatives. See the main report for more information.

4.3 Alternative 2: Alternative 1 plus Sacramento Bypass Widening

Alternative 2 starts with Alternative 1 (strengthen levees in place) as a base and adds the widening of the Sacramento Bypass/Weir. The purpose of this alternative is to redirect more floodwaters from the Sacramento River to the Yolo Bypass and thereby reduce the extent of levee repairs required to meet current design guidance for seepage and stability in the project area. Currently, the Sacramento Weir is 1,920 feet wide with 48 wooden gates that are manually removed when the water surface elevation on the Sacramento River at the I Street gage reaches 30.0 feet NAVD88. If the Sacramento Bypass were widened, it would allow more water to flow into it and, therefore, into the Yolo Bypass. This would lower the water surface elevation on the Sacramento River downstream of the confluence with the American River and subsequently reduce the need for levee raising along the Sacramento River in the Pocket area. Table 4-1 shows the extent (length) of levee raising needed per reach for Alternatives 1 and 2.

The widening of the Sacramento Bypass and Weir was analyzed by expanding the width in increments from 500 feet to 3,000 feet to the north. Each width variation included adding gates (identical to the ones already in place) to the new portion of the weir and widening the bypass to the north. Widening the bypass/weir by 1,500 feet was found to be optimal; however a limited amount of levee raising along the Sacramento River downstream of the confluence is still needed.

For the purposes of this analysis the operation of the expanded Sac Weir was originally set to same condition as the rest of Sac Weir by maintaining a water surface elevation at the I-street Gage on the Sacramento River.

In an attempt to minimize additional flows into the Yolo Bypass for frequent events and in coordination with the sponsor, the new portion of the Sacramento Weir is proposed to be activated based on Folsom Releases. The new portion of Sacramento Weir will only operate when flows from Folsom into the American River exceed 115,000 cfs. This would occur for flood magnitudes between 1% (1/100-Yr) ACE event and a 0.5% (1/200-Yr) ACE.

It is assumed that further more detailed analysis would occur during Preconstruction, Engineering and Design (PED).

Table 4-1:Length of Levee Raising Per Reach (miles)

River	Basin	Bank	Reach Length (miles)	Alt 1		Alt. 2	
				Length of Raise (mi)	Average Height (ft)	Length of Raise (mi)	Average Height (ft)
American River	ARN	Right	13.8	E	-	E	-
Arcade Creek	ARN	Right	2.1	0.5	0.5	0.5	1.0
Arcade Creek	ARN	Left	2.1	0.52	1.0	2	1.0
Dry/Robla Creek	ARN	Left	2.0	0.4	.5	0.4	0.5
Dry/Robla Creek	ARN	Right	1.5	-	-	-	-
Magpie Creek	ARN	Left	0.3	0.5	3	0.5	3
Natomas East Main Drain Canal	ARN	Left	3.6	-	-	-	-
American River	ARS	Left	11.5	E	-	E	-
Sacramento River	ARS	Left	14.9	8.1	1.0	1.0	1.0
Natomas Cross Canal	NAT	Left	5.0	R	-	R	-
Natomas East Main Drain Canal	NAT	Right	12.4	R	-	R	-
Pleasant Grove Creek Canal	NAT	Left	3.8	R	-	R	-
Sacramento River	NAT	Left	18.2	R	-	R	-
		Totals	91.2	10.0		2.9	

R - Removed per EO11988 considerations

E - American River Levees Height set to slightly different profile, raises assumed not to be necessary.

5 FLOODPLAIN HYDRAULICS AND FLOODPLAIN DELINEATION

5.1 FLO-2D Model Development

Floodplain mapping was delineated using FLO-2D, a 2-dimensional, finite-difference flood routing model that used breach hydrographs generated from HEC-RAS model runs simulating failures at the various reaches within the Natomas, the American River North and American River South areas. An existing calibrated HEC-RAS model of the Sacramento and American River system (described in Chapter 3) was used to develop the needed breach hydrographs at all seven frequencies [50% (1/2), 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5% (1/200-Yr) and 0.2% (1/500)] at each breach location. These breach hydrographs were then used as inflows for the FLO2D model. The FLO-2D Documentation Technical Memorandum (Tetratech, December 2008) provides detailed information on model development. Much of this information was also provided as part of the F3 Hydraulic Technical Documentation. Plate 25 shows the model extents; the resulting floodplains are shown in Plates 26–30.

For Natomas in particular, the basin acts much like a bathtub. As a breach occurs, floodwaters are contained by the surrounding levees and the area fills up (Plate 7). The Natomas Basin is generally not impacted by roadways and other obstructions in modeling large flood events such as a levee breach. Rainfall and interior flooding are also considered insignificant compared to the volume that would be achieved with a levee breach, and therefore were not considered in the development of the with- and without-project floodplains used in the economic analysis.

The project area is represented with two separate FLO-2D models, one for the floodplain north of the American River and one for the floodplain south of the American River. The study area was split into two floodplains primarily because the north and south floodplains have significantly different topographic characteristics. The north floodplain consists of two basins, the Natomas Basin and North Basin, created by surrounding levees and high ground. The south floodplain slopes away from the American River to the south and west, such that breakout flows from the American River flow across and down valley until diverted or confined by the levees along the Sacramento River and other levees. The American River South model and the American River North model (consisting of the North Basin only) were originally developed for the American River Economic Evaluation Report (ERR) study. For the ARCF GRR study, the Natomas Basin has been added to the American River North model.

The following key assumptions were used in the development of the American River North (Including Natomas) and American River South floodplain FLO-2D models:

- **Grid element size: 400 feet.** The goal was to optimize the grid size to ensure reasonable run times while retaining the ability to adequately define floodplain features.

- **Study origin (top left) point: X = 6,670,800 and Y = 1,998,800.** Using a common study origin point allows for different grid systems to be based on the same grid spacing. Models can be merged and enlarged as needed.

- **Grid element elevation based on the FLO-2D Grid Developer System (GDS) interpolation routine with the high and low outlier elevations determined based on the standard deviation difference filtering scheme.** Due to the large amount of point data available from the LiDAR data, the filtering scheme ensures that any low or high outlier points do not unduly influence

the final grid elevation.

- **No streets modeled.** Streets are typically used for modeling interior drainage and are not used for riverine flood delineation, especially given the significant volume of water that would overwhelm the streets in the study area.

- **No rainfall on the floodplain modeled.** No information was available to determine the concurrent rainfall events that would occur for the flood events modeled; therefore, a clear sky was assumed at the time of the levee breakouts.

- **Soundwalls along freeways are not modeled.** Soundwalls are not built to the same structural integrity as an engineered floodwall, and it is assumed that the soundwalls would not hold more than 2 to 3 feet of water at a maximum. In most areas having soundwalls, the road embankments are 2 to 3 feet, eliminating the need to separately model the soundwalls. Only the raised roadway embankment was added a barrier for flow in the FLO2D model.

- **Infiltration was not modeled in the FLO-2D models.** This was due to a number of factors including (1) the short duration of the of the initial breakout flow hydrographs, (2) the urban nature of the primary floodplain with limited potential infiltration area, and (3) the probable saturation of the ground from the storm event and preceding storm events, creating a very low to no initial infiltration potential. While any infiltration that does occur will have a noticeable effect on the final floodplain extent and depth (as accounted for in the dewatering analysis), it would not noticeably affect the maximum extent and floodplain depths, which are the focus of this analysis.

- **Existing interior pump stations and discharge points to the American or Sacramento rivers are assumed to be inoperable.** This is partially based on lessons learned from New Orleans during Hurricane Katrina, including such causes as high stages in the respective rivers, direct and backup power failures, submerged equipment damage, etc. that occur when pump stations are overwhelmed and flooded.

5.2 Levee Breach Hydrograph Sensitivity

Levee breach conditions in the HEC-RAS model are dependent on many parameters. A sensitivity analysis was performed to determine how a breach hydrograph is impacted by selection of levee breach elevation, timing of breach, breach formation duration and breach width. Index point B on the American River South Basin (American RM 4) was used for this analysis, which is documented in the Levee Breach Sensitivity Technical Memorandum (USACE, May 2013h).

The changes in peak river stage, peak river flow and breach hydrograph volume were used to evaluate the sensitivity of the selected breach parameters at both the 4% (1/25) and 0.5% (1/200) ACE. Of the three variables, volume is seen as having the greatest impact for floodplain extents and depths. The same levee breach assumptions described in Section 3.5 were used for each levee break scenario (at each index point for each the seven frequencies.)

General trends were observed and are noted below and addition information can be found in the Levee Breach Sensitivity Technical Memorandum.

- Floodplains are not sensitive to changes in levee breach elevations, but are sensitive to the timing of the hydrograph of the flood event.

- Floodplains are not sensitive to breach formation duration, based testing done for the Sutter County Feasibility Study.

- Floodplains are sensitive to breach width during frequent flood events [4% (1/25)] but not infrequent flood events [0.5% (1/200)]. However, many Sacramento Corps feasibility studies generally use infrequent flood events (such as the 1% (1/100) ACE event) based on historical levee breach information. It is also important to have consistent breach widths (500 ft) for the full suite of frequency flood events, so the same breach width was used for frequent and infrequent flood events.

- Floodplains are sensitive to the timing of the breach, particularly when the levee breaches after the peak flow during a flood event (on the receding limb of the river hydrograph). When the breach occurs at the end of a flood event, a smaller floodplain occurs because the amount of water conveyed into the floodplain decreases. The sensitivity to the breach timing is independent of the flood frequency because much of the volume of water in the flood event has already passed by the levee breach location. Thus, even though this parameter affects the floodplain volume, assuming a breach on the receding limb of the hydrograph results in a smaller floodplain extent, and is not considered the most likely condition. Breach formation was therefore assumed to occur on the rising limb of the hydrograph to reflect the most likely flooding condition in each damage area.

The conclusion from this sensitivity analysis is that, for the purposes of the feasibility study, the assumptions used for the levee breaches are appropriate for use in the economic analysis.

5.3 With-Project Floodplains

For the with-project floodplains, the without-project condition floodplains were used with adjustments made to the frequency of the floodplains.

To approximate each with-project floodplain, the with-project breach hydrographs were compared to the corresponding without-project breach hydrographs. Peak flow and volume were the variables used to compare the two levee breach hydrographs. For each alternative and at each index point, the following comparison was made for each of the seven frequencies:

- If the change between without- and with-project breach hydrograph volumes were within 10%, then the without-project levee breach hydrograph and corresponding floodplain could be substituted for use as the with-project levee breach hydrograph and corresponding floodplain.

- If the change in volume was greater than 10%, then the without-project levee breach hydrograph and corresponding floodplain from the next largest flood event were evaluated based on the same threshold. If that comparison failed, the process was repeated with increasingly large flood events until a substitute event was found that met the threshold. For example, the 10-yr with-project levee breach hydrograph was compared to the 10-yr without-

project levee breach hydrograph at each index point and if the volume differed by greater than 10%, the 10-yr with-project levee breach hydrograph was then compared to the 25-yr without-project levee breach hydrograph. If the volume again differed by greater than 10% for that comparison, the 10-yr with-project levee breach hydrograph was then compared to the 50-yr event and so on until the threshold was met.

Table 5-1 shows the specific changes in Annual Chance Exceedance (ACE) used to adjust the floodplains from the without-project condition to with-project conditions. The shaded areas in the table represent where a without-project floodplain from a different frequency was used for the with-project floodplain for each alternative.

Table 5-1 Alternative Floodplain Key

Basin	Index Point	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Future Without Project / Alt. 1: Strengthen in Place								
ARN	A	-	-	25-yr	50-yr	100-yr	200-yr	500-yr
ARN	E	-	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
ARS	A	-	-	25-yr	50-yr	100-yr	200-yr	500-yr
ARS	F	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
NAT	D	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
Alt. 2: Alt. 1 +Sacramento Bypass Widening								
Basin	**Index Point**	**2-yr**	**10-yr**	**25-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
ARN	A	-	-	25-yr	50-yr	100-yr	200-yr	500-yr
ARN	E	-	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr
ARS	A	-	-	25-Yr	50-Yr	100-Yr	200-Yr	500-Yr
ARS	F	2-yr	10-yr	25-Yr	50-Yr	100-Yr	100-Yr	500-Yr
NAT	D	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr	500-yr

6 RISK ANALYSIS

Inputs were generated for risk analysis from the hydraulic modeling. The Hydrologic Engineering Center's Flood Damage Assessment modeling software (HEC-FDA) is the principal tool used by the Corps to calculate flood damage risks. The HEC-FDA model performs Monte Carlo random sampling of the discharge-frequency, stage-discharge, stage-probability of failure, and damage-stage relationships and their respective uncertainty distributions. The primary outputs of HEC-FDA are expected annual damage (EAD) and project performance statistics. Project performance statistics include the annual exceedance probability (AEP, or the expected annual probability of flooding in any given year), the long-term risk of flooding over a 10-, 25-, or 50-year period, and the conditional non-exceedance probability (CNP) for specific Annual Chance of Exceedance (ACE) events (the probability of passing specific ACE flood event).

Recent guidance has come out that provides a means for more explicitly performing a risk analysis in a system setting such as the Sacramento River (HEC, 2009). Some processes derived from this new guidance were implemented in generating inputs for the HEC-FDA analyses. The guidance was based

upon a demonstration project using the Sacramento River system and an earlier version of the HEC-RAS Common Features model. The work was done by West Consultants, Inc., for the Hydrologic Engineering Center (HEC). Some values derived from the study are therefore directly applicable to this study. A similar assessment was conducted by MBK Engineers and David Ford Consulting Engineers (MBK Engineers, 2009 and David Ford, 2009) for the Sacramento Area Flood Control Agency (SAFCA). Information derived from these reports including FDA models including uncertainty values from HEC and the updates from the follow on applications of the policy by the local sponsor (SAFCA) was considered and used in developing the inputs for the West Sacramento GRR study.

6.1 Index Points

Hydraulic results are available at each cross section in the HEC-RAS model. For economic purposes, a single point is needed to represent each reach and is often referred to as an index point. The levees surrounding Sacramento, already separated by a waterway, are further divided into reaches represented by similar geotechnical conditions, as described in the geotechnical report. Each reach was originally represented by a single index point located at the same position as the geotechnical fragility curve.

Data is generated at representative index points within each reach and are used to estimate project performance statistics under both without-project and with-project conditions. The engineering data is also used in conjunction with economic data to estimate expected damages and benefits. Both sets of results are then used together to describe the flood risk in the study area.

Twenty-five reaches were originally identified based on extensive geotechnical analyses of the levee conditions along each source of flooding within the study area. From these 25 reaches, the project delivery team (PDT) selected five of them, each containing one index point, for which to generate engineering data for use in the economic modeling and the associated without-project damage and with-project benefit analyses. They are also listed in Table 6-1.

Table 6-1. Index Points

Index Point	Basin	Index Point	Project Reach	River Mile
American River North Levee	ARN	A	American River	7.8
Arcade Creek North Levee	ARN	E	Arcade Creek	0.9
American River South Levee	ARS	A	American River	8.9
Sacramento River South	ARS	F	Sacramento River	50.3
Natomas Cross Canal South Levee	NAT	D	Natomas Cross Canal	2.7

The PDT also selected three additional index points -- two located on the right and left banks of the American River and one located on the NEMDC/PGCC (also known as the Sankey Gap) at locations where there are no levees. These index points were not part of the original 25, but were included in order to aid in a more accurate description of residual flood risk in the study area.

The representative index points used in economic analysis were selected based on preliminary estimates of the chance of flooding and consequences of flooding using flood plain extents and depths, levee fragility (geotechnical fragility curves), and estimates of ACE event damages.

In this analysis "representative index points" refers to those locations whereby the without-project condition (damages and performance) of the study area is best characterized. The PDT's intent was to balance rigor with practicality in choosing the number of index points to use in the analysis. Once the number of index points was determined for this GRR – essentially one index point to represent a major source of flooding (per bank side) plus several others to be able to check for residual damages (e.g., outflanking locations on the American River), the PDT then made a preliminary comparison of the chance of flooding and the consequences of flooding – in other words the overall flood risk associated with a levee breach at various locations – in selecting the representative index points. During the course of the study, two of the index points (ARS B and ARS E) that were originally selected were replaced by alternate index points (ARS A and ARS E).

6.2 Stage-Discharge Frequency Curves

Peak stage data for all index points was derived for the 10% (1/10) ACE through the 0.2% (1/500) ACE events in the same manner for both with- and without-project conditions. Results were taken directly from the HEC-RAS model runs. However, the 99.9% (1/1.001) ACE and the 50% (1/2) ACE stage data was derived via a different process using gage data, and is further discussed in the Risk Analysis Technical Memorandum (USACE, May 2013i). The use of flow-frequency and stage-discharge relationships in HEC-FDA is preferable; however, currently HEC-FDA requires an increasing flow value for an increasing stage value (in this case a stage-frequency relationship must be used). For index points ARN A, ARS B, and ARS E, flow-frequency and stage-discharge relationships were generated for the HEC-FDA analysis (see Plate 8 for location of index points). A stage-stage relationship similar to a stage frequency relationship was used for ARN E and NAT D due to backwater effects.

6.3 Uncertainty

6.3.1 Hydraulic Uncertainty

Following guidance in Engineer Manual EM 1110-2-1619, "Risk-Based Analysis for Flood Damage Reduction Studies," the performance and reliability of the project features were assessed with an uncertainty-based analysis. The stage uncertainty parameter in HEC-FDA is used to account for uncertainties in the calculated water surface elevations. These uncertainties can be attributed to accuracy and precision of the topographic data, hydraulic computational assumptions (roughness coefficients and bridge debris loading), sedimentation and operations (gates/pumps) and other potential factors. The total uncertainty from these attributes is a combination of the following factors from EM 1110-2-1619: natural variations, model uncertainty, sedimentation, and operations factors. Table 6-2 has the total stage uncertainty for each index point for the suite of frequencies. See the Risk Analysis Technical Memorandum (USACE, May 2013i).

Table 6-2: Total Stage Uncertainty (One Standard Deviation), Feet						
River		American	Arcade	American	Sacramento	Natomas Cross Canal
Index Point		A	E	A	F	D
RS		7.83	0.95	8.90	50.25	2.71
Basin		ARN	ARN	ARS	ARS	NAT
Percent Annual Chance Exceedance	50%	0.97	0.85	1.00	0.75	0.85
	10%	1.23	0.90	1.29	0.77	0.92
	4%	1.38	0.93	1.45	0.76	1.03
	2%	1.38	0.95	1.45	0.76	1.04
	1%	1.36	0.93	1.43	0.76	0.98
	0.50%	1.53	0.86	1.59	0.75	0.84
	0.20%	0.76	0.75	0.75	0.78	0.75

6.3.2 Hydrologic Uncertainty

For index points along the Sacramento River (ARS E), Natomas Cross Canal (NAT D) and Arcade Creek (ARN E), the flow frequency analysis is based on a graphical method. The period of record (equivalent years of record) for index points NAT D and ARN E is 71 years and period of record for index point ARS E is 73 years. The period of record was chosen based upon the HEC report for the systems risk and uncertainty analysis (HEC, 2009). Results from locations closest to index points were used. Values for Arcade Creek were taken from the SAFCA 408 Request (MBK, June 2009), which is based on EM 1110-2-1619.

The index points along the American River (ARN A & ARS B) are based on analytical flow frequency analysis. The input statistics for FDA analysis are shown in Table 6-2.

Table 6-3: American River at Fair Oaks (1905-2004)
Adopted Unregulated Inflow Statistics

Log Mean	4.581
Log Std Dev	0.43
Log Skew	-0.077
Equivalent Record Length (yrs)	100

6.3.3 Inflow-Outflow Uncertainty

The purpose of the inflow-outflow curves is to translate unregulated flow-frequency curves and uncertainty to the regulated condition. It also provides an additional means of accounting for hydrologic uncertainty within the system, recognizing that flow entered into the upstream ends of the system attenuates. How much it attenuates depends in large part upon the capacity of the river or levee system. Inflows correspond to the analytical and graphical inflow frequency curves in FDA (Reference f). The outflows were taken from standard HEC-RAS output tables at each index point. Inflow-outflow

curves were generated for both with-project and without-project conditions assuming no upstream levee failures. Uncertainty for the inflow-outflow curve was based on work done in the Natomas Post Authorization Change Hydraulics and Hydrology Appendices.

6.4 Flood Damage Modeling

In addition to the no-levee-failure model runs, flood damage assessment was done by simulating the flow of water from a levee failure into each basin. Levee failures were simulated for each reach using seven frequencies (50% (1/2), 10% (1/10), 4% (1/25), 2% (1/50), 1% (1/100), 0.5%(1/200), 0.2%(1/500) ACE) to generate a stage-damage relationship for each reach for the economic analysis. As described in Section 5.2, levee failure runs were made only using the without-project condition. Plates 65 through 69 contain the water surface elevations at the project index points for the full suite of frequencies and the following conditions and alternatives:

- Future without-project condition
- Alternative 1: Strengthen in place
- Alternative 2: Strengthen in place with Sacramento Bypass widening

A summary of the key results are described below:

- For all index points, there are no significant changes in stage or flow between the future without-project condition and the Strengthen Levees in Place Alternative 1.
- As expected, there are reductions in stage and flow on the Sacramento River Reach below the confluence with the American River (at ARS E) when Alternative 2 is compared to the future without-project condition.
- The results for Natomas Index Point D, located on the Natomas Cross Canal, are similar for all conditions.

6.4.1 Upstream Levee Performance

As part of the CF GRR F3 analysis, upstream levee performance was considered in a sensitivity analysis (USACE, 2009e). A single index point at Verona (just downstream of the Natomas Cross Canal and Sacramento River confluence) was tested using historical data. The analysis showed that there was no significant influence on the stage and resulting expected annual damages from upstream levee performance. Based on this information, a decision was made to proceed with analyses assuming no upstream levee failures. All work under the American River Common Features GRR assumes no upstream levee failures.

6.5 Performance Evaluation

Future without-project annual exceedance probability (AEP) was computed on a reach/index point-specific basis using the HEC-FDA model. The HEC-FDA model integrates the hydrologic, hydraulic, geotechnical and economic relationships with uncertainty to create exceedance probability-damage functions with uncertainty.

The annual exceedance probability (AEP) represents the percent chance of a target stage being exceeded in any given year, thereby causing flooding and subsequent significant property damage. The

annual exceedance probability results for each damage area are computed by HEC-FDA based on specific engineering data: frequency-stage curve, equivalent record length, and top-of-bank stage.

The AEP results were used to establish the future without-project expected annual damages (EAD) to determine economic benefits and evaluate performance of the alternatives. Table 6-4 shows the results of the levee performance evaluation for each index point in the project area. The 0.5% assurance values are a linear interpolation of HECFDA results between the 1% and 0.4% Assurance values. The future without project condition is included in Table 6-4 because it is the basis of comparison for the alternatives; this is discussed in greater detail in Section 2.2. More information about the economic benefits and expected annual damages can be found in the economic appendix.

Table 6-4: Performance at each Index Point

	Basin	ARN	ARN	ARS	ARS	NAT
	Index Point	A	E	A	F	D
	River	American	Arcade	American	Sacramento	NCC
	River Station	7.8	0.9	8.9	50.3	2.7
FWOP	Annual Exceedance Probability (AEP)	0.010	0.017	0.011	0.031	0.009
	1/AEP	96	61	93	32	108
	1% Assurance	75%	54%	76%	69%	84%
	0.5% Assurance	47%	29%	45%	55%	58%
	0.2% Assurance	22%	7%	18%	24%	37%
Alt. 1	Annual Exceedance Probability (AEP)	0.006	0.005	0.005	0.007	0.006
	1/AEP	182	200	185	135	159
	1% Assurance	90%	94%	91%	95%	84%
	0.5% Assurance	59%	69%	64%	93%	56%
	0.2% Assurance	24%	23%	31%	89%	27%
Alt. 2	Annual Exceedance Probability (AEP)	0.006	0.004	0.005	0.007	0.006
	1/AEP	172	256	192	147	164
	1% Assurance	89%	95%	91%	95%	85%
	0.5% Assurance	57%	80%	60%	94%	57%
	0.2% Assurance	22%	28%	32%	81%	28%

6.6 Considerations and Assumptions

The results of the risk analysis are affected by technical considerations and assumptions regarding the inputs to HEC-FDA. For example, geotechnical studies developed relationships that characterize the reliability of the levees. Perhaps the most significant assumption is the levee failure methodology, which can significantly influence simulated breach hydrographs. These assumptions are described in Section 3.5 and were also evaluated in a sensitivity analysis in the Levee Breach Sensitivity Technical Memorandum (USACE May 2013h). The methodology chosen provides a conservative and consistent simulation of the potential flooding extent for system-wide hydraulic and economic evaluations. It does not necessarily represent conditions during an actual flood event, when flood fighting and other emergency actions are likely to take place.

6.7 FEMA Certification/Accreditation

The Engineering Circular 1110-2-6067 serves as guidance for USACE to provide the necessary Risk and Uncertainty (R&U) rationale to certify/accredit levees for FEMA. FEMA certification was not determined at this time. The local sponsor has an interest in having the strengthened levees meet the minimum requirements needed for FEMA accreditation. By traditional FEMA methodology (Title 44 CFR Section 65.10), it is likely that the local sponsor could achieve FEMA Certification in all three basins using this proposed project, recent projects (Natomas PAC) and the locals' ongoing efforts under the Natomas Levee Improvement Program (NLIP). If the sponsor conducted the certification, they would have to meet the requirements of Title 44 CFR Section 65.10. If USACE performed the certification, they would have to meet additional requirements described in EC 1110-2-6067. At a minimum during design, the locally preferred plan will have a top of levee profile that would be set to meet the minimum height requirements as defined in Title 44 CFR Section 65.10

The Engineering Circular 1110-2-6067 serves as guidance for USACE to provide the necessary Risk and Uncertainty (R&U) rationale to certify/accredit levees for FEMA. FEMA certification was not determined at this time. The local sponsor has an interest in having the strengthened levees meet the minimum requirements needed for FEMA accreditation. By traditional FEMA methodology (Title 44 CFR Section 65.10), it is likely that the local sponsor could achieve FEMA Certification in all three basins using this proposed project, recent projects (Natomas PAC) and the locals' ongoing efforts under the Natomas Levee Improvement Program (NLIP). If determined to be needed, this additional analysis will most likely be conducted during refinement of the selected alternatives (including a possible locally preferred plan) or during the design phase. If the sponsor conducted the certification, they would have to meet the requirements of Title 44 CFR Section 65.10. If USACE performed the certification, they would have to meet additional requirements described in EC 1110-2-6067. At a minimum this would be likely be completed by ensuring that there is 3 three feet of freeboard above the 1% (1/100) ACE for all the levees in the project area.

6.8 Urban Levee Design Criteria (ULDC)

Urban Levee Design Criteria (ULDC) is a state standard established by the CA Dept of Water Resources where from a hydraulic perspective; urban levees are required to have at least 3' feet of free board above the mean 200-Yr event or a combination of freeboard (2-3) and assurance (90%-95%) to contain the mean 200-Yr event.

The State has established a standard for urban flood protection in California which applies to cities with populations greater than 10,000 inhabitants. This standard requires levees to withstand flows with a top elevation equal to the mean 200-year water surface profile, plus three feet of freeboard, plus an allowance for wave run-up, plus one foot to account for climate change. USACE does not identify a target level of risk reduction but rather identifies the plan which reasonably maximizes net benefits. The analysis to identify the plan which maximizes net benefits was done with an awareness of the State's goal for urban flood protection for the purpose of informing the State of where the individual plans fall with regards to the State's standards. Neither of the final alternatives is currently able to contain a 1/200 ACE event with 90% assurance. The levee improvements along the Sacramento River will increase the assurance to a level close to 90% but the assurance for the levees along the American River will remain lower than the ULOP criteria for the 1/200 ACE. However, the locally preferred plan will meet the minimum height requirements as described in the ULDC. It will be contingent upon the local community to prove to the State that the aggregate flood risk management projects meet the State's standard.

6.9 Systems Risk and Uncertainty

Each of the final alternatives included setting the top of levee profile at the 0.5% (1/200) ACE plus 3 feet (except for Sankey Gap), and a systems risk analysis was conducted to determine if there are hydraulic impacts from this levee raising. A process for evaluating system-wide hydraulic impacts of proposed modifications to the levees of the Sacramento River Flood Control Project (SRFCP) has been developed by the Hydrologic Engineering Center (HEC) and further information can be found in their "Documentation and Demonstration of a Process for Risk Analysis of Proposed Modifications to the SRFCP Levees" report. The process utilized risk analysis methods that followed USACE policy as outlined in ER 1105-2-101. The Systems Risk Technical Memorandum (USACE, May 2013l) further details the application of this ER and HEC guidance to this study. The system wide risk analysis method defined by HEC was considered applicable to the ARCF GRR study.

A key assumption of the system-wide risk analysis is that risk of a levee failure is associated with overtopping only. Levee fragility curves are not used in this analysis and levees are assumed to convey water to the top of levee throughout the system. This assumption is based on USACE Letter on Guidance on System Risk for modifications to Corps of Engineer Projects (USACE, July 2008).

The purpose of this evaluation was to determine if potential system-wide impacts can be identified based on the increase in annual exceedance probability (AEP) or a decrease in conditional non-exceedance probability (CNP, also referred to as 'assurance') within the FDA model. Using the model HEC created for the Sacramento River Flood Control Project (SRFCP) levees, new plans were created for each of the four scenarios. The following four scenarios were analyzed:

- Future without-project baseline condition
- Alternative 1: Strengthen in place
- Alternative 2: Strengthen in place with Sacramento Bypass widening

Potential impacts are identified when an increase in the AEP and a reduction in CNP occur at locations throughout the system when compared to the hydraulic baseline condition. The median AEP is computed directly from the inflow discharge-exceedance probability, the inflow-outflow and stage-discharge relationships that are defined at each index location. The expected AEP incorporates

uncertainty in these relationships. Typically, an increase in water surface elevation without a change in the levee height will result in an increase in AEP and a reduction in CNP, which indicates an increase in the level of risk.

The following changes in AEP and CNP were identified based on comparison of the two alternatives and the two baseline conditions:

- There was no significant change in median overtopping AEP
- There was no significant change in expected overtopping AEP (rounded at three significant figures)
- There are small changes in the overtopping CNP/assurance, mostly in the thousandths place.

6.10 Potential Hydraulic Impacts to the Yolo Bypass

The proposed project features main purpose is to reduce flood risk in the project area. Hydraulic Impacts outside of the project area as result of these features being implemented have to be disclosed and possibly accounted or mitigated for in this study. With the widening of the Sacramento Bypass, there was added attention to how this widening would impact the Yolo Bypass.

From the executive summary HEC's PR-71 document:
"The potential impacts defined from deterministic analysis results are changes in water surface elevation and freeboard that are defined in units of length such as feet. Due to the common use of length units in everyday affairs, the significance of differences expressed in units of length are generally well understood. In contrast, the potential impacts defined from risk analysis results are changes in probabilities. In general, the significance of differences in probabilities, particularly small differences in probabilities, are difficult to conceptualize. Consequently, a need exists for development of guidance or criteria to define the significance of risk analysis results."

For purposes of this analysis, the definition of a potential hydraulic impact was defined as a change in water surface elevation. With the advent of risk and uncertainty, guidance is lacking on what constitutes a significant impact though changes in stage on the order of 0.1 feet to 1.0 feet are often used as a threshold.

The hydraulic baseline is the future without-project condition where most of systems exist as it is today and includes the recent and in-construction Folsom improvements (including the JFP) in place.

For with-project conditions, the peak releases from Folsom Dam for the 1% (1/100) ACE and 0.5% (1/200) ACE events are 115,000 cfs and 160,000 cfs. This amount of flow continues on down the American River to the Sacramento River. Flow conditions splits for the 10% (1/10) ACE, 1% (1/100) ACE, and 0.5% (1/200) ACE events are depicted on the Sacramento-American River Confluence Plates 70-72.

With the widening of the Sacramento Weir and Bypass and for when flows exceed 115,000 cfs on the American River, some of the American River flow that would have gone downstream on the Sacramento River is instead drawn upstream to the widened Sacramento weir.
To determine if there are potential hydraulic impacts in the Yolo Bypass, stages the future without-project condition were compared with the stages from Alternatives 1 and 2. The additional water that

would flow through the weir and into the Sacramento Bypass could raise water surface elevations in the Yolo Bypass up to 0.11 feet for the 0.5% (1/200) ACE and 0.8 feet for 0.2% (1/500) ACE event. This increase is considered less than significant because it would not change land uses, require additional levee remediation, and is not expected to significantly increase flood risk. For a 0.2% (1/500) ACE event, many areas are subject to inundation from overtopping or other levee failure mode. Tables 6-6 and 6-7 contain water surface elevations at Yolo Bypass stream gages upstream and downstream of the Sacramento Bypass. It is assumed that further more detailed analysis would occur during Preconstruction, Engineering and Design (PED) to further reduce any increase in water surface elevation.

Given the geographic connection of the current ARCF project and several ongoing American River projects (JFP Spillway, Natomas PAC, WRDA 96/99 Sites), there was a rationale to evaluate the individual projects together as a single project to evaluate hydraulic effects or impacts. Many of the projects are tied to the larger single American River Watershed Investigation study that occurred in the early 1990s. After significant discussion, this idea of separating the hydraulic baseline from the economic baseline was abandoned.

Table 6-5. Water Surface Elevation Summary for the Yolo Bypass at the Woodland Gage (RM 50.9).

Water Surface Elevation Summary				
Yolo Bypass at the Woodland Gage(RM 50.9)				
Frequency	FWOP	Alt. 1 Strengthen in Place	Alt. 2 Sac Bypass	FWOP - Alt. 2
	NAVD88	NAVD88	NAVD88	NAVD88
2-Yr	26.6	26.6	26.6	0.00
10-Yr	30.2	30.2	30.2	0.00
25-Yr	32.9	32.9	32.9	0.00
50-Yr	33.7	33.7	33.7	0.00
100-Yr	34.7	34.7	34.7	0.00
200-Yr	36.6	36.6	36.7	0.05
500-Yr	37.3	37.3	38.0	0.77

Table 6-6. Water Surface Elevation Summary for the Yolo Bypass at the Lisbon Gage (RM 35.7).

Water Surface Elevation Summary				
Yolo Bypass at the Lisbon Gage (RM 35.7)				
Frequency	FWOP	Alt. 1 Strengthen in Place	Alt. 2 Sac Bypass	FWOP - Alt. 2
	NAVD88	NAVD88	NAVD88	NAVD88
2-Yr	19.7	19.7	19.7	0.00
10-Yr	24.5	24.5	24.5	0.00
25-Yr	27.0	27.0	27.0	0.00
50-Yr	27.7	27.7	27.7	0.00
100-Yr	28.6	28.6	28.6	0.00
200-Yr	29.6	29.6	29.7	0.11
500-Yr	30.7	30.7	30.7	-0.02

7 RESIDUAL RISK

Several methods and types of analysis are used to describe the hydraulic impacts and residual risk of the proposed alternatives. They are described below.

7.1 Residual Risk

Residual risk is the risk of being inundated after the selected alternative has been implemented which can include residual risk associated with the project features, residual risk from physical conditions not related to project features, and residual risk from an event exceeding the design of the system. Residual flood risk after completion of the selected plan would vary throughout the study area. The levees in the project area have not been designed for overtopping with the exception of the Sankey Gap in Natomas.

The residual risk associated with project features is captured by the with-project fragility curves and floodplains, and is covered in Chapters 4 through 6 of this report. The residual risk floodplains were developed using HEC-RAS and FLO-2D, and provided to the Economics Section to be included as part of the overall net benefit calculation. Additional information on Risk can also be found on the Economic Appendix.

The residual risk from both project features and physical conditions not related to project features are reflected in the residual floodplains for each of the three basins (Plates 62-64). The residual risk for each basin is described below.

The three primary sources of residual flood risk for the Natomas Basin would be:

-Overtopping Flows from the Sankey Gap.

-Infrequent large flood events [greater than 0.5% (1/200) ACE] that overtop the project levees.
-Unforcasted geotechnical failure of the project levees [mostly for events greater 1% (1/100) ACE]

In the Natomas basin, the Sankey Gap is located in the northeastern corner of the basin between the Pleasant Grove Creek Canal and the Natomas East Main Drain Canal (see Plate 7). The Sankey Gap is a hardened overtopping weir built to handle flow from ponded water that flows into the basin. During a flood event on the Sacramento River, water will pond on the northeastern exterior edge of the Natomas Basin and then back up small creeks along the Pleasant Grove Creek Canal and eventually flow through this hardened weir. The height of the ponded water at the Sankey Gap is tied directly to stages in the Sacramento River, and flow through the Sankey Gap was observed in the 1986 and 1997 flood events. Plate 62 show the 0.2% (1/500) ACE residual floodplain based on overtopping from the Sankey Gap. There are no plans to change the operation of this feature to reduce the residual risk.

An overtopping flood event would likely be preceded by flood warning and river guidance issued by the National Weather Service (NWS) and California Nevada River Forecast Center (CNRFC) five days in advance. A more accurate warning would likely be made 24 to 36 hours in advance. Overtopping Risk could come from any of the levees along the Sacramento River, American River, Natomas East Main Drain Canal (NEMDC), Natomas Cross Canal (NCC), and Please Grove Creek Canal. The likely first overtopping locations would be along the Sankey Gap and parts of the NEMDC where the volume of water is significantly less than in the American or Sacramento Rivers.

The Natomas Basin Levees does have some superiority built into them by way of the Fremont Weir and the Sutter-Yolo Bypass. Much of the water(approx. 75%) coming down the Sacramento River Flood Control Project goes over the Fremont Weir just upstream of the Natomas Basin. Given that the Sacramento River and Natomas Cross Canal were both strengthened (as part of Natomas PACR and SAFCA Natomas 408) raised (SAFCA's 408), it is very likely the other parts of the system would begin to overtop before these levees. The American River water is limited by both flows out of Folsom and channel capacity as described more in the next section on the other two basins in the project (ARN and ARS). However, any failure of the levee system surrounding Natomas will continue to have consequences given the large population and deep floodplains with depths greater than 20 feet for breaks along the Sacramento River, American River and the lower portions of the NEMDC. The extents of the floodplains for the unforcasted geotechnical failure would be similar to the without project floodplains found on Plates 30.

The two primary sources of residual flood risk for the American River North and American River South Basins would be:

-Infrequent large flood events [greater than 0.5% (1/200) ACE] that overtop and outflank the channel upstream from the leveed system.
-Unforcasted geotechnical failure of the project levees [mostly for events greater 1% (1/100) ACE] mostly driven by a risk of erosion failure due to high velocities in the American River.

An overtopping flood event would likely be preceded by flood warning and river guidance issued by the National Weather Service (NWS) and California Nevada River Forecast Center (CNRFC) five days in advance. A more accurate warning would likely be made 24 to 36 hours in advance. Plates 63–64 only contain the 0.2% (1/500) ACE residual floodplains for the two basins as it is assumed that the channel will be able to hold up to a 0.5% (1/200) ACE coming out of Folsom after completion of the Joint Federal Project Auxiliary Spillway and levee improvements along the American River. This assumption is based

on the auxiliary spillway's ability to control flows out of Folsom up to the 0.5% (1/200) ACE. The extents of the floodplains for the unforcasted geotechnical failure would be similar to the without project floodplains found on Plates 26 and 28.

The American River Levees have superiority built in by this channel outflanking as there is a maximum amount of water that continues down the channel with the excess flow leaving the system in a somewhat calmer manner than a levee break.

In the American River South Basin, the Sacramento River has strengthened levees and superiority is built in by the use of the Sacramento Weir and Bypass that divert high flows away from the Sacramento and out into the Yolo Bypass. The use of weirs to help with superiority follows ETL 110-2-299. Alternative 2 enhances this feature by widening the Sacramento Weir and Bypass allowing more water to be diverted away from Sacramento.

According to ETL 1110-2-299, "Overtopping of Flood Control Levees and Floodwalls," two design types can be used to control initial overtopping. The first is the use of different levee heights relative to the design water surface from reach to reach to force overtopping in a desired location. The second design uses notches, openings, or weirs in the structure. The inverts for these features are at or above a design water surface elevation but below the neighboring top of levee. Examples are railroad or road crossings of levees and rock weirs.

For the areas described above, the residual risk associated with project features, and physical conditions not related to project features is assumed to be the same for the final array of alternatives. The levee improvements and possible Sacramento Bypass widening do not significantly change the hydraulic conditions on the American River upstream of the leveed section or the northern part of the Natomas basin.

7.2 Climate Change – Hydrology

A sensitivity analysis was conducted to assess the impact of climate change for the American River Common Features GRR. Studies have shown that increasing temperatures associated with climate change are causing a shift in the runoff patterns of Pacific slope watersheds with a large snowmelt component. The runoff shifts for those watersheds include increased runoff in winter, less snowmelt in summer, and earlier runoff in the spring (USACE, 2011b).

The methodology for the climate change sensitivity analysis of runoff peaks and volumes was developed by the Sutter Basin Pilot Study, and this method was applied to the American River Common Features Study. The Sutter team made further refinements to this method, but because the refinements yielded results similar to the first attempt, the ARCF PDT continued to use the results of the first method. The approach is summarized below, and more details on the application of this method can be found in the Climate Change Technical Memorandum (USACE, May 2013b).

The present-condition hydrology in the study was assumed to be representative of 2009 conditions. For future-condition hydrology scenarios, results from a University of California, San Diego study on Sierra Nevada runoff (UCSD, 2011) were interpolated and extrapolated to determine the percent difference of the 4% (1/25), 1%(1/100), 0.5%(1/200), 0.2%(1/500) ACE events. The return period was plotted as a function of the percent difference, and a logarithmic curve was fit to the graph. The resultant estimated

climate change differences from the study presented in Table 7-1 were used to translate the frequency of the water flowing into the various reservoirs in the Sacramento River system.

Table 7-1. Climate Change Differences for Northern Sierra Nevada, WY 2049

% Difference in 3-day Unregulated Flow			
Frequency	CNRM CM3	GFDL CM2.1	NCAR PCM1
1/2	12	22	6
1/5	16	23	-4
1/10	21	27	-10
1/20	27	32	-14
1/50	35	40	-19
1/100	35	40	-19
1/200	35	40	-19
1/500	35	40	-19

Global Climate Change Models:

CNRM CM3: French National Centre de Recherches Meteorlogiques Climate Models.

GFDL: Geophysical Fluids Dynamics Laboratory model version 2.1

NCAR PCM 1: National Center for Atmospheric Research Parallel Climate Model

A sensitivity analysis was conducted at two locations in the study to evaluate the effect of climate change on regulated flows: at the American River Fair Oaks gage and at the Sacramento River Verona gage. The analysis was performed by applying the changes shown in Table 7-1 to the unregulated flow-frequency curves at the two locations. Reservoir operations were assumed to remain the same for future conditions, and therefore inflow-outflow relationships would not change. The translation of regulated flows was made graphically with more information on this process found in the Climate Change Technical Memorandum (USACE, May2013b). Tables 7-2 and 7-3 show the future regulated flows and anticipated annual chance of exceedance (ACE) for both index locations.

Table 7-2. Change in Frequency of Flows with Climate Change at American River Fair Oaks

Climate Model		CNRM CM3	GFDL CM2.1	NCAR
Present Regulated Frequency and Flow		Future Regulated Frequency: WY 2049	Future Regulated Frequency: WY 2049	Future Regulated Frequency: WY 2049
ACE	Flow (cfs)	ACE	ACE	ACE
½	26,000	1/2	1/2	1/2
1/10	72,000	1/7	1/7	1/13
1/25	115,000	1/17	1/14	1/39
1/50	115,000	1/25	1/25	1/83
1/100	115,000	1/48	1/40	1/167
1/200	160,000	1/83	1/71	1/385
1/500	224,000	1/200	1/167	1/1000

Table 7-3. Change in Frequency of Flows with Climate Change at Sacramento River Verona

Climate Model:		CNRM CM3	GFDL CM2.1	NCAR
Present Regulated Frequency and Flow		Future Regulated Frequency: WY 2049	Future Regulated Frequency: WY 2049	Future Regulated Frequency: WY 2049
ACE	Flow (cfs)	ACE	ACE	ACE
½	70,000	1/2	1/2	1/2
1/10	93,000	1/6	1/6	1/14
1/25	110,000	1/13	1/13	1/50
1/50	113,000	1/20	1/20	1/111
1/100	120,000	1/33	1/33	1/250
1/200	130,000	1/56	1/56	1/500
1/500	155,000	1/125	1/111	---

Climate change may also have an effect upon the levees, where a levee raise might be needed to maintain a desired levee performance. While the project will be constructed to maintain a design flow rate, this sensitivity analysis estimates a new frequency for overtopping. The levee crest elevation for future conditions was set at a 0.5% (1/200) ACE event stage plus 3 feet. This new top of levee was compared with present levee crest heights. For the American River Fair Oaks, it appears that there is no overtopping concern needed in response to climate change. However, for the Sacramento River Verona gage, it appears that the left levee crest would have a potential overtopping concern and would need to be raised an average of 3 feet and the right levee crest will need to be raised by 3.5 feet to provide the same performance in response to climate change. The current alternatives have an average levee height raise of 1-2 feet, so to maintain the same performance this average height raise would need to be doubled to account for the estimated effects of climate change along the Sacramento River reach.

The analysis described above should be considered a sensitivity analysis, not a rigorous analysis of climate change using snowmelt hydrology models, reservoir operations models, and river routing models. The State of California is developing a state-wide approach to climate change with a system-wide historical

record for unregulated conditions (no reservoirs) along with one regulated condition (with reservoirs). Some of the preliminary data from that state-wide approach was used in this analysis, but the final results are not currently available for use in the ARCF GRR study.

7.3 Sea Level Rise

A second aspect of climate change is sea level rise. Rising sea levels have been observed at locations around the world, and the rate is expected to continue at the current level or increase in the future (IPCC, 2007). Increases in sea level can have a variety of impacts on coastal areas, including flooding, changing ecosystems, and declining water quality. Local subsidence can also cause a greater apparent sea level rise. To analyze potential effects on the Sacramento River system from these changes, several sea level rise scenarios were developed for 50 and 100 years. A subsidence rate was also applied to the low and high 100-year sea level rise scenarios.

Three sea level rise scenarios were developed based on the information contained in EC 1165-2-211, Water Resources Policies and Authorities Incorporating Sea-Level Change Considerations in Civil Works Programs (USACE, 2009). Following the method described in EC 1165-2-212, values for low, intermediate, and high sea level rise rates were developed for 50 and 100 years. The information describing the application of EC 1165-2-211 came from an existing report developed for USACE for work on the Sacramento-San Joaquin Delta (Dynamic Solutions, 2011) and a summary of that information is provided below.

7.3.1 Low Sea Level Rise-

Following guidance outlined in EC 1165-2-211, the low sea level rise scenario was developed using historically measured data at the San Francisco tide gage. EC 1165-2-211 suggests using a tide gage with a minimum of 40 year period of record. The San Francisco tide gage period of record begins in 1897, which is more than sufficient to see long term patterns. Figure 7-1 shows the sea level trend at San Francisco with the seasonal cycle removed.

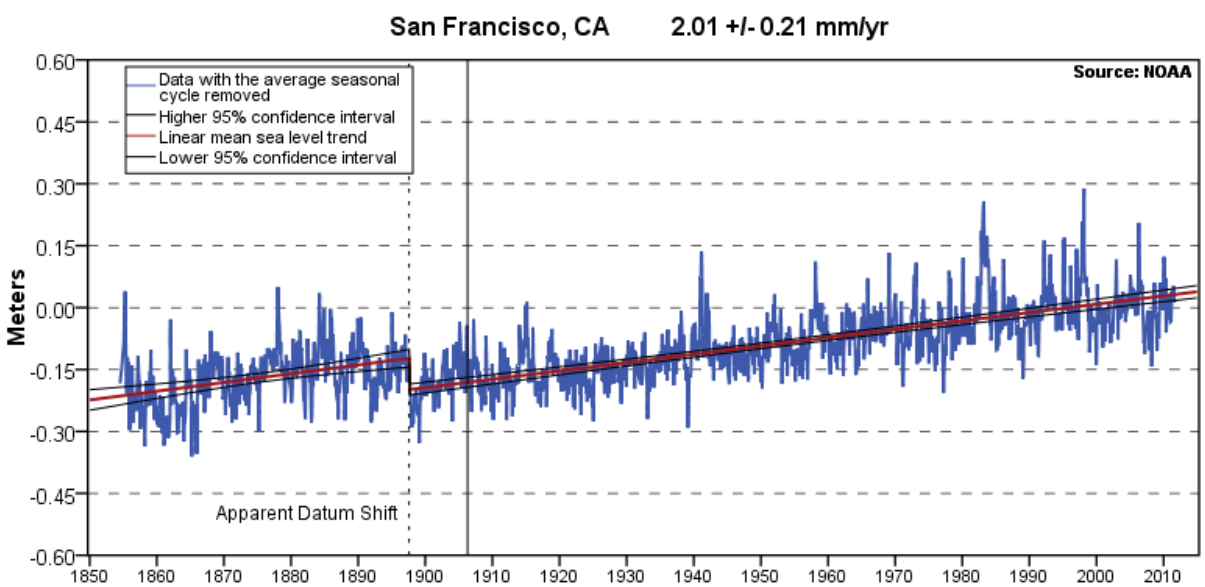

Figure 7-1. Sea Level Trend at San Francisco (NOAA, 2009)

The red line shows the mean sea level trend of 0.08 in/yr (2.01 mm/yr), and the black lines are the 95 percent confidence intervals. The solid vertical line is the 1906 earthquake, while the dashed vertical line is an apparent datum shift. Based on the historical data observed at San Francisco and following the guidance in EC-1165-2-211 of using the historical trend, a sea level rise of 0.08 in/yr (2.01 mm/yr) was chosen for the low case. This sea level rise value resulted in a 50-year increase of 0.33 ft (0.10 m) and a 100-year increase of 0.66 ft (0.20 m) at this location.

7.3.2 Intermediate Sea Level Rise

The intermediate sea level rise case was calculated using the modified NRC Curve I, as described in EC 1165-2-211. The equation used was

$$E(t_2) - E(t_1) = 0.07(t_2 - t_1) + b({t_2}^2 - {t_1}^2)$$

where t_2 is the time between the projected time and 1986, t_1 is the time between current time and 1986, and b is a constant value of 7.74E-5 (2.36E-5 for metric) for the medium sea level rise. To estimate the sea level rise in 2061, 50 years from 2011, values of 75 and 25 were used for t_2 and t_1, respectively. For the 100 year scenario, values of 125 and 25 were used for t_2 and t_1, respectively.

Using the above equation, sea level rise values of 0.66 ft (0.20 m) and 1.71 ft (0.52 m) was calculated for the 50 and 100 year scenarios, respectively.

7.3.3 High Sea Level Rise

The high sea level rise case was calculated using the modified NRC Curve III as described in EC 1165-2-211. The equation is the same as given above, with a b of 3.30E-4 (1.005E-4 for metric). Again, for the 50 year scenario, 75 and 25 were used for t_2 and t_1, respectively, and for the 100 year scenario, 125 and 25 were used for t_2 and t_1, respectively.

Using the above values, a sea level rise of 1.94 ft (0.59) m was calculated for 50 years, and 5.51 ft (1.7 m) for 100 years.

7.3.4 Summary of Sea Level Rise Values

The sea level rise values calculated above were checked against other sources to determine their validity. Table 7-4 presents a summary of the calculated sea level rise values, and Table 7-5 presents a sample of the range of sea level rise values described in the literature.

Table 7-4. Summary of Calculated Sea Level Rise Values at San Francisco Gage 94114290

Sea Level Rise Scenario	50-Year Rise (ft)	100-Year Rise (ft)
Low	0.33	0.66
Intermediate	0.66	1.71
High	1.94	5.51

Table 7-5. Sea Level Rise Values Seen in Literature

Source	100-Year Sea Level Rise Range (ft)
California Climate Change Center – Projecting Future Sea Level Rise (CCCC, 2006)	0.43–2.92
International Panel on Climate Change – Synthesis Report (IPCC, 2007)	0.59–1.94
Delta Risk Management Strategy (DRMS) – Climate Change (DRMS, 2008)	0.66–4.59

As shown in the above tables, the 100-year range calculated from EC 1165-2-211 of 0.66 – 5.51 ft (0.2–1.7 m) compares well with the ranges presented in the literature.

The low sea level rise rate was verified with observed data at the San Francisco station. For 2001, the arithmetic mean of the hourly water surface elevations was 9.02 ft (2.75 m) NAVD88. After applying the 0.08 in/yr (2.01 mm/yr) sea level rise, an average of 9.02 ft (2.77 m) was predicted. This matched well with the observed average in 2010 of 9.09 ft (2.78 m).

7.3.5 Sensitivity of Hydraulic Model Results

The estimates in sea level rise described previously were used in a sensitivity analysis to evaluate the impacts of sea level rise on the water surface profiles in the American River Common Features project area. More information can be found in the Downstream Boundary Sensitivity Analysis Memorandum for File (USACE, January 2010b). The analysis focused on the downstream boundary conditions. The sensitivity of the downstream boundaries for the American River Common Features project was tested by varying downstream stage hydrographs at three locations to reflect increases in stage due to sea level rise. Water surface profiles from the original model and the sensitivity runs (with shifted downstream boundary stage hydrographs) were compared along the American River reach and Sacramento River reach.

The effects of shifting the downstream hydrograph to account for changes in stage due to sea level rise resulted in no changes on the Sacramento at Verona and minimal changes on the Sacramento at Freeport. The largest difference in stage was two-tenths of a foot for the10% (1/10) ACE event on the Sacramento River at Verona, and the average difference in stage was one-hundredth of a foot or less for the 1% (1/100) ACE event along the Sacramento River. There were also minimal variations in surface water elevations in the Yolo Bypass, indicating no significant change in the routing of the flood event through the combined waterways of the Sacramento River and the Yolo Bypass. These minimal changes in water surface elevations within the project area indicate that the project water surface profiles are dominated by riverine conditions and are not sensitive to reasonably estimated future sea level rise conditions.

7.4 Interior Drainage

An analysis was done to examine the interior drainage of the smaller, non-leveed streams in the three project basins (USACE November 2012). Measures to reduce the risk for flooding from these small streams are not being considered for alternatives, but the risk of flooding is being accounted for in the economic analysis. The results (flood depths and water surface elevations for the 10% (1/10), 4% (1/25), 1% (1/100), and 0.2% (1/500) ACE events will be used to estimate residual damages in the floodplain

when doing the larger-scale risk estimation for the ARCF study. Plate 58 shows the project area for the interior drainage study.

Existing FEMA Digital Flood Insurance Rate Maps (DFIRMs) and associated flood insurance studies (FIS) were used to represent the interior flooding within the three basins. This analysis is general and approximate in nature and the level of detail is deemed appropriate in light of applying SMART Planning to this study. More information on the interior drainage analysis and process performed can be found in Interior Drainage Technical Memorandum (USACE November 2012).

Flood depths were determined for each recurrence interval by rasterizing the topographic data, the DFIRM shape files (30-foot grid cells), and the FIS data points in GIS and determining the difference between the two. The floodplains were created by interpolating the resultant rasterized flood depths. Plates 59-61 show the floodplains for the three areas.

The results indicate that the Interior drainage floodplains are significantly smaller than a floodplain from a levee break. The modifications to existing interior drainage facilities have been limited to bringing the facilities in compliance with Corps criteria for penetrations through levees (upgrading discharge lines, pumps, etc. to raise the drainage over the top of levee). An assessment of the capacity of existing facilities to address the residual flooding from interior runoff will be accomplished during the design phase or by the local maintaining agencies as part of their FEMA certification requirements.

7.5 Life Safety

Life safety information was taken from the USACE Levee Screening Tool (LST) for use in this study. The Levee Screening Tool supports the levee screening process by facilitating a preliminary assessment of the general condition and associated risks of levees in support of the USACE Levee Safety Program. (RMC, 2011)

The LST determines a screening risk index that considers routine inspection results and ratings coupled with a review and evaluation of historical performance data, as-built drawings, economic and life loss consequences, historic and current hydraulic and hydrology data, and other data. This helps determine the potential for failure and the consequences of failure. The culmination of the LST process is a screening risk index and risk classification that can be weighed against other screened levee segments in the portfolio.

Life safety can be evaluated using the consequence portion of the Levee Screening Tool (LST). Readily available data and information are used along with limited analysis to assess the potential consequences related to two different flooding scenarios: overtopping of a levee segment (with or without breach) and breach prior to overtopping of a levee segment. Consequence estimates focus on loss of life, but also include population at risk, number of structures, and direct monetary damage estimates to structures. The following is a description of the consequence results:

- **Population at Risk (Day/Night)**. These values represent the computed total number of people that would get wet if they did not evacuate when a levee breach occurred and inundated the entire leveed area up to the maximum profile elevation of the levee segment being screened.

- **Exposure Weighted Life Loss Estimates**. Computed "average" life loss estimates for each scenario that represent the loss of life caused by breach of the levee based on the movement of people in and out of the leveed area throughout the day.

The life safety and life loss estimates can be found in Table 7-6. This information comes from a series of Levee Screen Tool Presentations by the Sacramento District on the three basins or systems. (USACE, 2011), (USACE, 2012a), (USACE 2012b)

Table 7-6. Life Safety and Life Loss Information
From USACE's Levee Screening Tool

American River North		Natomas	
Population at Risk (Day)	58,558	Population at Risk (Day)	76,973
Population at Risk (Night)	51,380	Population at Risk (Night)	65,696
Loss of Life (Day)	170	Loss of Life (Day)	669
Loss of Life (Night)	156	Loss of Life (Night)	553
American River North, Small Streams		**American River South**	
Population at Risk (Day)	15,457	Population at Risk (Day)	350,000
Population at Risk (Night)	23,816	Population at Risk (Night)	439,491
Loss of Life (Day)	77	Loss of Life (Day)	503
Loss of Life (Night)	131	Loss of Life (Night)	978

8 EROSION

8.1 Overview and Assumptions

Erosion is the removal of sediment, rocks, cobble, vegetation and general deterioration of a bank or a levee due to the power of water, often measured by shear stress and velocity. The probability of erosion eroding a levee resulting in failure can present a significant flood risk. There have been many studies on erosion, sediment transport, and channel stability and in the study area, with most of the focus on the American River.

The primary concern about erosion related flood risk in the project area is on the American River and secondary concern is on the Sacramento River. While there may be erosion occurring on the smaller tributaries in the project area, it is assumed that any repairs would be incorporated into current designs with limited added costs, would not involve large quantities of rock, and would not have specific designs called out.

The plan for erosion management features is ongoing; more analysis is expected to provide greater insight. Erosion repairs are expected to be part of all three alternatives and refinement efforts will continue beyond the Tentatively Selected Plan (TSP) milestone. Existing erosion conditions in the project area are presented briefly in the following section. A separate multidisciplinary Erosion Protection Report was developed for this study that contains addition information.

8.2 Existing Bank Erosion Conditions

Below is a brief description of the existing bank erosion condition for each of the reaches in the project area. This section is based on existing annual erosion survey reports from the Sacramento River Bank Protection Project that covers the entire Sacramento River Flood Control System. (USACE 2012a) See Plate 3.

Sacramento River – Middle Reach, Colusa to Sacramento (RM 79 to RM 61). The middle reach of the Sacramento River has the levees close to the river and multiple diversion structures to move flow into the bypass system. The Sacramento River was split at the confluence with the American River for the purposes of this discussion because the conditions of the river change at this location. The middle reach was intentionally designed with the levees close to the banks to help move some of the bed load and debris that remained from the days of hydraulic mining. In addition, USACE was responsible for keeping the river navigable up to the city of Colusa. As a result of this design, much of the reach is protected with rock, especially the outsides of bends. The majority of the rock in this reach is cobbles placed prior to the 1960s and some areas with more recent quarry stone. The cobble sites are reaching the end of their design life. Figure 8-2 shows a typical view of the middle reach of the Sacramento River.

Figure 8-1. Typical View of the Middle Reach of the Sacramento River

Sacramento River – Delta Section (RM 61 to RM 45). The Delta reach of the Sacramento River has levees placed directly adjacent to the main channel and is tidally influenced. The location of the channel has been relatively stable for the past 150 years. A large percentage of this reach has already been armored with riprap. This area has heavy wave action from recreational boats and wind, and the banks are heavily used by the public. Many of the levees are constructed of dredged soils from the bottom of the channel. Figure 8-3 shows a typical view of the Delta section of the Sacramento River. The causes of erosion in this reach are boat wake, wind-wave, mass failure, fluvial processes, and public use.

Figure 8-2. Typical View of the Delta Section of the Sacramento River

American River. The American River reach is located downstream of Folsom Dam, is therefore generally sediment-starved, and has been eroding and transporting the fine materials from the channel bed. Once the fines have been removed and the bed is armored, the channel is expected to move laterally and erode the banks. The right bank levee is set back from the channel for the lower 5 miles. Boat wake is not a concern as there is a no wake zone for the entire river. The main causes of erosion are fluvial, tree undercutting, and public use. This river is generally well maintained and has had many bank repairs in the recent years. Figure 8-4 shows a typical view of the American River.

Figure 8-3. Typical View of the American River

Natomas East Main Drainage Canal, Arcade Creek, and Dry Creek. Arcade Creek and Dry Creek (formerly known as Linda Creek, and now more commonly referred to as Big Dry Creek) drain water from the Rio Linda, Roseville, Antelope, Citrus Heights, and Carmichael areas. Arcade Creek has the levees relatively close to the channel; however, the small amount of floodplain maintains a healthy riparian habitat. Dry Creek has a large floodplain but relatively little riparian habitat, as the floodplains appear to be used for cattle grazing. Figure 8-5 shows a typical view of Dry Creek. The Natomas East Main Drainage Canal (NEMDC) directs the flow from Arcade and Dry creeks and sends it south to the American River. NEMDC is a man-made channel that runs north-south and protects the east side of Natomas.

Erosion is not considered to be a significant problem on these smaller tributaries or on the Natomas Cross Canal, Pleasant Grove Canal, or Coon Creek Interceptor (described below). Any work needed to address erosion will be part of the levee design effort and were accounted for in the cost contingency and is not expected to add any cost or change the hydraulics of these reaches.

Figure 8-4. Typical View of Dry (Linda) Creek

Natomas Cross Canal, Pleasant Grove Canal, and Coon Creek Interceptor. Pleasant Grove Canal and Coon Creek Interceptor collect water from the east foothills and communities of Lincoln and Pleasant Grove. These flows are then directed into the Natomas Cross Canal, which moves the water down to the Sacramento River. Pleasant Grove Canal and Coon Creek only have levees on the east side. The levees are steep with some grass and shrub vegetation. The Natomas Cross Canal is man-made and the levee on the south side was recently rebuilt. The south levee is mowed and grazed by sheep in the summer while the north levee has tall grasses with shrubs/trees on the lower bank. Figure 8-6 shows a typical view of the Natomas Cross Canal.

Figure 8-5. Typical View of the Natomas Cross Canal

8.3 Existing Sediment Transport

A sedimentation analysis was not completed for this study. However, a sediment study of the Sacramento River from Colusa to Freeport is near completion under the Sacramento River Bank Protection Project (NHC, 2012). The main objective of this sediment study was to investigate sediment transport processes and geomorphic trends along the lower Sacramento River and its major tributaries and distributaries. A HEC-6T sediment transport model was developed for the study reaches of the Sacramento, Feather, and American Rivers to estimate degradational or aggradational trends over the next 50 and 100 years.

For the entire study reach of the Sacramento River (RM 79-46), the average bed elevation decreases by 0.02 ft for the 50-year simulation period and decreases by 0.10 ft for the 100-year simulation period. Despite a few significant (on the order of feet) localized vertical adjustments in the channel geometry (mostly associated with infilling of deep pools and scour of elevated riffles), the study reach of the Sacramento River appears to be generally stable, with a slight degradational trend.

On the lower American River, the long-term simulation results indicate that most of the 22-mile long study reach is actively degrading. Upstream sediment supply on the American River is interrupted by Folsom and Nimbus Dams, which results in “sediment-hungry” waters and channel degradation below the dams. Simulated long-term changes in the American River bed profile range from 9-16 ft of degradation to about 3-4 ft of aggradation. Degradation is simulated upstream of RM 12 and downstream of RM 11, while aggradation is simulated in a short reach between RMs 12-11. For the entire study reach of the American River, the average bed degradation is 4.8 ft and 5.8 ft for the 50- and 100-year simulations, respectively.

It should be noted that the channel of the American River is highly irregular at many locations (especially in braided reaches upstream of RM 8). These irregular reaches may not be adequately represented in the 1-d HEC-6T model. Therefore, results obtained for the irregular reaches may be subject to modeling errors and should be treated with caution. In general, however, the degradational trend predicted by

the model agrees with stage-discharge records showing ongoing channel degradation of the American River channel.

8.4 Existing American River Channel Stability

Specific to the American River, multiple analyses have been completed and many are still underway to better understand the overall channel stability. These efforts are ongoing and are expected to be incorporated into the design of the tentatively selected plan.

Recognizing that significant efforts have been completed and that current studies are not yet finished, the hydraulic characteristics of the American River channel under with-project conditions were evaluated using existing information. The 2004 Ayres Report, "Lower American River – Erosion Susceptibility Analysis for Infrequent Flood Events" for the American River provided 2-D hydraulic model results of velocity, shear stress and water depth for flows of 115,000 cfs, 130,000 cfs, 145,000 cfs, and 160,000 cfs. The report and model results were provided to the Civil Design and Geotechnical Sections; additional information on erosion designs can be found in their respective appendices.

The conclusions from the Ayres 2004 report provide further evidence for the need of erosion protection measures to reduce the flood risk on both sides of the American River and are described below:

> *Based upon our modeling efforts, field review and overall experience with the Lower American River system, we offer the following conclusions:*
>
> 1. *Geomorphic principles, the thalweg profile, and the field review all agree that the river system is degradational under present operating conditions.*
>
> 2. *The Lower American River is starved of sediments by Folsom and Nimbus dams. Bedrock has been reached in the channel bottom as far downstream as Guy West Bridge, and this bedrock is slowing further degradation. With the river starved for sediments and without significant bed slope reduction, it will now tend to erode laterally to satisfy the need for sediment.*
>
> 3. *The hydraulic modeling shows areas of riverbank and levees where allowable velocities for vegetative cover and soil materials are exceeded. These sites need to be evaluated in more detail to determine if a levee failure is likely to occur.*
>
> 4. *The field review verified that erosion of the riverbank is occurring (RM 9.0R) even at low flow conditions of 7,000 cfs, which was the peak flow from the 2003 runoff season. Erosion on the American River is continually occurring. This condition is leaving the channel banks scarred and susceptible to further erosion, especially during a high flow event. In addition, this condition is further reducing the amount of berm separating the main channel from the levee. The loss of underlying vegetation is leaving bare soil, which is susceptible to erosion at a lower velocity.*

8.5 Existing Wind-wave

Wind-wave analysis was done to evaluate the risk of failure due to wind-wave erosion for about 85 miles of the American River Common Features levees in Sacramento and Sutter Counties for coincident 0.5% (1/200) ACE event water levels and extreme wind events (NHC, 2010). The study approach and methods

followed Engineering Circular 1110-2-6067 and other technical publications related to wind-wave analysis. Wind-wave characteristics were calculated from the highest observed winds on record at stations in the Sacramento area. Frequency analysis of the annual maxima at the stations, by direction, suggested that the maximum 1-hour gusts had about a 2% (1/50) ACE event. No studies were performed to determine the coincident probability of the (1/200) ACE event water level and the maximum wind occurring simultaneously.

Each site was assigned a risk level based on the highest risk assigned for either levee face erosion or overtopping for any wind direction at a given site. The risk at each study site was than generalized to nearby sites, which were expected to experience similar wave heights and which had similar geometry and protection. Overall, 46 miles of levee were determined to be at high risk of failure due to wind-wave erosion during coincident extreme wind and water levels, 25 miles were determined to be of moderate risk, and 14 miles were assumed to be low risk. High risk sites are likely to require repair for the levee to be a certifiable flood defense structure. Sections of levee with moderate risk are not expected to require repair and any damage at these locations during a large flood should likely be mitigated with flood fighting. Low risk sites do not require repair and likely will not require any flood fighting for wind-wave erosion.

It should be noted that the possibility of levee breach due to wind-wave action is small compared to other issues currently being considered, such as underseepage and stability, and that conservative assumptions were made in regards to the need for erosion protection due to wind-wave action on the PGCC and the upper NEMDC.

8.6 Existing Boat Wave Erosion

Boat wave erosion has not been accounted for in this analysis because the impact of boat wave erosion in the project area is unlikely to be significant. Only smaller recreational boats operate in the Sacramento and lower American Rivers, and the other project reaches do not have enough consistent depth or width of channel to sustain boat traffic. Any repairs needed from boat waves is assumed to be addressed as part of standard operation and maintenance of the levees.

8.7 Existing Vegetation Analysis (Tree Scour)

The preliminary designs for erosion protection include leaving some of the vegetation in place, an option made possible by a waiver process included in ETL 1110-2-571. A pier scour analysis to represent tree scour (likely using HEC-18) is included in the application for waiver. This effort is considered part of the erosion analysis, and is expected to be done as part of the refinement during PED.

8.8 With-Project Erosion Features

With the levees set back on the American River, there are some additional options available to address erosion. A launchable rock trench at the levee toe is considered a viable measure, along with protecting the bank with a rock layer. All launchable rock trenches would be constructed outside of the natural river channel and designed to deploy once erosion has removed the bank material covering it.

In a flood event where the bank erodes back to the levee, the launchable rock would already be in place to protect the levee slope and nearby bank, halting the erosion. The rock trench can be covered with

dirt and vegetation so that the entire fix is not visible. A key assumption for the rock trench is that it would not change the hydraulics, because the design would not affect the cross sectional area of the channel. See the geotechnical report for information on the details of this erosion repair measure.

The preliminary locations where bank protection (as opposed to rock trench protection) was proposed suggested a concern about channel capacity. An initial hydraulic model run was made with a revised geometry reflecting the obstruction estimated for the bank protection. This model run showed stage increases approximating 1 foot for the 0.5% (1/200) ACE event (currently set to be 160,000 cfs). Given the significant increase in stage, the option of replacing the bank protection upstream of the narrowest part of the American River (near Guy West Bridge, approximately RM 6.5) with rock trench measures was evaluated with another hydraulic model run. The results indicated that this limited erosion fix option caused very little change in stage for the 0.5% (1/200) ACE event.

Based on this analysis, the rock trench measure is proposed for areas upstream of the Guy West Bridge (approx. RM 6.5) with bank protection or a rock trench downstream of this point. Further refinement in PED will likely be necessary to verify this measure.

8.9 Bridge Scour

There are over 15 bridges crossing the channel on multiple reaches in the project area. Bridges along the Sacramento and American rivers will likely need an analysis during design to account for bridge scour protection. This effort is considered part of the erosion analysis and is expected to be done as part of the refinement during PED.

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LEGEND

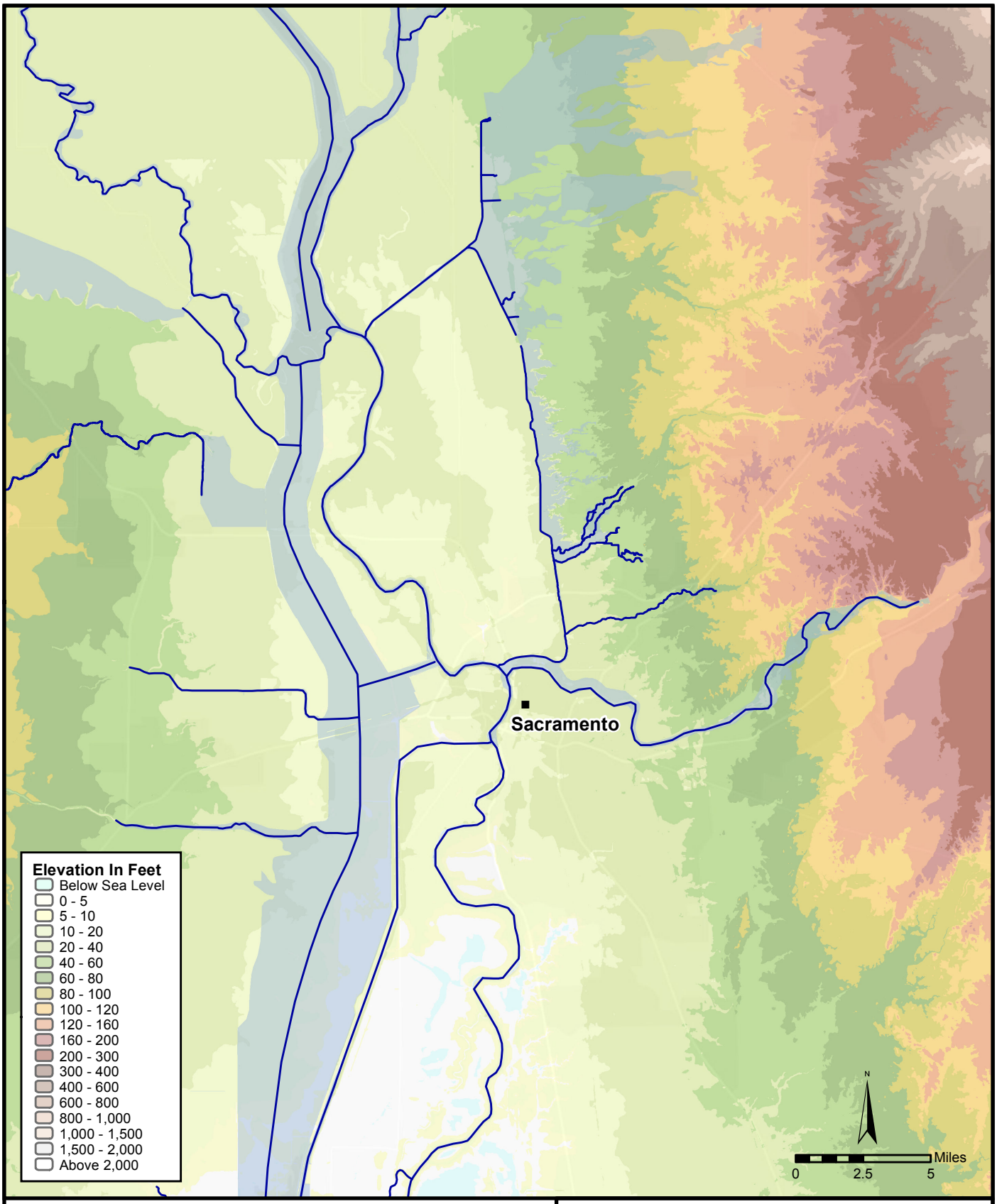
- Rivers
- Sacramento Watershed
- Lakes and Reservoirs
- Designated Floodways

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

SACRAMENTO RIVER WATERSHED

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Feb 2013



LEGEND

Rivers

Floodways

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

GENERAL TOPOGRAPHIC MAP

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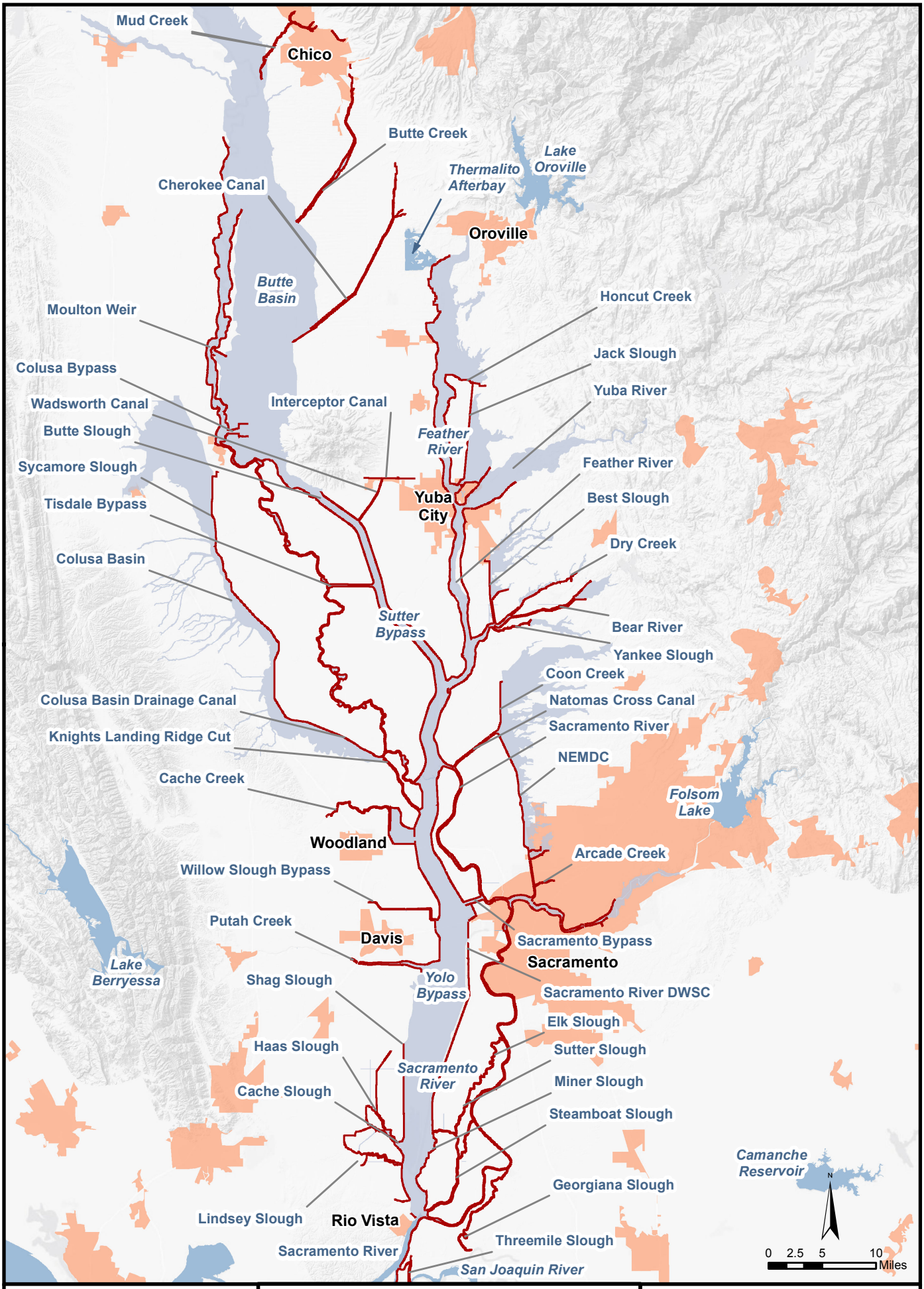
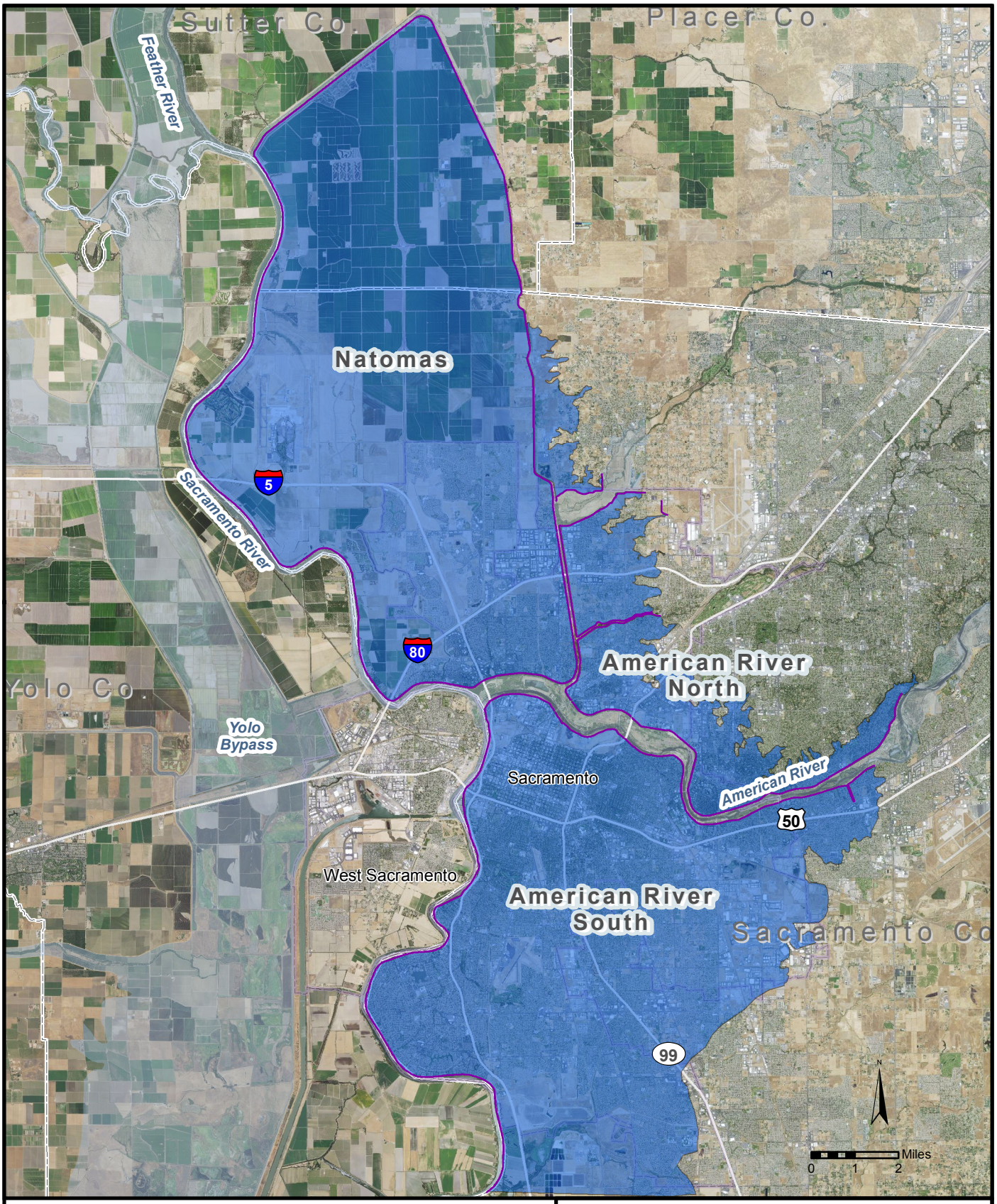
SACRAMENTO DISTRICT

Feb 2013



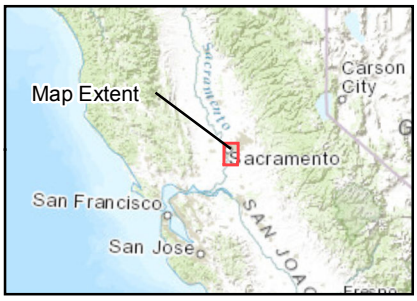
AMERICAN RIVER COMMON FEATURES GRR SACRAMENTO, CALIFORNIA	**Sacramento River Flood Control System**	U.S. ARMY CORPS OF ENGINEERS SACRAMENTO DISTRICT

Feb 2013



LEGEND

- ARCF Levees
- ARCF Project Area
- Floodways
- Cities
- County Lines

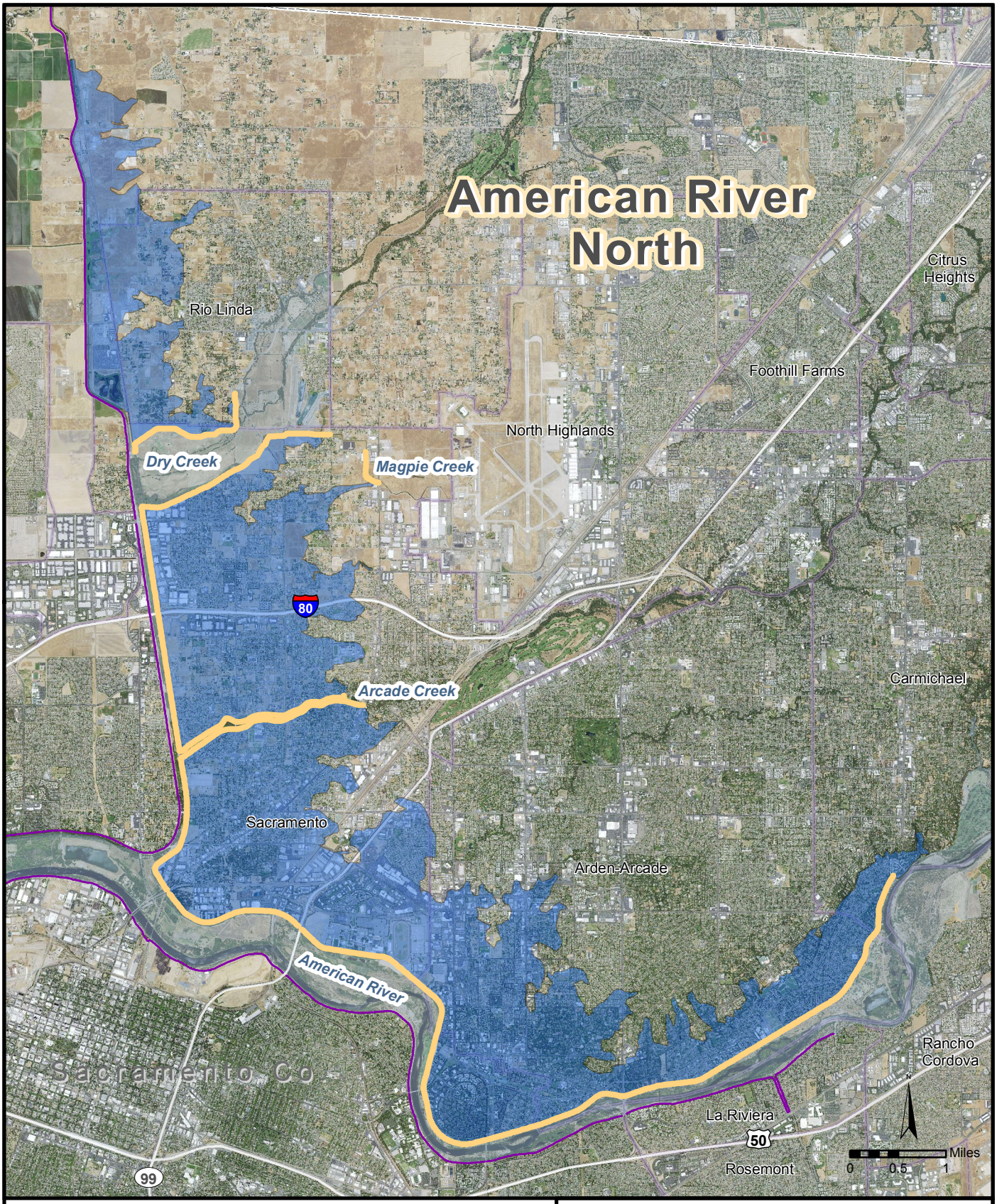


AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

PROJECT AREA MAP

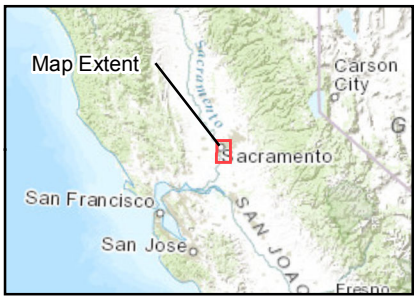
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Sept 2015



LEGEND

- ARN Project Area
- ARN Levees
- ARCF Levees
- Floodways
- County Lines
- Cities

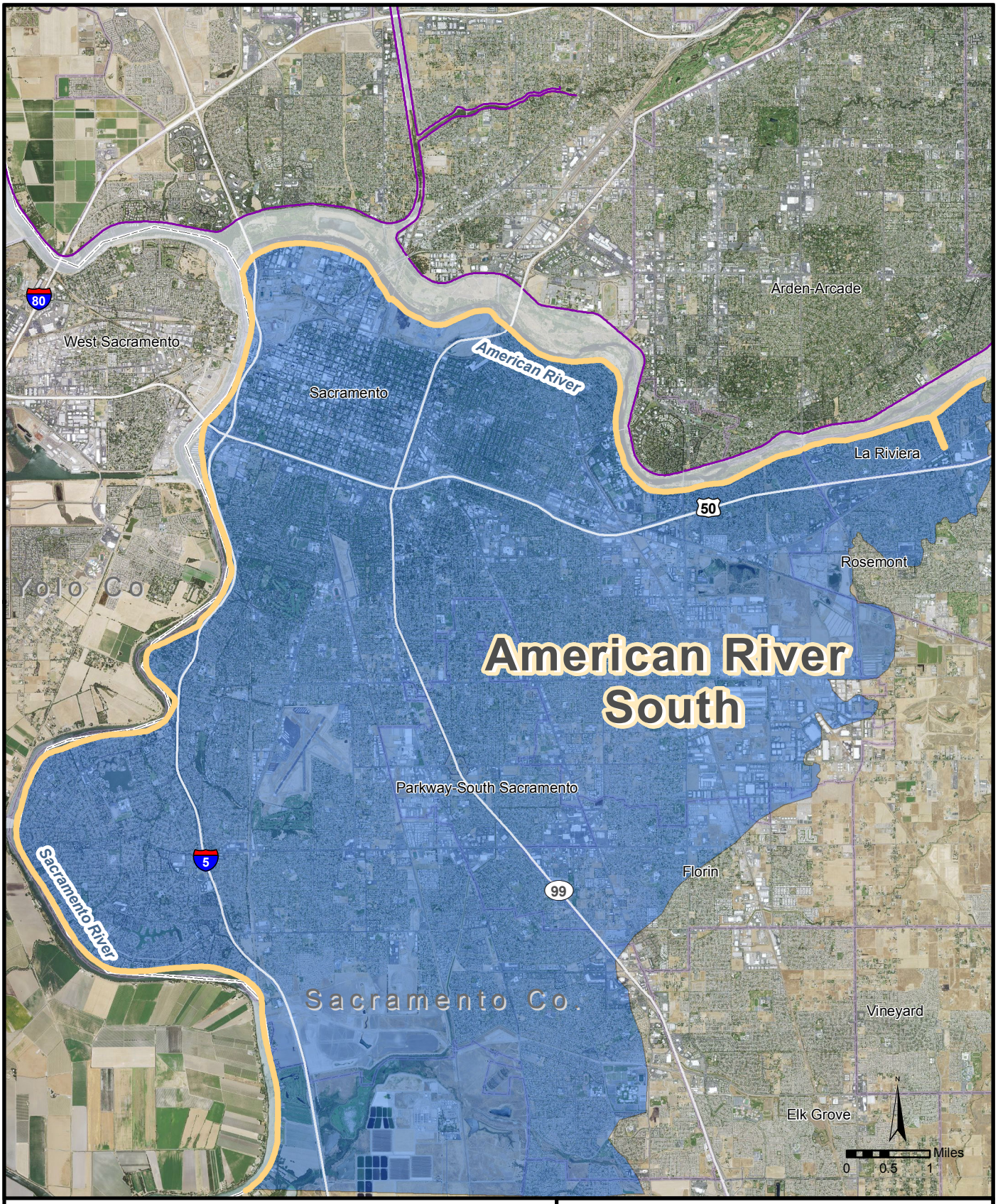


AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER NORTH PROJECT AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Sept 2015



LEGEND

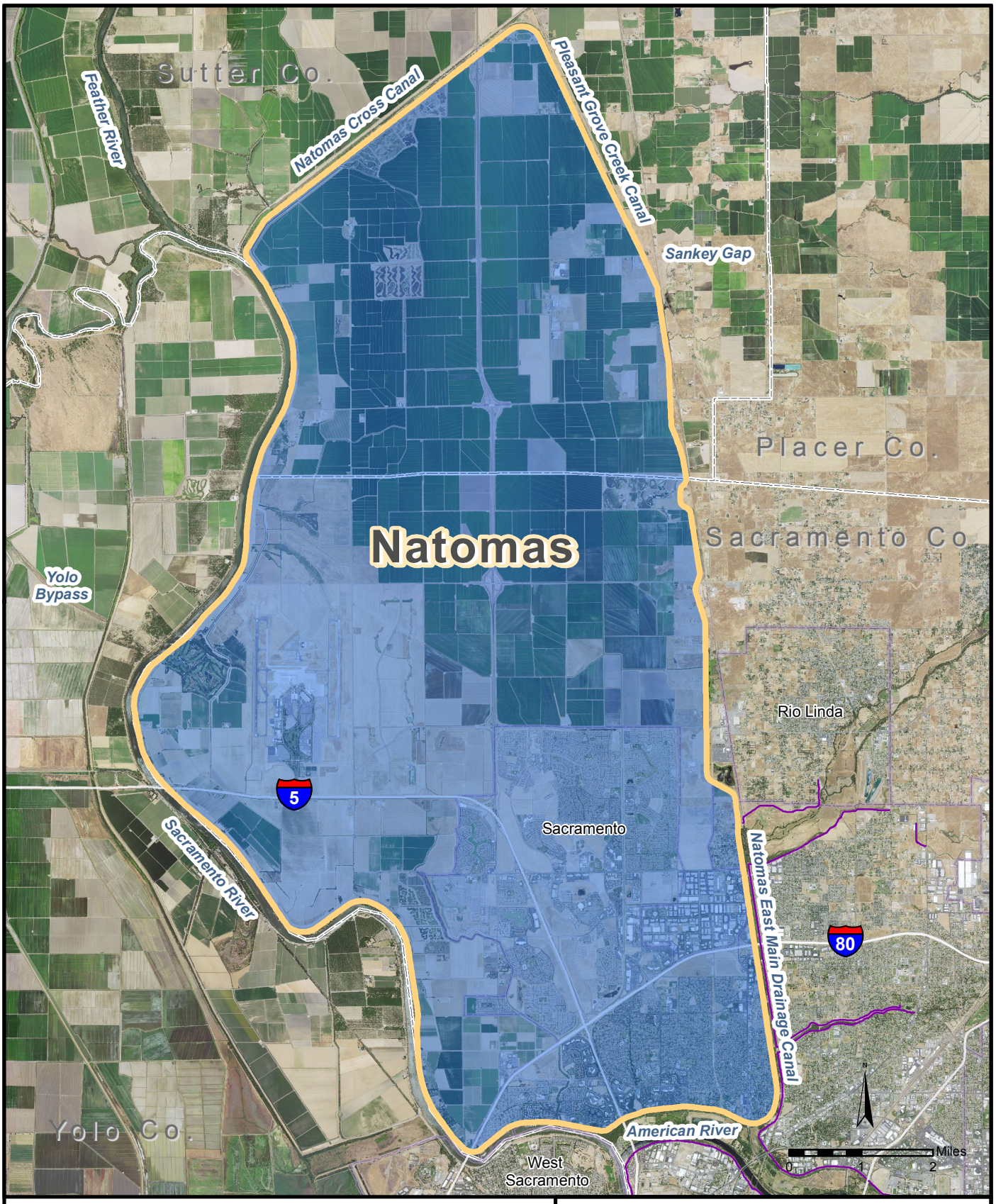
- ARCF Levees
- ARS Levees
- County Lines
- Cities

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER SOUTH PROJECT AREA

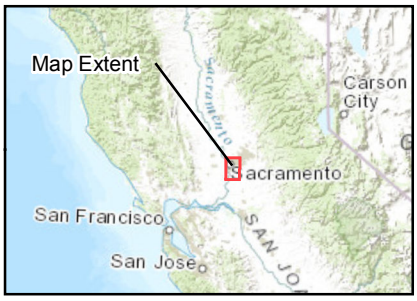
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Sept 2015



LEGEND

- ARCF Levees
- Natomas Levees
- Cities
- County Lines

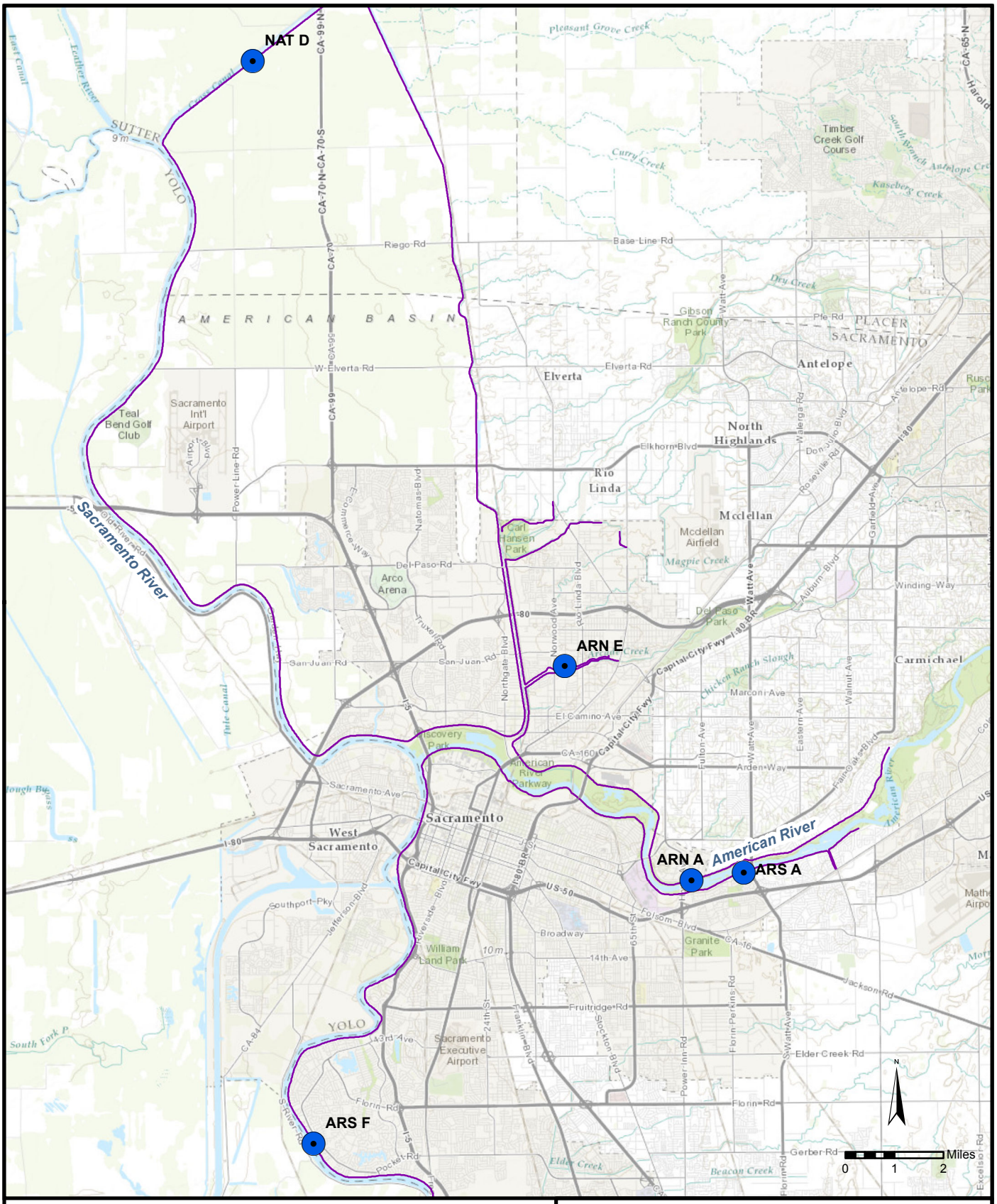


AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

NATOMAS BASIN PROJECT AREA

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Sept 2015



LEGEND

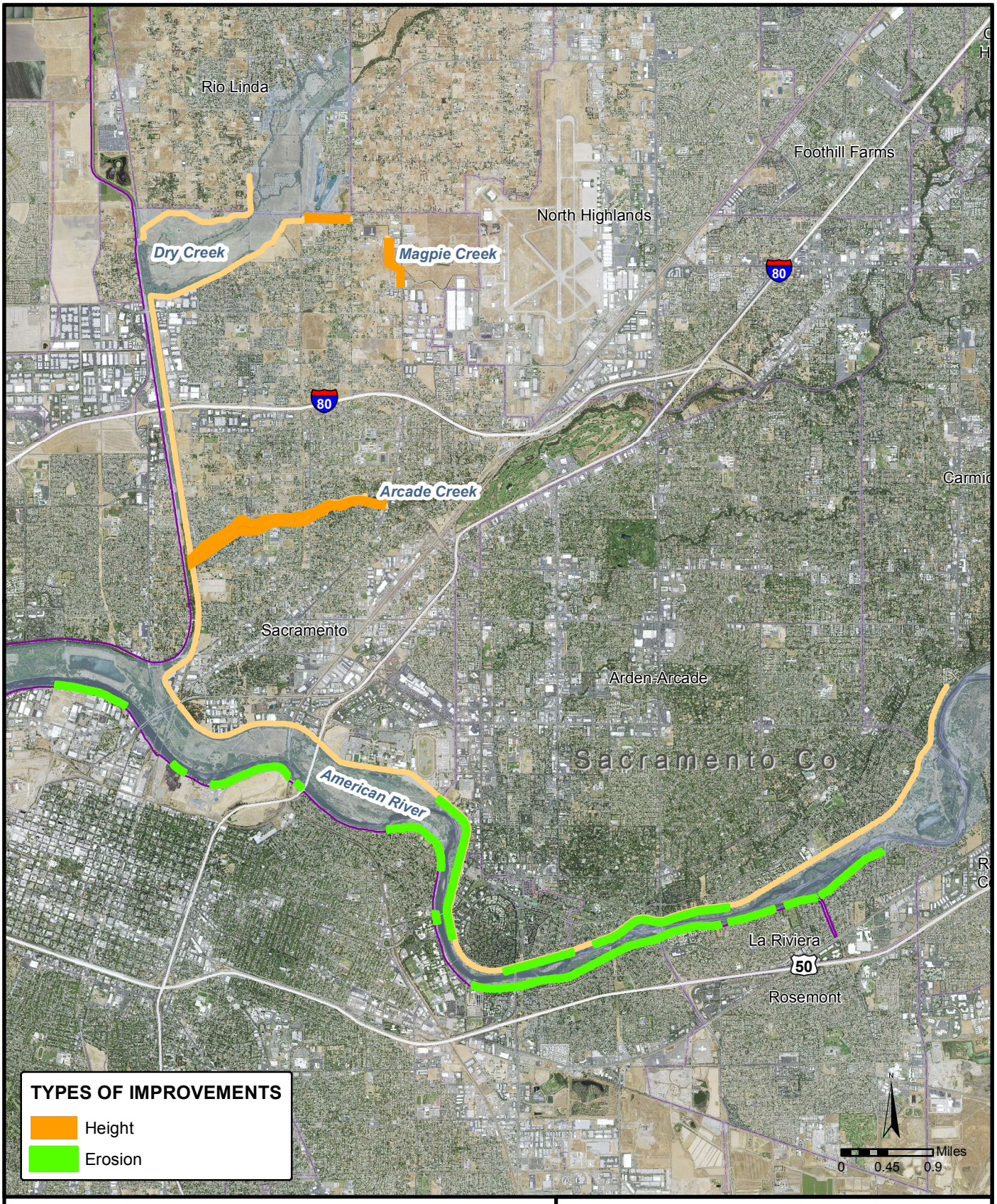
- ARCF Index Points
- ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

INDEX POINT LOCATION MAP

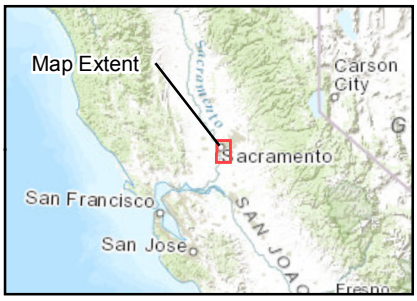
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Sept 2015



LEGEND

- ARN Levees
- ARCF Levees
- Floodways
- County Lines
- Cities

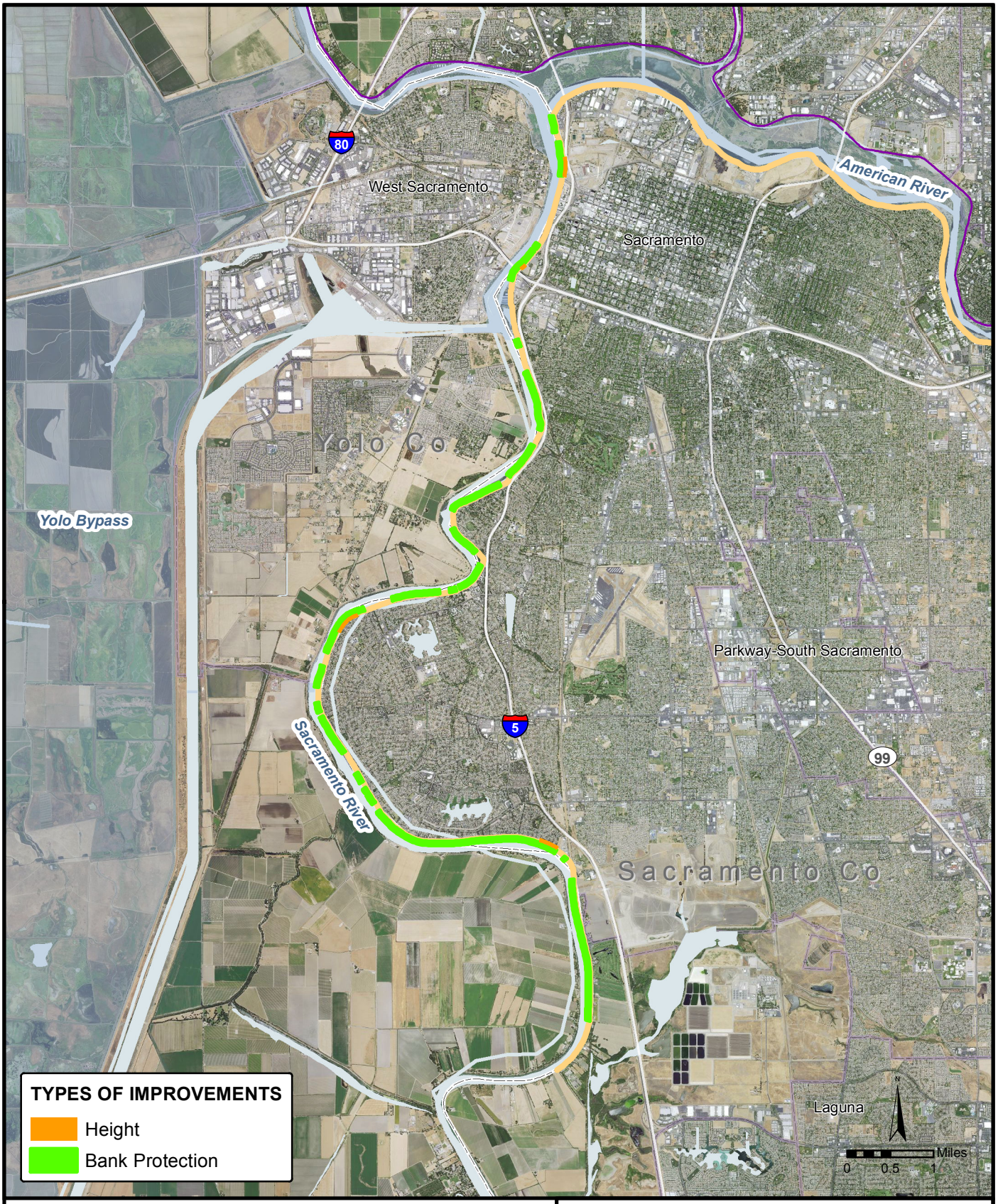


AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

LOCATIONS OF HEIGHT AND EROSION IMPROVEMENTS ALONG THE AMERICAN RIVER AND EAST SIDE TRIBUTARIES

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Aug 2015



LEGEND

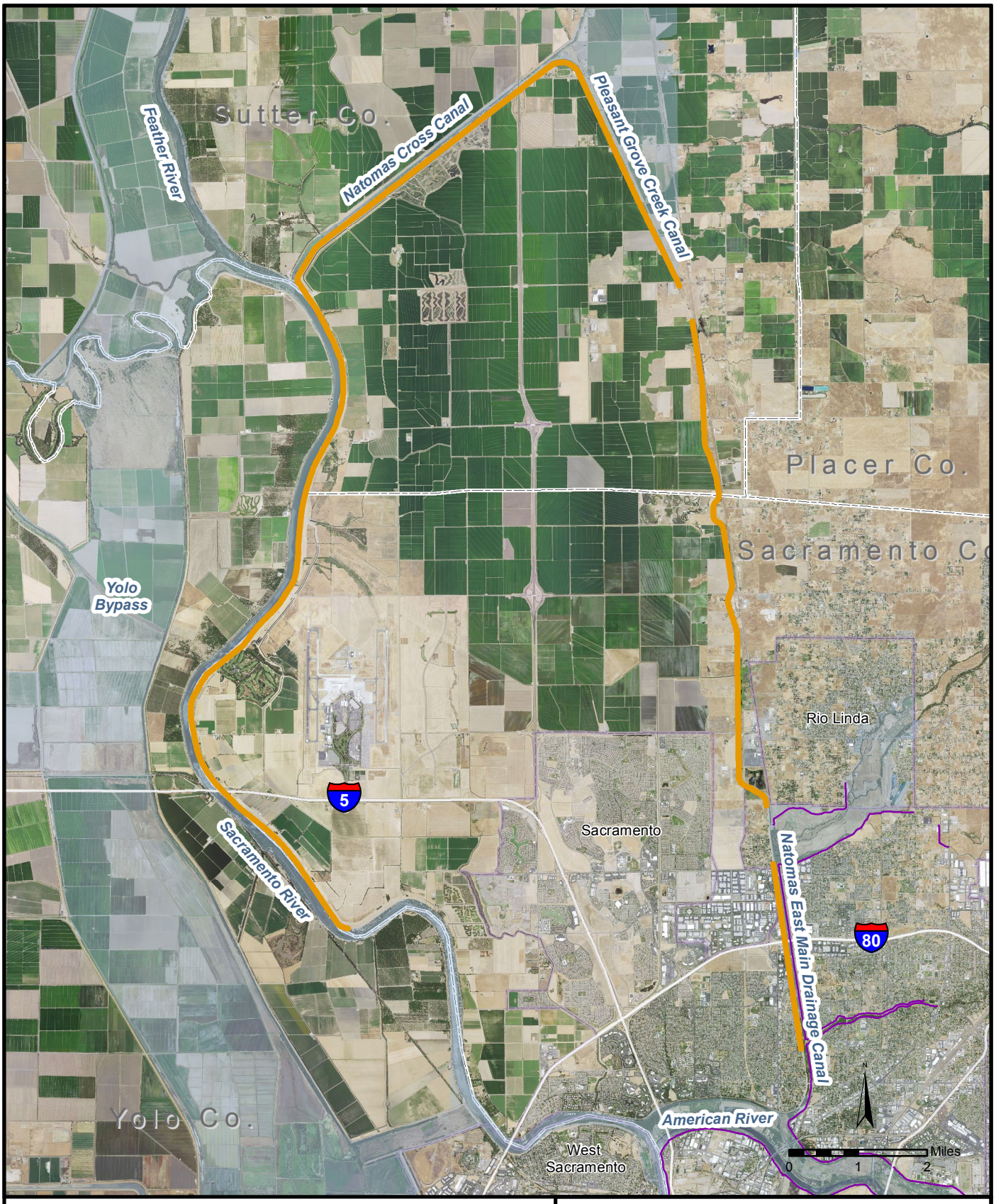
- ARCF Levees
- ARS Levees
- Floodways
- County Lines
- Cities

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

LOCATIONS OF HEIGHT AND EROSION IMPROVEMENTS ALONG THE SACRAMENTO RIVER

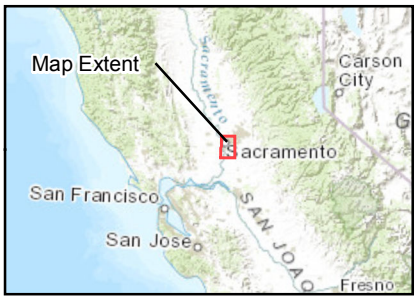
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Sept 2015



LEGEND

- Height
- ARCF Levees
- Floodways
- Cities
- County Lines



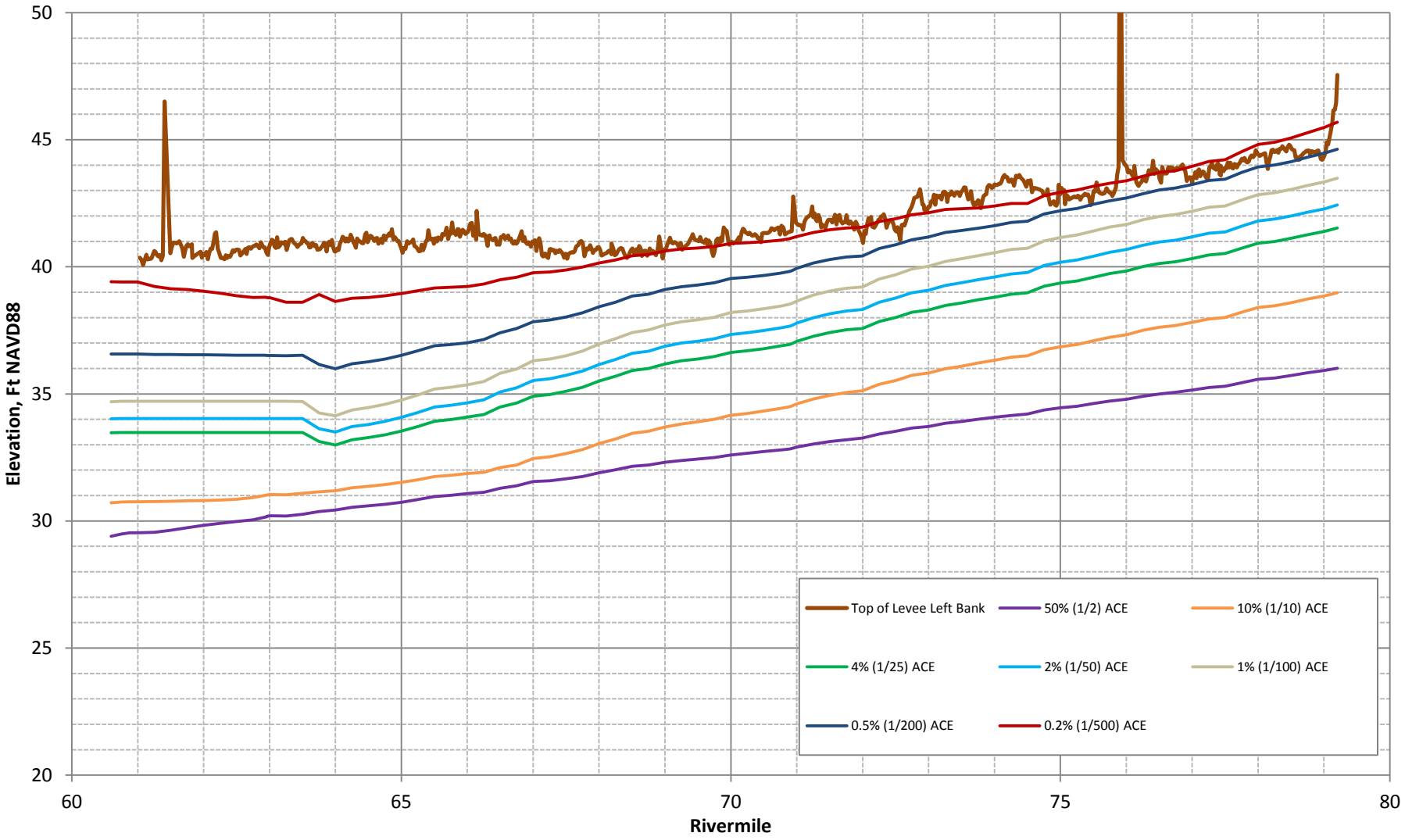
AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

LOCATIONS OF HEIGHT IMPROVEMENTS ALONG THE NATOMAS BASIN

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

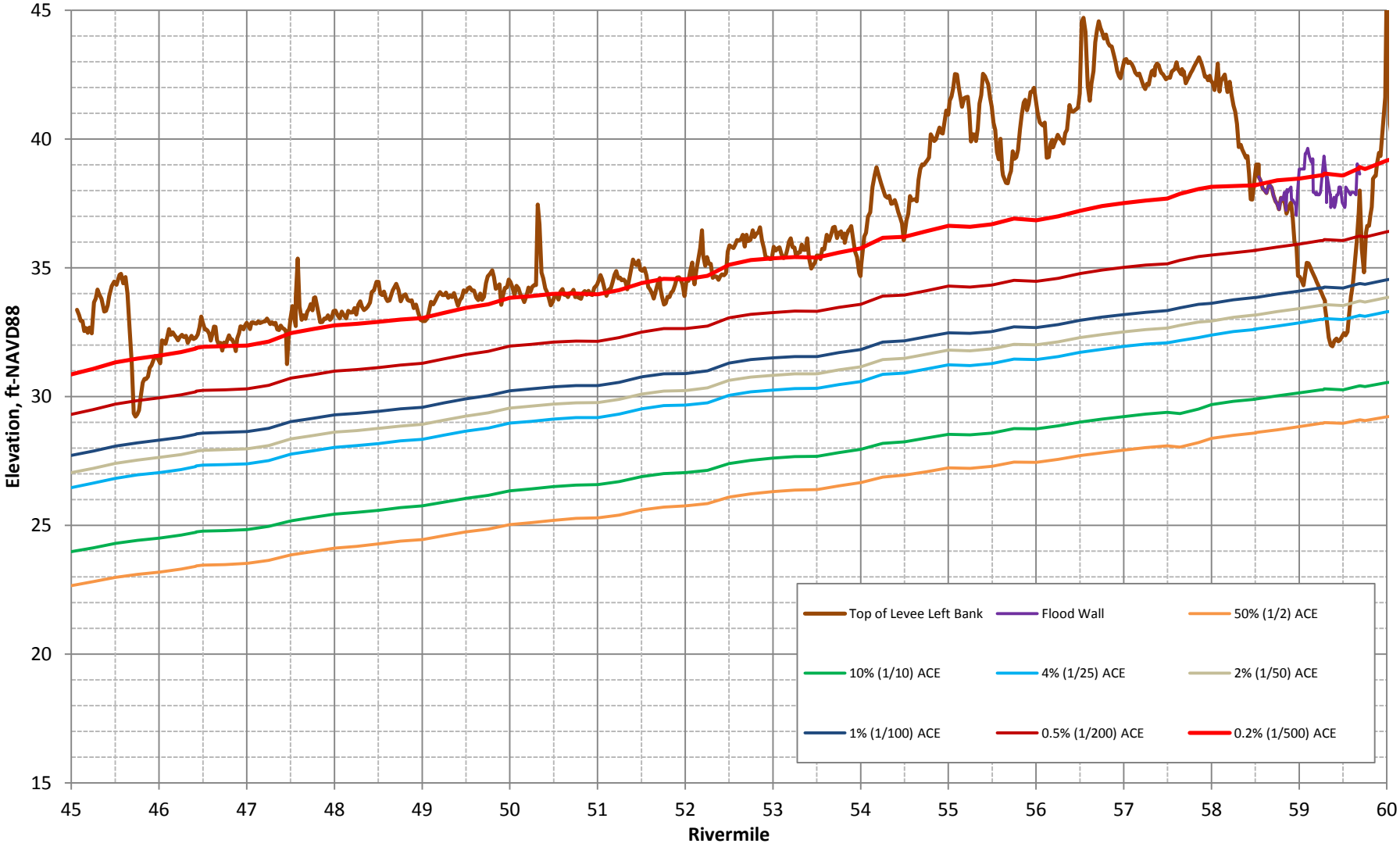
Sept 2015

Sacramento River (Upstream of the American River) - Left Bank Levee

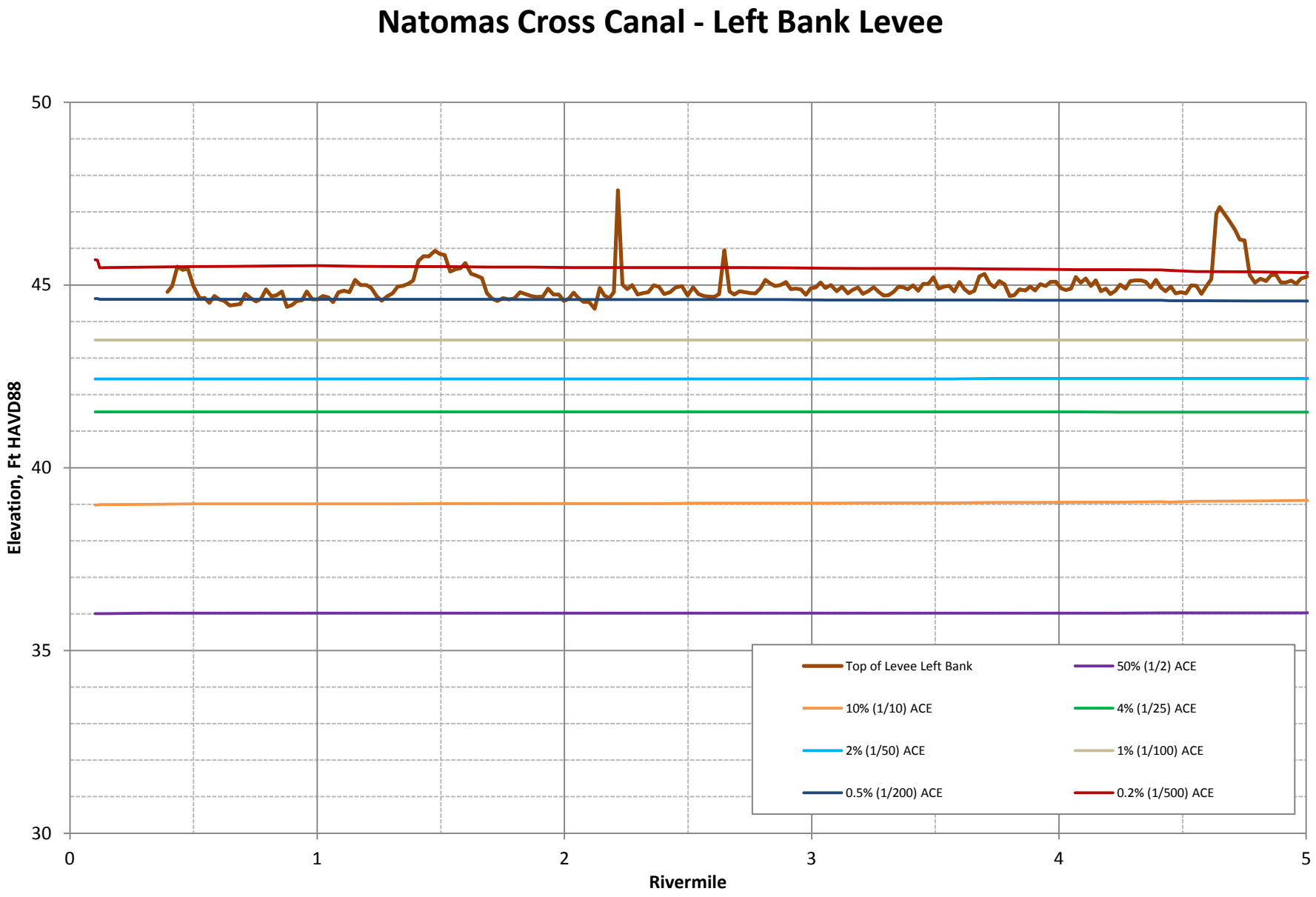


American River Common Features GRR **Sacramento, California**	**Sacramento River (U/S of the American River) – Left Bank Levee** **N-Yr Water Surface Profiles Future Without-Project Condition**	**U.S. Army Corps of Engineers** **Sacramento District**

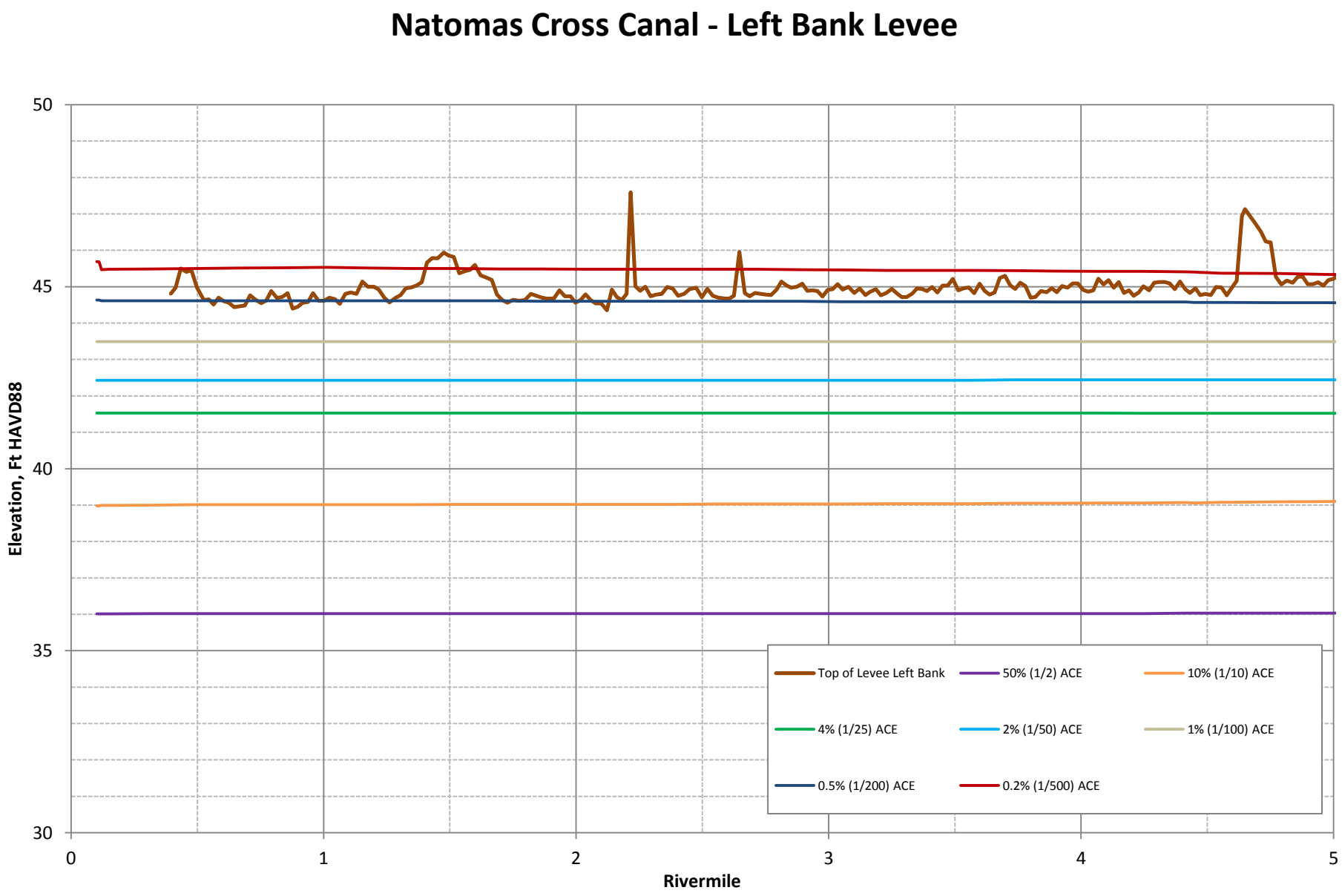
Sacramento River (Downstream of the American River) - Left Bank Levee



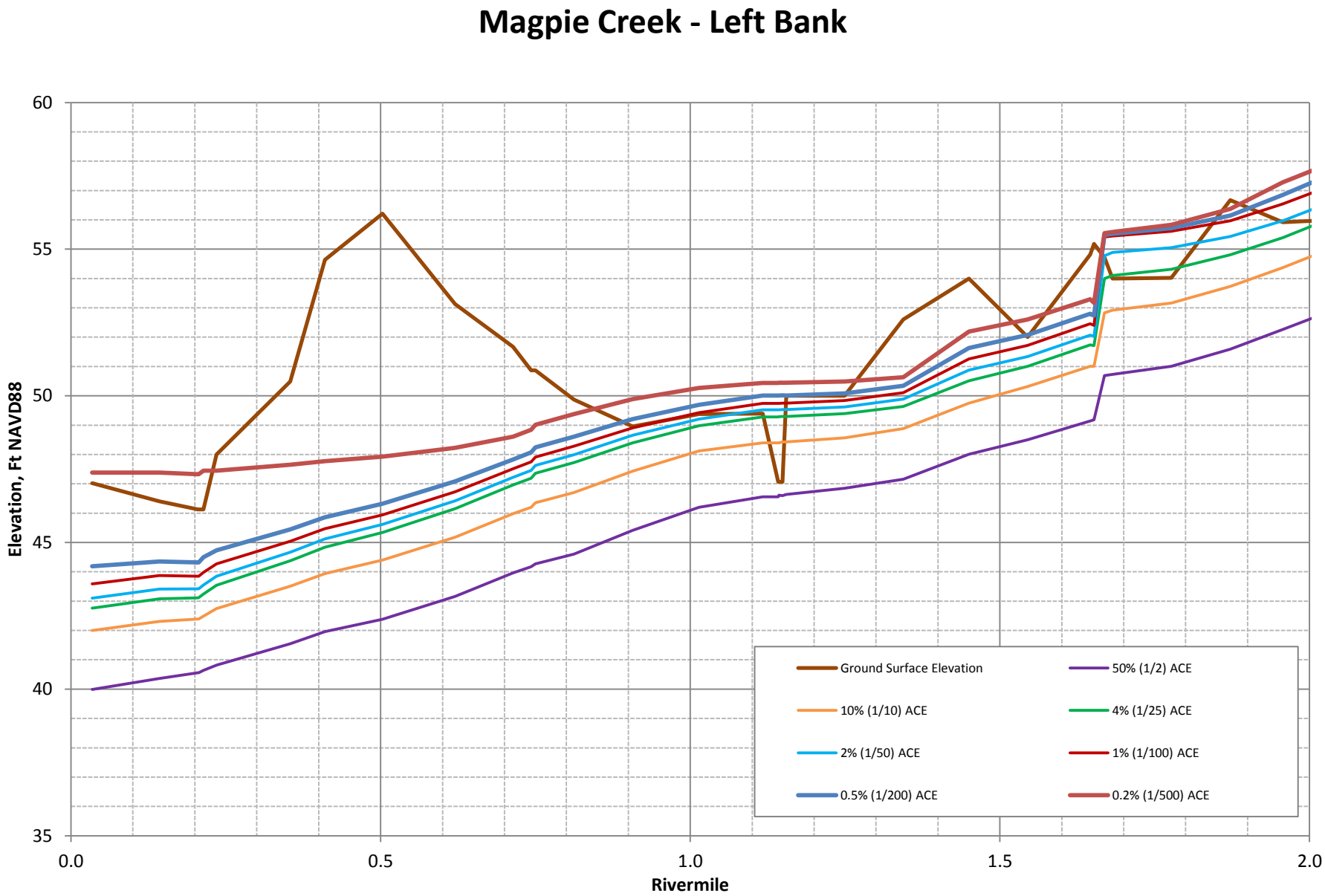
American River Common Features GRR Sacramento, California	Sacramento River (D/S of the American River) – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District



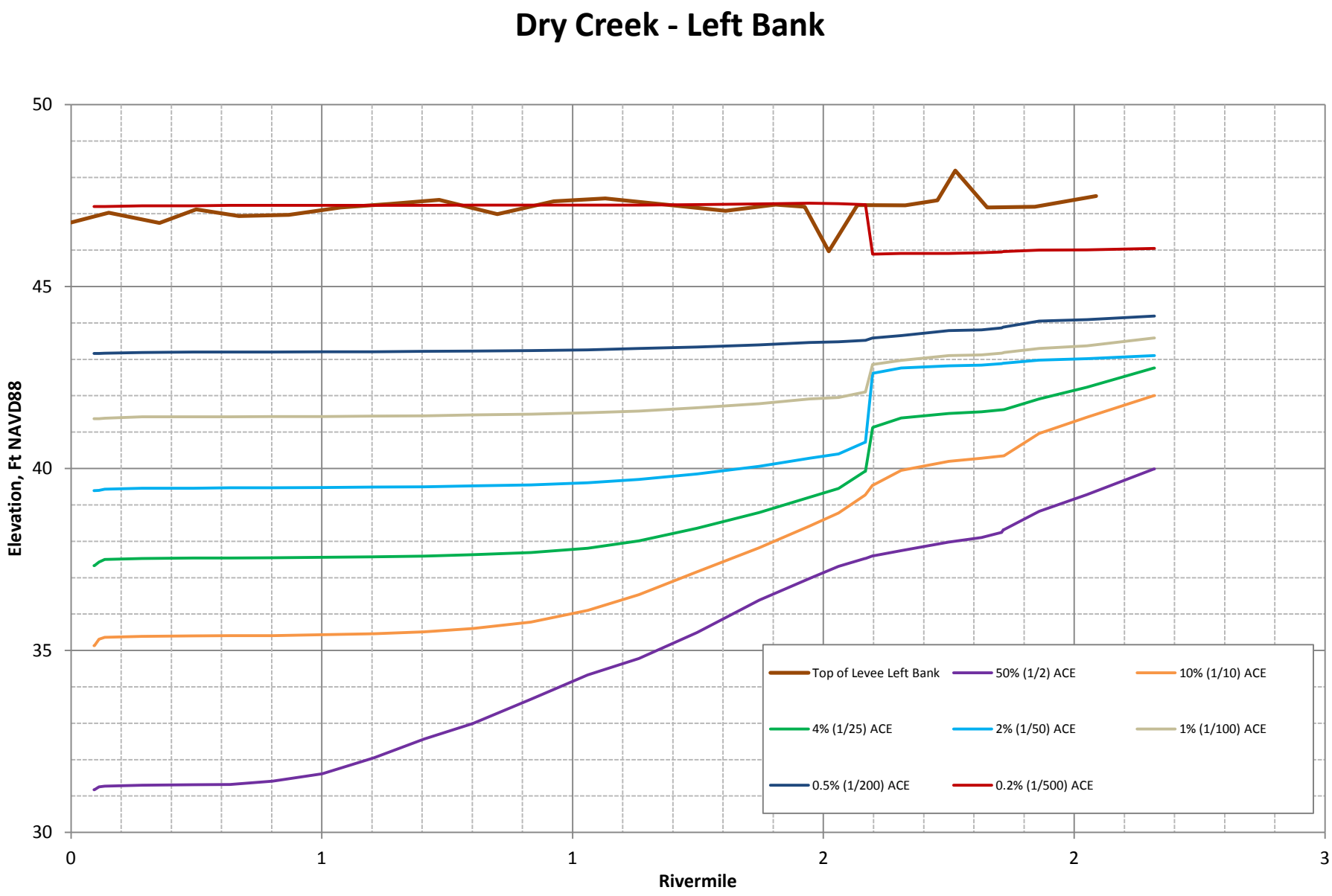
American River Common Features GRR Sacramento, California	Natomas Cross Canal – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District



American River Common Features GRR Sacramento, California	Pleasant Grove Creek Canal – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District

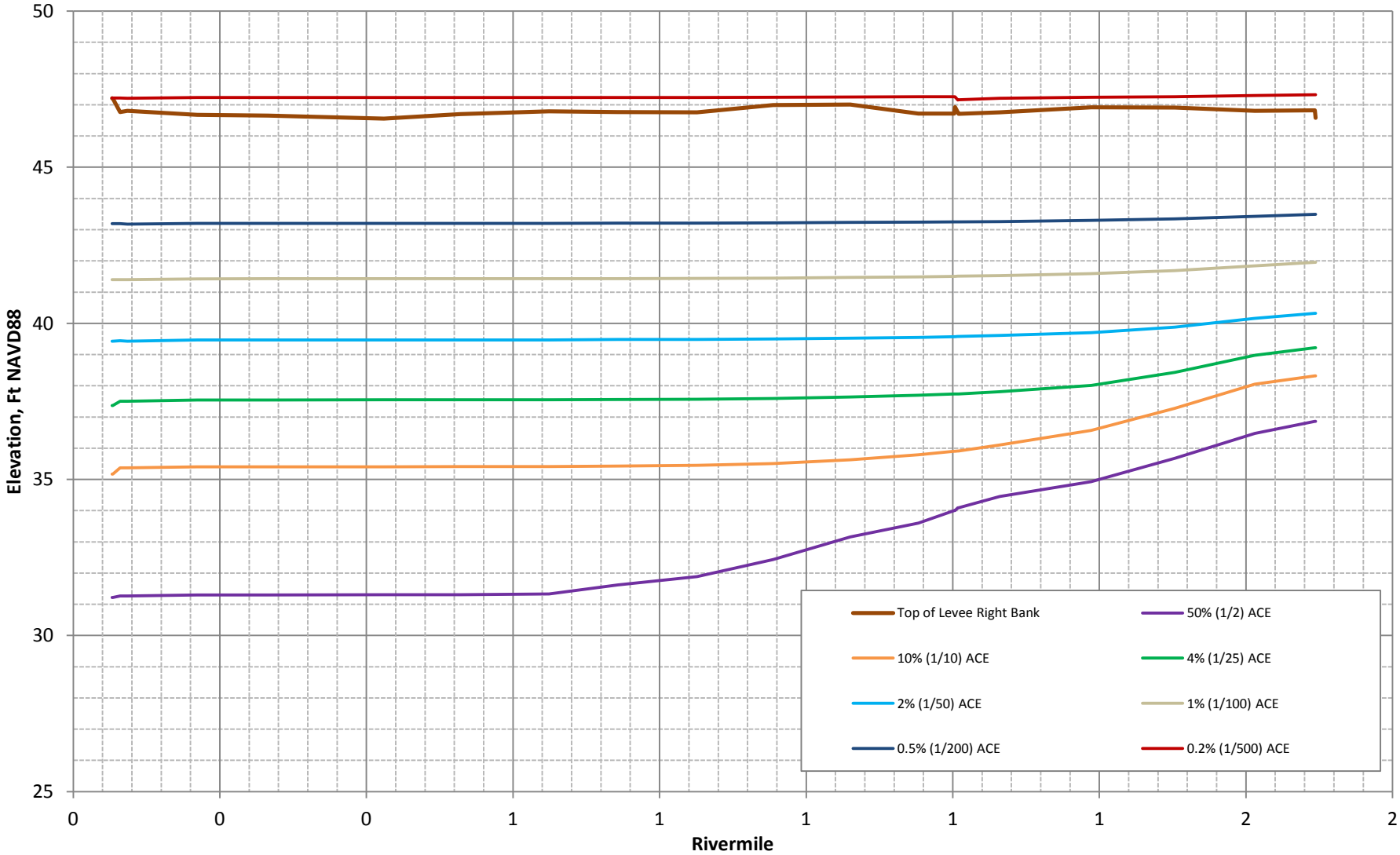


American River Common Features GRR **Sacramento, California**	**Magpie Creek – Left Bank Levee** **N-Yr Water Surface Profiles Future Without-Project Condition**	**U.S. Army Corps of Engineers** **Sacramento District**



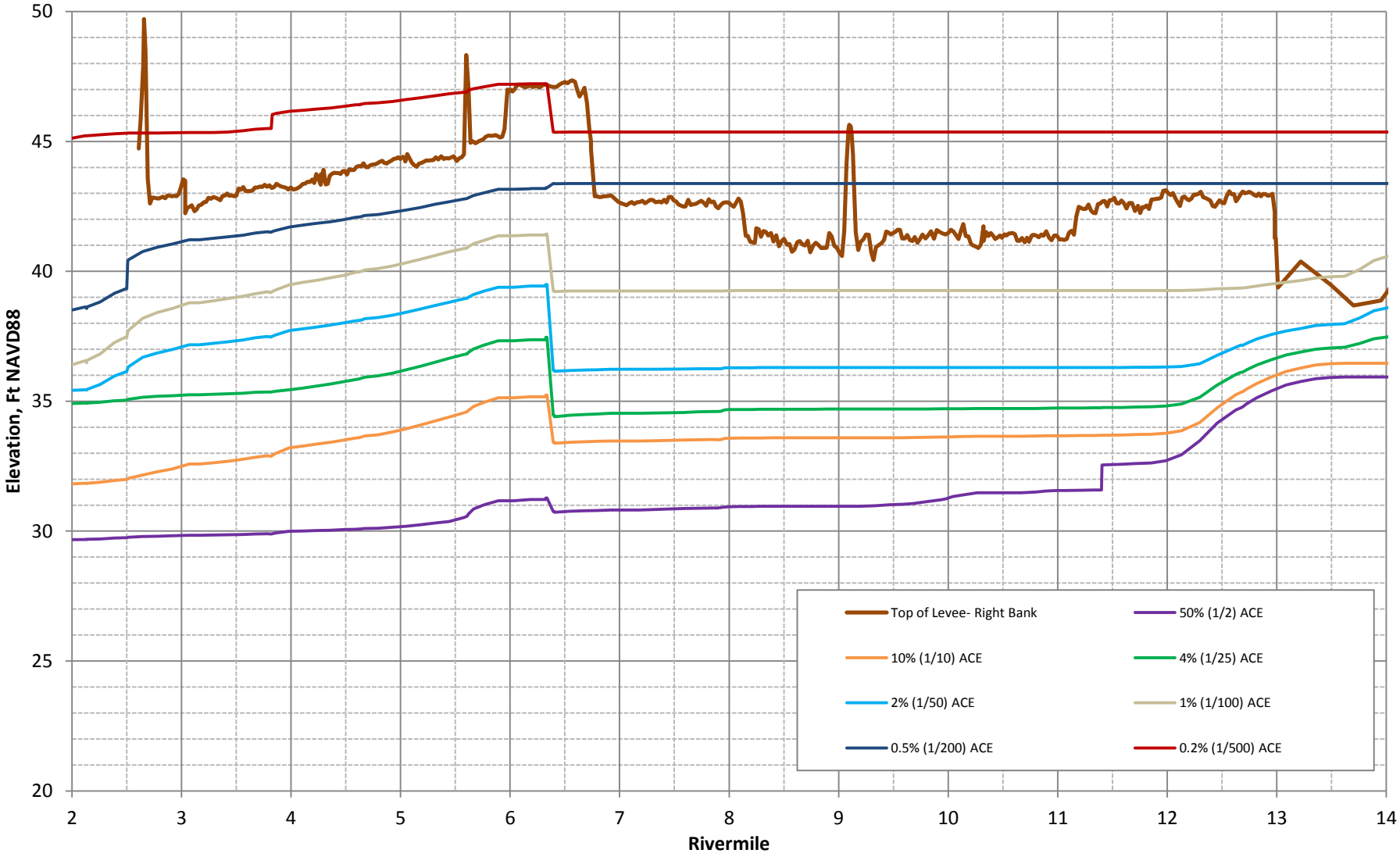
American River Common Features GRR Sacramento, California	Dry Creek – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District

Dry Creek - Right Bank

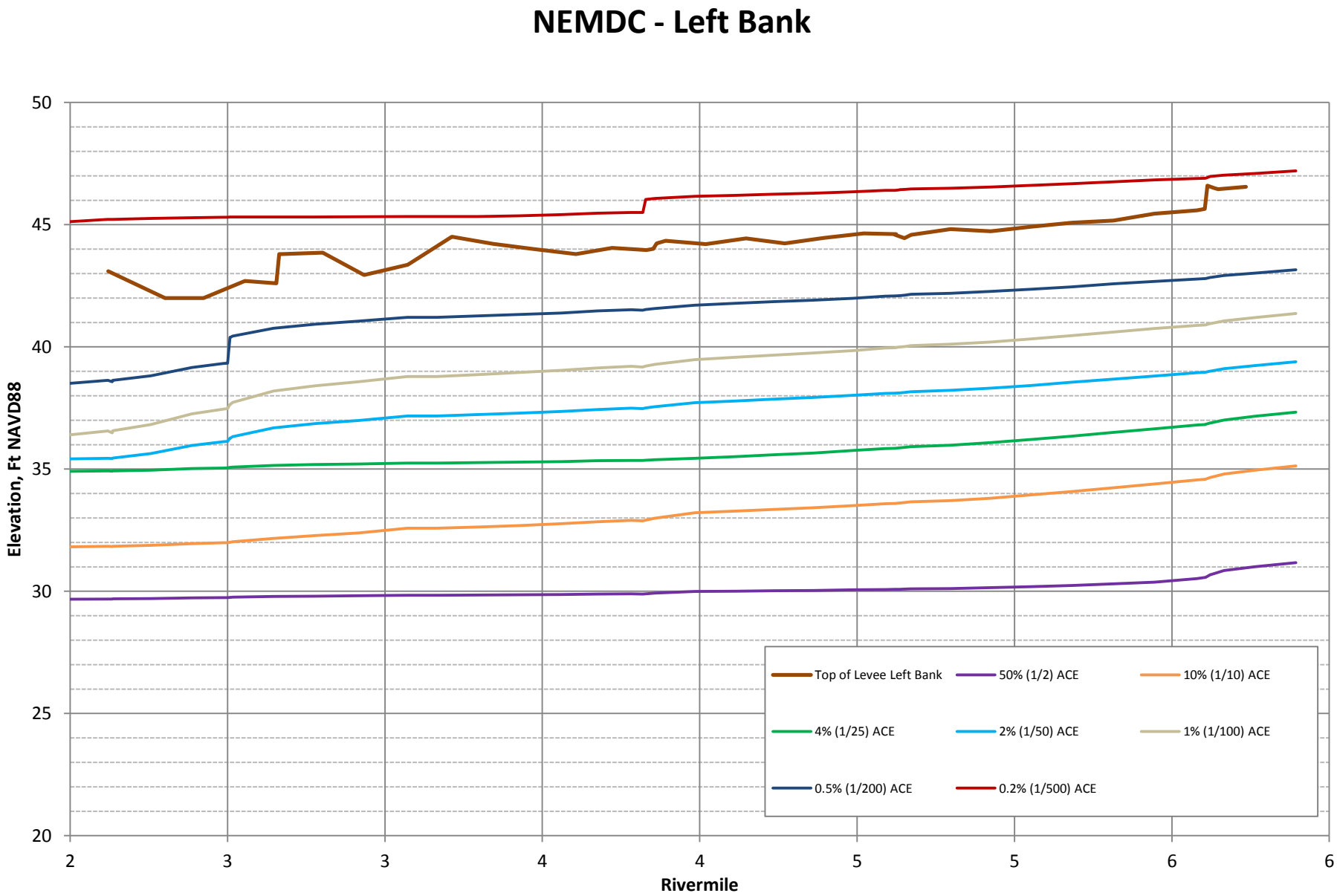


American River Common Features GRR Sacramento, California	Dry Creek – Right Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District

NEMDC- Right Bank

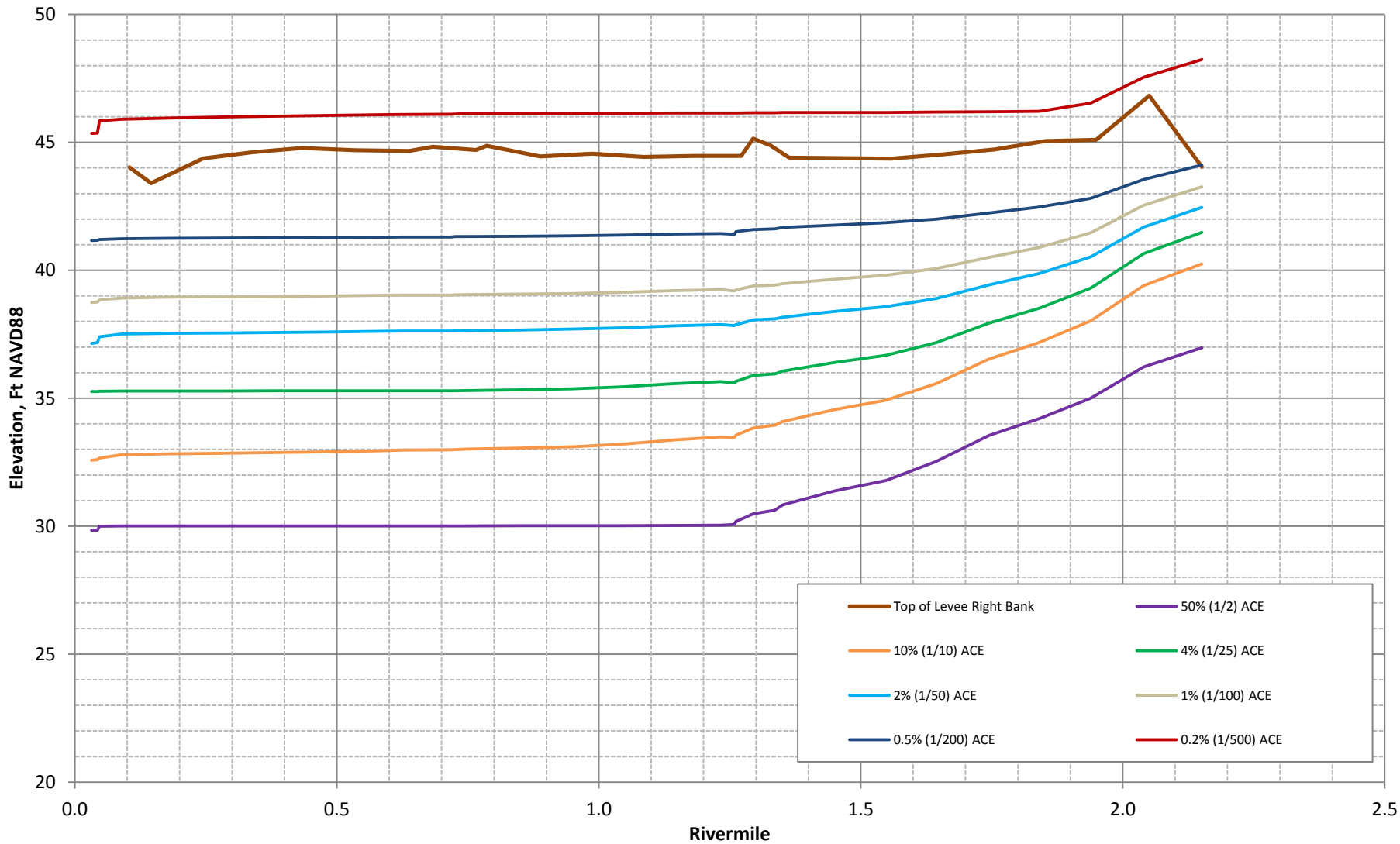


American River Common Features GRR Sacramento, California	NEMDC – Right Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District



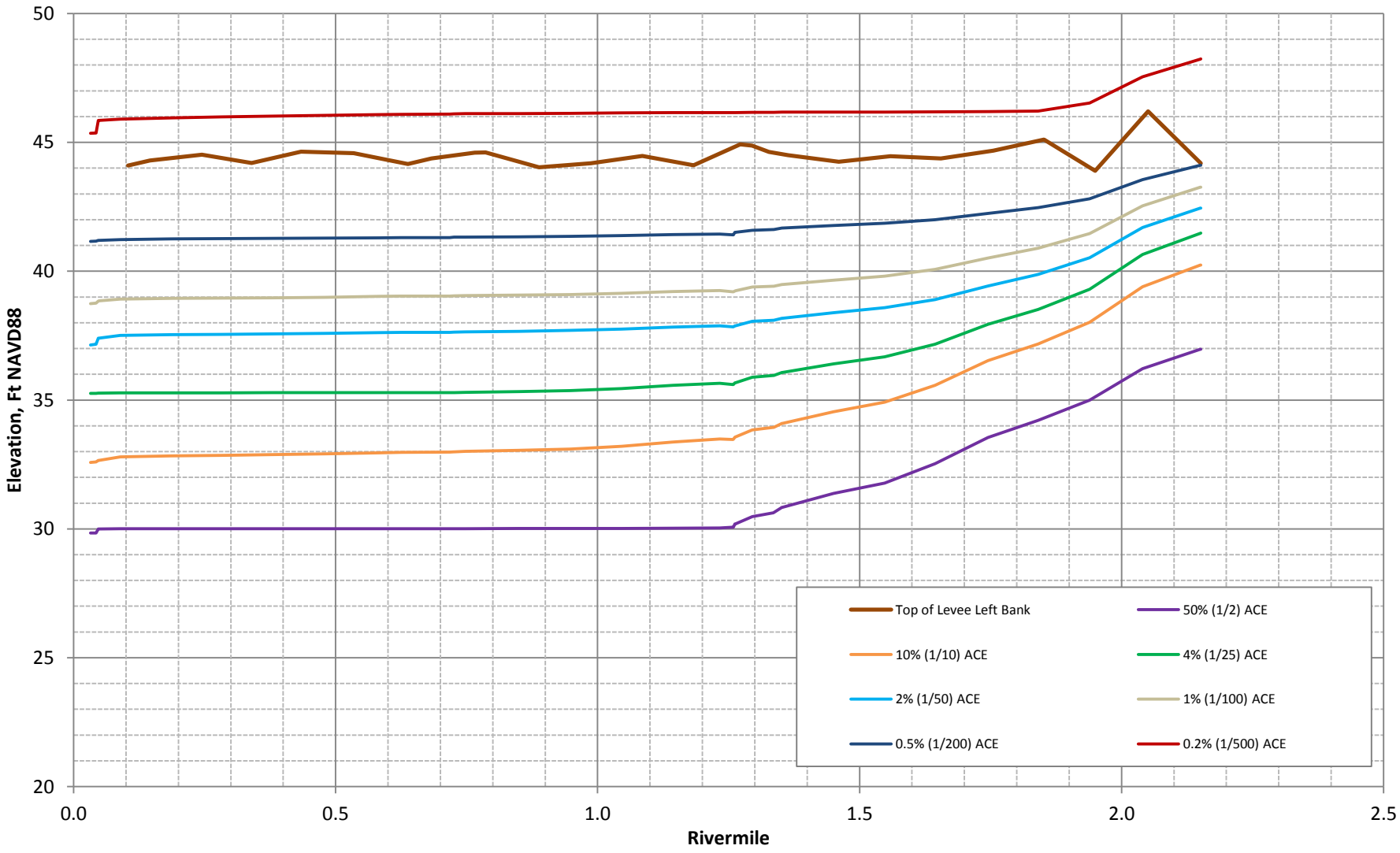
American River Common Features GRR Sacramento, California	NEMDC – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District

Arcade Creek - Right Bank

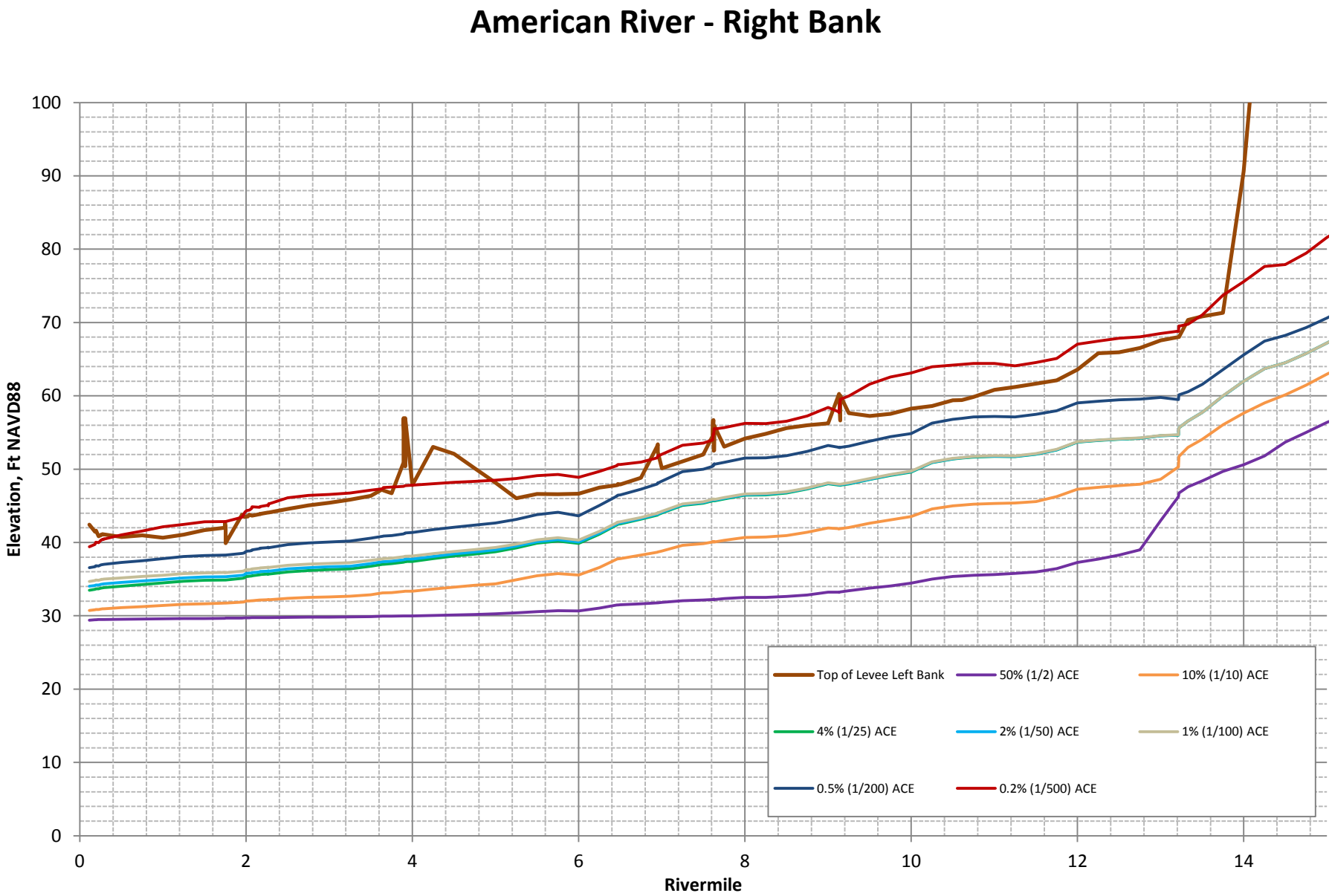


American River Common Features GRR Sacramento, California	Arcade Creek – Right Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District

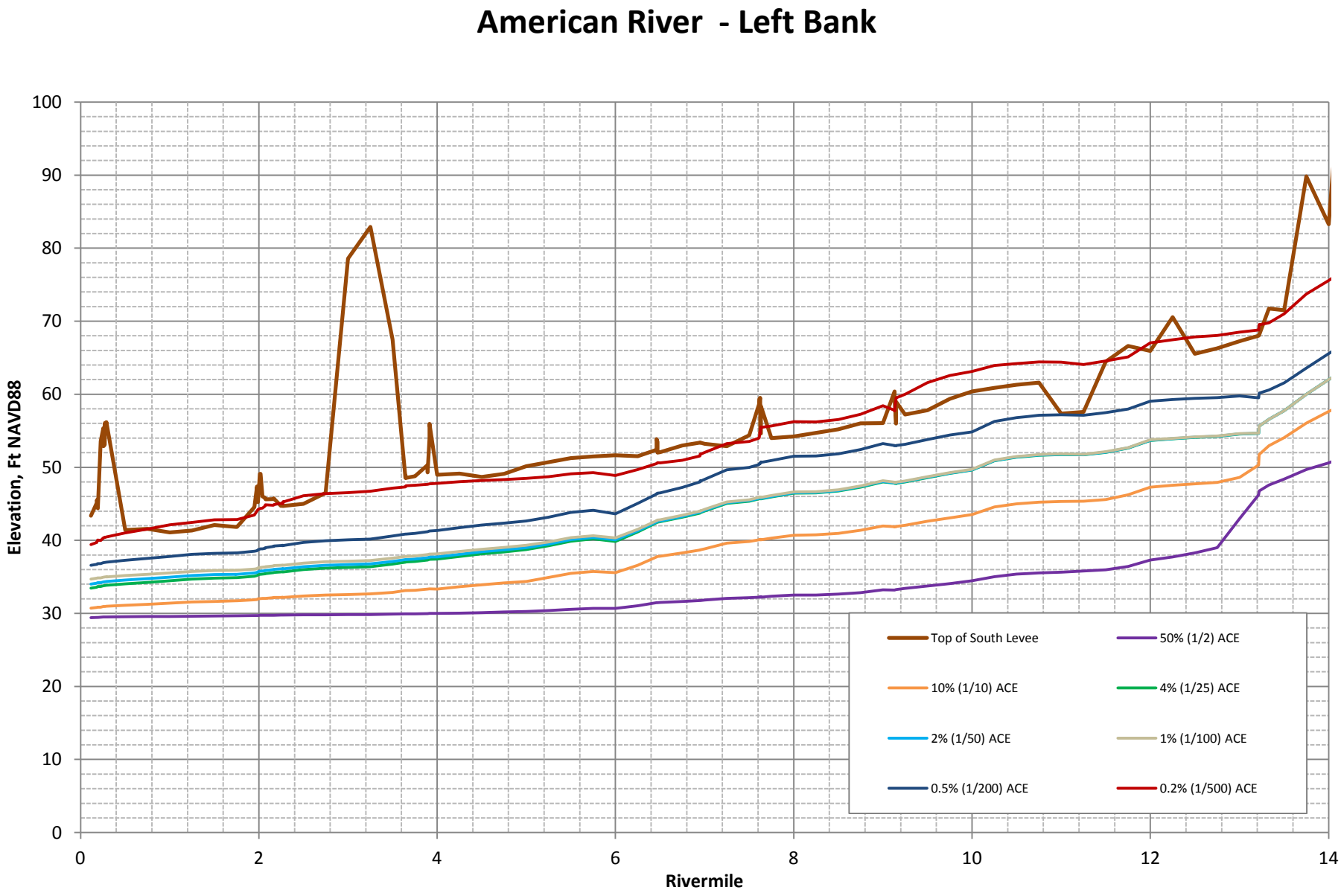
Arcade Creek - Left Bank



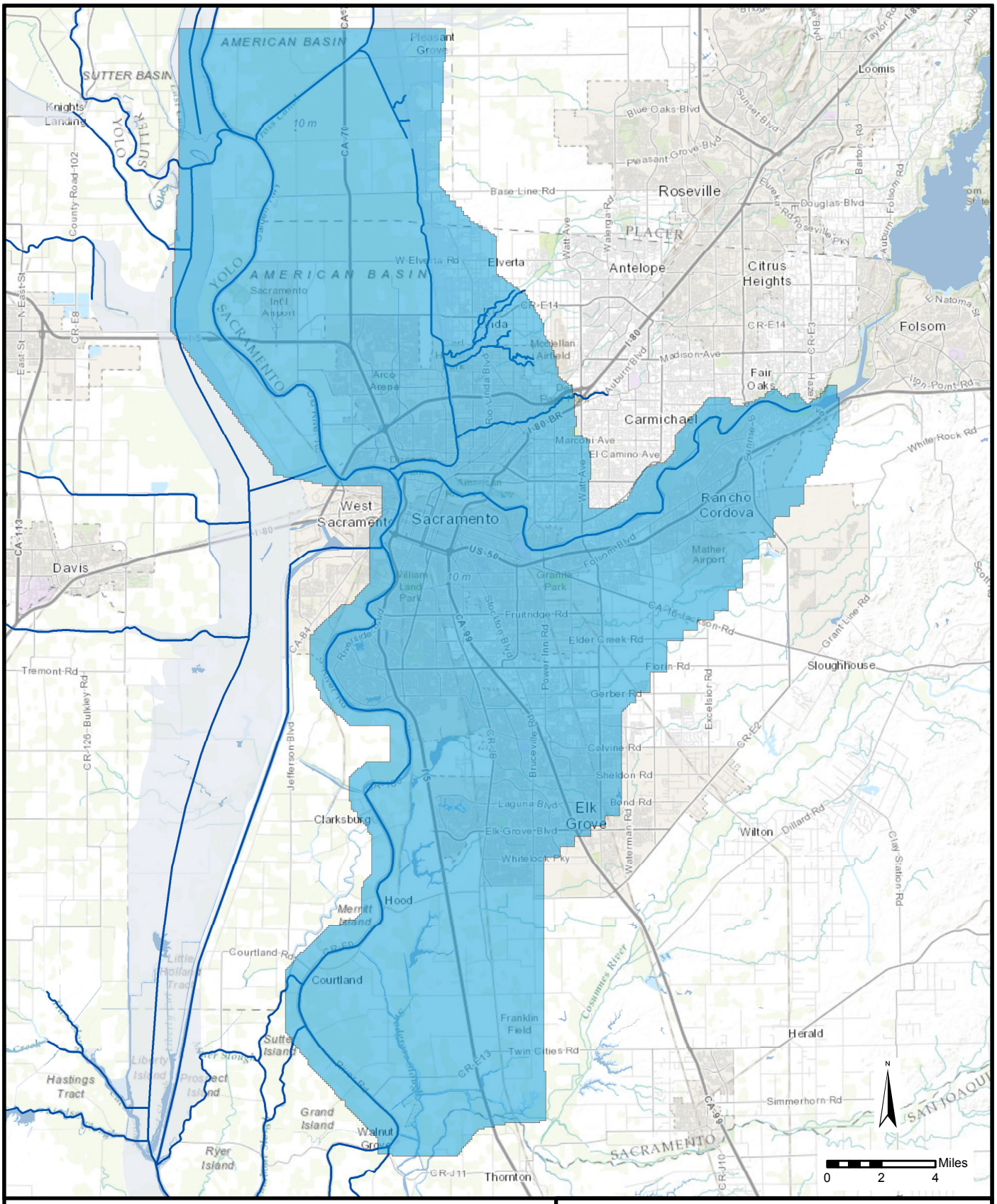
American River Common Features GRR Sacramento, California	Arcade Creek – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District



American River Common Features GRR Sacramento, California	American River – Right Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District



American River Common Features GRR Sacramento, California	American River – Left Bank Levee N-Yr Water Surface Profiles Future Without-Project Condition	U.S. Army Corps of Engineers Sacramento District



LEGEND

- FLO2D Extents
- Rivers and Streams

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

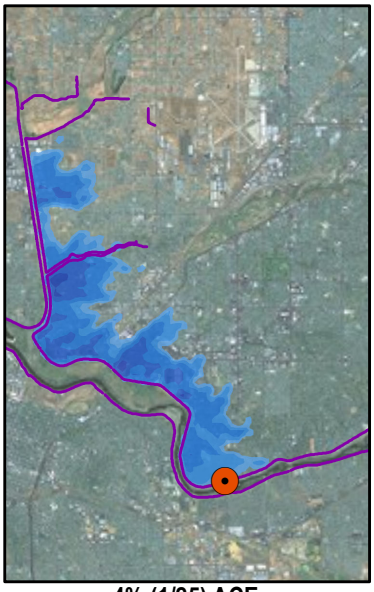
FLO2D MODEL EXTENTS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013

50% (1/2) ACE

10% (1/10) ACE



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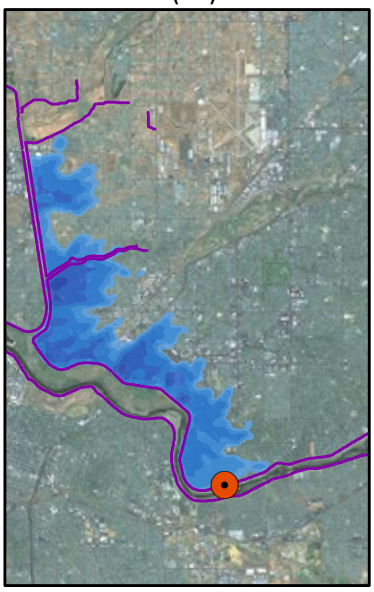

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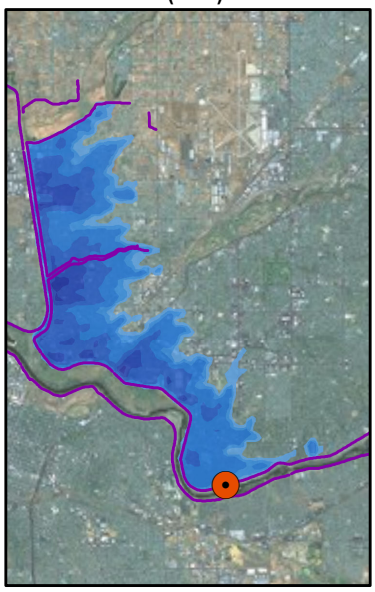
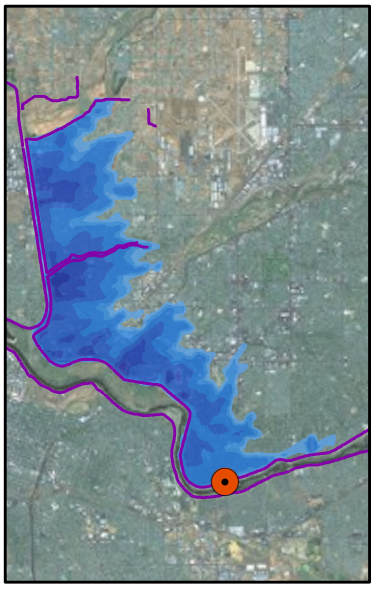


1% (1/100) ACE



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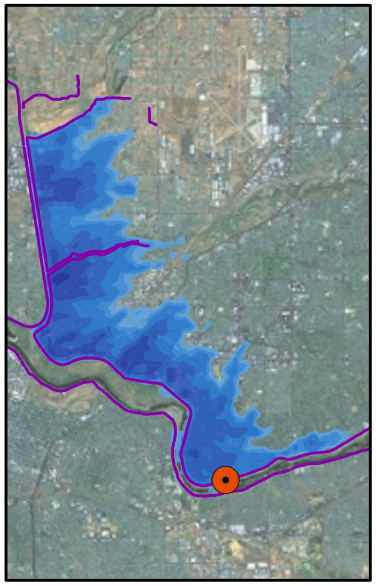
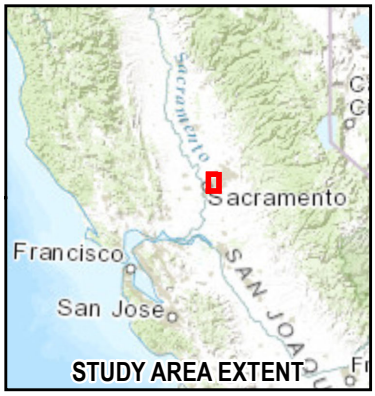


0.2% (1/500) ACE

LEGEND

Depths of Flooding (Feet)

- < 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 +



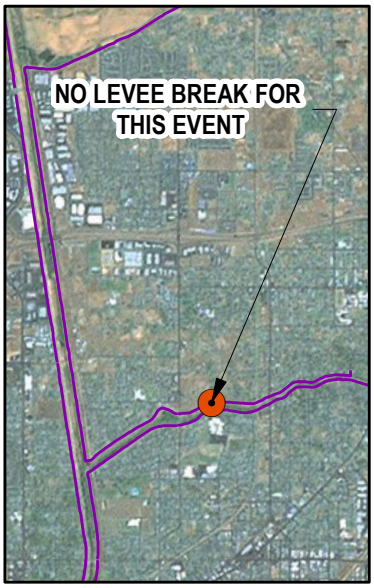
N

0 1.5 3 Miles

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

ECONOMIC FLOODPLAINS
BASED ON A LEVEE BREACH SIMULATION
AMERICAN RIVER NORTH INDEX PT A.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



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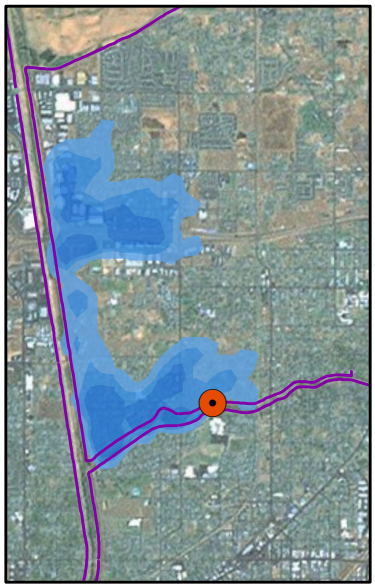

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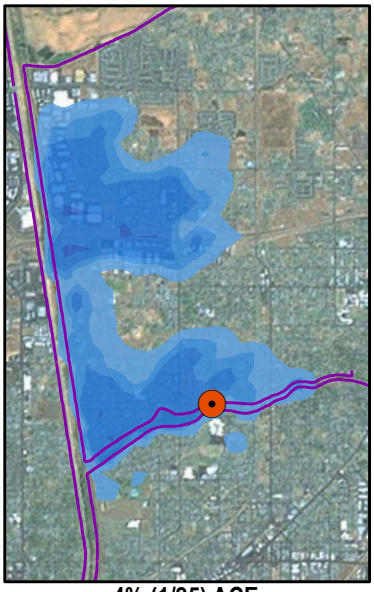

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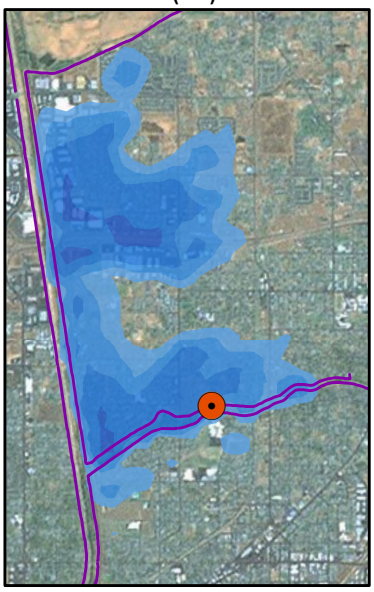

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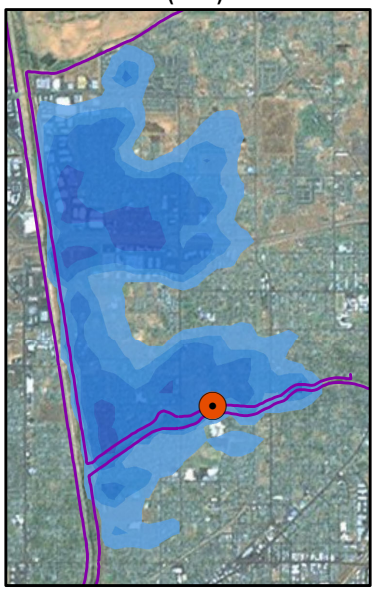

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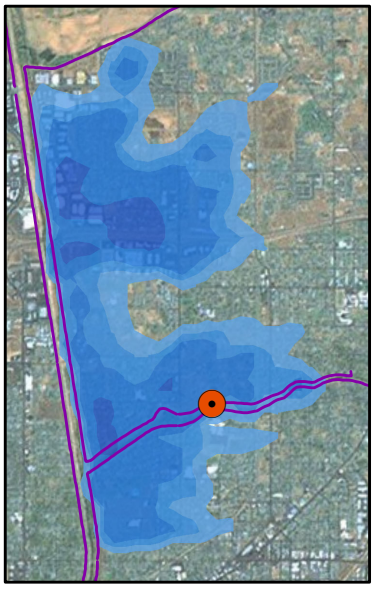

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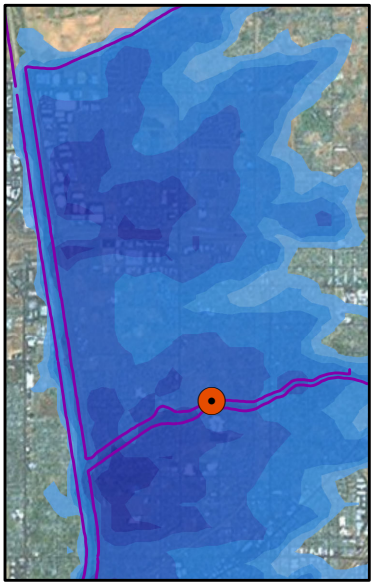
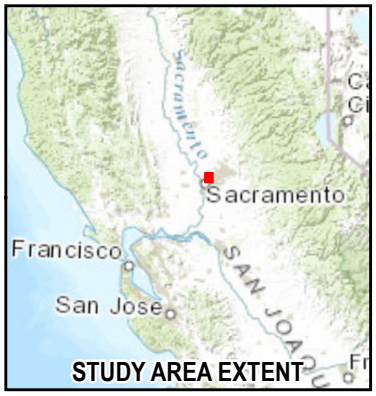


0.2% (1/500) ACE

LEGEND

Depths of Flooding (Feet)

- < 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 +



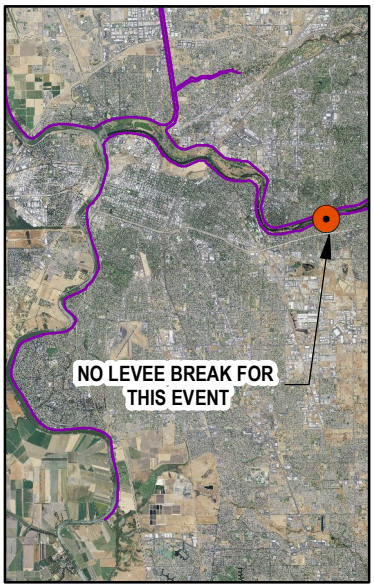
N

Miles
0 0.5 1

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

ECONOMIC FLOODPLAINS
BASED ON A LEVEE BREACH SIMULATION
AMERICAN RIVER NORTH INDEX PT E.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



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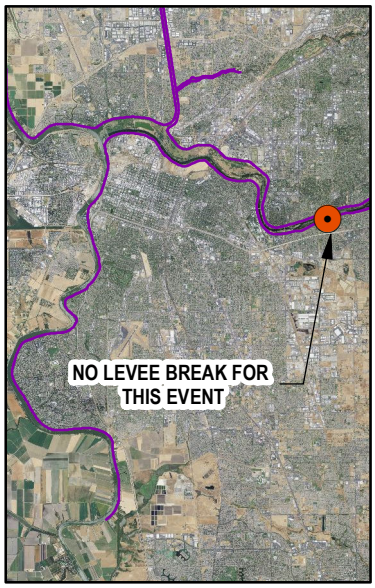

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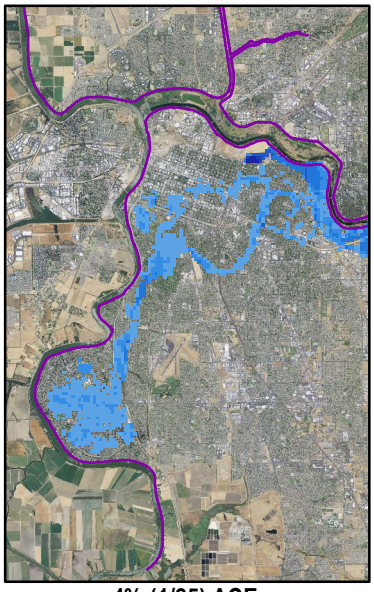

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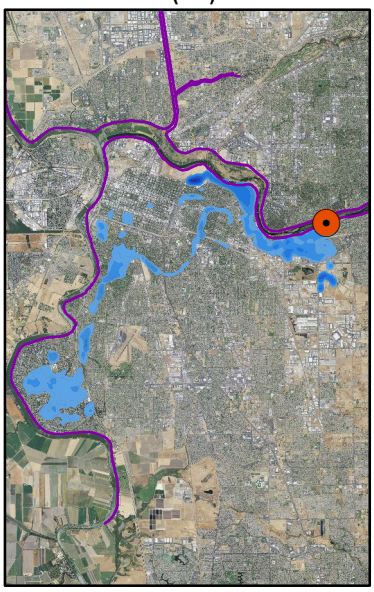

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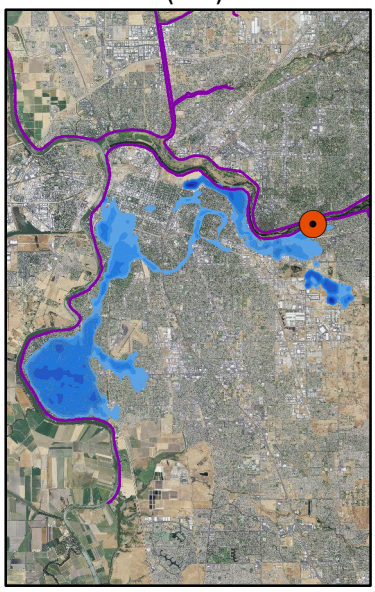

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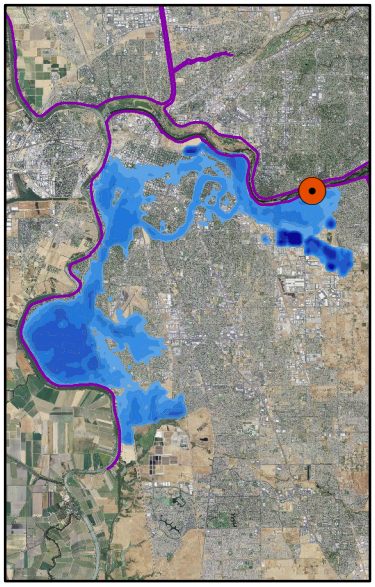

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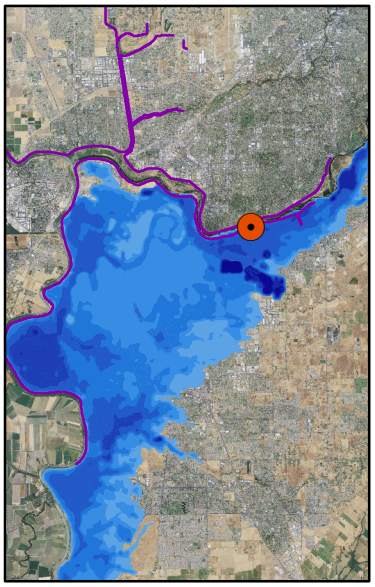


0.2% (1/500) ACE

LEGEND

Depths of Flooding (Feet)

- < 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 +

STUDY AREA EXTENT

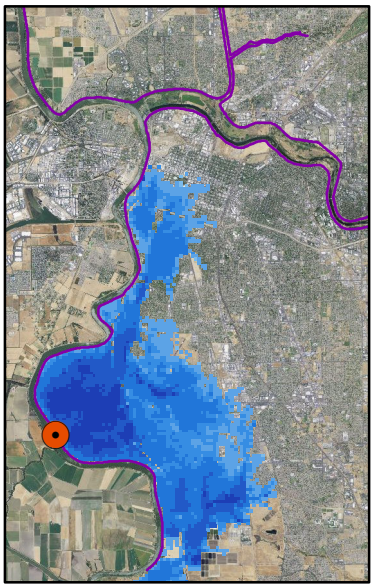
N

Miles
0 3 6

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

ECONOMIC FLOODPLAINS
BASED ON A LEVEE BREACH SIMULATION
AMERICAN RIVER SOUTH INDEX PT A.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



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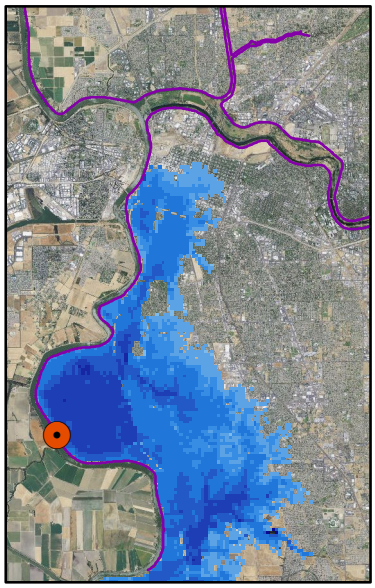

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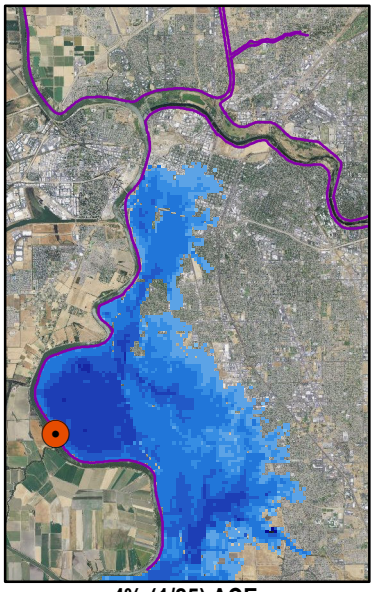
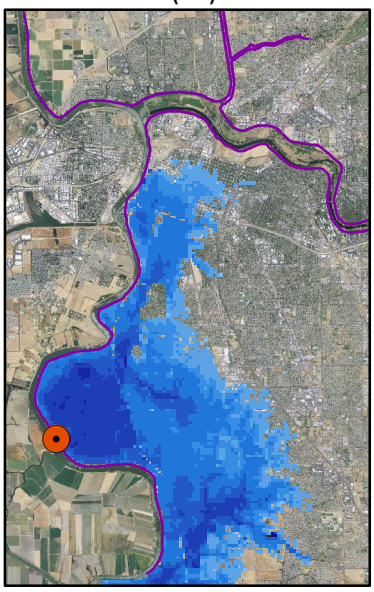
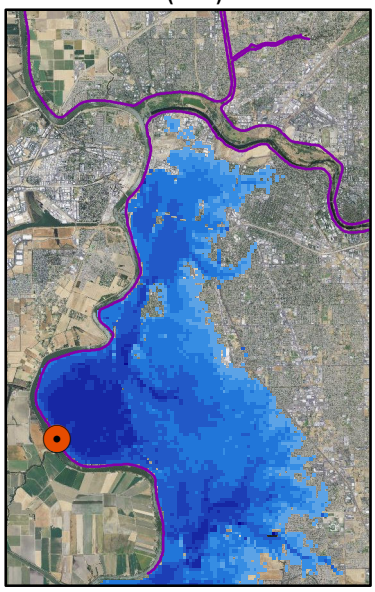


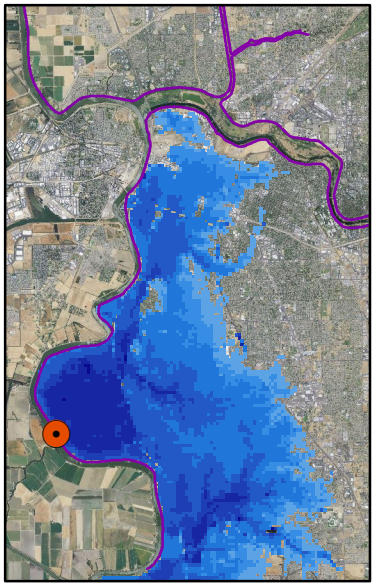
4% (1/25) ACE



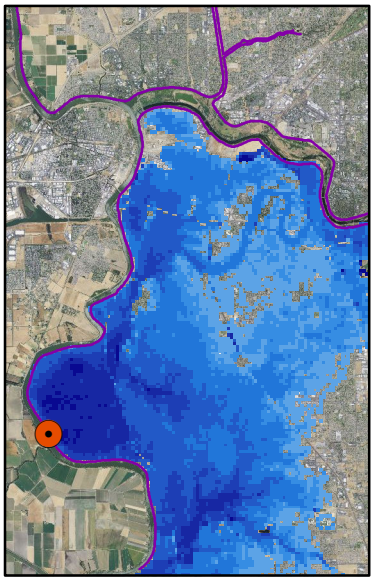
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

LEGEND

Depths of Flooding (Feet)

- < 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 +

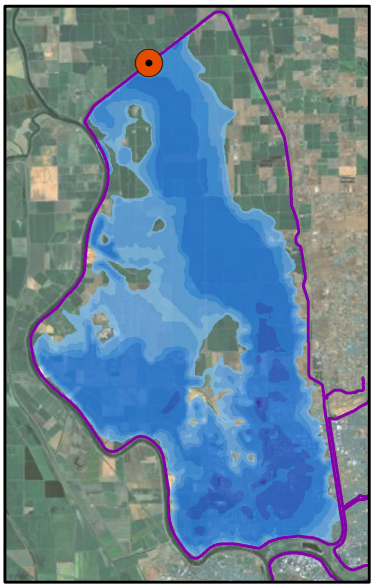
N

Miles
0 2 4

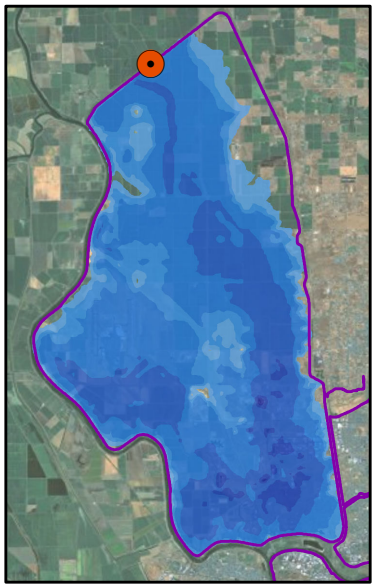
AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

ECONOMIC FLOODPLAINS
BASED ON A LEVEE BREACH SIMULATION
AMERICAN RIVER SOUTH INDEX PT F.

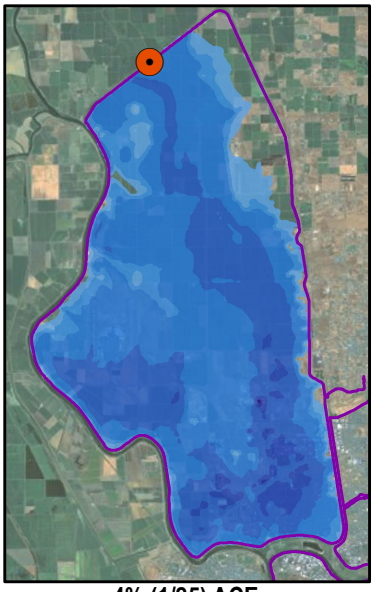
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



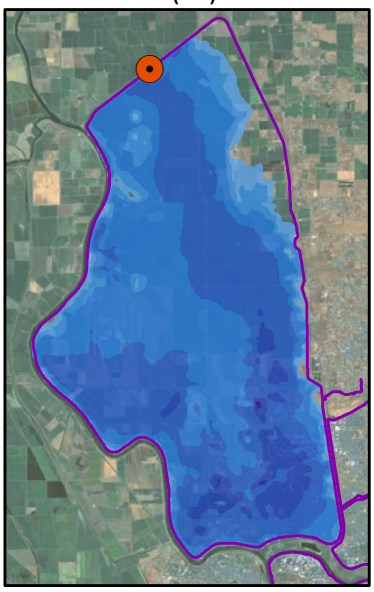
50% (1/2) ACE



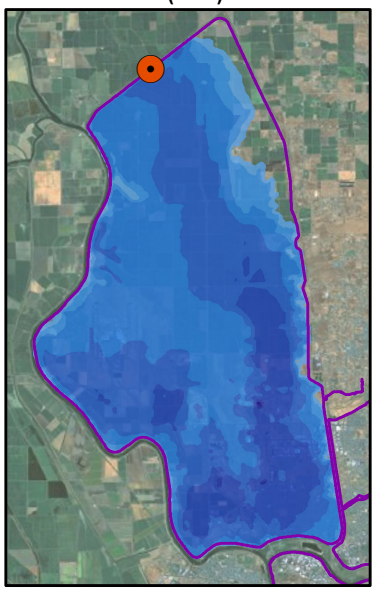
10% (1/10) ACE



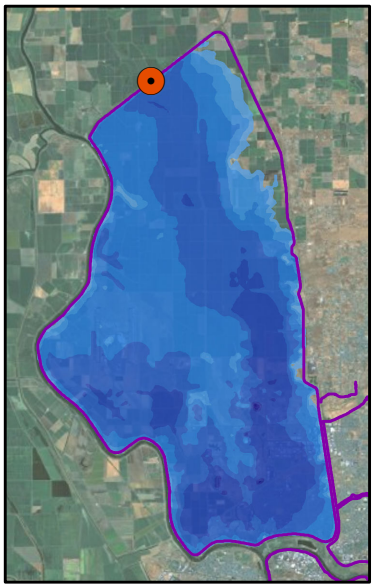
4% (1/25) ACE



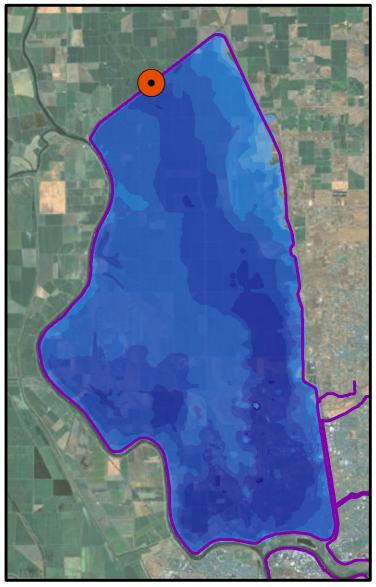
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE

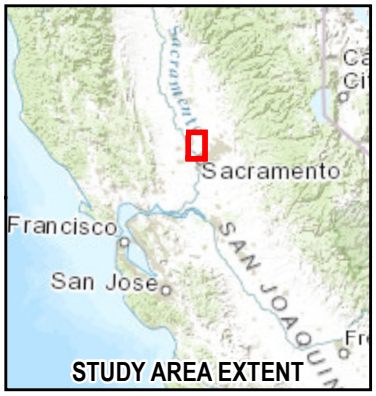


0.2% (1/500) ACE

LEGEND

Depths of Flooding (Feet)

- < 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 +



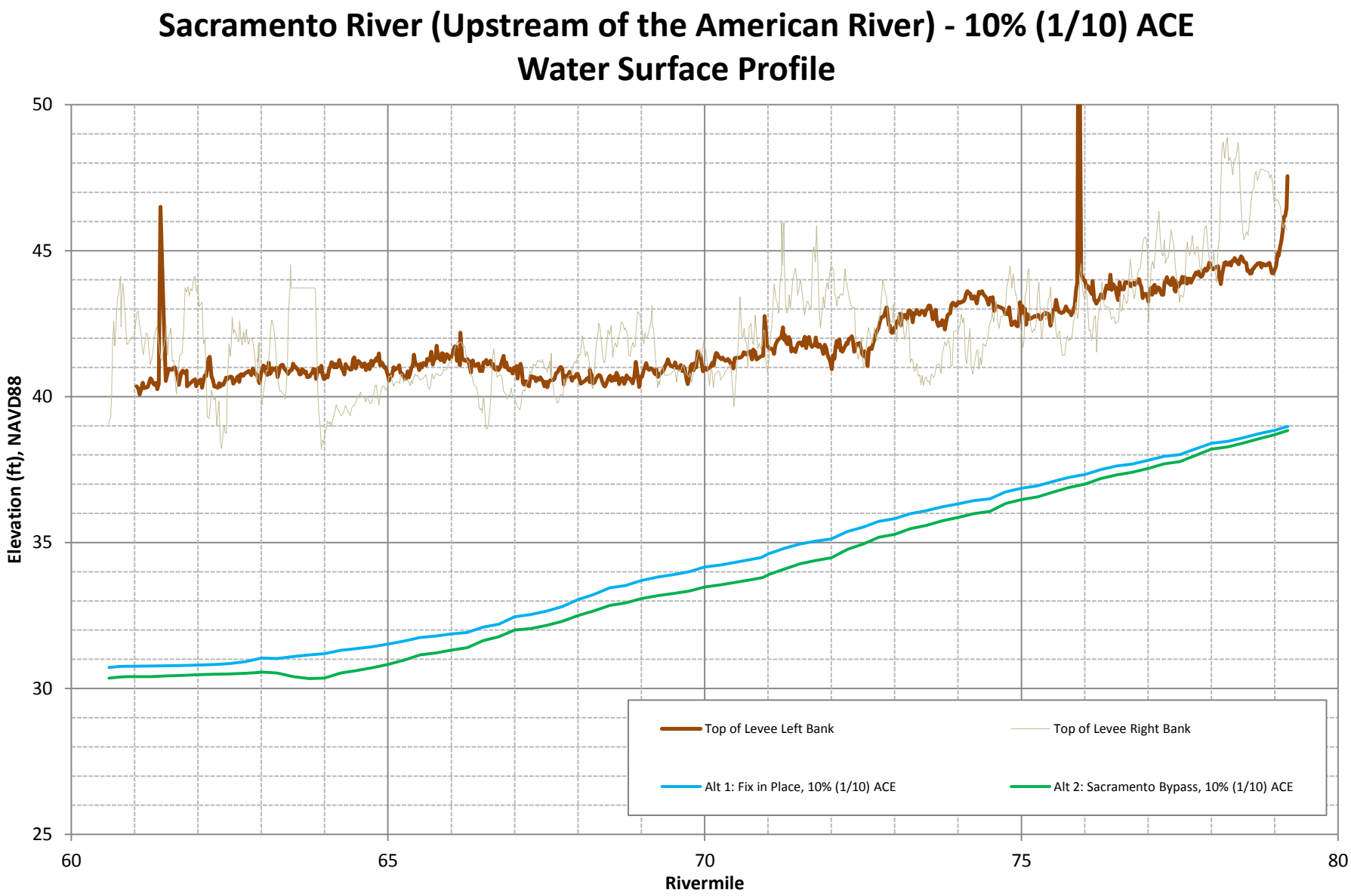
N

Miles
0 2.5 5

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

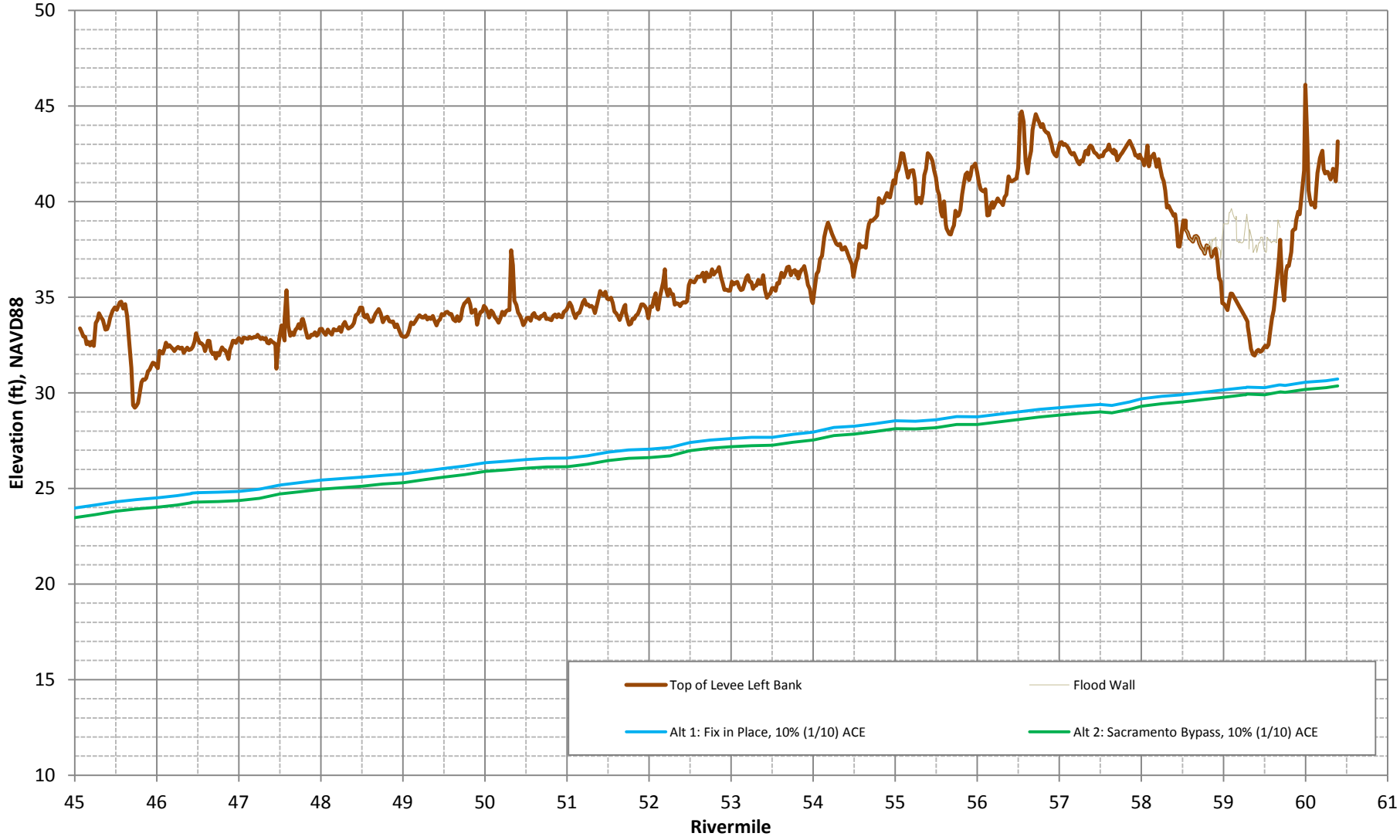
ECONOMIC FLOODPLAINS
BASED ON A LEVEE BREACH SIMULATION
NATOMAS BASIN INDEX PT D.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

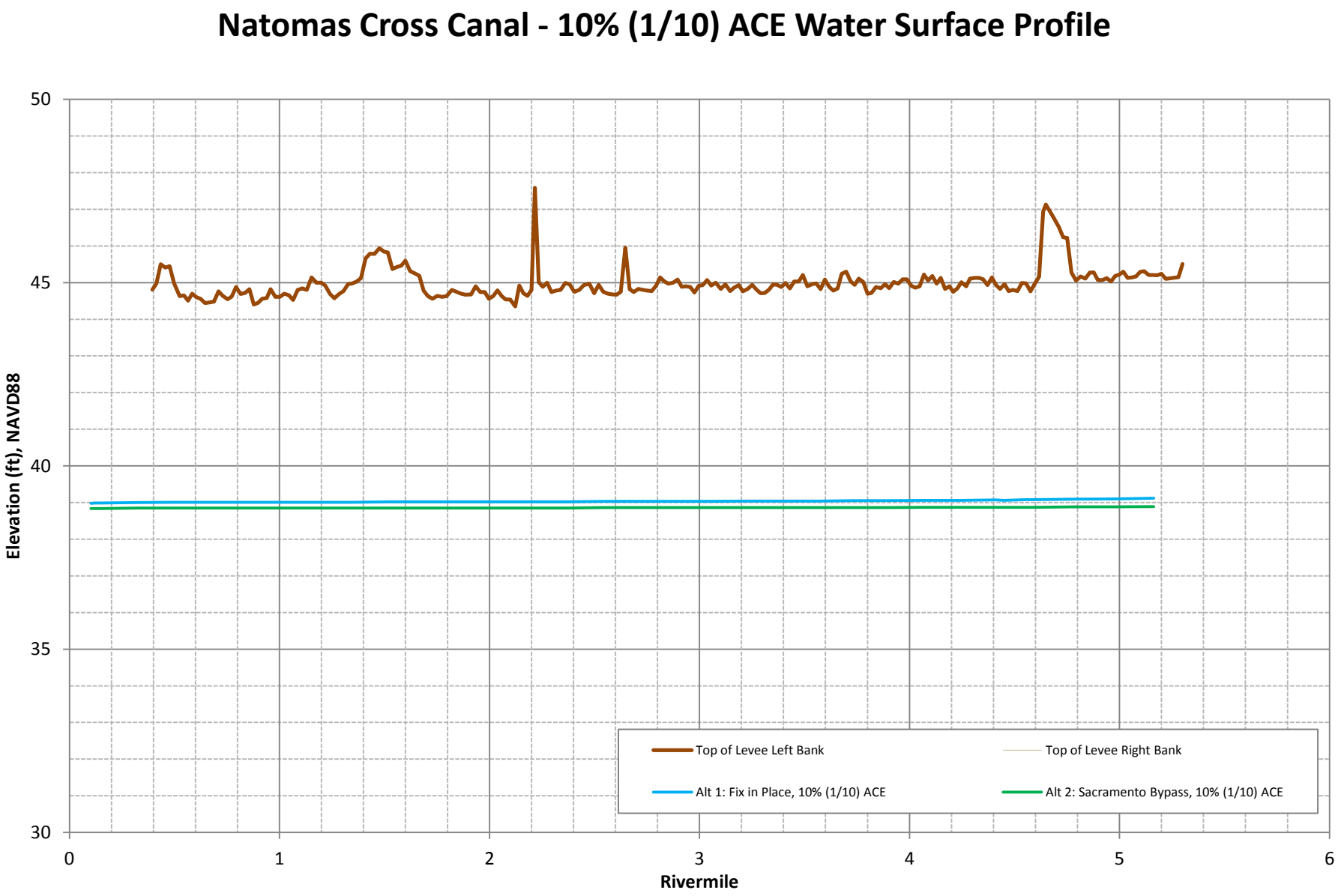


American River Common Features GRR Sacramento, California	Sacramento River (U/S of the American River) – Left Bank Levee 10% (1/10) ACE Water Surface Profiles With-Project Alternatives	U.S. Army Corps of Engineers Sacramento District

Sacramento River (Downstream of the American River) - 10% (1/10) ACE Water Surface Profile

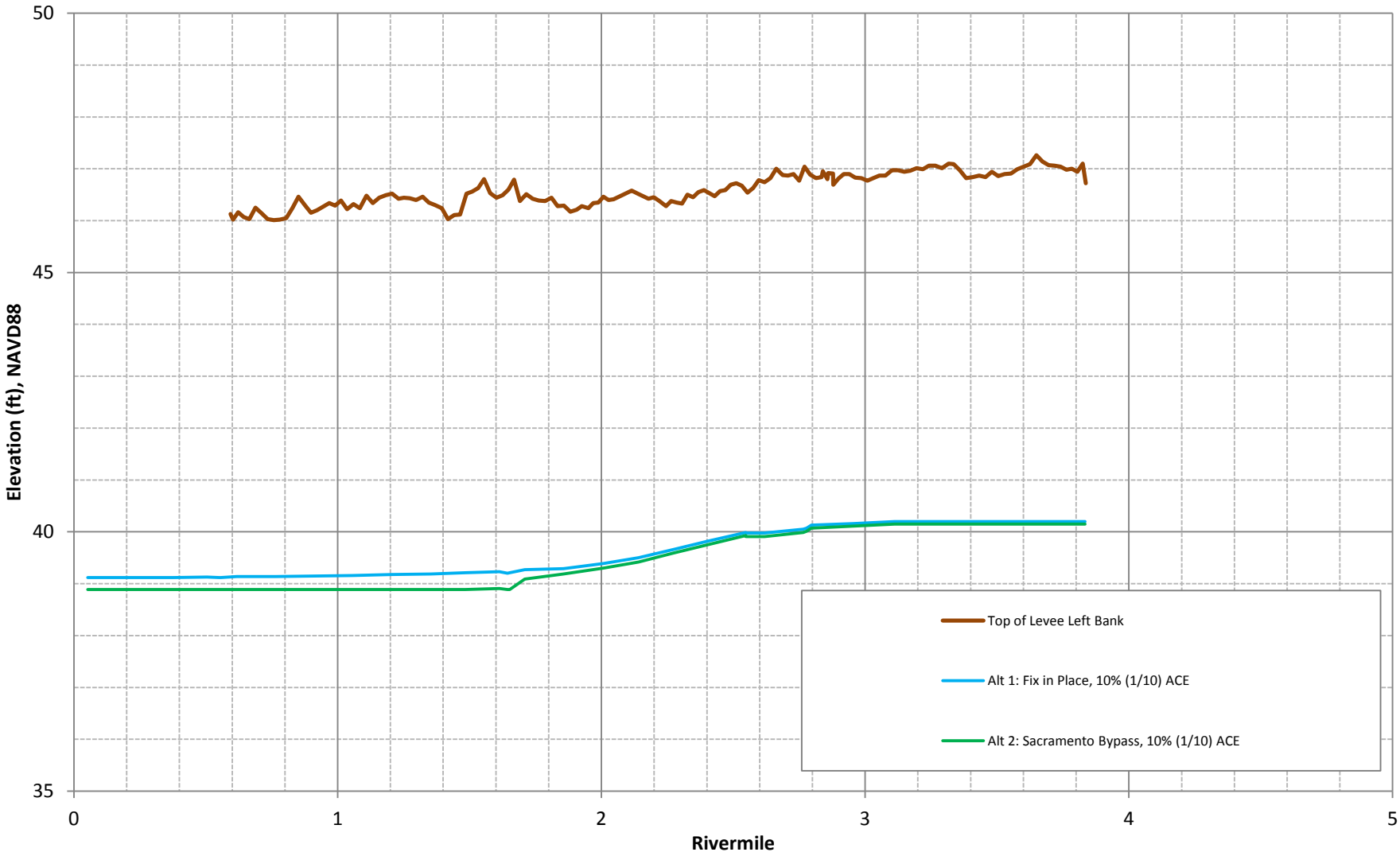


American River Common Features GRR Sacramento, California	Sacramento River (D/S of the American River) – Left Bank Levee 10% (1/10) ACE Water Surface Profiles With-Project Alternatives	U.S. Army Corps of Engineers Sacramento District



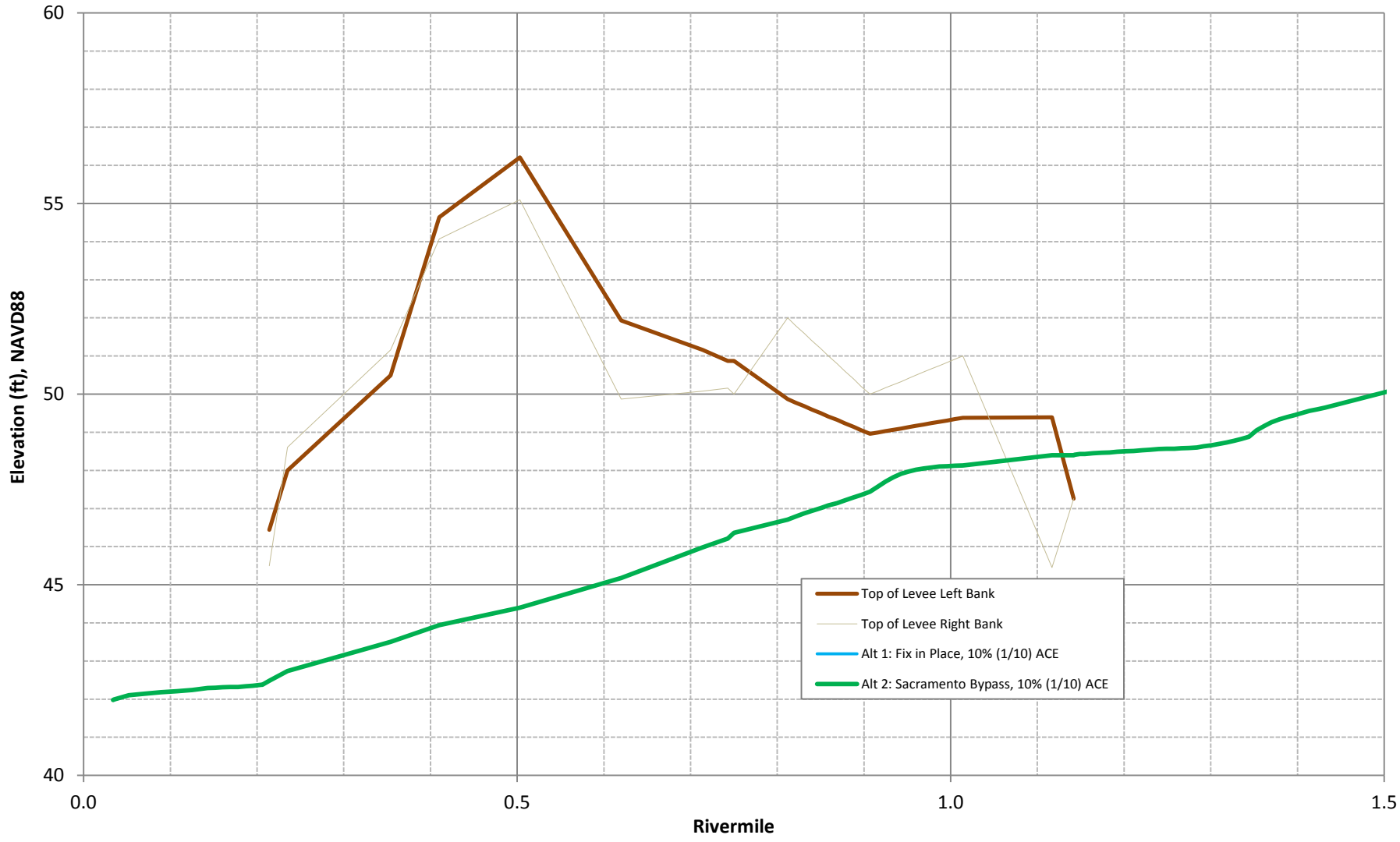
American River Common Features GRR **Sacramento, California**	**Natomas Cross Canal – Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Pleasant Grove Creek Canal - 10% (1/10) ACE Water Surface Profile

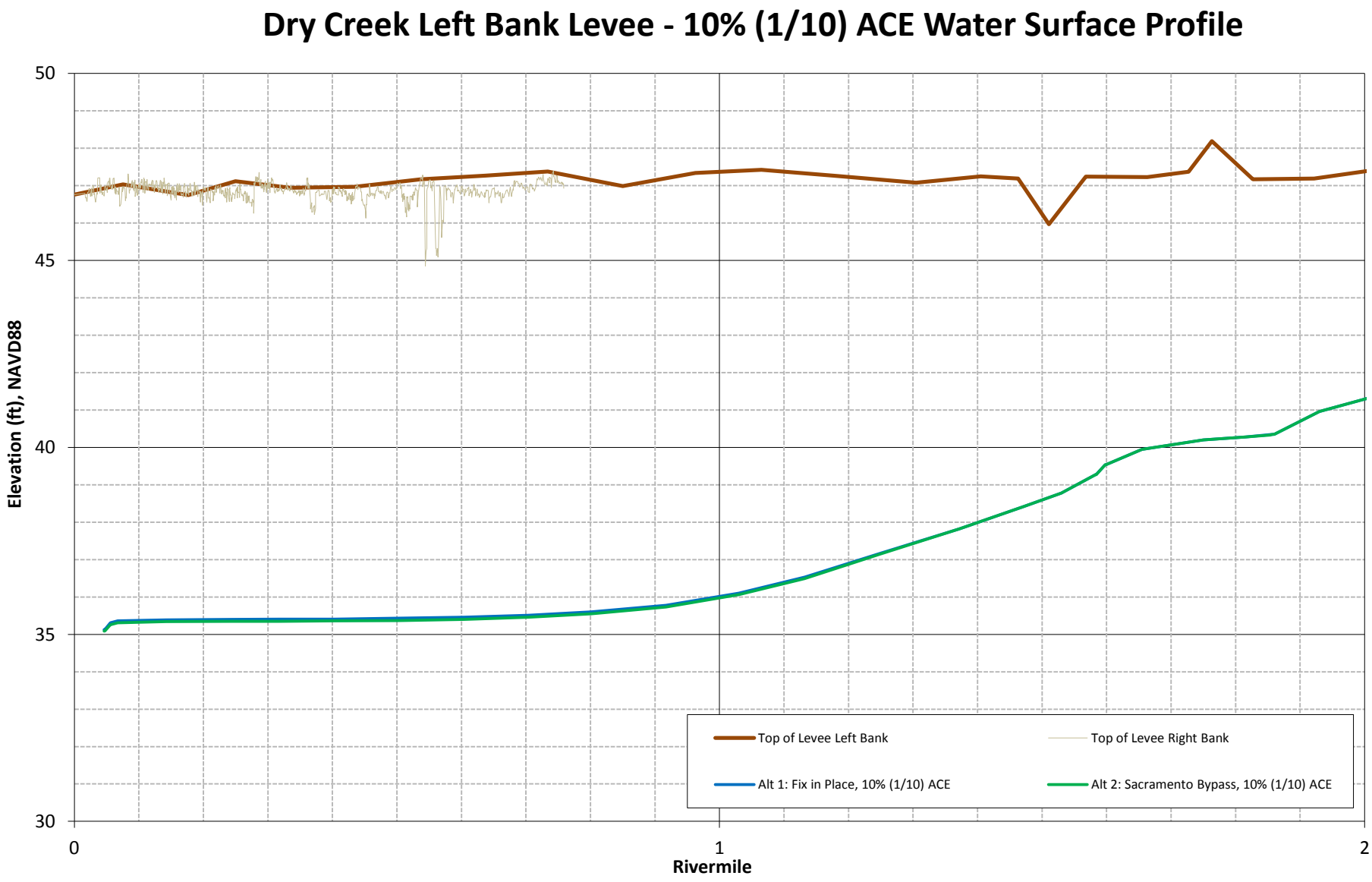


American River Common Features GRR **Sacramento, California**	**Pleasant Grove Creek Canal – Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

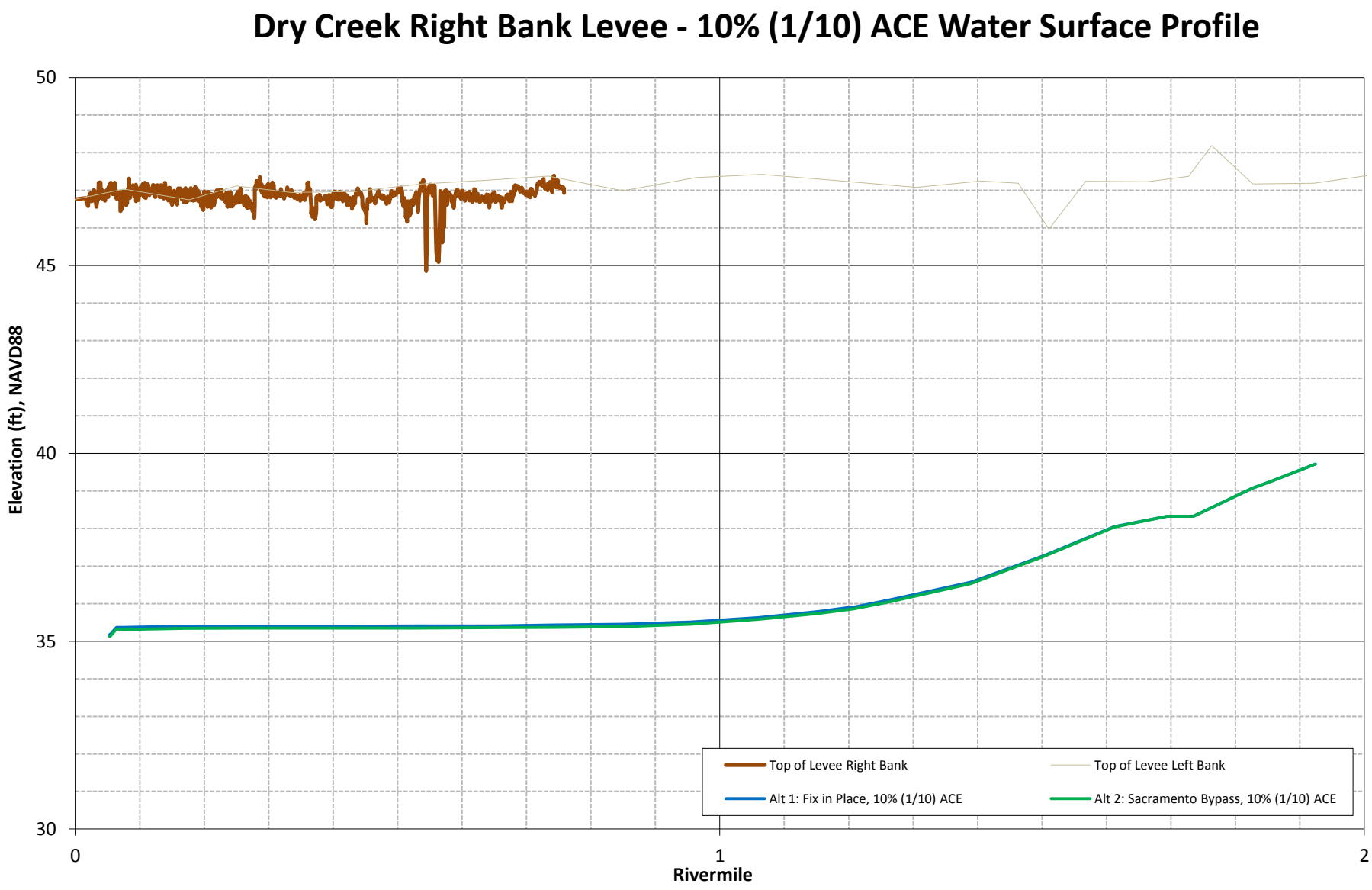
Magpie Creek Left Bank Levee - 10% (1/10) ACE Water Surface Profile



American River Common Features GRR **Sacramento, California**	**Magpie Creek – Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

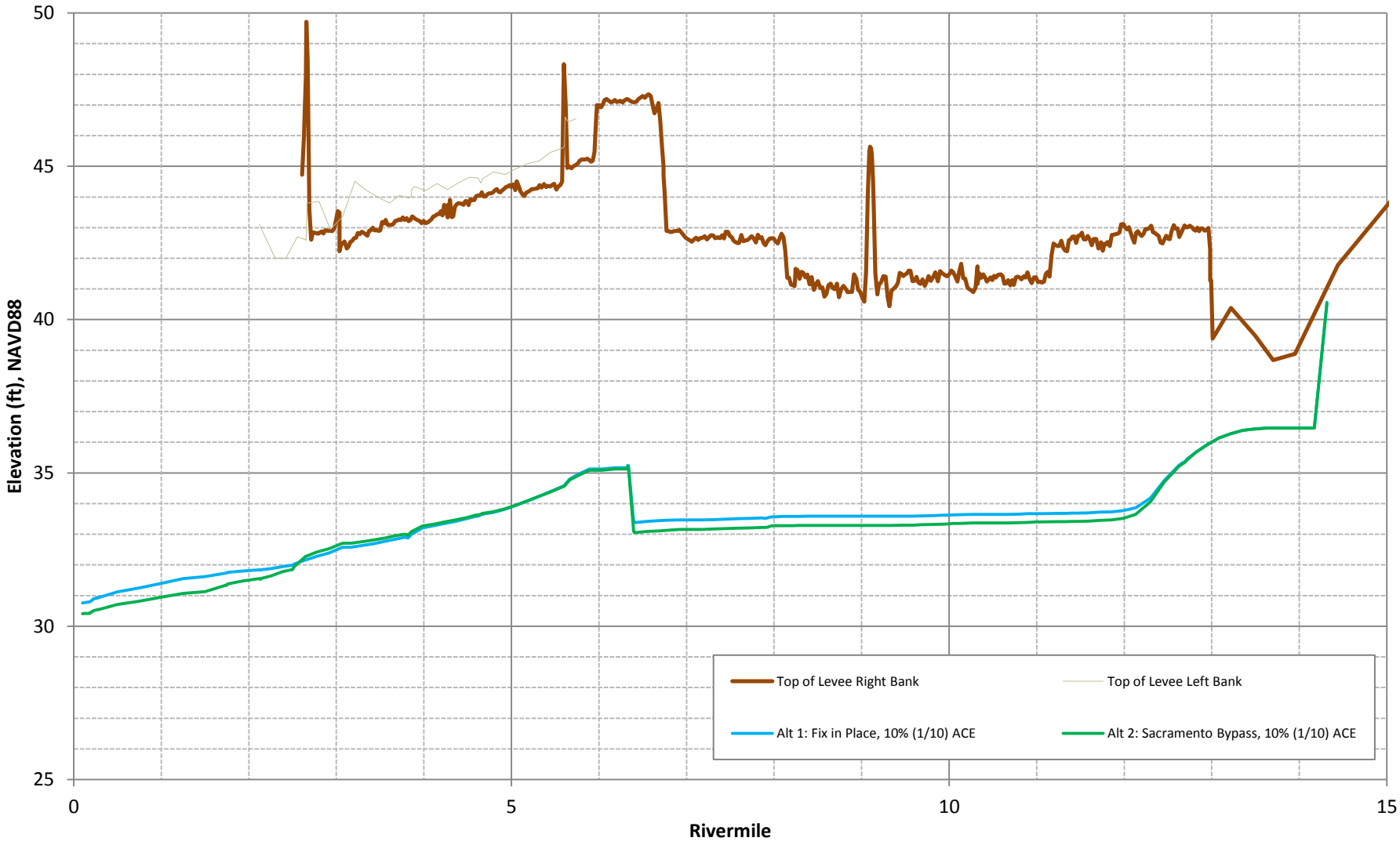


American River Common Features GRR **Sacramento, California**	**Dry Creek – Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**



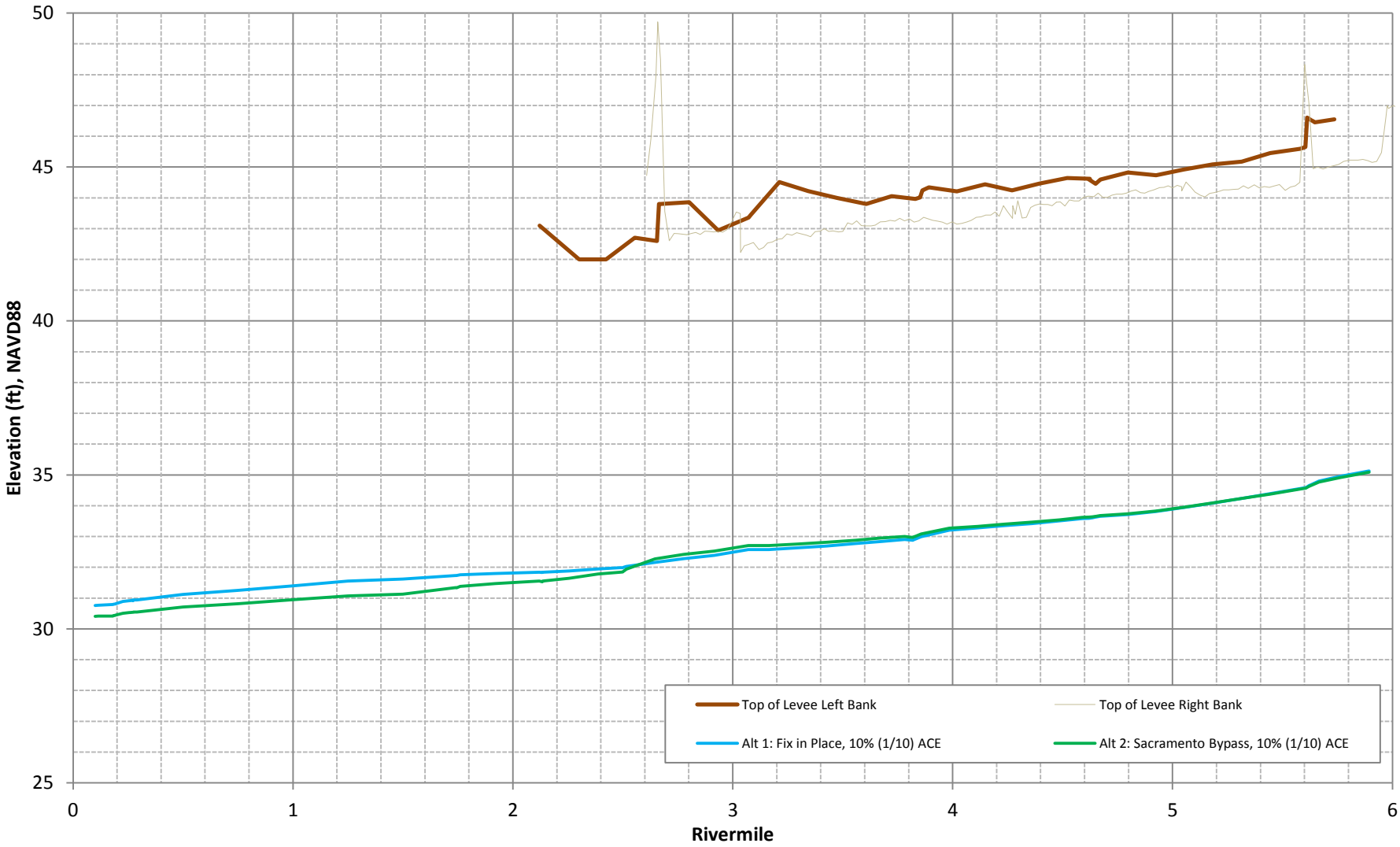
American River Common Features GRR **Sacramento, California**	**Dry Creek – Right Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

NEMDC Right Levee - 10% (1/10) ACE Mean Water Surface Profile



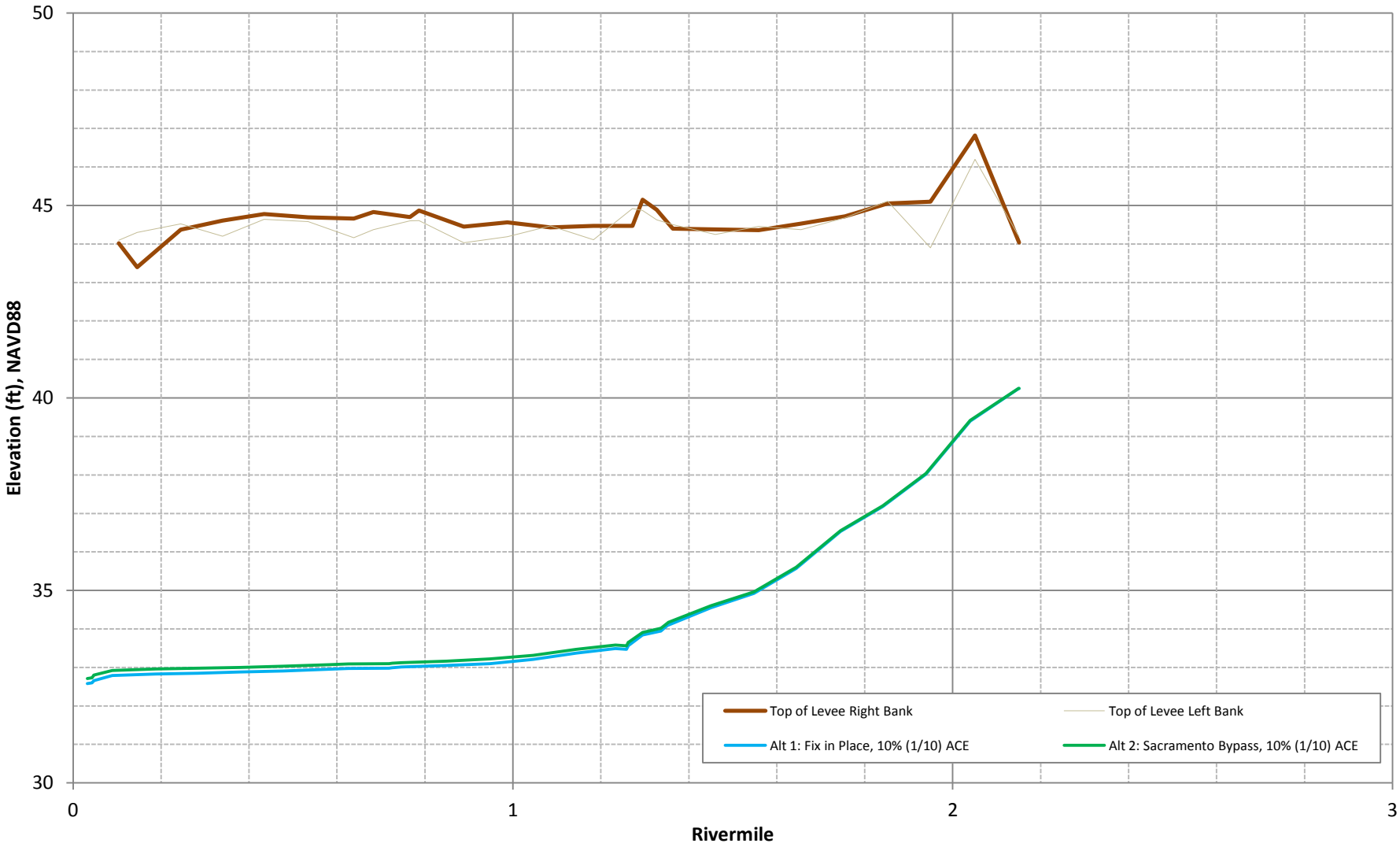
American River Common Features GRR **Sacramento, California**	**NEMDC – Right Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

NEMDC Left Levee - 10% (1/10) ACE Water Surface Profile



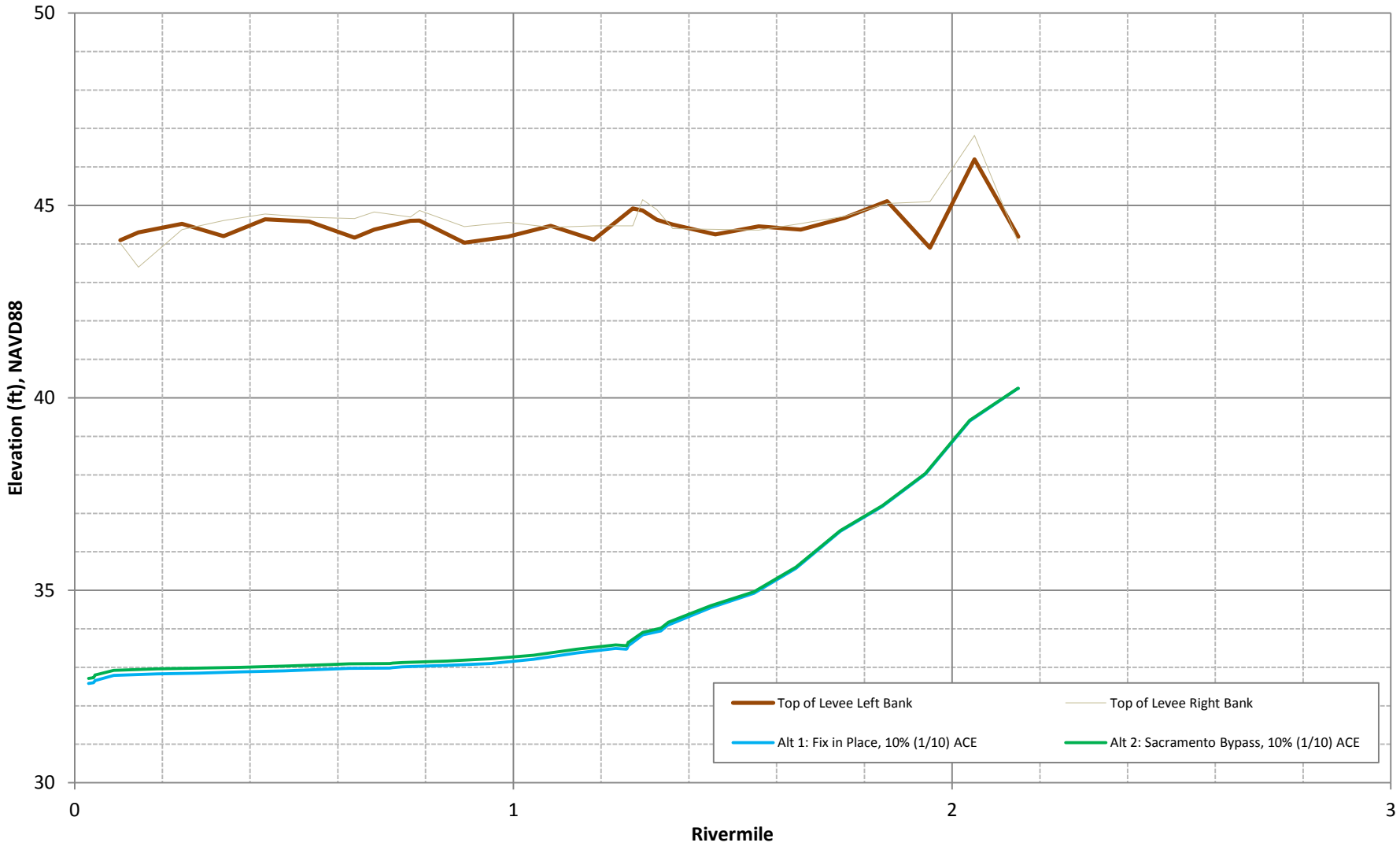
American River Common Features GRR **Sacramento, California**	**NEMDC – Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Arcade Creek Right Bank Levee - 10% (1/10) ACE Water Surface Profile



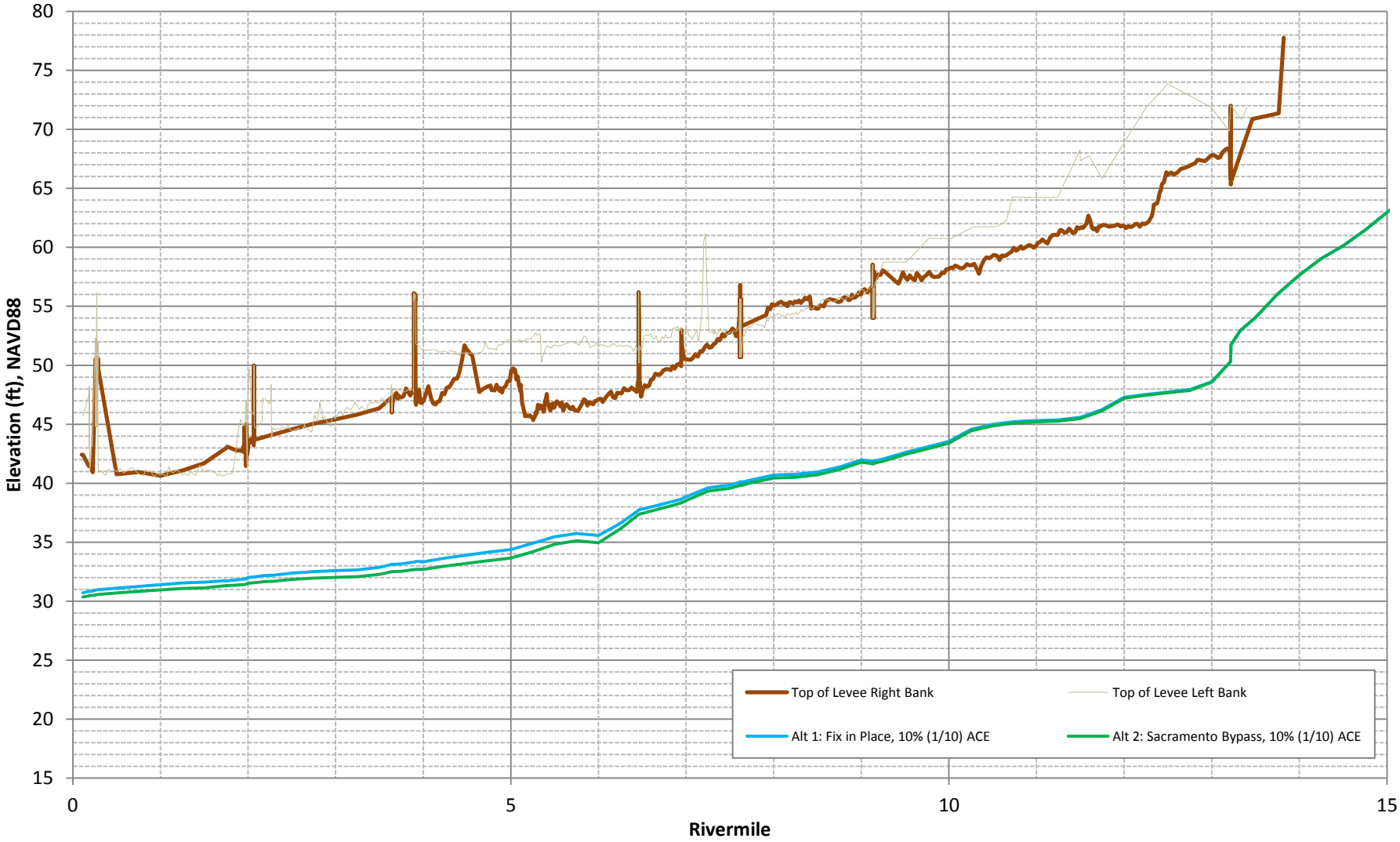
American River Common Features GRR **Sacramento, California**	**Arcade Creek - Right Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Arcade Creek Left Bank Levee - 10% (1/10) ACE Water Surface Profile



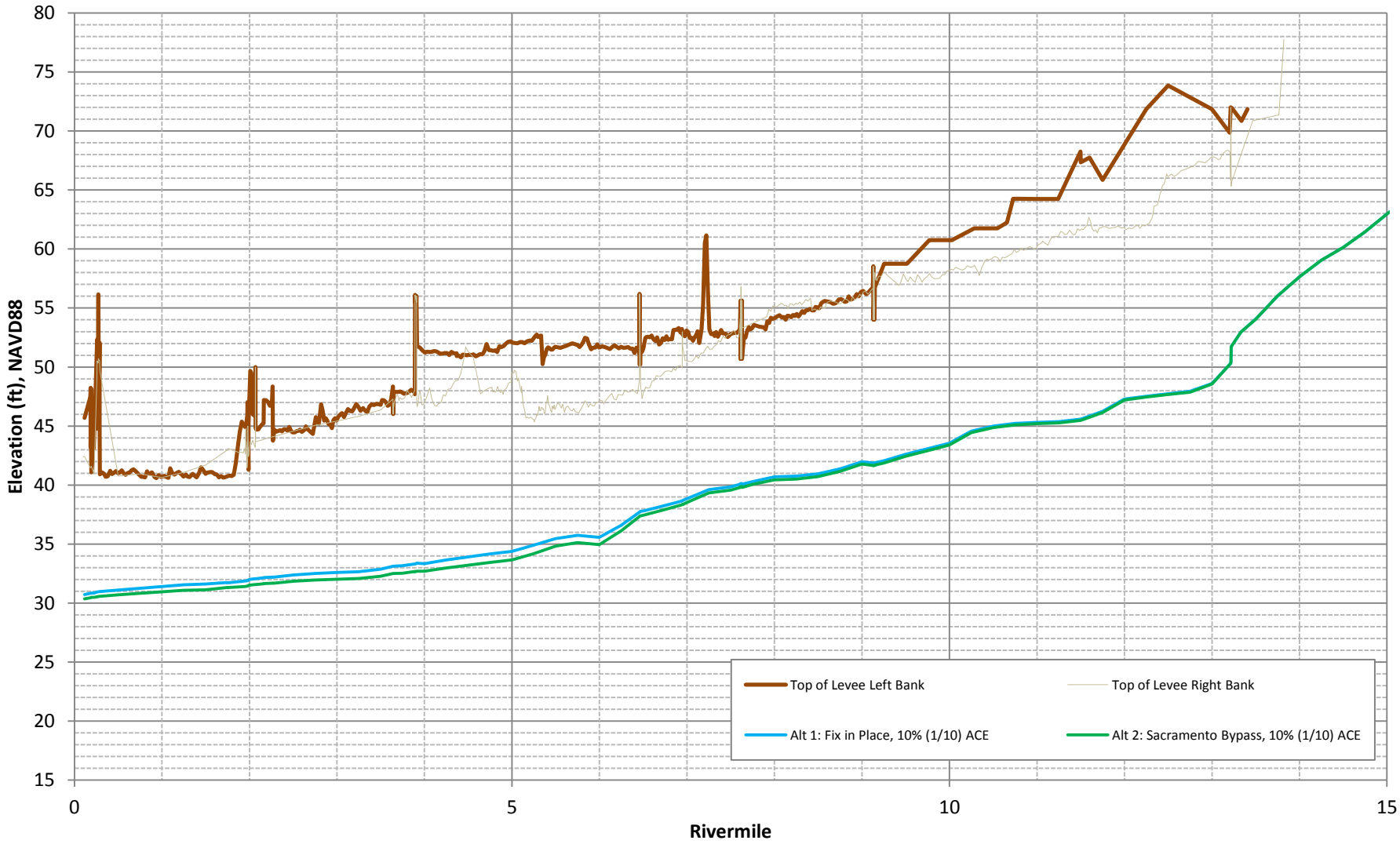
American River Common Features GRR **Sacramento, California**	**Arcade Creek - Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

American River Right Bank Levee - 10% (1/10) ACE Mean Water Surface Profile

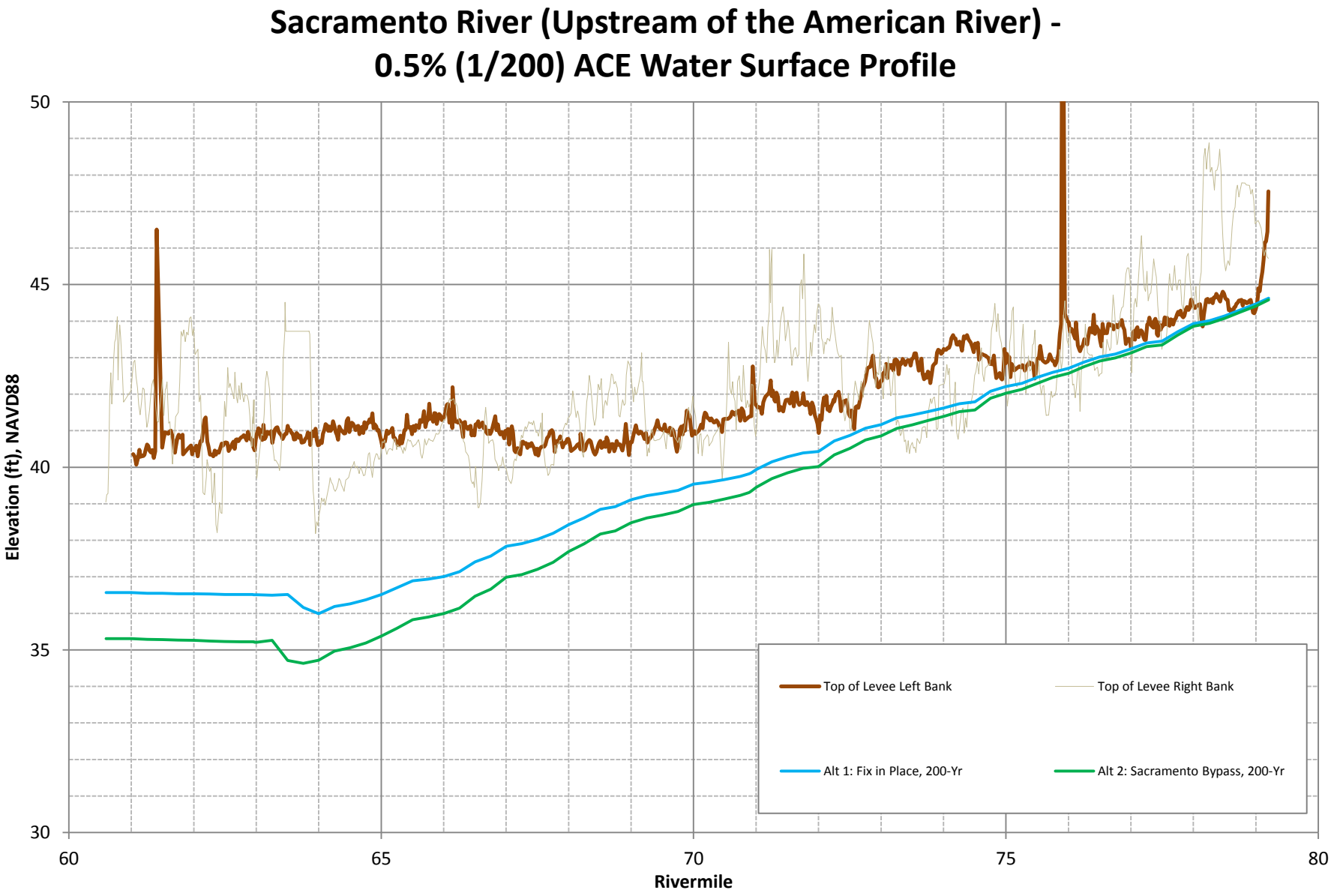


American River Common Features GRR **Sacramento, California**	**American River – Right Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

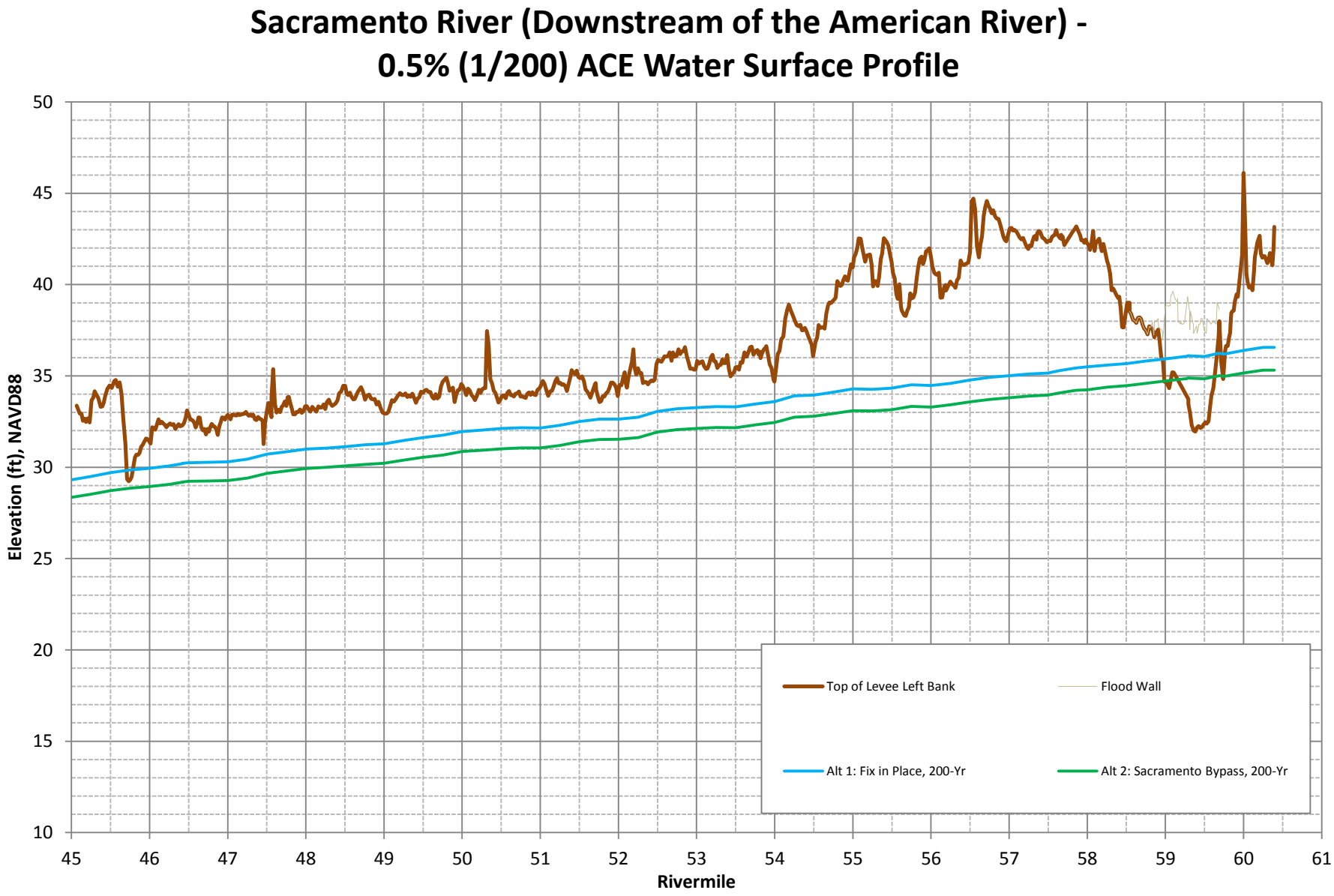
American River Left Bank Levee - 10% (1/10) ACE Water Surface Profile



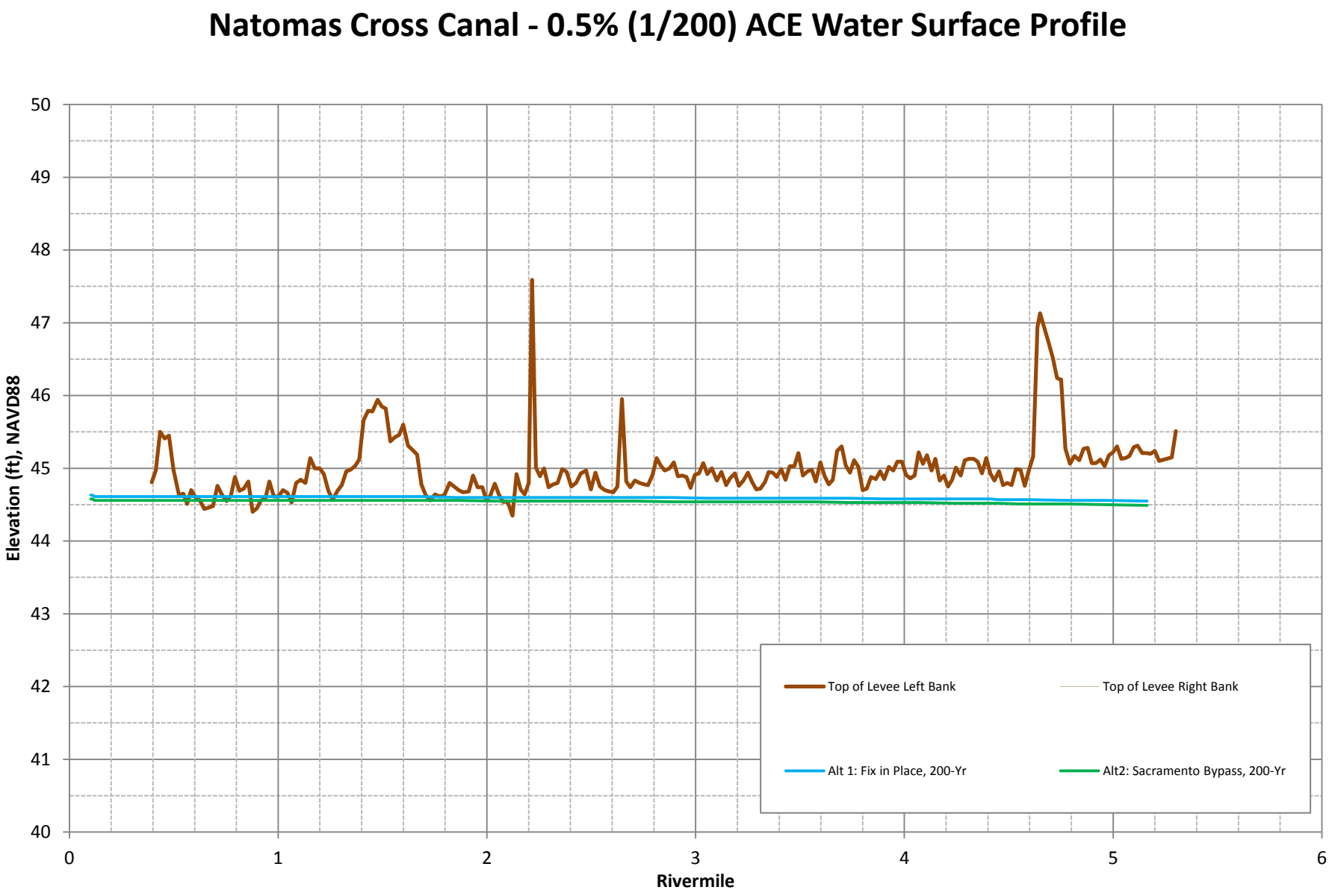
American River Common Features GRR **Sacramento, California**	**American River – Left Bank Levee** **10% (1/10) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**



American River Common Features GRR Sacramento, California	**Sacramento River (U/S of the American River) – Left Bank Levee 0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers Sacramento District**

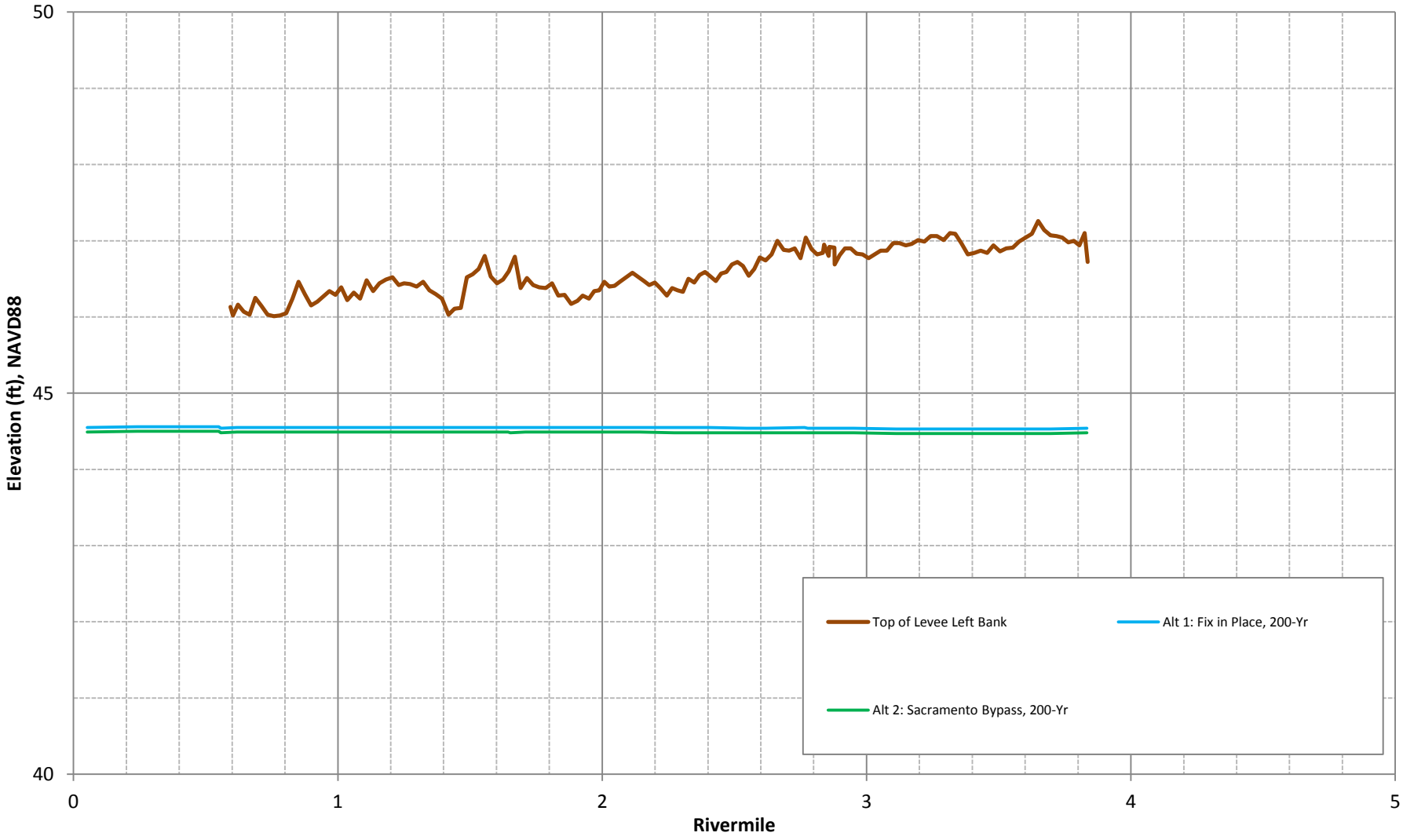


American River Common Features GRR Sacramento, California	**Sacramento River (D/S of the American River) – Left Bank Levee 0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers Sacramento District**



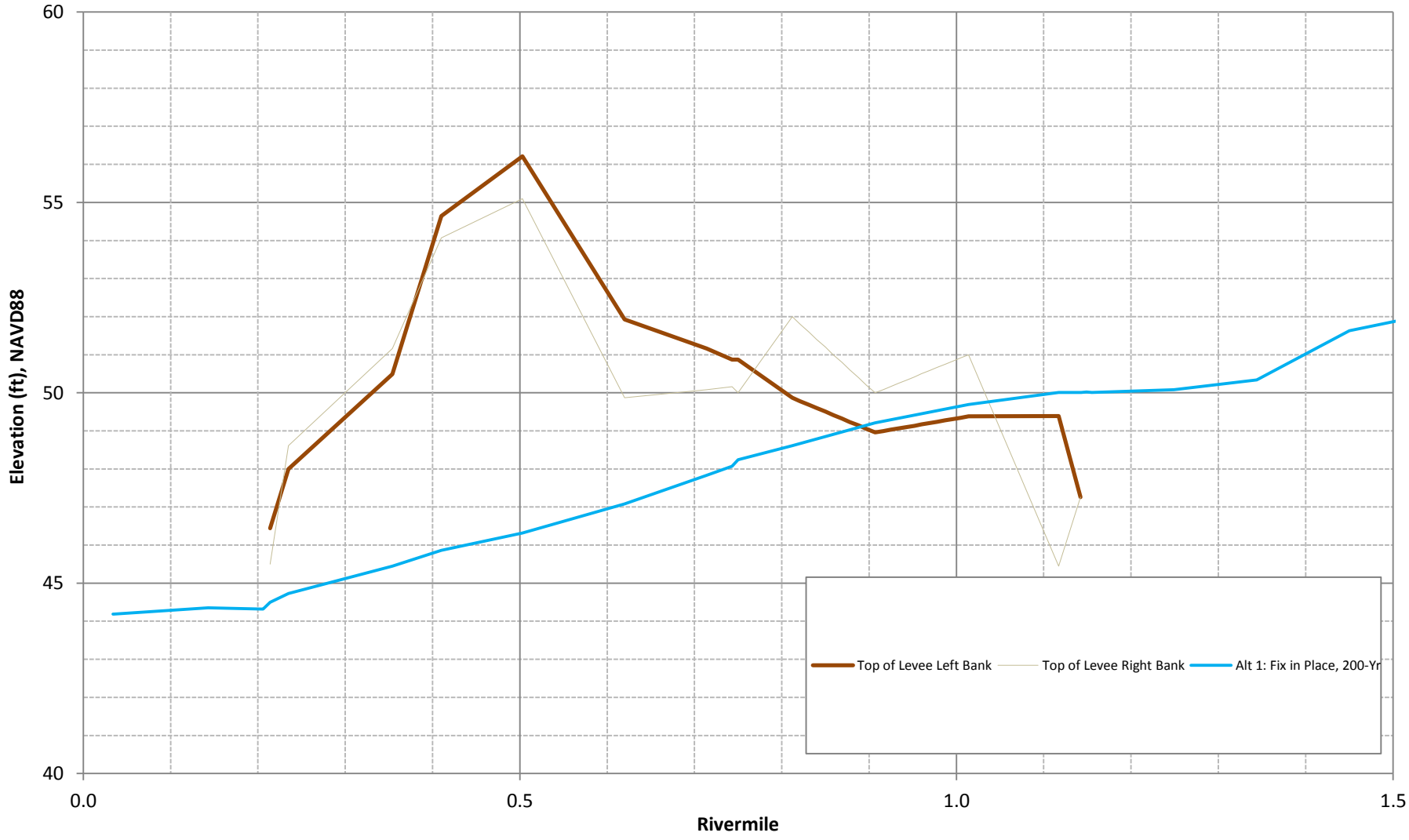
American River Common Features GRR **Sacramento, California**	**Natomas Cross Canal – Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Pleasant Grove Creek Canal - 0.5% (1/200) ACE Water Surface Profile

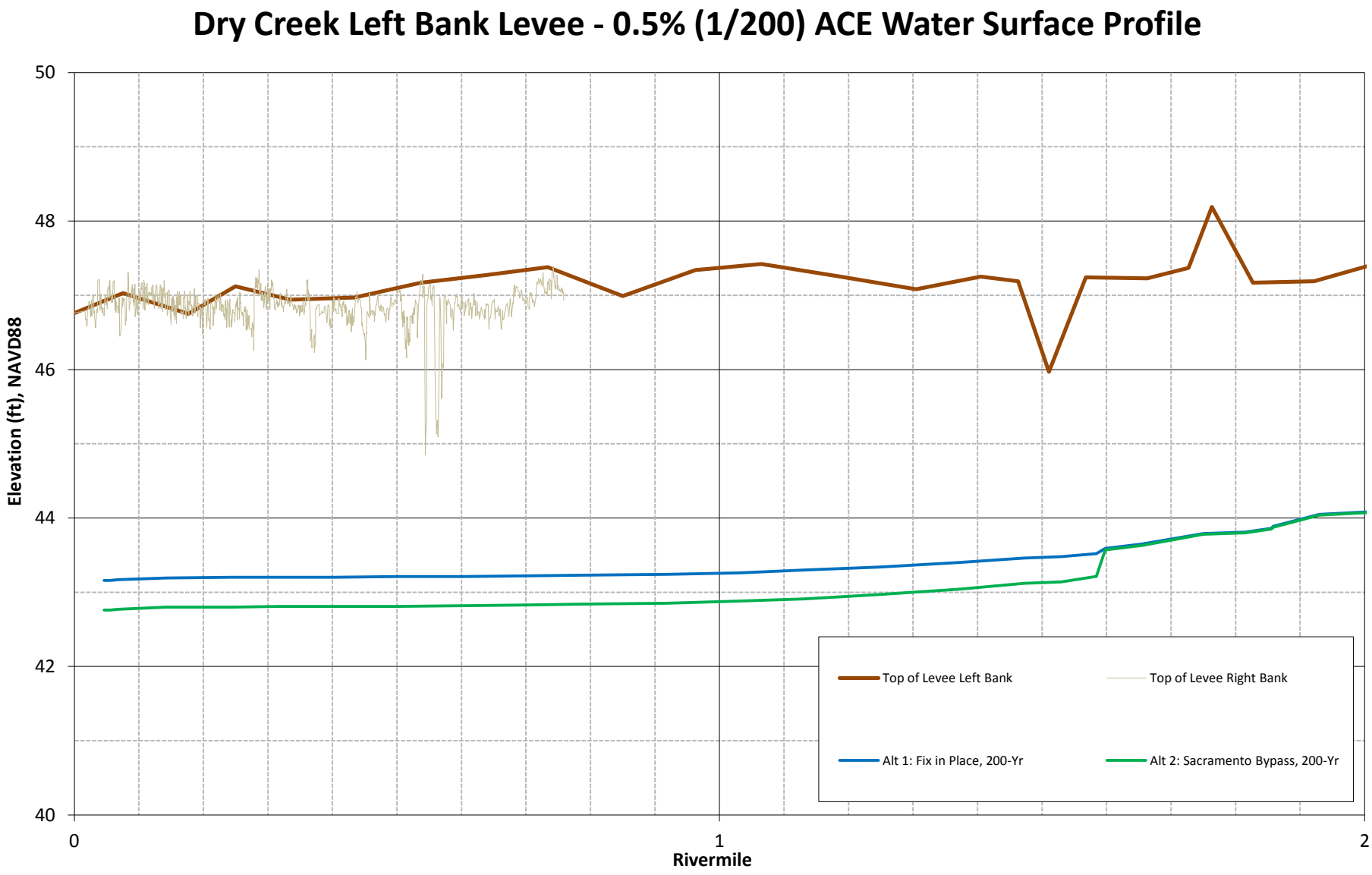


American River Common Features GRR **Sacramento, California**	**Pleasant Grove Creek Canal – Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

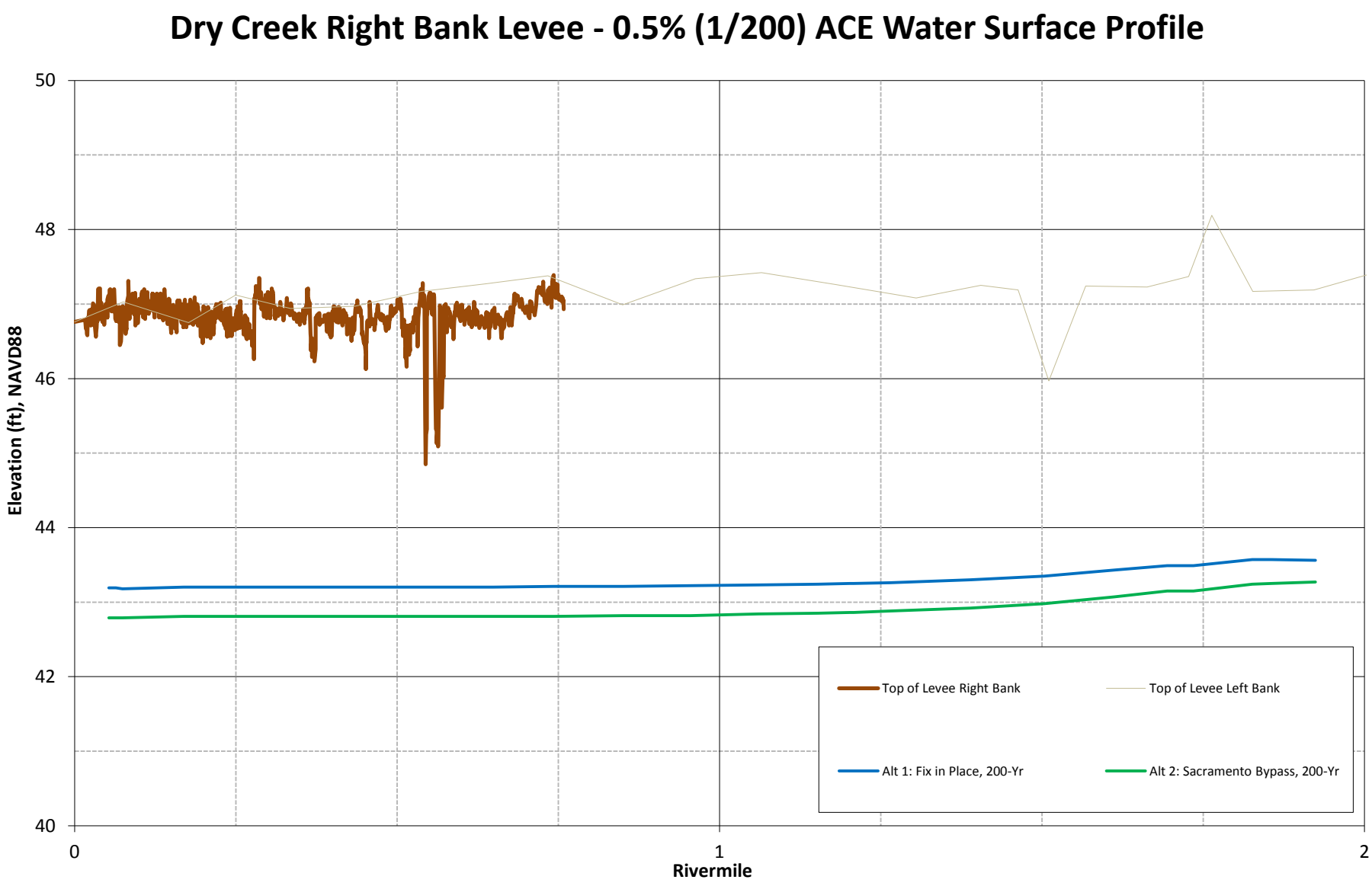
Magpie Creek Left Bank Levee - 0.5% (1/200) ACE Water Surface Profile



American River Common Features GRR **Sacramento, California**	**Magpie Creek – Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

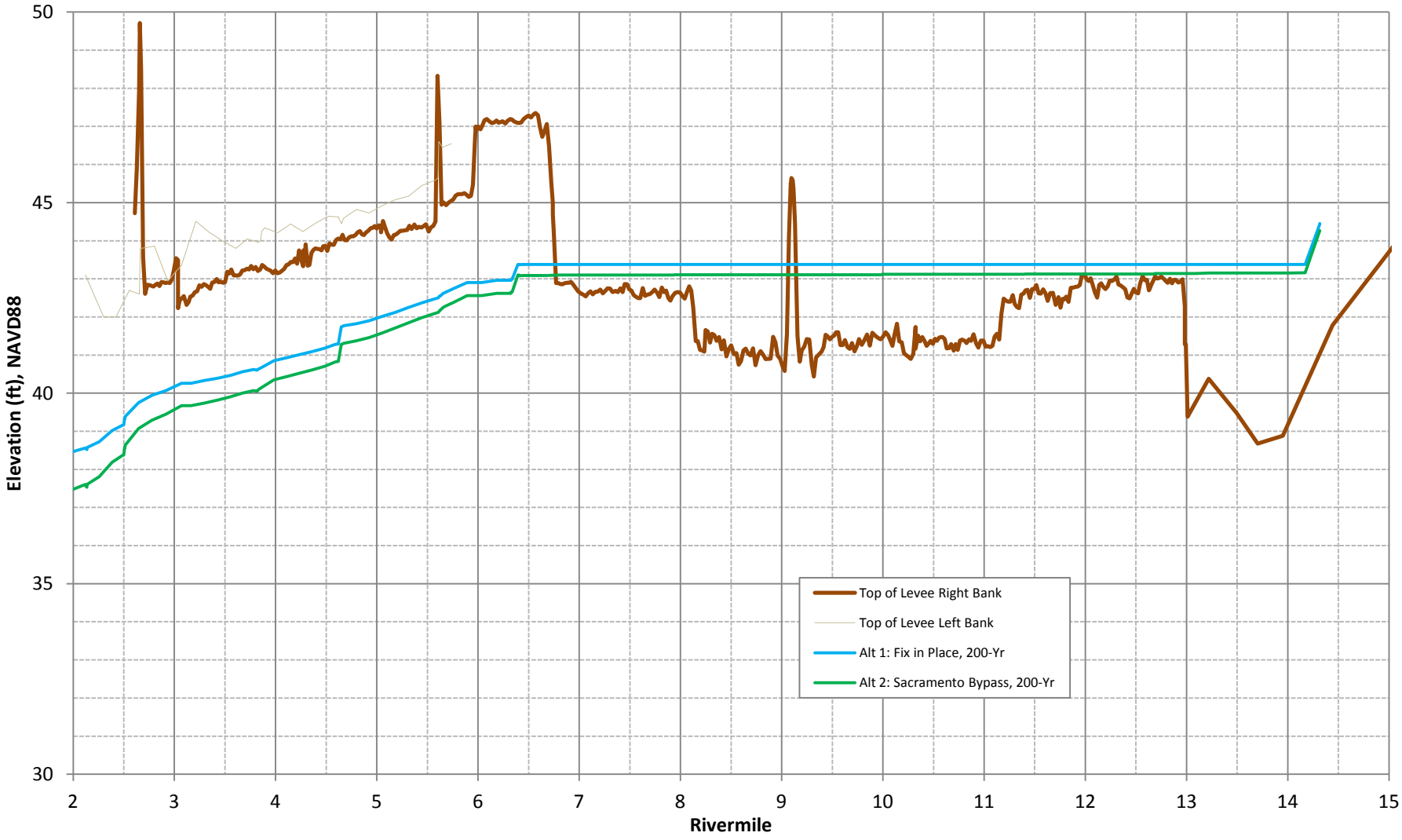


American River Common Features GRR **Sacramento, California**	**Dry Creek – Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**



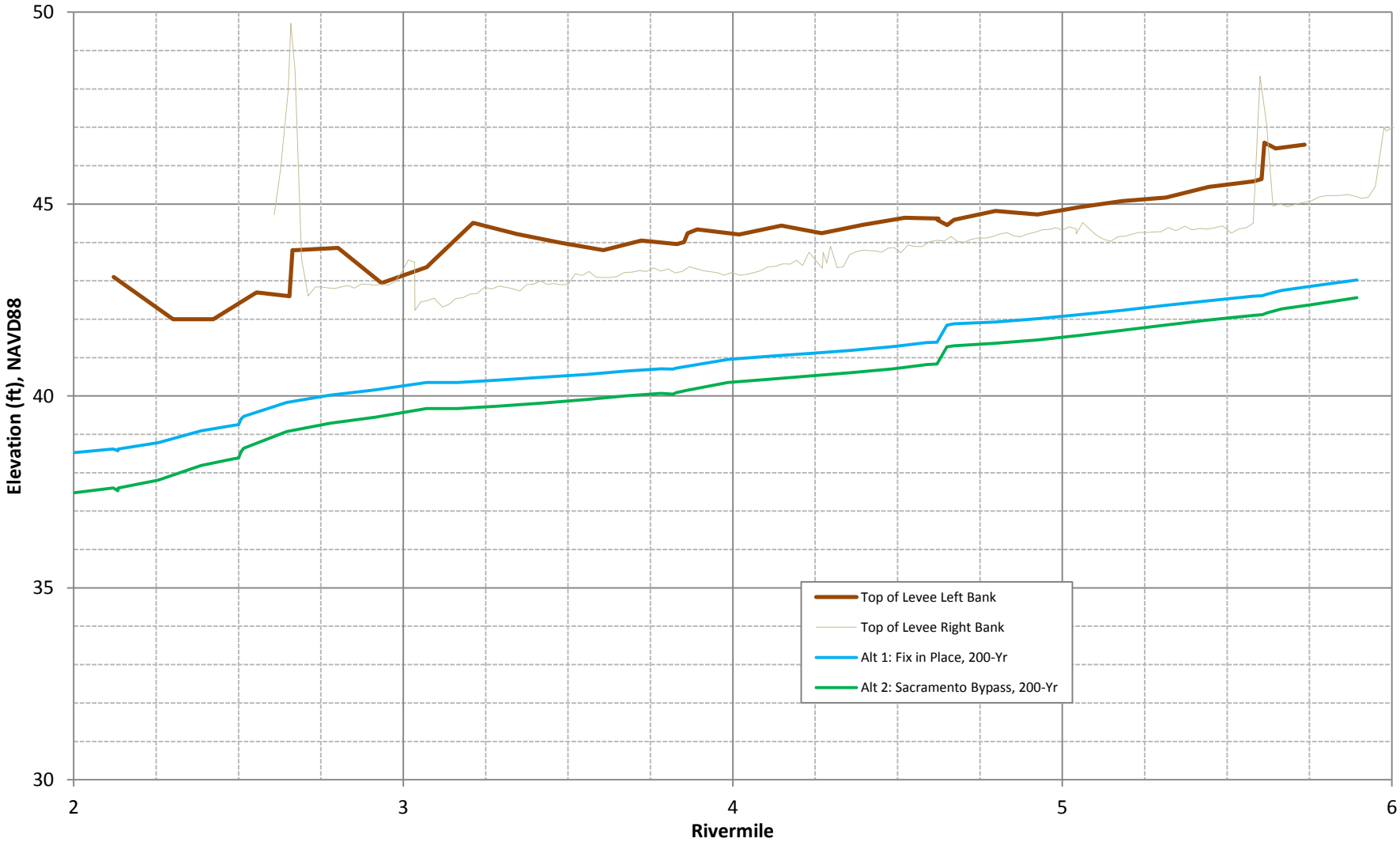
American River Common Features GRR **Sacramento, California**	**Dry Creek – Right Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

NEMDC Right Levee - 0.5% (1/200) ACE Water Surface Profile



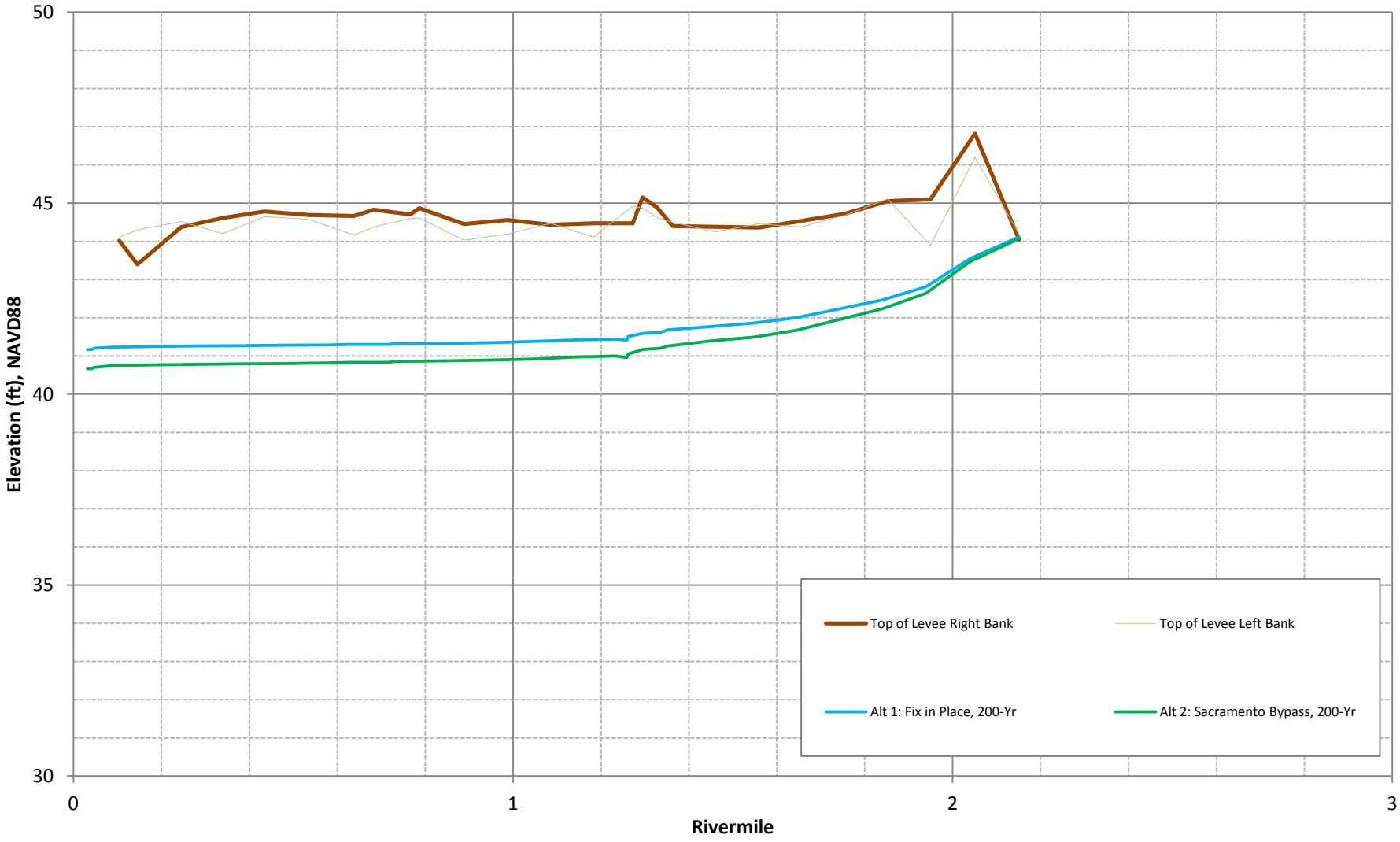
American River Common Features GRR **Sacramento, California**	**NEMDC – Right Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

NEMDC Left Levee - 0.5% (1/200) ACE Water Surface Profile



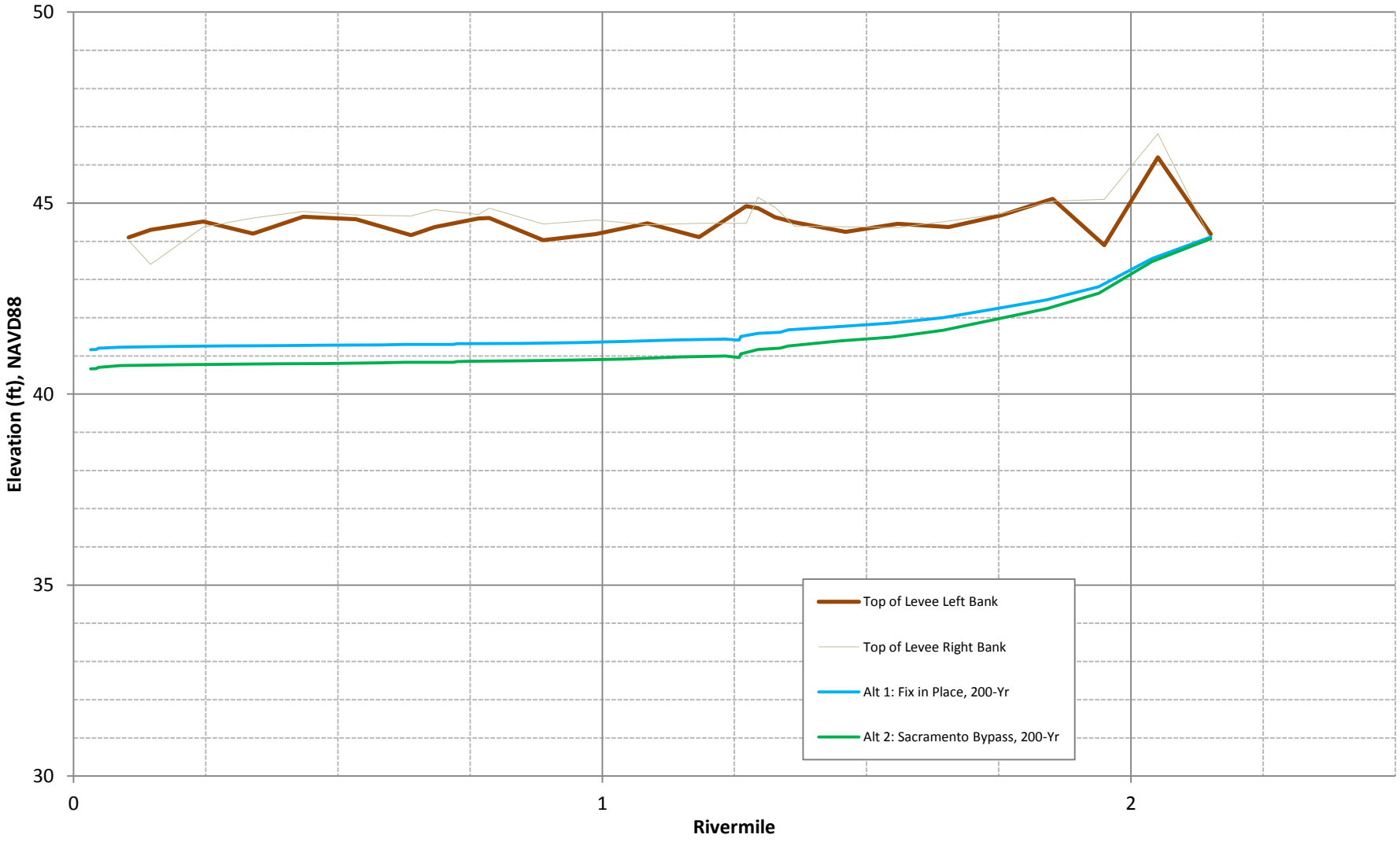
American River Common Features GRR **Sacramento, California**	**NEMDC – Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Arcade Creek Right Bank Levee - 0.5% (1/200) ACE Water Surface Profile



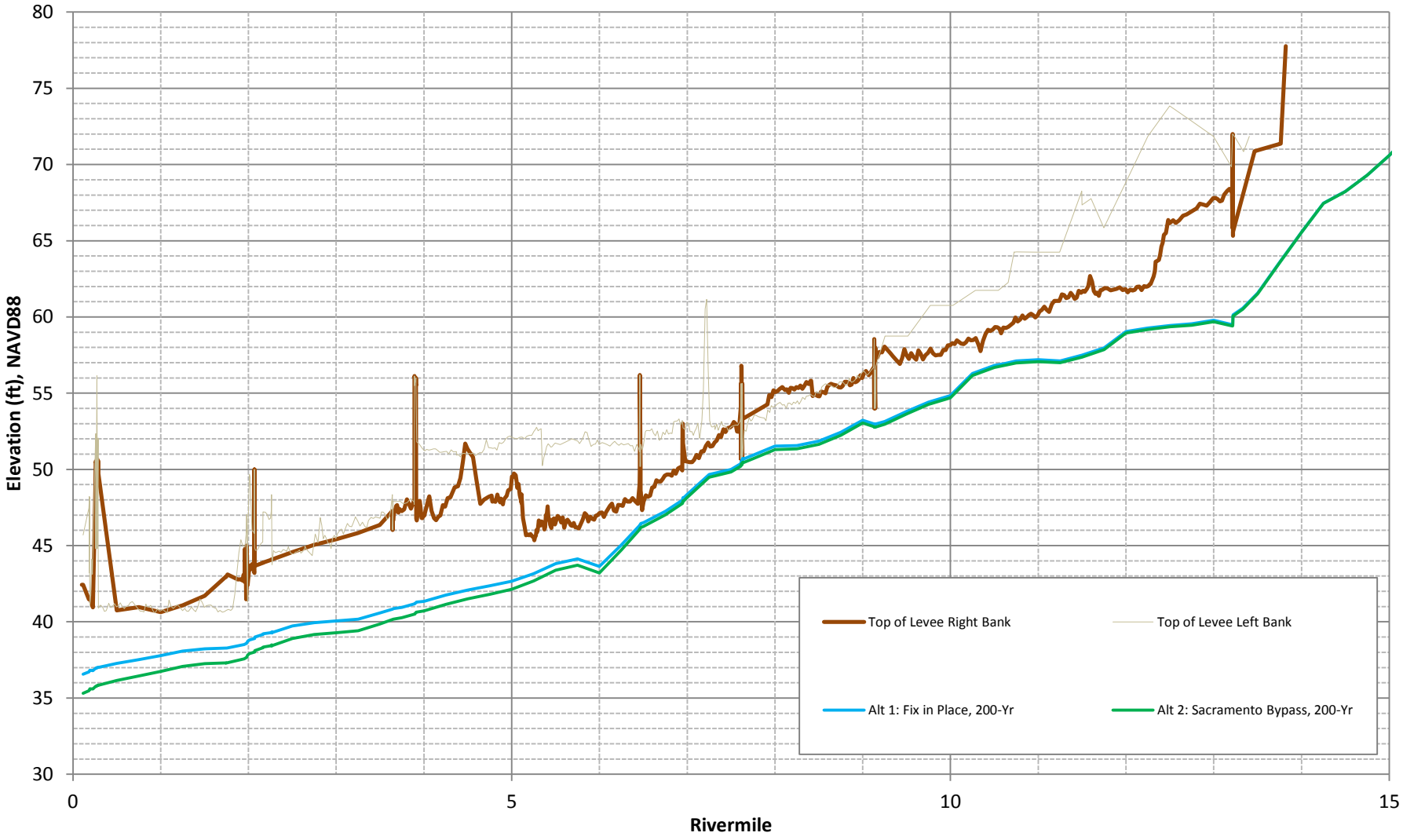
American River Common Features GRR **Sacramento, California**	**Arcade Creek - Right Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Arcade Creek Left Bank Levee - 0.5% (1/200) ACE Water Surface Profile



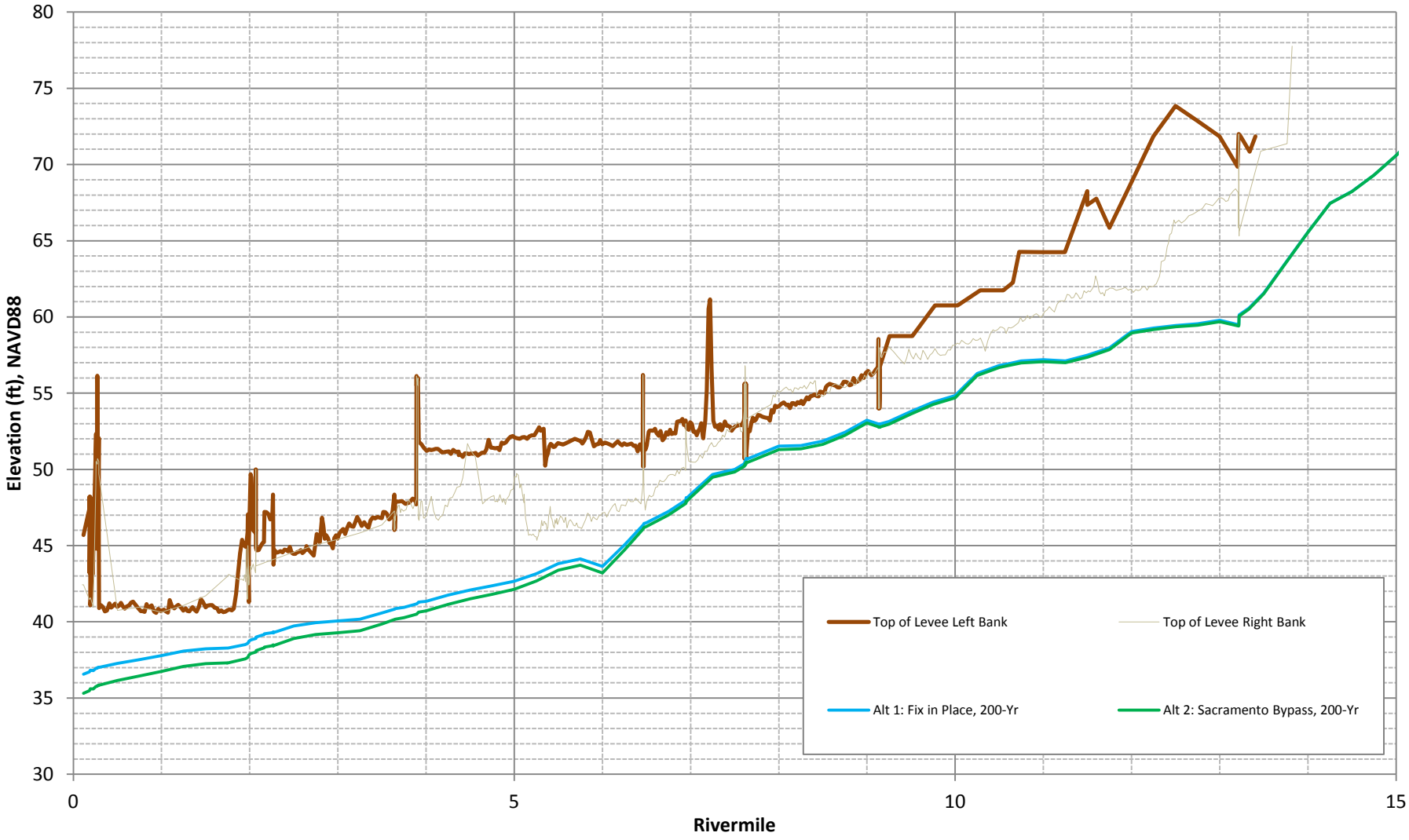
American River Common Features GRR **Sacramento, California**	**Arcade Creek - Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

American River Right Bank Levee - 0.5% (1/200) ACE Water Surface Profile



American River Common Features GRR **Sacramento, California**	**American River – Right Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

American River Left Bank Levee - 0.5% (1/200) ACE Water Surface Profile



American River Common Features GRR **Sacramento, California**	**American River – Left Bank Levee** **0.5% (1/200) ACE Water Surface Profiles With-Project Alternatives**	**U.S. Army Corps of Engineers** **Sacramento District**

Lake Oroville
Oroville
Live Oak
Colusa
Yuba City
Woodland
Folsom Lake
Lake Berryessa
Davis
Sacramento
West Sacramento
Mokelumne River
San Francisco Bay Delta
N
Miles
0 5 10

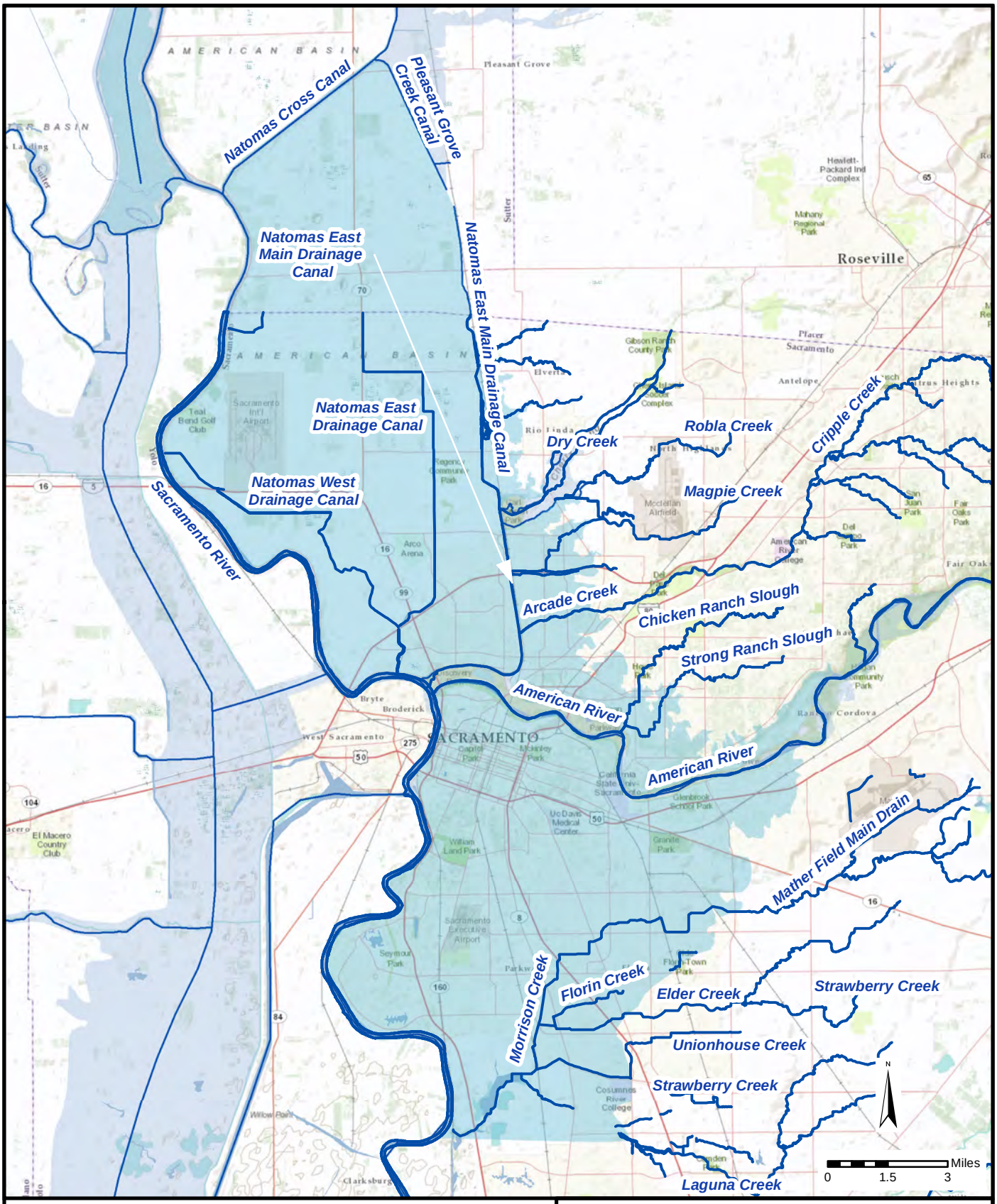
LEGEND

- Hydrologic - Hydraulic Handoff Points
- Rivers
- Cities

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

BOUNDARY CONDITIONS HYDROLOGIC - HYDRAULIC HANDOFF POINTS

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



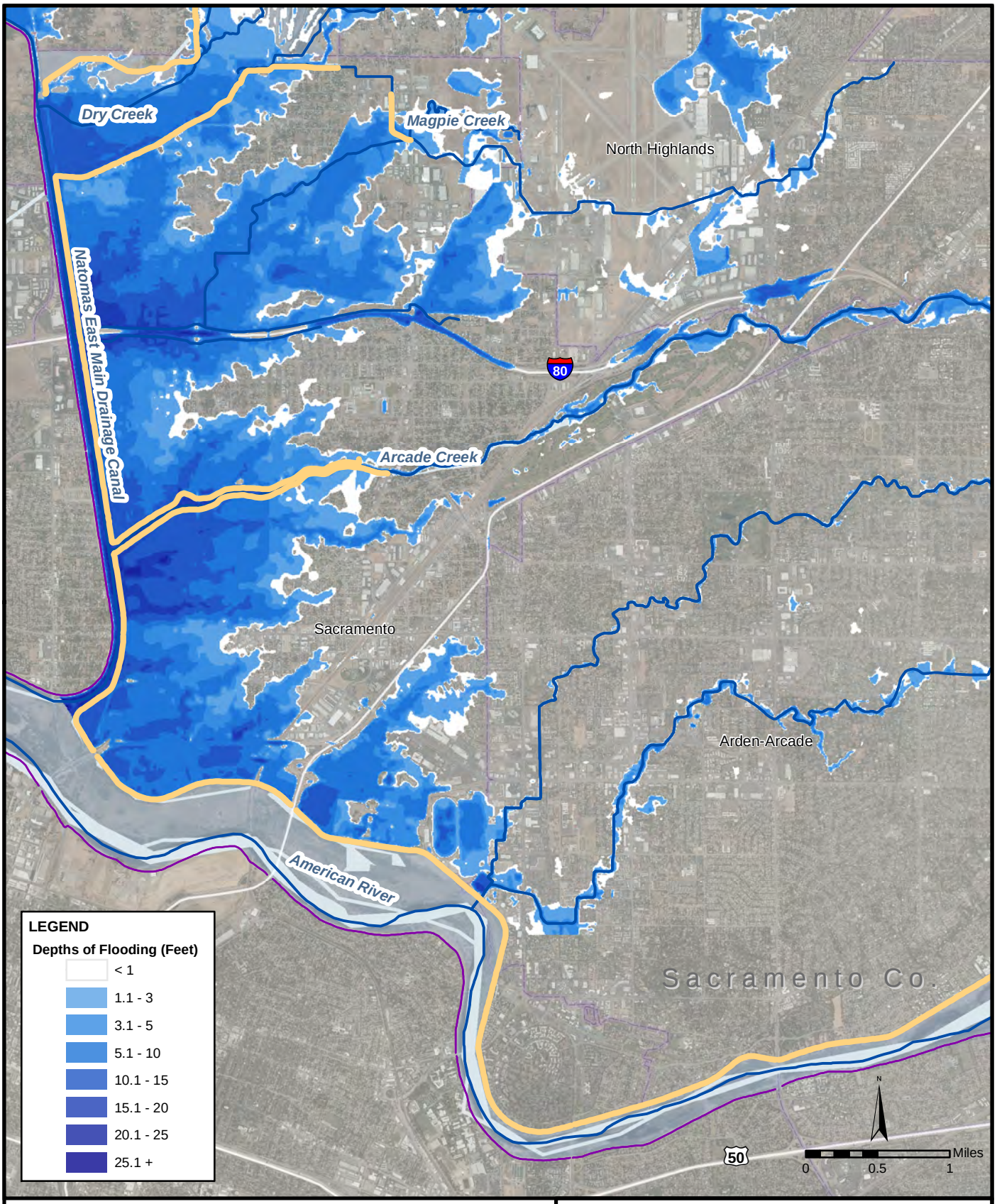
LEGEND

- Streams
- Floodways
- ARCF Study Area

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

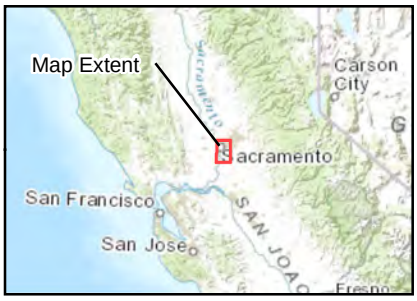
INTERIOR DRAINAGE STUDY AREA MAP

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



LEGEND

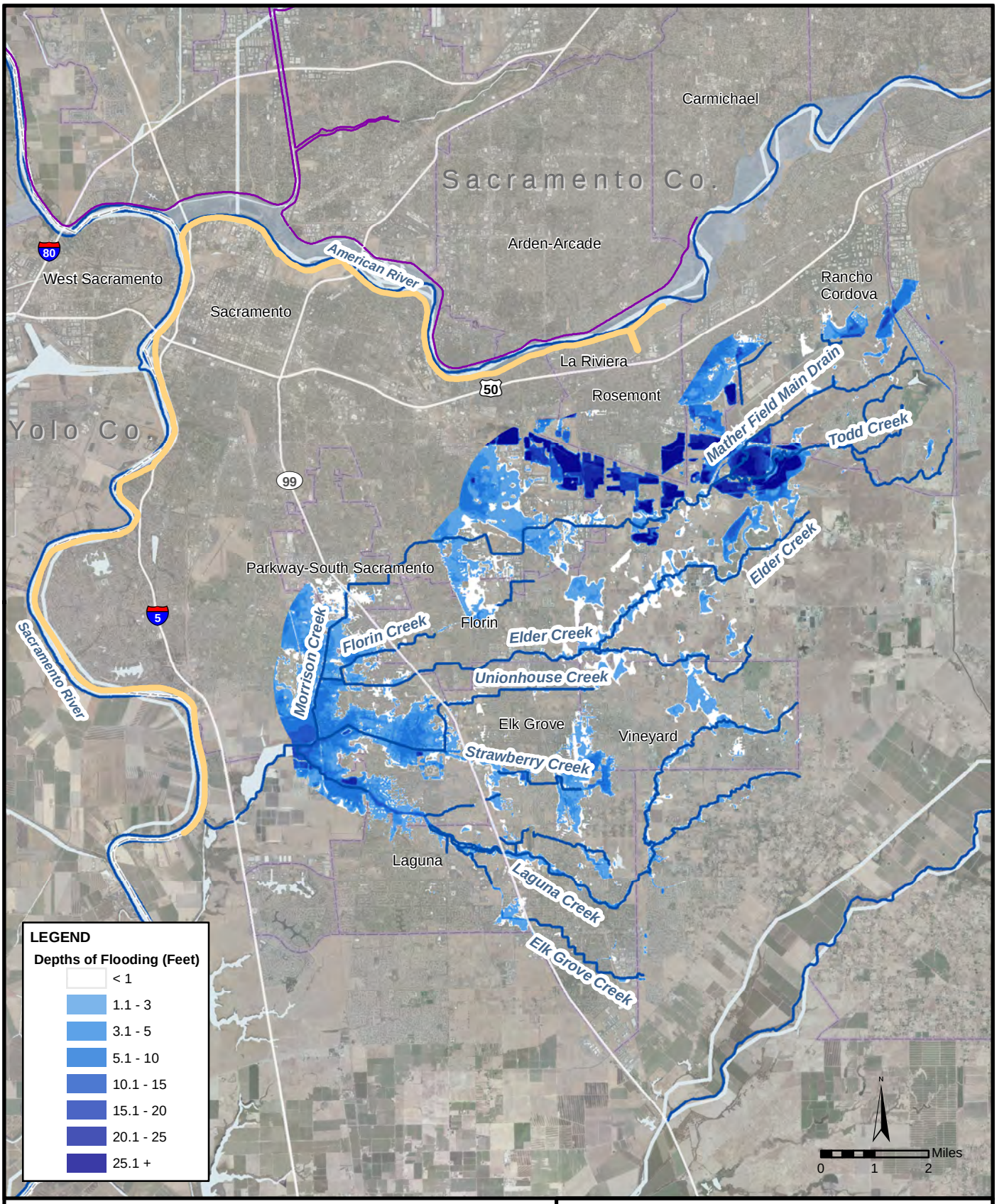
- ARCF Levees
- ARN Levees
- Streams
- Floodways
- County Lines
- Cities



AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER NORTH
1% ACE (100 YEAR)
INTERIOR DRAINAGE FLOODPLAIN

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



LEGEND

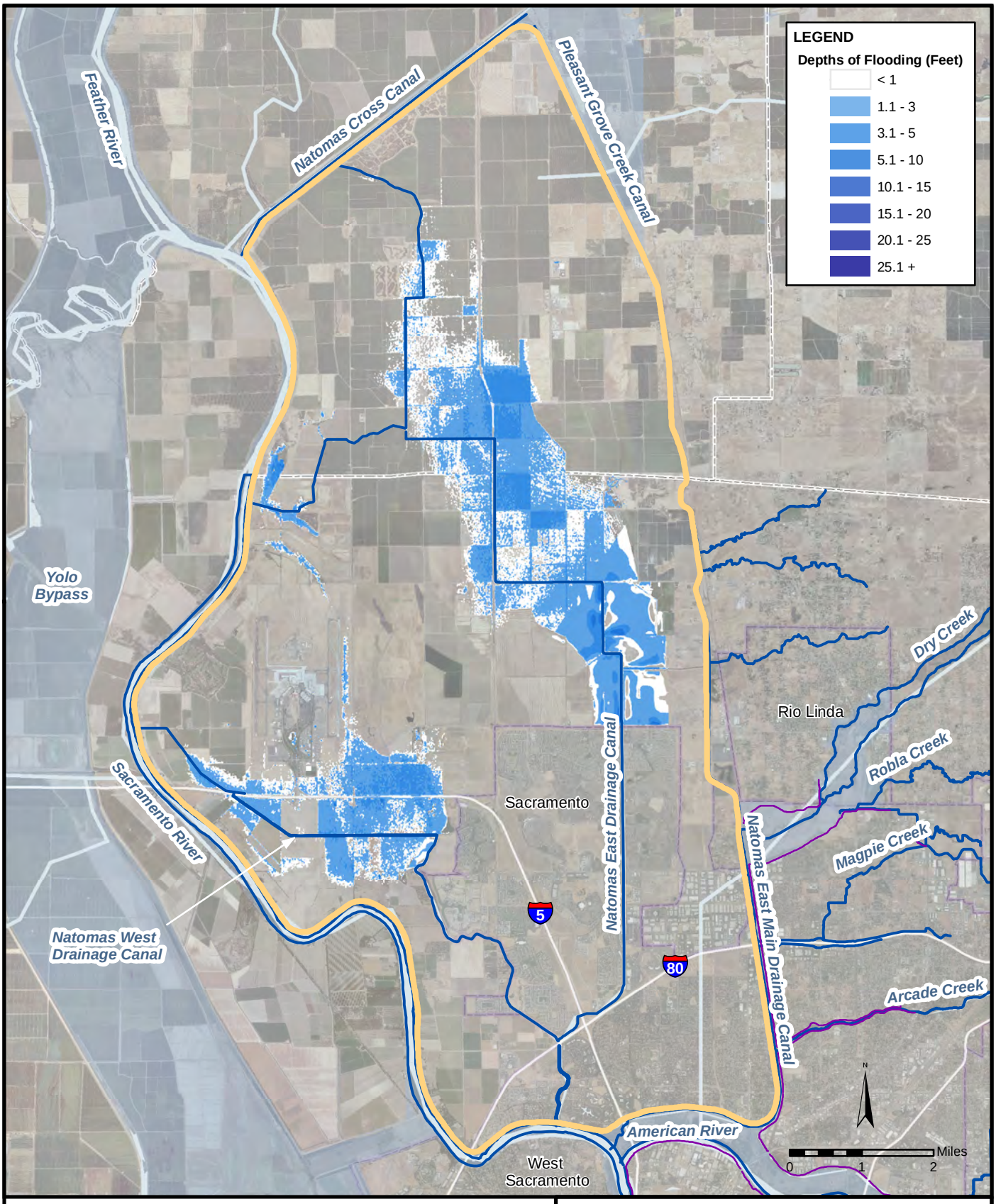
- ARCF Levees
- ARS Levees
- Streams
- Floodways
- County Lines
- Cities

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER SOUTH
1% ACE (100 YEAR)
INTERIOR DRAINAGE FLOODPLAIN

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Feb 2013



LEGEND

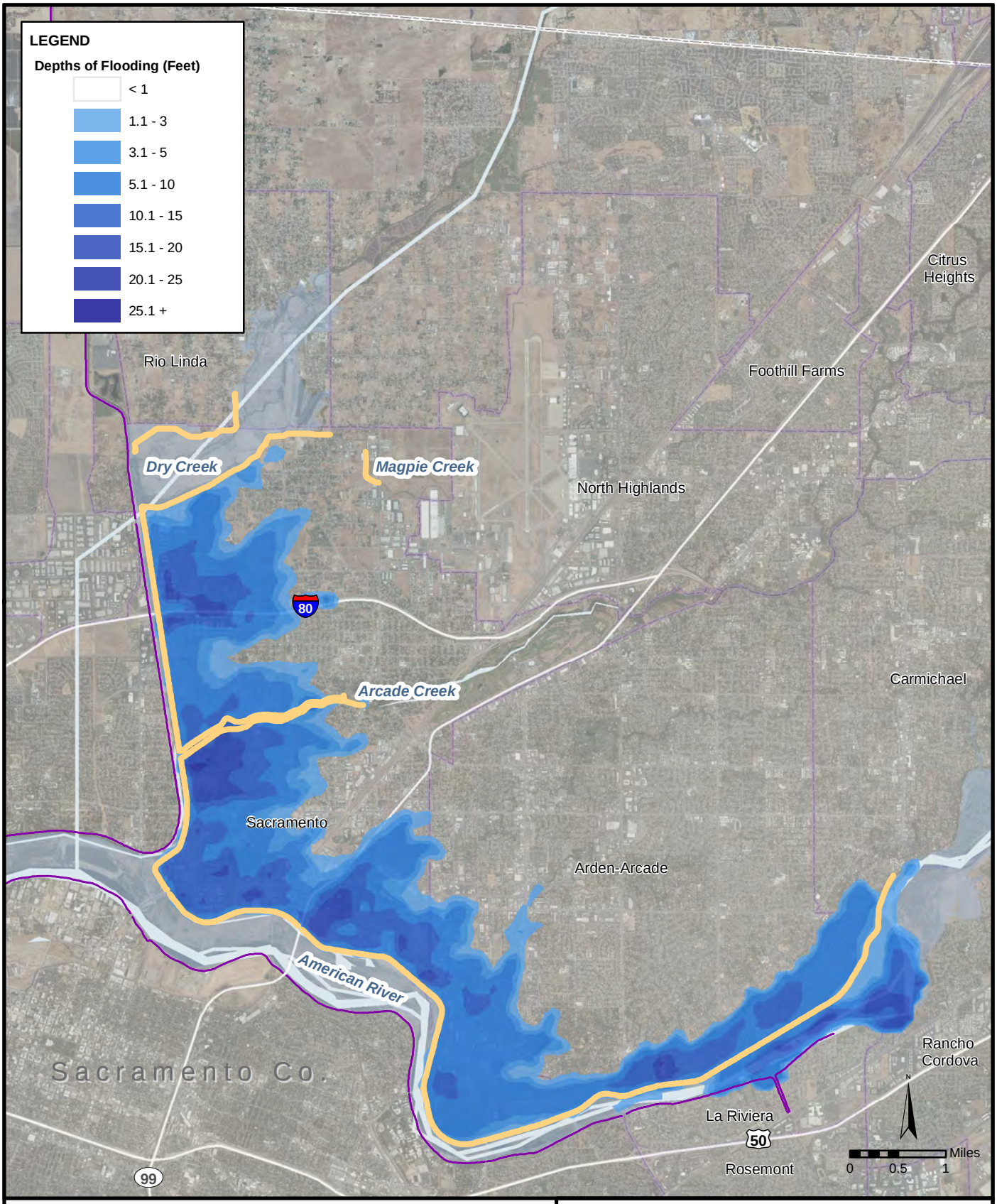
- ARCF Levees
- Natomas Levees
- Streams
- Floodways
- Cities
- County Lines

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

NATOMAS BASIN
1% (1/100) ACE
INTERIOR DRAINAGE FLOODPLAIN

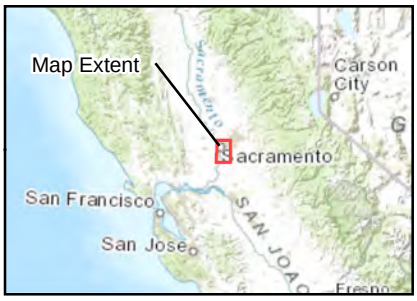
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013



LEGEND

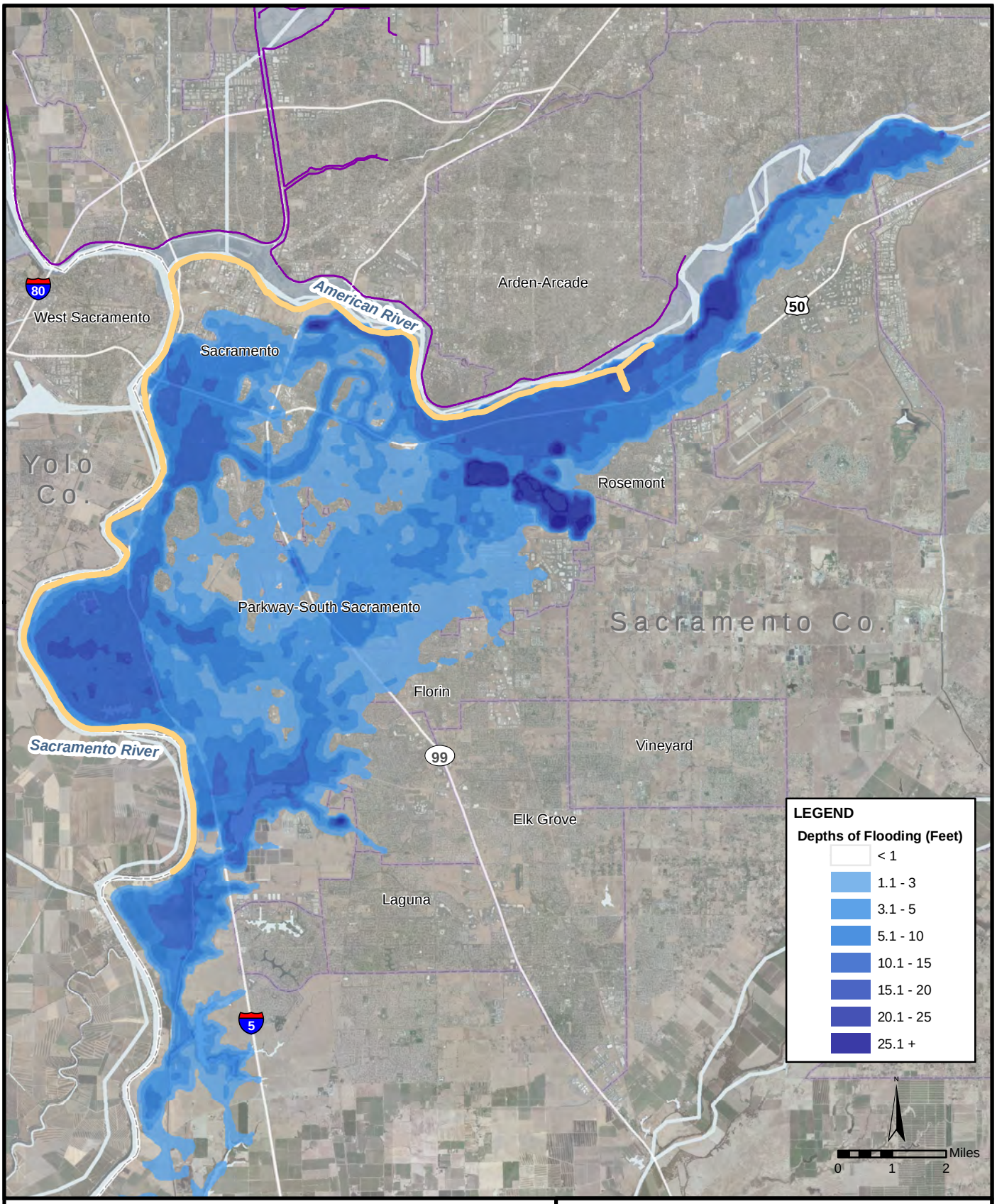
- ARN Levees
- ARCF Levees
- Floodways
- County Lines
- Cities



AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

RESIDUAL FLOODING
FROM UPSTREAM CHANNEL OUTFLANKING
INTO THE AMERICAN RIVER BASIN

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



LEGEND

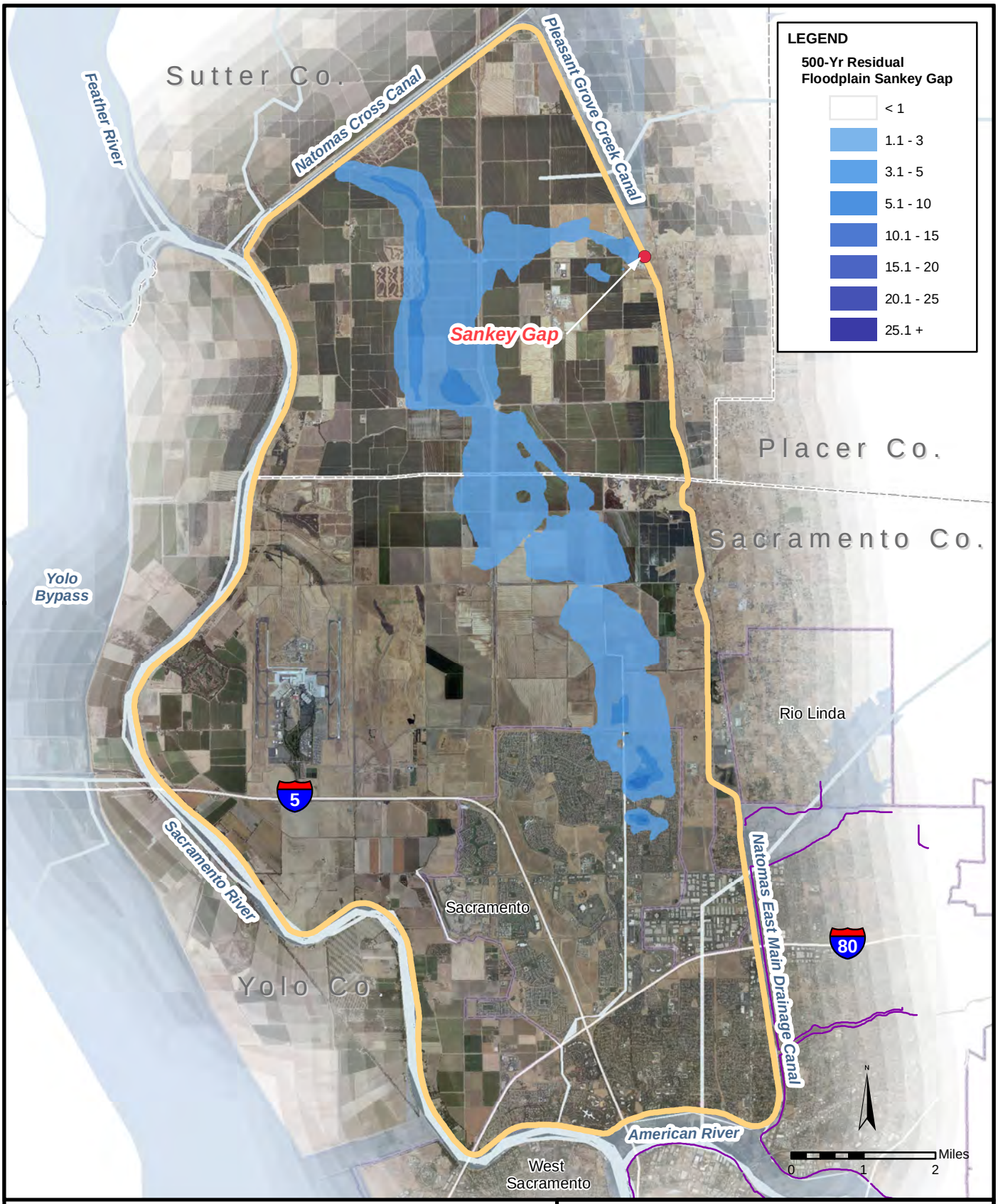
- ARCF Levees
- ARS Levees
- County Lines
- Floodways
- Cities

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

RESIDUAL FLOODING
FROM CHANNEL OUTFLANKING
INTO THE AMERICAN RIVER SOUTH BASIN

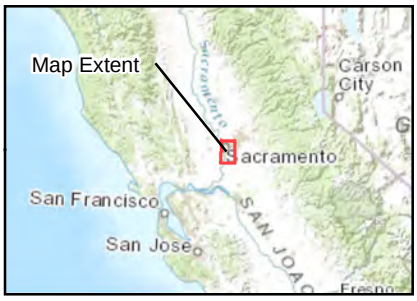
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Feb 2013



LEGEND

- ARCF Levees
- Natomas Levees
- Floodways
- Cities
- County Lines



AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

RESIDUAL FLOODING FROM SANKEY GAP INTO THE NATOMAS BASIN

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Feb 2013

American River South (ARS) IP A			
American River RM 7.8			
	Future Without Project Condition	Fix In Place	Sacramento Bypass Widening
Frequency	Stage, NAVD88		
1yr = .999	24.1	24.1	24.1
2yr = .5	31.9	31.9	31.9
10yr = .1	42.0	42.0	41.8
25yr = .04	48.0	48.0	47.9
50yr = .02	48.1	48.1	47.9
100yr = .01	48.2	48.2	48.0
200yr = .005	53.2	53.2	53.0
500yr = .002	58.1	58.1	58.1
Frequency	Flow		
1yr = .999	1423	1423	1439
2yr = .5	25977	25977	25998
10yr = .1	71654	71654	71655
25yr = .04	114993	114993	114990
50yr = .02	115000	115000	114999
100yr = .01	114999	114999	114999
200yr = .005	159995	159995	159982
500yr = .002	254357	254357	254410

Source: Hydraulic Analysis Section, Sacramento District, USACE

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER SOUTH
INDEX POINT A
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

American River South (ARS) IP F			
Sacramento River RM 50.3			
	Future Without Project Condition	Fix In Place	Sacramento Bypass Widening
Frequency	Stage, NAVD88		
1yr = .999	11.1	11.1	11.1
2yr = .5	20.8	20.8	20.8
10yr = .1	26.4	26.4	26.0
25yr = .04	29.0	29.0	27.9
50yr = .02	29.6	29.6	28.5
100yr = .01	30.3	30.3	29.3
200yr = .005	32.0	32.0	30.9
500yr = .002	33.9	33.9	33.4
Frequency	Flow		
1yr = .999	52823	52823	47842
2yr = .5	94600	94600	87375
10yr = .1	100687	100687	99631
25yr = .04	115395	115395	107204
50yr = .02	118141	118141	110188
100yr = .01	121788	121788	113973
200yr = .005	133200	133200	124750
500yr = .002	152523	152523	144263

Source: Hydraulic Analysis Section, Sacramento District, USACE

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER SOUTH
INDEX POINT F
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

American River North (ARN) IP A			
American River RM 7.83			
	Future Without Project Condition	Fix In Place	Sacramento Bypass Widening
Frequency	Stage, NAVD88		
1yr = .999	23.3	23.3	22.7
2yr = .5	32.4	32.4	30.5
10yr = .1	40.5	40.5	40.6
25yr = .04	46.2	46.2	46.4
50yr = .02	46.2	46.2	46.5
100yr = .01	46.3	46.3	46.6
200yr = .005	51.2	51.2	51.4
500yr = .002	55.9	55.9	55.7
Frequency	Flow		
1yr = .999	1690	1690	1631
2yr = .5	25969	25969	25996
10yr = .1	71653	71653	71654
25yr = .04	114991	114991	114987
50yr = .02	114999	114999	114999
100yr = .01	115000	115000	114999
200yr = .005	159998	159998	159979
500yr = .002	220684	220684	215253

Source: Hydraulic Analysis Section, Sacramento District, USACE

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER NORTH
INDEX POINT A
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

American River North (ARN) IP E			
Arcade Creek RM .95			
	Future Without Project Condition	Fix In Place	Sacramento Bypass Widening
Frequency	Stage, NAVD88		
1yr = .999	27.0	27.0	26.6
2yr = .5	30.0	30.0	29.4
10yr = .1	33.1	33.1	33.2
25yr = .04	35.4	35.4	34.8
50yr = .02	37.7	37.7	36.1
100yr = .01	39.2	39.2	38.6
200yr = .005	41.4	41.4	40.9
500yr = .002	46.1	46.1	45.2
Frequency	Flow		
1yr = .999	-	-	-
2yr = .5	-	-	-
10yr = .1	-	-	-
25yr = .04	-	-	-
50yr = .02	-	-	-
100yr = .01	-	-	-
200yr = .005	-	-	-
500yr = .002	-	-	-

Source: Hydraulic Analysis Section, Sacramento District, USACE

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

AMERICAN RIVER NORTH
INDEX POINT E
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

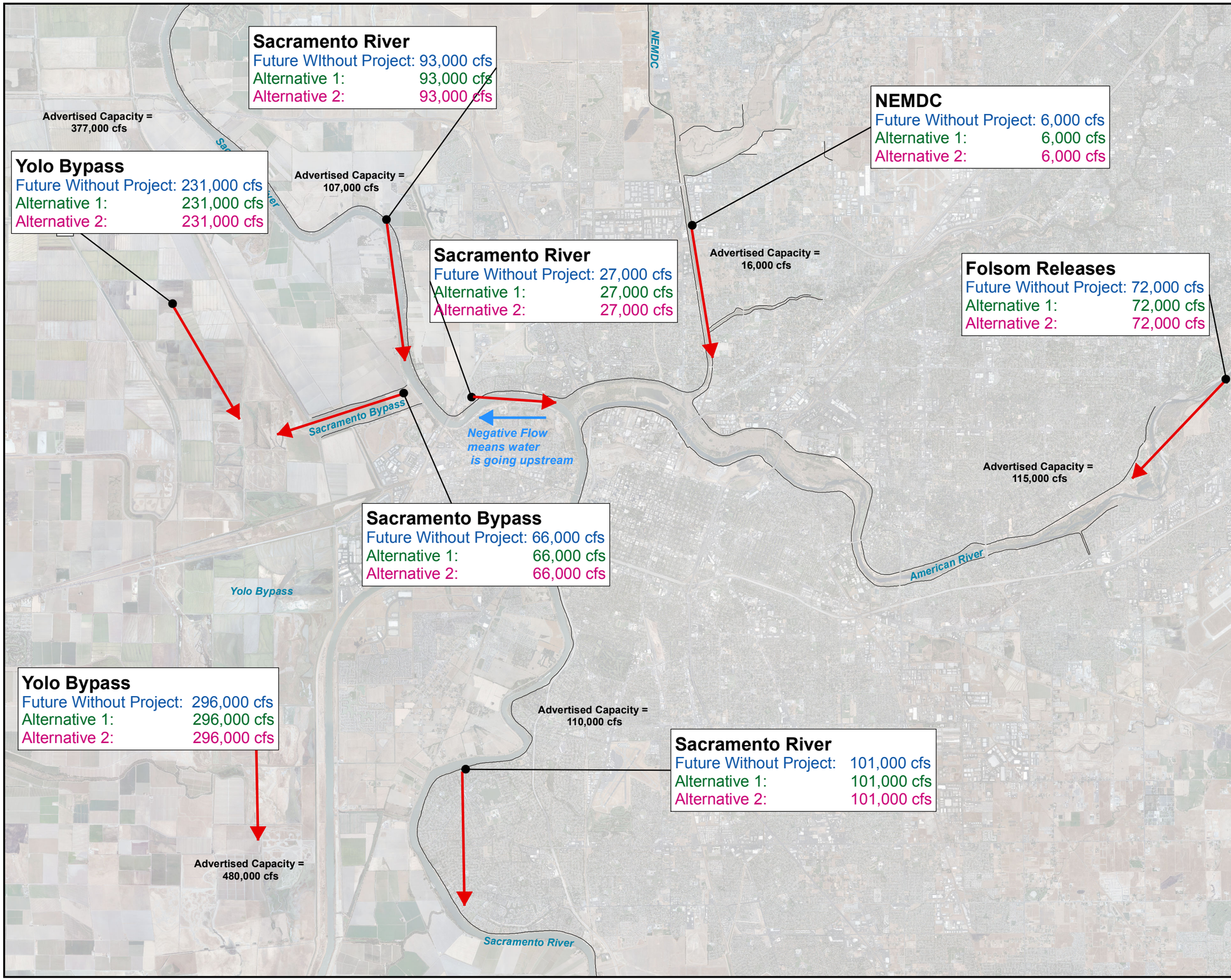
Natomas (NAT) IP D			
Natomas Cross Canal RM 2.71			
	Future Without Project Condition	Fix In Place	Sacramento Bypass Widening
Frequency	Stage, NAVD88		
1yr = .999	20.6	20.6	20.5
2yr = .5	33.6	33.6	33.5
10yr = .1	39.0	39.0	38.9
25yr = .04	41.5	41.5	41.4
50yr = .02	42.4	42.4	42.3
100yr = .01	43.5	43.5	43.4
200yr = .005	44.6	44.6	44.6
500yr = .002	45.5	45.5	45.5
Frequency	Flow		
1yr = .999	-	-	-
2yr = .5	-	-	-
10yr = .1	-	-	-
25yr = .04	-	-	-
50yr = .02	-	-	-
100yr = .01	-	-	-
200yr = .005	-	-	-
500yr = .002	-	-	-

Source: Hydraulic Analysis Section, Sacramento District, USACE

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

NATOMAS
INDEX POINT D
RISK ANALYSIS INPUTS

U.S ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT



LEGEND

- Levee Reaches (ARCF)
- Flow Direction
- Backflow

Reach
Future Without Project Condition Flows
Alternative 1 Flows
Alternative 2 Flows

N

0 0.5 1 2 Miles

1:100,000

US Army Corps of Engineers
Sacramento District

Maximum 10% (1/10) ACE Future Without Project Conditions & With Project Flows

AMERICAN RIVER COMMON FEATURES GRR

Maxiumum Flows are the greatest flow from either the Sacramento or American Storm Centerings.

Date: 9/8/2015
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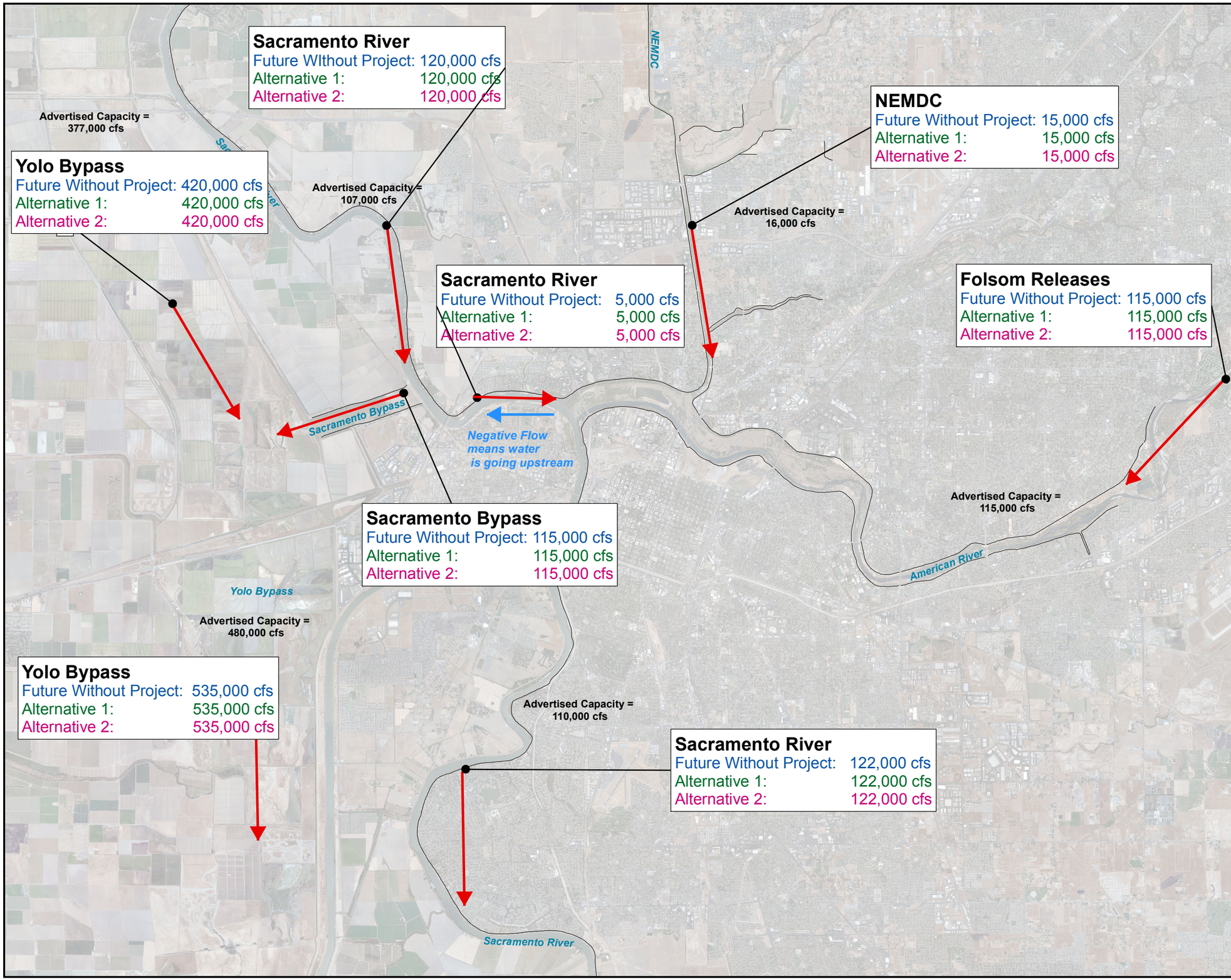
Sept 2015

Plate 70



LEGEND

- Levee Reaches (ARCF)
- Flow Direction
- Backflow

Reach
Future Without Project Condition Flows
Alternative 1 Flows
Alternative 2 Flows

N

0 0.5 1 2 Miles

1:100,000

US Army Corps of Engineers
Sacramento District

Maximum 1% (1/100) ACE Future Without Project Conditions & With Project Flows

AMERICAN RIVER COMMON FEATURES GRR

Maxiumum Flows are the greatest flow from either the Sacramento or American Storm Centerings.

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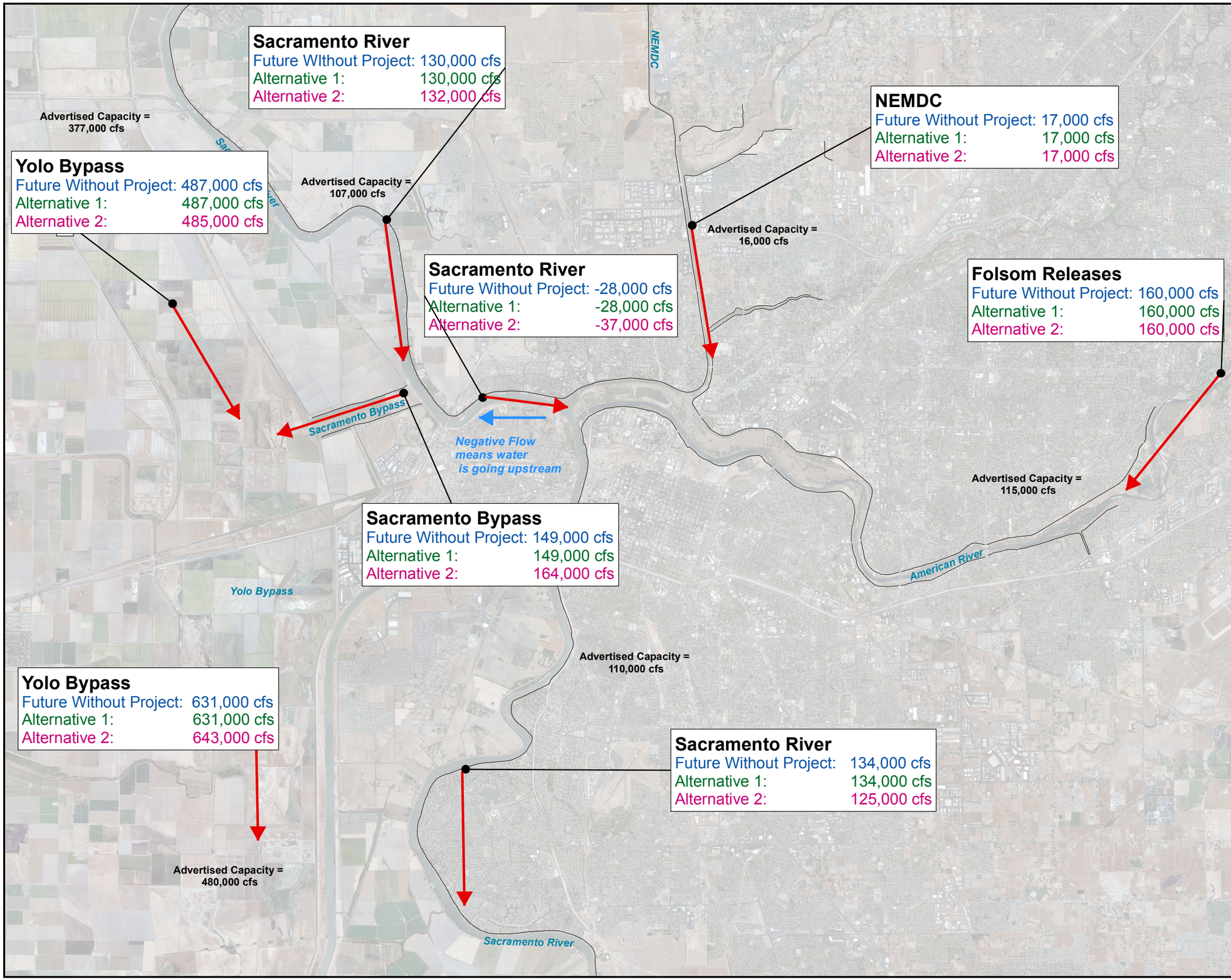
Sept 2015

Plate 71



LEGEND

- Levee Reaches (ARCF)
- Flow Direction
- Backflow

Reach
Future Without Project Condition Flows
Alternative 1 Flows
Alternative 2 Flows

N

0 0.5 1 2 Miles

1:100,000

US Army Corps of Engineers
Sacramento District

Maximum 0.5% (1/200) ACE Future Without Project Conditions & With Project Flows

AMERICAN RIVER COMMON FEATURES GRR

Maxiumum Flows are the greatest flow from either the Sacramento or American Storm Centerings.

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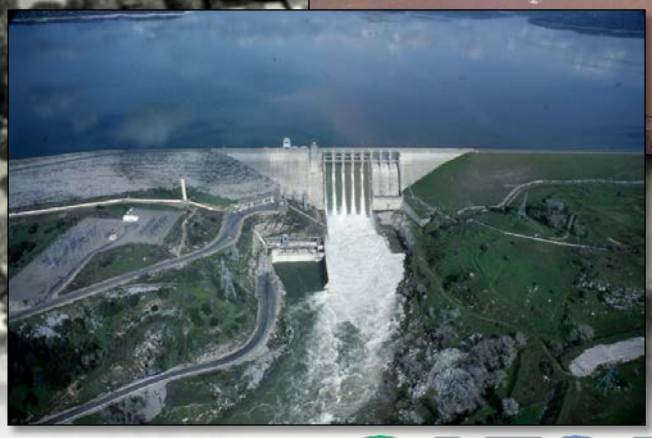
Sept 2015

Plate 72

American River Watershed

Common Features
General Reevaluation Report



Attachment C
Geotechnical Report

December 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Attachment C
Geotechnical Report

U.S. Army Corps of Engineers
Sacramento District

December 2015

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AMERICAN RIVER WATERSHED
COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT
ATTACHMENT C
GEOTECHNICAL REPORT

US Army Corps of Engineers
Sacramento District

PREPARED BY

GEOTECHNICAL ENGINEERING BRANCH

October 2013

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ENCLOSURES

Enclosure 1 – Analyses Calculation Package
Enclosure 2 – Steady State Seepage and Landside Slope Stability Analyses Results
Enclosure 3 – Probabilistic Analyses and Levee Performance Curves

ABBREVIATIONS

ACN	Arcade Creek North
ACS	Arcade Creek South
ARCF	American River Common Features
ARFCD	American River Flood Control District
ARFCP	American River Flood Control Project
ARN	American River North Basin
ARS	American River South Basin
ASTM	American Society of Testing and Materials
ARWI	American River Watershed Investigation
BGS	Below Ground Surface
BTA	Blanket Theory Analysis
CB	Cement-Bentonite
CFS	Cubic Feet Per Second
CHP	California Highway Patrol
COS	City of Sacramento
CPT	Cone Penetrometer Test
CW	Cutoff Wall
CVFPB	Central Valley Flood Protection Board
CVFPP	Central Valley Flood Protection Plan
CY	Cubic Yard(s)
DBH	Diameter at Breast Height
DCN	Dry Creek North
DCS	Dry Creek South
DMM	Deep Mix Method
DSM	Deep Soil Mixing
DWR	Department of Water Resources
DWSC	Deep Water Ship Channel
EFA	Erosion Function Apparatus
EIP	Early Implementation Project
EM	Engineering Manual
ETL	Engineering Technical Letter
EVS	Environmental Visualization System
FEMA	Federal Emergency Management Agency
FOS	Factor(s) Of Safety
FOSM	First Order Second Moment
FT	Foot/Feet
FT/S	Feet Per Second
GER	Geotechnical Engineering Report
GIS	Geographical Information System
GMS	Groundwater Modeling Software
GRR	General Reevaluation Report
H:V	Horizontal To Vertical Ratio
HTRW	Hazardous, Toxic, and Radioactive Waste
HQUSACE	Headquarters U.S. Army Corps Of Engineers
IBC	International Building Code

IWM	In-Stream Woody Material
JET	Jet Erosion Test
K	Coefficient Of Permeability
K_H	Horizontal Hydraulic Conductivity Under Fully Saturated Conditions
K_H/K_V	Ratio Between The Vertical And Horizontal Conductivities; Anisotropic Ratio
K_V	Vertical Hydraulic Conductivity Under Fully Saturated Conditions
Ky	Yield Acceleration
LAR	Lower American River
LiDAR	Light Detection and Ranging
LM	Levee Mile
MA	Maintenance Area
MCDC	Magpie Creek Diversion Canal
MCY	Million Cubic Yards
MSWL	Mean Summer Water Level
MUSYM	Map Unit Symbol
Mw	Moment Magnitude
NAD83	North American Datum of 1983
NAFCI	Natomas Area Flood Control Improvement
NALP	North Area Levee Project
NAT	Natomas Basin
NAVD88	North American Vertical Datum of 1988
NCC	Natomas Cross Canal
NCEER	National Center for Earthquake Engineering Research
NCMWC	Natomas Central Mutual Water Company
NCSS	National Cooperative Soil Survey
NGA	Next Generation Attenuation
NGVD29	National Geodetic Vertical Datum of 1929
NEMDC	Natomas East Main Drainage Canal
NLD	National Levee Database
NLIP	Natomas Levee Improvement Project
NPACR	Natomas Post Authorization Change Report
NRCS	National Resources Conservation Service
NSF	National Science Foundation
NULE	Nonurban Levee Evaluations
OCR	Over-Consolidation Ratio
PACR	Post Authorization Change Report
PDT	Project Delivery Team
PED	Pre-Construction Engineering and Design
PGA	Peak Ground Acceleration
PGCC	Pleasant Grove Creek Canal
PGL	Policy Guidance Letter
Pr(f)	Probability of Failure
PSHA	Probabilistic Seismic Hazard Analysis
P1GDR	Phase 1 Geotechnical Data Report
P1GER	Phase 1 Geotechnical Engineering Report
QA	Quality Assurance

QC	Quality Control
RD	Reclamation District
RM	River Mile
SAFCA	Sacramento Area Flood Control Agency
SB	Soil-Bentonite
SCB	Soil-Cement-Bentonite
SGDR	Supplemental Geotechnical Data Report
SOP	Standard Operating Procedure
SPT	Standard Penetration Test
SRBPP	Sacramento River Bank Protection Project
SRFCP	Sacramento River Flood Control Project
SRN	Sacramento River North
SRS	Sacramento River South
SSURGO	Soil Survey Geographic Database
SUALRP	Sacramento Urban Area Levee Reconstruction Project
SWIF	System-Wide Improvement Framework Policy
TEC	Topographic Engineering Center
TM	Technical Memorandum
TRM	Technical Review Memorandum
ULE	Urban Levee Evaluations
USACE	U.S. Army Corps Of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Society
V:H	Vertical To Horizontal Ratio
$\overline{V}_{S30}$	Velocity Of The Upper 30 Meters
VVR	Vegetation Variance Request
WRDA	Water Resources Development Act
WSAFCA	West Sacramento Area Flood Control Agency
WSE	water surface elevation

1.0 INTRODUCTION

The following briefly outlines pertinent geotechnical information regarding a General Reevaluation Report (GRR) for the American River Common Features (ARCF) Project. This report presents the results of geotechnical analyses and feasibility level geotechnical design recommendations to address levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies within the ARCF GRR study area.

The project area includes portions of the Sacramento and American River Watersheds. The flood plain includes most of the developed portions of the City of Sacramento, the Natomas basin, and portions of Sacramento and Sutter Counties. The study area also includes other flood facilities, including the Fremont and Sacramento Weirs and Yolo Bypass. A Post Authorization Change Report (PACR) for the Natomas portion of the Common Features project and a Chief's Report for the Natomas Post Authorization Change Report (NPACR) were completed in December 2010. The remaining portion of the project, including potential Natomas Basin levee raises, is being addressed in this report.

The ARCF GRR study area, shown in Figure 1-1, has been divided into three basins; Natomas, American River North, and American River South, which were further subdivided into study reaches. This report covers the following areas:

- About 12 miles of the north and south banks of the American River
- About 33 miles of the east bank of the Sacramento River
- About 5 miles of the south bank of the Natomas Cross Canal (NCC)
- About 3 miles of the Pleasant Grove Creek Canal (PGCC)
- About 26 miles of the Natomas East Main Drainage Canal and tributaries (NEMDC)

The ARCF GRR study area has been divided into three basins; Natomas, American River North, and American River South, which were further subdivided into study reaches. For the purposes of the feasibility planning process, the three study area basins were further subdivided into reaches based on common properties (both technical and non technical), such as geographic and geomorphic features. The levees in the American River North Basin have been divided into nine planning reaches; ARN A, B, C, D, E, F, G, H, and I. The levees in the American River South Basin have been divided into seven planning reaches; ARS A, B, C, D, E, F, and G. The levees in the Natomas Basin have been divided into nine planning reaches; NAT A, B, C, D, E, F, G, H, and I.

The ARCF GRR is evaluating federal interest in alternatives to reduce flood risk in the study area. The ARCF GRR has identified several technical deficiencies associated with the flood risk management system protecting the study area. There are various alternatives under consideration to address these deficiencies and the geotechnical components of those alternatives are discussed and or evaluated in this report. The alternatives consist of a combination of structural measures to mitigate seepage, slope stability, erosion protection, and overtopping including the widening and construction of new levees on the Sacramento Bypass and Weir.

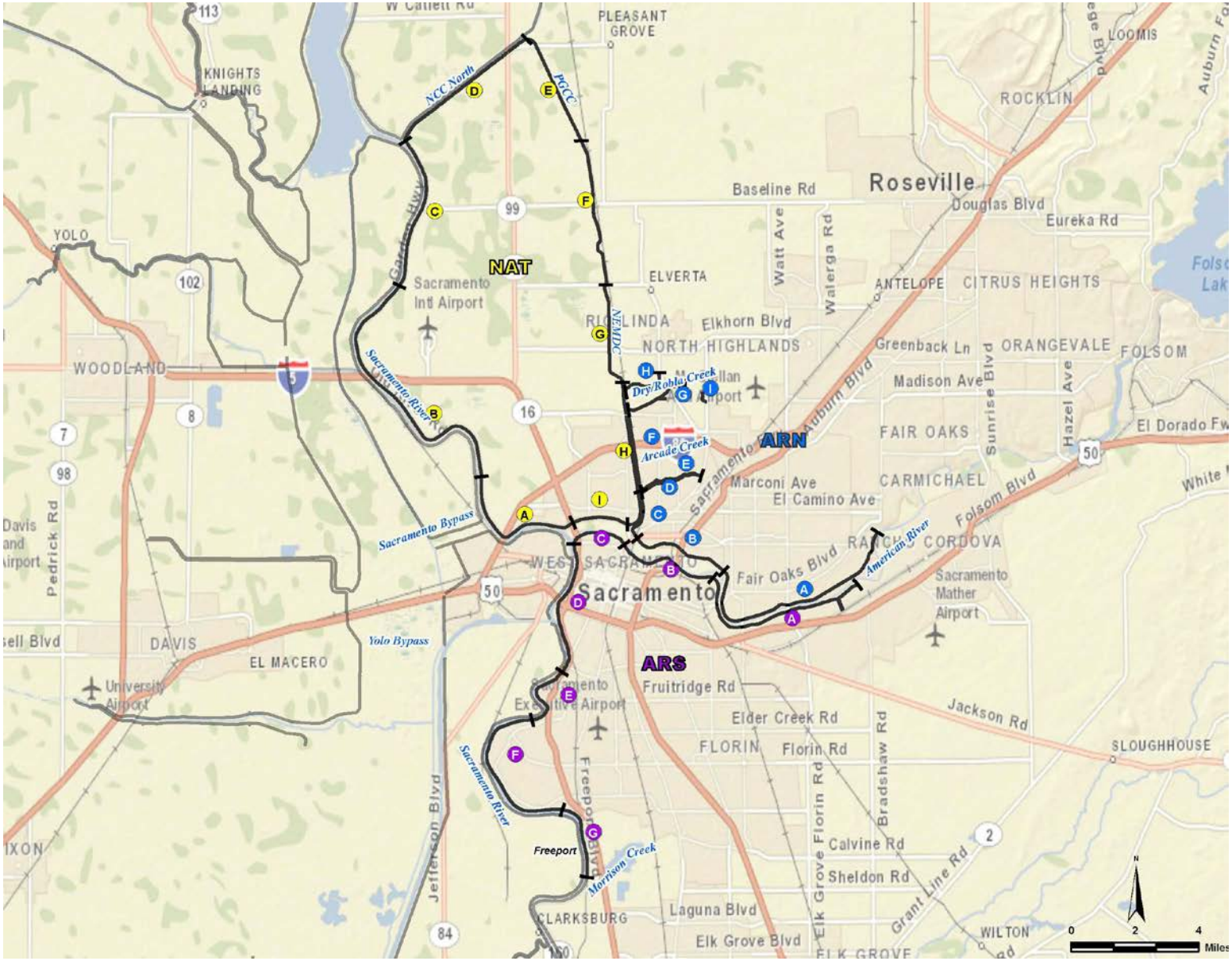

Figure 1-1: Study Area Map of the American River Common Features Project

2.0 GEOLOGY AND GEOMORPHOLOGY

2.1 GEOLOGIC SETTING

The ARCF GRR study area lies in the central portion of the Sacramento Valley which lies in the northern portion of the Great Valley Geomorphic Province of California. The Sacramento Valley lies between the northern Coast Ranges to the west and the northern Sierra Nevada to the east, and has been a depositional basin throughout most of the late Mesozoic and Cenozoic time. A large accumulation of sediments, estimated over two vertical miles in thickness in the Sacramento area, were deposited during cyclic transgressions and regressions of a shallow sea that once inundated the valley. This thick sequence of clastic sedimentary rock units was derived from adjoining easterly highlands erosion during the Late Jurassic period with interspersed Tertiary volcanics. They form bedrock units now buried in mid-basin valley areas. These bedrock units were covered by coalescing alluvial fans during Pliocene-Pleistocene periods by major ancestral west-flowing Sacramento Valley rivers (Feather, Yuba, Bear, and American). These rivers funneled large volumes of sediment into the Sacramento basin. Late Pleistocene and Holocene (Recent) alluvial deposits now cover low-lying areas. These deposits consist largely of reworked fan and stream materials deposited by meandering rivers prior to construction of existing flood control systems.

The Sacramento River is the main drainage feature of the region flowing generally southward from the Klamath Mountains to its discharge point into the Suisun Bay in the San Francisco Bay area. Located in central northern California, the Sacramento River is the largest river system and basin in the state. The 27,000 square mile Sacramento River Basin includes the eastern slopes of the Coast Ranges, Mount Shasta, and the western slopes of the southernmost region of the Cascades and the northern portion of the Sierra Nevada. The Sacramento River, stretching from the Oregon border to the Bay-Delta, carries 31% of the state’s total runoff water. Primary tributaries to the Sacramento River include the Pit, McCloud, Feather, and American Rivers. Within the Sacramento area, the Sacramento and American Rivers have been confined by man-made levees since the turn of the century. The confluence with the Sacramento River, only 20 feet above sea level, is subject to tidal fluctuation although more than 100 miles north of the Golden Gate and San Francisco Bay. Within the study area, these levees were generally constructed on Holocene age alluvial and fluvial sediments deposited by the current and historical Sacramento River and its tributaries. Pleistocene deposits underlie the Holocene deposits.

2.2 GEOMORPHOLOGY

Prior to the late Pleistocene (10,000 to 30,000 years ago), the Sacramento River Basin depositional environment was influenced by a lowered base level due to sea levels as low as 400 feet below present (Harden 1998). These lowered global sea levels would have had their greatest influence in present coastal areas such as the San Francisco Bay area, but based on interpretation of the depth to denser, coarser Pleistocene soils it is estimated that average river levels in this area could have been 50 to 60 feet below current levels. The rivers would have been characterized by high energy flow with greater downward erosion rather than deposition, and would have had greater capacity to carry and deposit sand and gravel deposits into the project

area. This older geomorphology is largely covered by the more recent (Holocene) sediments in the project area. The thick zone of materials deposited above the dense, older Pleistocene alluvial deposits are therefore less than 10,000 to 30,000 years old, which is reflected in these deposits consisting of very soft to firm clays and silts and abundant loose to medium dense sands.

The filling of the Sacramento Valley with sediments following the rise in sea level to the current level has significantly reduced the gradient of the rivers flowing down from the Sierra Nevada and Klamath Mountains (including the Sacramento and American Rivers). This gradient reduction has caused the energy of these rivers to transition from erosional to graded. Graded rivers are characterized by downward erosion that is less dominant and more directed toward side-to-side movements than down-cutting. The lateral energy of a graded river causes synchronous erosion and deposition in sweeping bands commonly referred to as meanders. The outside of the meander is a zone of erosion. Material removed by the river at this zone is then deposited downstream as point bars in zones of decreased velocity on the inside of the subsequent meanders. In this way, the river migrates laterally across the flood plain. Often this erosion is slowed where the river encounters more resistant materials in the flood plain. This allows the next closest upstream meander to catch up and gradually erode away the “neck” between the two meanders. Flooding often accelerates this process as the higher energy flows can more easily cut a new thalweg (base of the active channel). The result of the conjoining meanders is the straightening of the river across the opening of the neck and the creation of an abandoned bend in the river, commonly referred to as an oxbow lake.

2.3 HYDRAULIC MINING

Hydraulic mining activity in the Sierra Nevada during the mid- to late-1800s supplied a substantial amount of sediment to many river channels draining the Sierra Nevada, which resulted in aggradation of the channels and flooding due to decrease in channel cross section area. Gold dredging and mining operations have destroyed some fluvial deposits and surfaces, confounding the understanding of the long-term geomorphic history.

This phenomenon, coupled with a disastrous flood in 1862, prompted the channelization of the Sacramento and American Rivers and re-alignment of the American River to its present-day configuration, from the former confluence with the Sacramento River to about two miles upstream. It was hoped that these actions would provide flood control as well as stimulate the flushing of accumulated mining-derived sediment from the channel.

3.0 CONSTRUCTION HISTORY

A mix of Federal, State, and local agencies have been involved in flood control project construction and operation since levees were first constructed in California in the mid-1800's. Since the creation of the State Reclamation Board (now the Central Valley Flood Protection Board or CVFPB) in 1911 and the authorization of the Sacramento River Flood Control Project (SRFCP) in 1917, most levee improvements have been first Federally authorized by Congress, then subsequently authorized by the State Legislature.

The SRFCP was authorized by the Flood Control Act of 1917 (PL 64-367) as modified by the Acts of 1928, 1937, 1941 and 1950. Features of the SRFCP, in the study area, consisted of levees along the lower American River, NEMDC, Arcade and Dry (Linda) Creeks, PGCC, NCC, and Sacramento River improvements, including new and reconstructed levees. The American River Flood Control Project (ARFCP), authorized by the Flood Control Act of 1954 (PL 83-780), consisted of a levee along the north bank of the river, extending from the terminus of the SRFCP project levee near Cal Expo upstream about 8 miles to Carmichael Bluffs. The levee along the American River up to Mayhew Canal was enlarged in 1948. Bank protection was installed along the levee in 1951. The completed flood control system was documented in 1957 in a design memorandum, which included design water surface profiles. To this day, these are the profiles that govern the operation and maintenance requirements of the levee system.

3.1 AMERICAN RIVER LEVEES

The levees along the American River left bank were originally constructed in the late 1800s to early 1900s, likely using clamshell dredges with material sourced from the channel. The levees were then reconstructed on the left bank between 16th Street and Mayhew and on the north bank between NEMDC and Cal Expo with materials sourced from waterside borrow pits using scrapers, dozers, and compactors between 1947 and 1957. Waterside borrow material was used on the right bank of the American River from Carmichael Bluffs downstream to the upper end of the existing flood protection system near Cal Expo under the ARFCP in 1958. Figure 3-1 below represents a typical constructed levee section on the American River in the 1940’s through 1950’s.

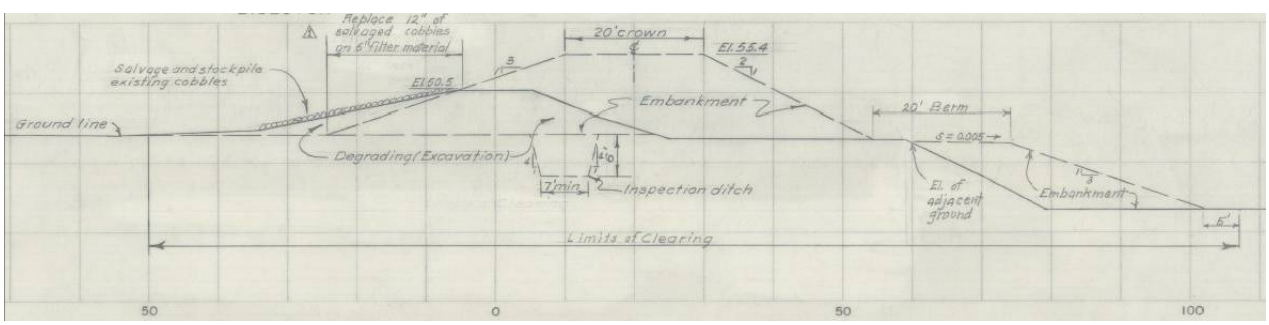

Figure 3-1: American River Typical Section 1940-1960

The ARCF Project was authorized by the WRDA 1996 and 1999 which included, seepage remediation and levee raising. Seepage remediation was completed by constructing a slurry cutoff wall to varying depths along the American River Right Bank Levee and Left Bank Levee

from the Mayhew Drain to the Sacramento River confluence. Due to restrictive site features, such as bridge and utility crossings, the cutoff wall was not constructed contiguously and gaps (windows) were left in the cutoff wall.

3.2 SACRAMENTO RIVER WEST LEVEE (SOUTH OF AMERICAN RIVER)

The levees along the Sacramento River south of the confluence with the American River were constructed by local interests using clamshell dredges excavating material from the Sacramento River in the early 1900's, Figure 3-2. This method of construction usually resulted in loose, sandy fill material that is deepest below the center of the levee. The current materials within the levee embankment are predominantly sands, silty sands, and cohesionless materials. A setback levee at the Edwards Break and riverbank protection was constructed in 1937 and in 1939 the Edwards Break levee slope had been rebuilt. In 1941 the levee was enlarged in the vicinity of Richfield Oil Co. Numerous riverbank and levee waterside slope protection were constructed along the Sacramento east bank levee. Shown below is the Dredge Neptune placing material at RM 57.3 in 1942 during the Sacramento Bank Protection Project.

Figure 3-2: Dredge Neptune at RM 57.3 in 1942

Under the SUALRP levee improvements were constructed along the Sacramento River between the NCC and Freeport. This included slurry cutoff walls constructed in the early 1990s varying in depth from 17 to 30 feet from the levee crest and were intended to address through-seepage. The American River Common Features, Pocket Geotechnical Project constructed a deep cutoff wall using deep soil mixing (DSM) in 2006 varying from 107 to 110 feet from the levee crest which is intended to address under-seepage. The Sacramento River East Bank Levee Under-Seepage Remediation Project, Pocket and Little Pocket Areas constructed a deep-mix method (DMM) cutoff wall in 2005 varying from 91 to 112 feet from the levee crest. This project also constructed an under-seepage cutoff wall using the DMM at the Sump 132 105 feet in depth.

3.3 SACRAMENTO RIVER WEST LEVEE (FROM NCC TO AMERICAN RIVER)

The levees protecting the Natomas Basin were constructed by a private mining and dredging company with the purpose of reclaiming and selling thousands of acres of farmland. The levees were constructed using large "clam shell" dredging machines. The work began in 1912 and was completed by the end of 1915. Based on typical construction schematics shown on basin-wide maps and historical literature, the levees along the Sacramento River were constructed in the following manner:

- A dragline was used to excavate a trench about 6 to 12 feet deep along the centerline of the levee alignment. The trench bottom width ranged from about 12 to 28 feet. The excavated material was deposited along both sides of the trench forming two small containment dikes.
- Hydraulic dredging operations placed material from the adjacent Sacramento River bottom into the excavation area between the dikes. This material consisted predominately of sands.
- The final levee configuration was achieved by covering the dredged sand with the adjacent dike materials. These materials consisted predominately of silt, clay, and fine sand, Figure 3-3.

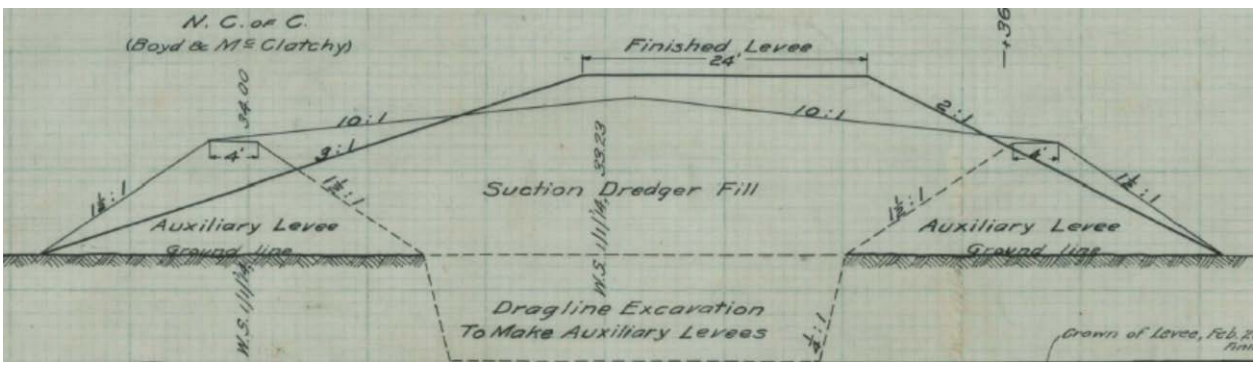

Figure 3-3: Sacramento River Typical Levee Section, 1912-1915

In 1991, between the Sacramento River and NCC confluence to Power Line Road, a drained stability berm was constructed to 10 feet in width extending to approximately half the levee height under the SUALRP. The berm was constructed over a drainage layer that extended as a chimney drain on the levee slope to prevent internal erosion due to seepage through the levee embankment. Filter fabric was placed between the drainage layer and the levee fill to preserve the functionality of the drainage layer. From Power Line Road to the confluence of the Sacramento and American rivers, an SCB cutoff wall was constructed to prevent through-seepage and internal erosion within the levee under SUALRP in 1994. The slurry wall was constructed to depths between 25 and 45 feet below the levee crest. The wall is considered to be hanging, as the tip is not "keyed in" to a lower impervious clay layer of the foundation.

3.4 NATOMAS CROSS CANAL SOUTH LEVEE

Construction on the south levee along the NCC began in 1909. The perimeter levees were constructed encompassing both RD 1000 and RD 1001 areas. In approximately 1912, clamshell dredgers were used to construct the drainage canal of what is now known as NCC between the two levee districts. Work was completed around 1914.

The NCC was excavated across an area that was not a preexisting drainage alignment. The clamshell dredges excavated the alignment of NCC by floating upon the excavated borrow channel located near the waterside levee toe. As the dredgers heaped spoils up from the channel, they were shaped into a levee configuration using small scrapers. The waterside slope was roughly at 3H:1V and the landside slope was about 2H:1V. The crest width was reported as 20 feet. A small core trench near the center of the embankment was also constructed, Figure 3-4.

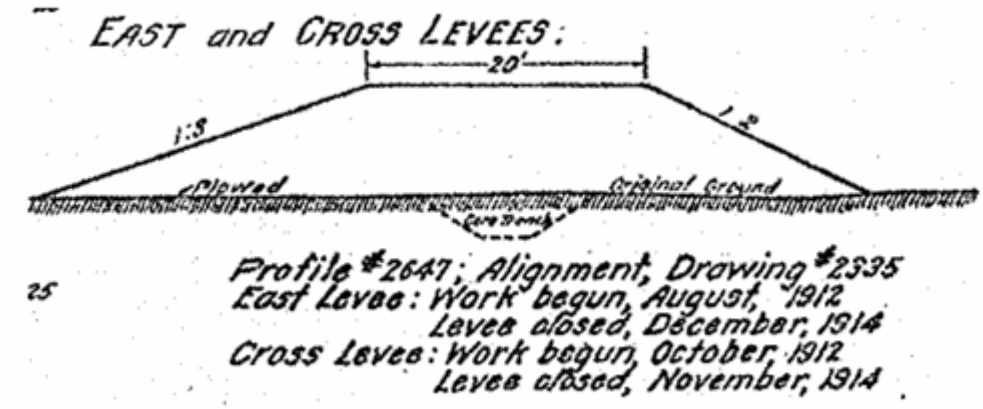

Figure 3-4: Natomas Cross Canal Typical Levee Section, 1912-1914

3.5 NEMDC, PGCC, ARCADE CREEK AND DRY CREEK LEVEES

The Natomas Company of California originally constructed the NEMDC and PGCC west levees from August 1912 to December 1914. A portion of the NEMDC levee was constructed using a clamshell dredge excavating from Steelhead Creek, but the majority of the NEMDC and PGCC west levees were constructed using horse-drawn excavators using material sourced from the channel.

From 1954 through 1958 the USACE completed construction and enlargement (widening and strengthening) portions of the NEMDC, PGCC, Arcade Creek, and Dry Creek levees. Portions of the NEMDC (east and west bank) and PGCC levees were enlarged to between 20 and 12 feet wide at the crest by placing additional material on the waterside levee slope. The NEMDC and PGCC levees were constructed with 3:1 waterside and 2:1 landside embankment slopes. The south bank levee of Arcade Creek was widened to have a 20-foot crest and the north bank levee was constructed (with a 20-foot levee crest). The south levee of Dry (Linda) Creek was constructed (with a 20-foot crest width). The Arcade and Cry Creek levees were constructed with 2:1 waterside and landside embankment slopes. The material was sourced from a waterside borrow trench that paralleled the levee alignment. Figure 3-5 shows a typical section from the 1958 enlargement of the NEMDC east levee.

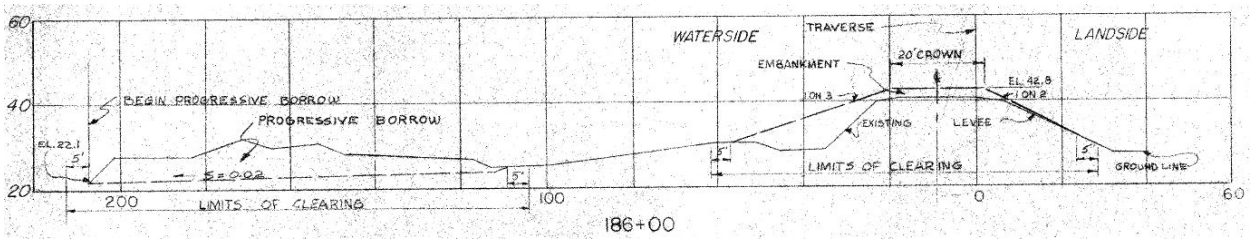

Figure 3-5: NEMDC Typical Levee Section (East Bank), 1958

SAFCA initiated construction of the North Area Local Project (NALP), in 1992 and completed work by 2001. Federal authorization occurred in 1993 under Section 9159 of the Defense Appropriation Act of 1993, as part Phase II of the Natomas Area Flood Control Improvement (NAFCI) Project of 1993, which was authorized by the SAFCA Board of Directors on April 28, 1996. The project consisted of levee embankment and floodwall improvements on the NEMDC east and west levee, Arcade Creek north and south levee, and construction of the Dry Creek north levee (see Figure 3-6).

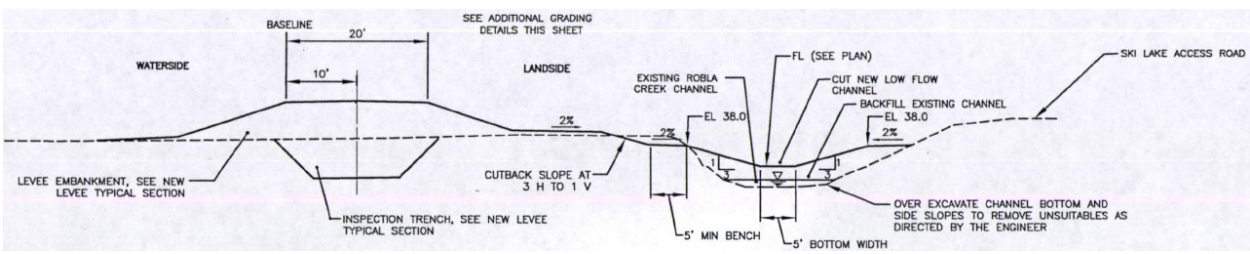

Figure 3-6: Robla Creek Typical Levee Section, 2001

4.0 PAST PERFORMANCE

The study area has experienced several large discharges in recorded history, the earliest was in 1850 when the City of Sacramento was founded and another, larger, flood occurred in January 1862, inundating and substantially damaging Sacramento. These flood events quickly spurred the construction of flood protection levees along many of the banks of the Sacramento River, as well as the cultural re-alignment of the American River in 1868. Additionally, a large flood in 1907 breeched the eastern Sacramento River levee near present day Derick Way (known as the "Edwards Break"), with subsequent flooding of reclamation districts on the eastern side of the river south to the Delta. Additional flood events occurred in 1907, the middle of the century in 1950 and 1955, and more recently in 1986 and 1997, despite the existence of the upstream Folsom Dam. At least eight large floods have occurred in the lower American and Sacramento River basins since Folsom Darn became operational, these occurred in 1955, 1963, 1964, 1969, 1970, 1980, 1982, and 1986. The early floods spurred construction of flood control levees along the lower American River near Sacramento, and the recent floods tested the performance and capacity of the modern levee system.

In February 1986 and January 1997, major storms in Northern California caused record flood flows on the Sacramento and American Rivers. Record high outflows from Folsom Dam and Reservoir, together with high flows in the Sacramento River, resulted in water levels rising above the design freeboard of levees protecting the Sacramento area. It is estimated that major sections of levees along the American and Sacramento rivers would likely have failed if the storms had lasted longer. These events caused undermining of the levee embankment and also washed away portions of the riverbank. Figure 4-1 below shows the erosion distress experienced on the American River as result of the 1986 event. Subsequently flood events in 1997, and late 2005 to early 2006 each caused minor surficial erosion along the American River.

Figure 4-1: 1986 Erosion Distress on the American River South Bank Near I-80

Flood events in 1986, 1997, and 2006 have also caused seepage at or near the landside levee toe as well as at distances of 2,500 to 4,000 feet landward. Seepage distress was experienced throughout the Sacramento River levee reaches. Further documentation including aerial photographs, and reports by landowners, detailed seepage boils as well as eroding and sloughing banks at locations of former channels and oxbows beginning in the late 1930's. Flood fighting (see Figure 4-2) has occurred throughout the Sacramento River reaches in both 1986 and 1997 as a response to seepage and stability concerns.

Figure 4-2: 1997 Flood Fighting on the Sacramento River in Natomas

5.0 GEOTECHNICAL REACH DESCRIPTION

American River North Basin

On the American River north bank (Reaches A and B), there is significant riparian habitat on a typically large waterside bench. In some areas, significant landside vegetation (mostly large trees) exists near the levee toe or on the levee slope. On the landside numerous encroachments include; fences at or near the landside levee toe, parking lots built, and residences. In Reach A the levee embankment is predominantly a silty sand to silt material constructed over a thick silt to silty sand blanket which is underlain by a poorly graded gravel aquifer. While in Reach B the levee embankment is predominantly a lean clay material constructed over a silt and lean clay blanket varying in thickness which is underlain by a silty sand and gravel aquifer. In both Reaches A and B a keyed in cutoff wall was constructed under WRDA 1996/1999 to mitigate underseepage.

On the East Side Tributaries (Reaches C through H), there is sparse vegetation on the levee slopes and adjacent to the embankment. On the landside of the NEMDC (Reaches C and F) levee embankment a railroad embankment is adjacent to the levee. Along approximately half of the Reach E alignment a concrete lined ditch is located at the landside levee toe which is approximately 5 to 10 feet deep. The NEMDC (Reaches C and F) levee embankment varies from clay sand and silt to lean clay and silt material. A lean clay blanket of variable thickness is underlain by a silty sand and poorly graded sand aquifer. On Arcade Creek (Reaches D and E), the levee embankment is predominantly clayey sand, lean clay, and silt constructed over a thin lean clay and silt blanket underlain by a silty sand to poorly graded sand aquifer. The Dry/Robla Creek (Reaches G and H) levee embankment is predominantly a clayey sand and silt constructed over a clayey sand, lean clay, and silt blanket of varying thickness. The blanket is underlain by a silty sand aquifer.

Reach I includes both leveed and non leveed portions of Magpie Creek and the Magpie Creek Diversion Canal (MCDC) between Rose Street, where the Magpie Diversion Canal flows into Robla Creek, to the west and McClellan Air Force Base to the east. The levees associated along Magpie Creek and the MCDC are composed of silty sand and is underlain by predominantly dense to very silty sand and stiff to hard sandy silt with a somewhat prevalent hardpan layer about 4 feet thick, 2 to 6 feet below grade.

American River South Basin

On the American River south bank (Reaches A, B and C), there is significant riparian habitat on a typically large waterside bench. In some areas, significant landside vegetation (mostly large trees) exists near the levee toe or on the levee slope. On the landside numerous encroachments include; fences at or near the landside levee toe, power poles, parking lots, and residences. The Reach A and B levee embankment is predominantly composed of silty sand and sandy silt while the Reach C levee is predominantly poorly graded sand. The levees are underlain by a thick silt to silty sand blanket which is underlain by a sand and gravel aquifer. In both Reaches A and B a

keyed in cutoff wall, and in Reach C a hanging cutoff wall, were constructed under WRDA 1996/1999 to mitigate underseepage.

On the Sacramento River, south of the American River confluence, (Reaches D through G), there is significant waterside and landside vegetation on both the slopes and at the toe of the levee. In all of the reaches, significant urban development has occurred up to the levee toe and/or the landside levee slope. Old Town Sacramento surrounds Reach D, Reaches E and F are residential areas of the Little Pocket and Pocket neighborhoods, and Reach G is the town of Freeport and an adjacent railroad alignment. On the landside numerous encroachments include; fences at or near the landside levee toe and across the levee crest, residences, commercial structures, stairways cut into the landside levee slope, and pools. The levee embankment is predominantly poorly graded sand and silty sand constructed over a lean clay and sandy silt blanket of varying thickness which is underlain by a poorly graded sand aquifer. A through-seepage cutoff wall was constructed which extends to a depth of approximately 18 to 40 feet in portions of Reach D and G and all of E through F. Sections of deep cutoff wall to approximately 110 feet were constructed in portions of Reaches E and F.

Natomas Basin

In the Natomas Basin, on the Sacramento River east bank (Reaches A, B, and C), the there is significant landside and waterside vegetation. On the waterside of the levee crest (levee slope and toe) there exists almost continuous residential structures and related features such as, driveways, out structures, and landscaping. On the landside numerous encroachments are mostly due to agricultural uses (ditches, utilities, and structures) in Reaches B and C and residential in Reach A. The levee embankment was constructed of hydraulically placed sandy core between clay trainer dikes. The trainer dikes were constructed of material obtained by excavating the natural impervious blanket. The levee was constructed over a lean clay and silt blanket underlain by a silty sand and poorly graded sand aquifer. In Reach A and portions of Reach B a shallow through seepage cutoff wall was constructed and in the rest of Reach B and C a landside stability berm. As part of the NPACR and adjacent levee is proposed for construction on the landside of the existing levee with either/or both a deep cutoff wall or landside seepage berm to mitigate levee underseepage.

On the Natomas Cross Canal south bank (Reach D), there is limited vegetation on both the landside and waterside of the levee, which was constructed on the canal bank. The levee embankment is predominantly a silt and clayey sand material constructed on a thin silt blanket which is underlain by poorly graded sand and silty sand aquifer. For a portion of the reach a landside stability berm was constructed to half the existing levee height. As part of the NPACR a cutoff wall is proposed for construction to mitigate levee underseepage.

On the PGCC and NEMDC west bank (Reaches E through H), there is vegetation on the waterside and landside of the levee. Encroachments are sparse for Reaches E through G (mostly agricultural uses) but in Reach H commercial development exists at the landside toe. The levee embankment is predominantly a clayey sand sandy lean clay constructed on a thin lean clay blanket which is underlain by silty sand to poorly graded sand aquifer. As part of the NPACR a

cutoff wall or landside seepage berm is proposed for construction to mitigate levee underseepage.

On the American River north bank (Reach I) there is significant vegetation on both the waterside and landside of the levee; predominantly comprised of trees. Encroachments include primarily commercial buildings near the landside levee toe, and parking lots adjacent to the levee embankment. The levee embankment is predominantly silty sand constructed on a sandy silt blanket which is underlain by silty sand and poorly graded sand aquifer. As part of the NPACR a cutoff wall is proposed for construction to mitigate levee underseepage.

6.0 LEVEE FAILURE MODES AND ANALYSES CRITERIA

For the purposes of problem identification and alternatives analysis, several different failure modes have been evaluated for the without project condition. The failure modes included seepage (under and through), slope stability, erosion, overtopping and seismic.

Steady state seepage analysis considered a maximum allowable vertical exit gradient at the toe of the levee to be less than 0.5 for the water at the design elevation and 0.80 for the water at the top of levee elevation. For landside seepage berms a maximum gradient of 0.8 is allowable at the berm toe. The minimum required factor of safety for the design water surface elevation for the landside steady state slope stability analysis was 1.40 and 1.20 for the top of levee water surface elevation.

The main purpose of seismic vulnerability analyses was to identify the potential seismic performance of a levee. Although seismic remediation generally will not be implemented based on these analysis results, a levee's seismic degradation potential should be considered during selection of a static remediation, or in developing an emergency action plan to be implemented following an earthquake. For the most critical category of levee (e.g., urban levees that are frequently hydraulically loaded) the following displacements are acceptable:

- Any deformation inducing crest displacement of 1 foot or less, unless larger lateral movements comprise the ability of foundation cut-offs or toe drains, etc. to provide for safe retention of high water.
- If more than 1 foot of seismic displacement is predicted, deformation is still acceptable if the levee continues to ensure water retention with 3 feet of freeboard for a 200-year flood event.
- If other safety criteria are met (e.g., cracking that can be repaired in a few days).

The typical USACE levee section, established by EM 1110-2-1913, is nationally considered to have a minimum 10-foot crest with 2:1 (horizontal: vertical) waterside and landside slopes. According to the Sacramento District 1969 "Design Manual for Levee Construction" levees should be constructed with 3:1 waterside and 2:1 landside slopes with either a 20 or 12-foot levee crest width for main stream or tributary levees respectively. The Sacramento District Geotechnical Engineering Branch, SOP-003 *Geotechnical Levee Practice*, suggests a 20-foot crest width with 3:1 waterside and landside slopes except existing levees with good past performance exists where existing 2:1 slopes are acceptable.

Vegetation, encroachment, and access policy includes EM 1110-2-1913, SOP 03, and ETL 1110-2-571 "Guidelines for Landscaping and Vegetation Management at Levees, Floodwalls, Embankments Dams, and Appurtenant Structures". The vegetation-free zone, as established by ETL 1110-2-571, is a three-dimensional corridor surrounding all levees, floodwalls, and critical appurtenant structures in a flood damage reduction system. The vegetation-free zone applies to all vegetation except grass. The minimum height of the corridor is 8 feet, measured vertically from any point on the ground. The minimum width of the corridor is the width of the flood-control structure (Levee toes or floodwall stem), plus 15 feet on each side, measured from the outer edge of the outermost critical structure.

7.0 TYPICAL LEVEE IMPROVEMENT MEASURES

Where levee height, geometry, erosion, access, vegetation, seepage, and slope stability deficiencies were identified (criteria not met) improvement measures consisting of cutoff walls, seepage berms, relief wells, stability berms, geotextile reinforcement, flattened embankment slopes, flood walls, retaining walls, sliver fills, and various other measures could be implemented.

Seepage cutoff walls are vertical walls of low hydraulic conductivity material constructed through the embankment and foundation to cut off potential through seepage and underseepage. In order to be effective for underseepage mitigation, cutoff walls usually tie into an impervious sublayer. The conventional method using a long stick and boom excavator has a maximum depth of 70 to 80 feet. Deeper cutoff walls, up to about 150 feet could be excavated using cable excavation method with crane rigs. Mix-in-place methods of cutoff wall construction include deep mixing method, jet grouting, and cutter soil mixing. Deep Mixing Method uses specialized construction equipment to mix the soil with bentonite and cement in situ and is capable of depths more than 100 feet. Pressure relief wells relieve excess pore pressures that can build up beneath a surficial blanket layer to reduce exit gradient. Relief wells collect seepage and bring it to the surface where it can be discharged freely on the ground surface or collected and drained away from the levee toe. Seepage berms are earth structures built at the landside toe that provide additional weight to prevent blanket layer heave, reduce exit gradients, and can allow safe exit of underseepage. The minimum seepage berm width is typically four times the levee height and the maximum width is generally 300 to 400 feet.

Slope flattening is a mechanical method to repair a slope that may not have stable slopes. Both the waterside and landside slopes can be graded using construction equipment. In most cases, this process requires the removal of all vegetation and encroachments from the levee slope being flattened. Slopes are typically flattened to 3H:1V to 5H:1V. Stability berms are constructed of a random fill material placed over blanket and chimney drainage features to capture seepage through the levee. A thin filter sand layer is placed between the drainage layer and the levee embankment and native soils. Drained stability berms have the benefit of also reducing susceptibility to through seepage. Geotextile is a type of synthetic material that is primarily used for soil reinforcement within an embankment. Geotextile is a woven pervious sheet of fabric constructed of synthetic plastic fibers. Geotextiles only provide reinforcement in tension, thus they are primarily buried within a soil at the tension surface to strengthen the soil.

Floodwalls are an efficient, space-conserving method for containing unusually high water surface elevations. They are primarily constructed from pre-fabricated materials, although they may be cast or constructed in place, and are constructed almost completely upright. Floodwalls are typically located along a levee hinge point to allow vehicular access along the crown. To address deficiencies found in the required levee freeboard various methods of raising the existing levee crown elevation could be implemented. A crown only levee raise assumes that the levee crown is currently wide enough to support the placement of additional embankment material while maintaining the minimum allowable crown width upon the completion of the raise. A full levee raise includes an embankment raise from the waterside crown hinge point upward at a

3H:1V slope, establishing a new crown width, and then down the landside at a new 3H:1V slope).

To protect against waterside erosion in areas where a waterside berm exists, a launchable rock trench may be constructed. This is accomplished by placing rip-rap a certain distance on the waterside slope and excavating a trench at the waterside toe, or where the waterside slope meets the berm. Rip-rap is then placed in the trench and then covered with random fill. As the waterside berm is erodes, it will eventually reach the launchable rock trench. At this point, the undermining action of the erosion event and soils surrounding the trench will allow for the rip-rap contained in the trench to “launch” into the void created adjacent to the trench. In areas that have no or minimal waterside berm, on bank rip-rap is placed on the waterside levee slope to protect against erosion. This entails filling the eroded portion of the bank and installing stone protection along the levee slope from the base of the erosion area to the top of the erosion area. Vegetation would be limited to grass. If there is a natural bank distinct from the levee that requires erosion protection, it would be treated with stone protection.

The purpose of the toe access easement is to allow for necessary maintenance, inspection, and floodfight access. For the ARCF project, the Project Delivery Team (PDT) has determined that a minimum toe access easement of 10 feet is required in association with other levee improvements. The actual toe access may vary depending on site specific constraints. Where vegetation management standards are not met, that levee section must be brought into compliance or a variance may be applied to a levee system or portion of that system to provide for the same levee functionality as intended in ETL 1110-2-571. In consideration for a vegetation variance request (VVR), the VVR will preserve, protect, and enhance the natural resources of the levee system or segment.

8.0 CROSS-SECTION SELECTION

Cross-sections for geotechnical analysis were selected to represent critical surface and subsurface conditions of each reach. The topography of each reach is inherently variable. The existence of access ramps on both landside and waterside of the levee, railroads running perpendicular and parallel to the levee, and/or pump stations or other structures built up adjacent to the levee section create difficulties to discern the typical versus critical cross-section. The sections were selected based on subsurface data, laboratory test results, geomorphology, surface conditions, field reconnaissance, historical performance, and levee geometry. The ground surface elevations used in the cross-sections were based on a LiDAR (light detection and ranging) survey completed in November 2008 for the DWR, ULE project. The natural soil layers were delineated based on boring logs and laboratory test results. Elevation references in this report are in feet and are based on the North American Vertical Datum of 1988 (NAVD88) unless otherwise noted. All horizontal references in this report are in feet and are based on the California State Plane, Zone II, North American Datum of 1983 (NAD83). Plate 1 shows the relationship between LM, RM, and stationing that were used to describe the location of the cross-sections. Table 8-1 and Plate 2 presents the cross-sections where geteochnical analyses were performed, and used in the economic analyses.

Table 8-1: Index Point Locations

Basin	Reach	Channel	Bank	Unit	Levee Mile
ARN	A	American River	North	9	1.32
ARN	E	Arcade Creek	North	7	0.90
ARS	B	American River	South	4	3.90
ARS	F	Sacramento River	East	1	5.92
NAT	D	NCC	South	2	1.17

9.0 HYDRAULIC LOADING CONDITIONS

Water surface profiles for the ARCF GRR study area were obtained from the Hydraulics and Hydrology Branch, Sacramento District. The profiles provide water surface elevations in NAVD 88 by river mile for various flood frequencies. Deterministic seepage and stability analyses were performed for various flood frequencies typically incorporating the 25yr, 50yr, 100yr, 200yr, 500yr, and top of levee. The probabilistic analyses were performed for a range of stages not correlated to flood frequency, but which represented stages from no head (landside toe of levee) to maximum head (top of levee).

During the preparation of this report, the hydraulic model was in the process being revised and updated. Due to the detailed review process required of the hydraulic model update, the decision was made to perform the deterministic analyses using draft hydraulic model water surface profiles for various flood frequencies. Water surface profiles for deterministic seepage and slope stability analyses for the Natomas Basin were based on the previous hydraulic model dated December 2010, for the American River North Basin (ARN) Reaches A and B and American River South Basin (ARS) Reaches A through G were based on a draft update dated July 2011, and for ARN Reaches C through H were based on a draft update dated March 2012. The various different models have a variability of 1 to 3 feet of stage for the same flood frequency.
Table 9-1 below summarizes the water surface elevations deterministically analyzed at each index point, by basin.

Table 9-1: Analyses Water Surface Elevations

Index Point	Event	Stage	Head
ARN Reach A U9 LM 1.32	Crest	52.95	9.69
	500yr	55.83	12.57
	200yr	51.1	7.84
	100yr	46.27	3.01
	50yr	46.16	2.9
	25yr	46.08	2.82
ARN Reach E U7 LM 0.90	Crest	43.94	12.25
	500yr	46.12	14.43
	200yr	41.34	9.65
	100yr	39.08	7.39
	50yr	37.68	5.99
	25yr	35.34	3.65
ARS Reach B U4 LM 3.90	Crest	48.83	16.03
	500yr	47.76	14.96
	200yr	41.31	8.51
	100yr	38.13	5.33
	50yr	37.73	4.93
	25yr	37.41	4.61

Index Point	Event	Stage	Head
ARS Reach F U1 LM 5.92	Crest	33.41	17.96
	500yr	33.33	17.88
	200yr	32.05	16.6
	100yr	30.33	14.88
	50yr	29.65	14.2
	25yr	29.03	13.58
NAT Reach D U4 LM 1.17	Crest	44.85	15.3
	500yr	45.16	N/A
	200yr	44.23	14.68
	100yr	42.84	13.29
	50yr	41.88	12.33
	25yr	41.11	11.56

10.0 SEEPAGE AND SLOPE STABILITY ANALYSES

Deterministic steady state seepage analysis was performed using the finite element program SEEP2D within GMS 6.5 (Groundwater Modeling System). Results from the seepage analysis were used to calculate average vertical exit gradients at the landside levee toe and/or at a more critical location near the levee toe if applicable, for example at the invert of the empty drainage ditch. The pore pressures and/or phreatic surfaces were exported to UTEXAS4.0 for use in slope stability analysis.

Boundary conditions along the waterside ground surface from the waterside model limits to the levee slope were assigned as fixed total head conditions corresponding to the analyzed water elevation. On the landside, exit face boundary conditions are applied from the landside crest hinge point to landside extents of the model. All other boundaries not explicitly assigned a condition are assumed by the program to be no flow which include both vertical faces of the model and the bottom nodes. The landside model extents were extended 2,000 feet from the levee centerline and for the waterside model extents to the channel centerline.

Embankment stability against shear failure was analyzed using the UTEXAS4.0 software package for steady state conditions. Analyses to find factors of safety against sliding were conducted using a floating grid automatic circular failure surface search routine to identify the critical failure surfaces with Spencer Procedure within the embankment and/or foundation. The Spencer Procedure satisfies both force and moment equilibrium for each slice. A minimum weight restriction was applied to the slices within the failure surface to eliminate surficial failure surfaces. Where tensile stresses exist on the failure surface, a water filled crack depth was introduced to eliminate the tensile stresses, but not compressive stresses.

Material properties including hydraulic conductivity for seepage analysis and drained (effective) shear strength and unit weight for slope stability analysis were developed based on a review of field and laboratory data that was then generalized into appropriate parameters by material type. The stratigraphy of the existing levee cross-section was divided into unique layers typically consisting of levee embankment fill, foundation or blanket layer, pervious aquifer layers separated by an aquitard, and a deeper fine grained layer. Analysis material parameters were assigned considering saturated conditions.

The results of the without project seepage and slope stability analyses indicate that the levees in ARN Reaches C through F and ARS Reaches D through G did not meet minimum criteria. The analyses showed that the levees did not meet criteria at varying flood frequencies typically between the 25 and 200 year events. In general, the analyses identified underseepage deficiencies and/or underseepage related slope stability deficiencies. Therefore, the with project analyses typically included deep cutoff walls which resulted in the with project levee analyses satisfying criteria.

10.1 ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

The without project conditions analyses includes the WRDA 1996/1999 cutoff wall and met criteria for both seepage gradients and slope stability factors of safety. As no seepage and stability deficiencies exist, no further improvements are recommended. Figure 10-1 displays steady state seepage and landside slope stability results for analyzed flood frequencies.

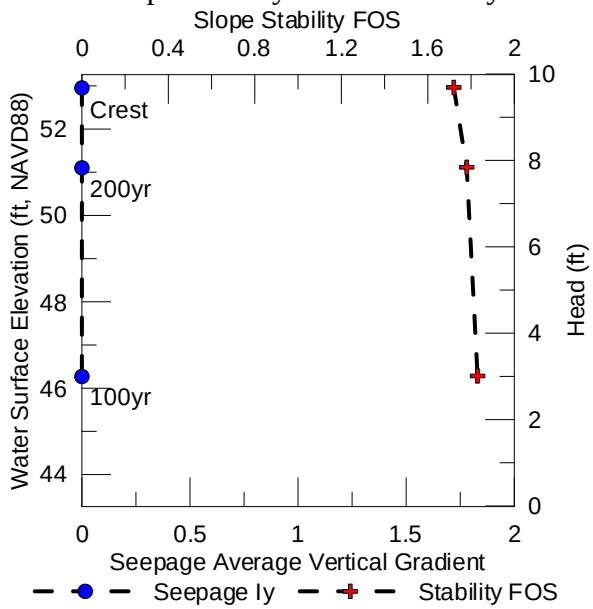

Figure 10-1: ARN Reach A U9 LM 1.32 Without Project Analyses Results

10.2 ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

The without project conditions seepage analysis of the Arcade Creek north levee have shown the potential for seepage gradients to exceed criteria beginning at the 100 year flood frequency event due to a thin clay blanket underlain by poorly graded sand layer. Related to the underseepage deficiency, slope stability factors of safety do not meet criteria beginning at the 50 year flood frequency event. The 100 year flood frequency event corresponds to a water surface elevation of 39.08 feet and 7.39 feet of head and the 50 year flood frequency event corresponds to a water surface elevation of 37.68 feet and 5.99 feet of head. Additionally, an open drainage ditch to the landside levee toe from NEMDC to Norwood Avenue amplifies the slope stability deficiency. With project conditions analyses addressed the underseepage and slope stability deficiencies by incorporating a cutoff wall be keyed-in to a low permeability confining layer at elevation –6.0 feet. With the improvement measures described above seepage and stability analyses met criteria. Figure 10-2 displays the without project conditions analyses results and Figure 10-3 displays the with project analyses results for analyzed flood frequencies.

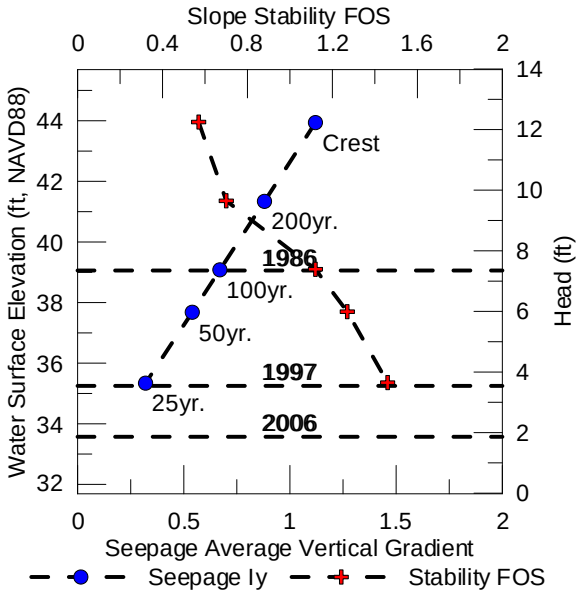

Figure 10-2: ARN Reach D U7 LM 0.90 Without Project Analyses Results

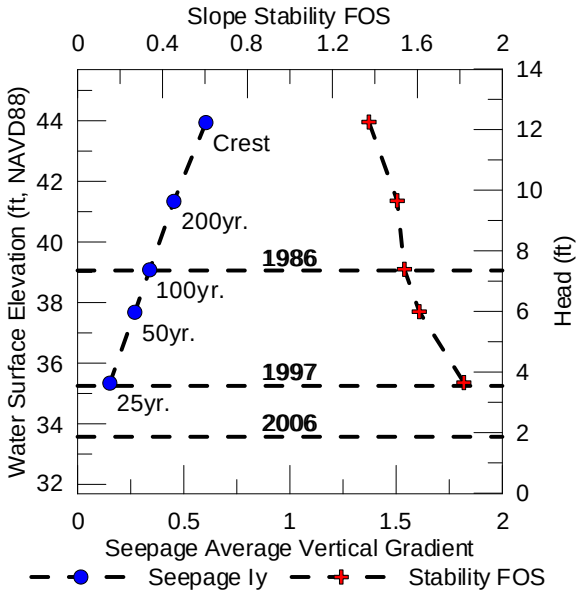

Figure 10-3: ARN Reach D U7 LM 0.90 With Project Analyses Results

10.3 ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

The without project conditions analyses includes the WRDA 1996/1999 cutoff wall and met criteria for both seepage gradients and slope stability factors of safety. As no seepage and stability deficiencies exist, no further improvements are recommended. Figure 10-4 displays steady state seepage and landside slope stability results for analyzed flood frequencies.

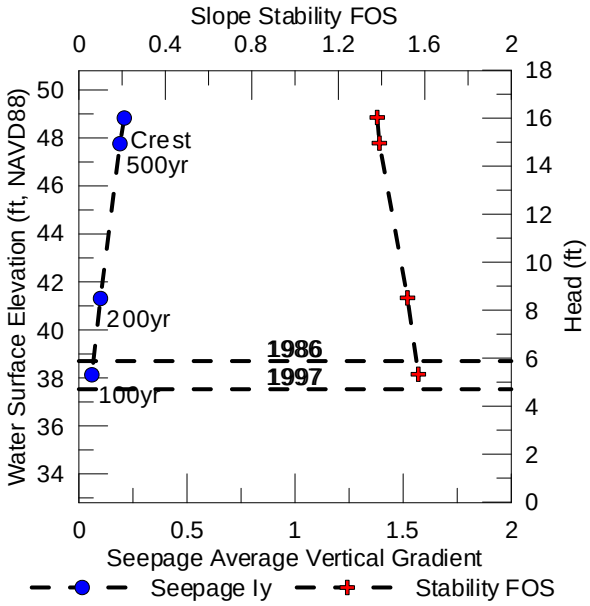

Figure 10-4: ARS Reach B U4 LM 3.90 Without Project Analyses Results

10.4 ARS REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

The without project conditions analysis on the Sacramento River, at this location, included a through seepage cutoff wall constructed by the SUALRP in the early 1990's. Slope stabilty analysis resulted in factors of safety below criteria beginning at the 25 year flood frequency event, which corresponded to a water surface elevation of 29.03 feet and 13.58 feet of head. Seepage analysis at the 25 year flood frequency event through crest water surface elevation indicated marginal underseepage gradients (0.4 to 0.5). A review of past performance indicated that seepage and boils were observed at numerous locations both before (1995) and after (1998) the construction of the through cutoff wall. Past flood event stages were compared to analyzed flood frequencies and the 1997 event (maximum recorded stage) was comparable to the 25 year flood frequency. The past performance is in agreement with the seepage and stability analyses results. With project conditions analyses addressed the underseepage deficiencies by incorporating a keyed-in cutoff wall to tip elevation -105.0 feet. Figure 10-5 displays the without project conditions analyses results and Figure 10-6 displays the with project analyses results for analyzed flood frequencies.

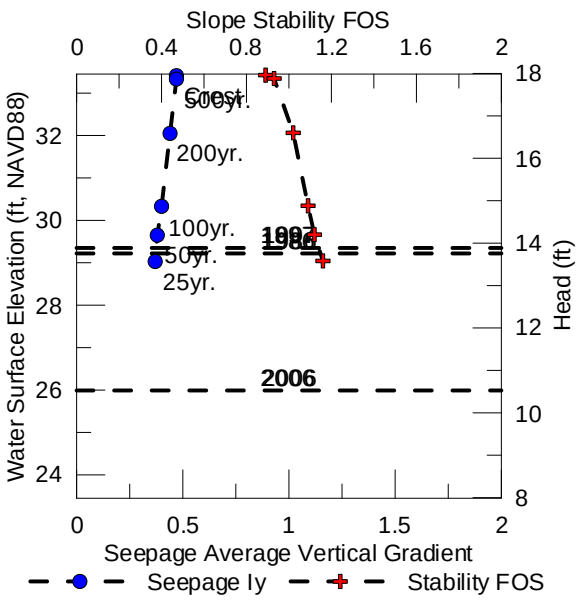

Figure 10-5: ARS Reach F U1 LM 5.92 Without Project Analyses Results

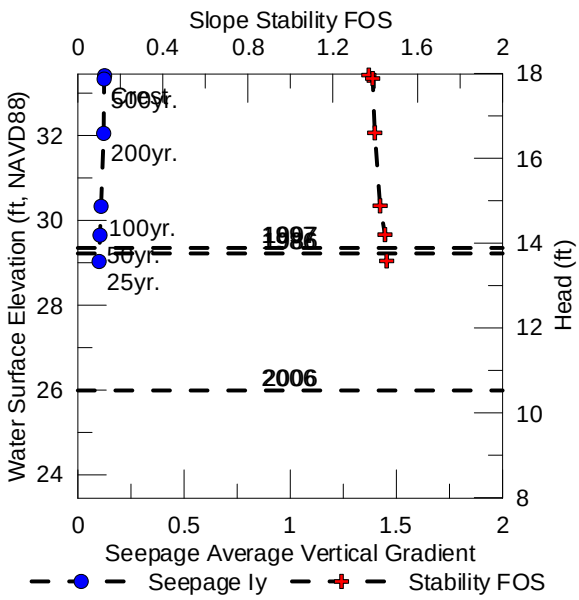

Figure 10-6: ARS Reach F U1 LM 5.92 With Project Analyses Results

10.5 NAT REACH D – NCC SOUTH – U1 LM 1.17

The without project conditions analyses includes the NPACR cutoff wall which satisfies criteria for both seepage gradients and slope stability factors of safety. The ARCF GRR included a levee raise, the NPACR analyses section met top of levee analyses criteria with the raise. Figure 10-7 displays steady state seepage and landside slope stability results for analyzed flood frequencies.

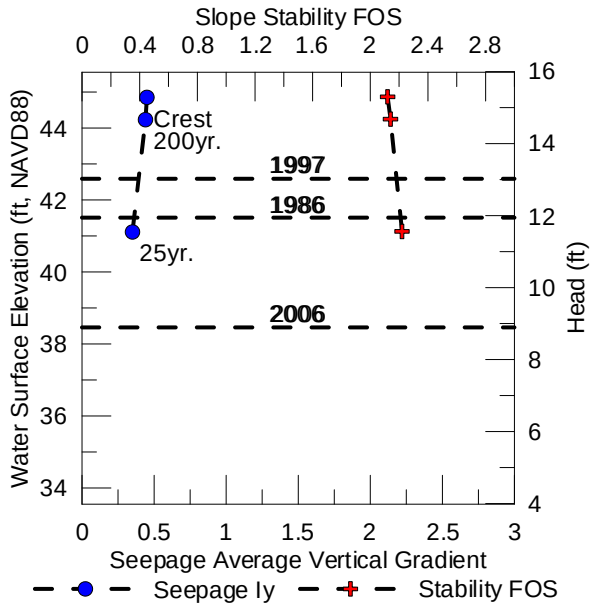

Figure 10-7: NAT Reach D U1 LM 1.17 Without Project Analyses Results

11.0 EROSION ASSESSMENT

The American River levees were originally intended to convey a release from Folsom Dam of 115,000 cfs. During several events since the construction of Folsom Dam, flows have exceeded design capacity and caused significant erosion distress. Additionally, the objective release from Folsom Dam is currently under review as part of the Folsom Dam Reoperations Study and the Joint Federal Project is currently constructing improvements to the dam for a release of 160,000 cfs.

Insufficient geotechnical data were available to adequately support existing and proposed channel stability analyses and potential design recommendations. Specifically the geotechnical and geologic study focused on characterization of soil properties through exploration and testing, geologic mapping, and 3-dimensional modeling of the subsurface stratigraphy. Additional geotechnical data was generated to characterize the material comprising the existing channel bed between the Right and Left bank levees of Lower American River (LAR) between River Mile (RM) 5.0 and 11.0. Specifically, the geotechnical study was directed to investigation the location and properties of a potentially erosionally resistant unit, better represent and organize the existing geotechnical data, and improve upon existing geologic mapping.

Subsurface exploration, soil borings and CPT, and subsequent laboratory testing were performed in support of the various tasks associated with studying erosion on the LAR. Relatively undisturbed samples were collected of the potentially erosionally resistant unit for erosion rate testing to be used in hydraulic modeling and analyses. Additional subsurface investigation consisted performing several geoelectrical surveys of the LAR channel and floodplain between RM 5.5 and RM 11.0 to characterize the extent and thickness of lithologic units that may have differing scour potential. The erosion resistance of the LAR was further assessed by performing Jet Erosion Tests (JET) and Erosion Function Apparatus (EFA) testing on undisturbed samples of cohesive materials located near the bed elevation of the LAR. The test results showed that the erodibility of each sample was related to the geologic unit and that most of the specimens within the Fair Oaks formation (below the erosionally resistant surface) could be categorized as Moderate Resistant to Very Resistant. Similarly, in general, the layer above erosionally resistant surface could be categorized as Very Erodible to Erodible.

Fugro Consultants performed the geologic portion of the erosion study, key findings from their report, *Lower American River Stratigraphic and Geomorphic Mapping Report* (2012), are reproduced below. Two levels of investigation were performed: (1) detailed mapping and analysis of the geologic deposits between the levees from RM 5.0 to 11.0, and (2) development of reconnaissance mapping along the channel corridor between RM 0.0 to 5.5 and RM 11.0 to 22.4. Detailed geologic mapping, as well as petrographic and pedogenic analyses, completed during this study demonstrated the presence of two potentially erosion-resistant units. These were: (1) a moderately cohesive silty and sandy interbed of relatively limited lateral and longitudinal extent within a thicker package of loose Holocene sediments (the “upper” unit); and (2) much thicker, more widespread relatively erosion-resistant deposits associated with the Pleistocene-aged Fair Oaks formation of Shlemon (1967) (the “lower unit”). Figure 11-1 presents a generalized stratigraphic section.

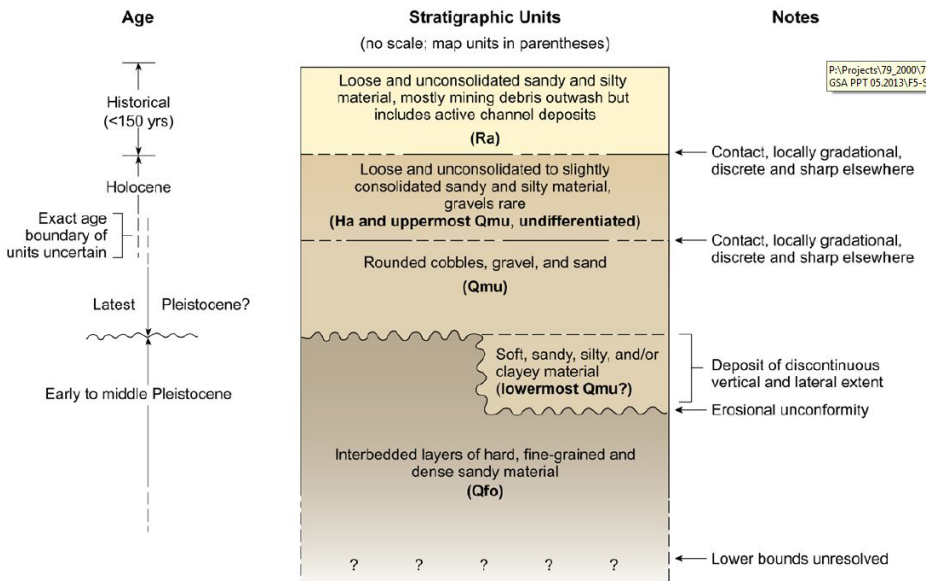

Figure 11-1: Generalized, Composite Stratigraphic Section of the Lower American River

A 3-dimensional (3D) stratigraphic model of the LAR study reach was developed by incorporating both existing and newly collected geotechnical and geologic data. The model described the stratigraphy and subsurface conditions of the study reach and help evaluate the stratigraphic susceptibility of this reach to erosion near the levee banks. Figure 11-2 presents a site specific representation of the generalized section presented in Figure 11-1.

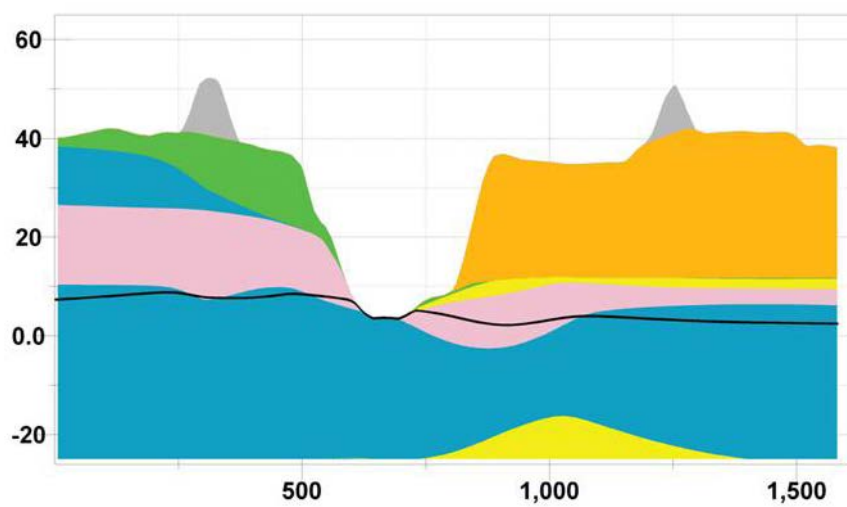

Figure 11-1: 3D Stratigraphic Model Section 11 Near RM 7.2

A review of the applied velocity and shear stresses at different simulated flows was performed on the left and right banks of the study area at several locations. Applied velocity exceeds permissible velocities for most soils by 50,000 cfs on the right bank and between 80,000 and 115,000 on the left bank. Therefore, it is reasonable to assume that, depending on flood event duration, channel and bank geometry, levee geometry, soil type, and vegetation cover, that erosion distress to the American River channel banks and levees has the potential to occur beginning at flows exceeding 30,000 cfs.

12.0 SEISMIC ASSESSMENT

To evaluate the potential to liquefaction resistance of soils, liquefaction triggering analysis was performed based on the procedure from the summary report of the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils, published as part of the Journal of Geotechnical and Geoenvironmental Engineer, dated October 2001 (Youd, Idriss, Andrus, & Arango, October 2001).

The result of the liquefaction triggering analysis and liquefaction-induced post-earthquake deformation based on limit equilibrium analysis indicates that liquefaction potential is highly likely at each critical location for all the reaches for Natomas Basin, Reach A of American River North Basin, and Reaches C to G of American River South Basin. Moreover, at these locations, the analysis indicates that the post-earthquake deformation as the result of liquefaction of the material beneath the embankment is a global or structural failure mode that is very likely to compromise the ability to provide flood protection at these critical locations.

13.0 VEGETATION VARIANCE REQUEST SUPPORTING ANALYSES

The majority of the Sacramento River levee within the study area, require seepage, slope stability, height, and erosion improvements in order to meet USACE criteria. Construction of the levee improvement measures will require complete vegetation removal on the levee from approximately 15 feet landward of the landside toe to approximately 1/3rd the height of the levee on the waterside slope. On the waterside, where construction does not remove vegetation, on the lower 1/3rd of the slope to 15 feet waterward of the waterside levee toe, the vegetation will be left in place and a Vegetation Variance Request (VVR) will be sought by the Sacramento District. To show that the safety, structural integrity, and functionality of the levee would be retained, an evaluation of underseepage and waterside embankment slope stability was completed given that a tree fell resulting in scouring of the root ball area.

The analyses section/index point at LM 5.92 was chosen for the VVR analyses because if was considered to be representative of the most critical channel and levee geometry and the without project analyses showed the section does not meet underseepage and slope stability criteria. The cross-section geometry of the index point incorporated tree fall and scour by using a maximum depth of scour for cottonwoods as approximately 11.0ft; the associated soil removed was projected at a 2:1 slope from the base of the scour toward both the landside, and waterside slopes. The base scour width was equal to the maximum potential diameter at breast height (dbh) of Cottonwoods (12.0ft) projected horizontally at a depth of 11.0ft below the existing ground profile. The results show that the tree fall and scour did not significantly affect levee performance and that the levee meets USACE seepage and slope stability criteria considering the seepage and stability improvement measures are in place (“with project” conditions). Therefore, it is a reasonable conclusion that with a VVR to allow vegetation to remain, the safety, structural integrity, and functionality of the Sacramento River levee would be retained.

14.0 GEOTECHNICAL RECOMMENDATIONS FOR LEVEE IMPROVEMENT

The levees protecting the ARCF GRR study area are susceptible to through seepage, underseepage, slope stability, and erosion. In some locations, on the levees along the American River and Natomas Basin, substantial projects have been authorized to address these deficiencies. However, seepage, slope stability, and/or erosion deficiencies still remain on portions of the Sacramento River, on the east bank of NEMDC, on both banks of Arcade Creek, and on both banks of the American River. To address seepage and seepage related slope stability deficiencies the predominant recommendation is cutoff walls. Due to several factors including constraints on expanding the levee footprint; seepage berms, relief, wells, and the vast majority of other seepage improvement measures were considered not feasible. Based on hydraulic modeling, some reaches may require raises to prevent overtopping at certain flood frequencies. Plate 3 shows the locations of those improvements.
On the American River erosion continues to be a potential failure mode that requires additional improvements to convey design flows. To accomplish this, two erosion protection measures have been proposed that could be implemented in combination along the levee alignment depending on factors such as, bank/bench geometry, existing habitat, and existing land use among other considerations. The two measures are a launchable rock trench and on bank rip-rap.

On the Sacramento River east levee (Reaches ARS D through G), the need for further seepage and slope stability improvements has been identified through geotechnical analyses. A combination of conventional open trench and Deep Soil Mixing (DSM) cutoff wall construction methods is anticipated. Levee raises are proposed in some segments of the Sacramento River levee which would be accomplished with a levee embankment raise and retaining wall at the landside levee toe or a flood wall constructed at the levee crest. The levee at Pioneer Reservoir was improved by the Sacramento District with relief wells and a landside seepage berm to meet criteria at the 100 year flood event. At this location, the seepage berm should be thickened to increase the level of protection (200 year flood event). To address a slope stability deficiency in Reach G, a full levee degrade and placement of geotextile within the reconstructed levee embankment is recommended. The Sacramento River levee requires erosion protection, which could be addressed with the measures presented for the American River. The extents of levee seepage and slope stability improvements for the Sacramento River are shown in Table 14-1.

Table 14-1: Sacramento River Reaches D through G Recommended Improvements

Reach	Beginning LM	Ending LM	Tip Elevation (ft)	Depth (ft)	Type	Description
D	0.00	0.18	NA	NA	NA	USACE 2000 CW
	0.18	1.25	NA	NA	NA	High Ground
	1.25	1.97	NA	NA	NA	Pioneer Reservoir
	1.97	3.2	-80	120	DSM	Hanging/Keyed In
	3.2	3.63	-45	80	Open Trench	Keyed In
	3.63	0.59	NA	NA	NA	High Ground
E	0.59	0.9	-95	135	DSM	Partial
	0.9	1.36	NA	NA	NA	SAFCA 2006 CW
	1.36	1.71	-75	115	DSM	Keyed In
	1.71	2.39	-65	105	DSM	Keyed In
E/F	2.39	3.39	-55	95	DSM	Partial
F	3.39	3.67	-75	115	DSM	Hanging
	3.67	3.99	NA	NA	NA	USACE 2006 CW
	3.99	4.57	-75	110	DSM	Keyed In
	4.57	5.01	-45	80	Open Trench	Keyed In
	5.01	6.03	-110	145	DSM	Partial
	6.03	6.11	NA	NA	NA	Sump 132 CW
	6.11	6.28	-85	120	DSM	Keyed In
	6.28	7.36	-65	100	DSM	Keyed In
F/G	7.36	8.32	-60	95	DSM	Hanging
G	8.32	10.64	NA	NA	NA	Geotextile

The NEMDC, Arcade Creek north, Dry Creek, and Robla Creek levees sections were improved in the 1990's to early 2000's by SAFCA and, although they did not include internal seepage improvements, the levees meet geotechnical analyses criteria for seepage and slope stability, except in limited segments. The exception being a portion of NEMDC from its confluence with the American River, both banks of Arcade Creek, and a section of NEMDC where the historic Magpie Creek intersects the levee foundation. To address underseepage and underseepage induced slope stability deficiencies the proposed improvement measure is a cutoff wall constructed with the conventional open trench method. The Arcade Creek south bank proposed cutoff wall is proposed in conjunction with a full levee height degrade and incorporation of geotextile placed within the reconstructed levee embankment. The Arcade Creek north bank a cutoff wall is proposed in conjunction with replacing the existing landside ditch with buried culverts from the confluence of NEMDC upstream to Rio Linda Blvd. Depths and locations of the proposed cutoff wall are shown in Table 14-2 below

Table 14-2: East Side Tributaries Reaches C through F Proposed Cutoff Wall Extents

Reach	Beginning		Ending		Tip Elevation (ft)	Depth (ft)
	Unit	LM	Unit	LM		
C	2	0.00	2	0.48	-45	80
D	1	0.00	1	2.08	-6	45
E	7	0.00	7	1.92	-6	45
F	2	2.01	2	3.24	-45	80

For the levees surrounding the Natomas Basin, the geotechnical recommendations for seepage and slope stability were addressed in the NPACR. The recommended alternative from that report included a combination of seepage berms and cutoff walls combined with either an adjacent levee or fix-in-place improvement to the existing levee. To address levee overtopping concerns, a floodwall at the waterside hinge point or a soil embankment raise is proposed where necessary.

15.0 MAGPIE CREEK

In the early 1990's, the Sacramento District and SAFCA began studying the Magpie Creek and MCDC flood control project after the realization that the system was overtopped during frequent events. In the late 1990's and early 2000's, both the Sacramento District and SAFCA developed varies improvement alternatives for the project. While the alternatives varied slightly, they included similar measures such as, levee raises (either embankment or floodwall), new levee construction, channel improvements (deepening or widening), and construction of detention basins. Levee improvements consisting of either levee embankment raises or flood wall raises were proposed for the left bank of Magpie Creek and the MCDC, while new levee construction was proposed for the right banks. Based on the available existing feasibility and design documents prepared in the 1990's and early 2000's by the Sacramento District and SAFCA, the levee, channel, and detention basin improvement measures appeared to be geotechnically adequate and require no further geotechnical analyses as part of the ARCF GRR.

16.0 SACRAMENTO WEIR AND BYPASS

The existing Sacramento Weir and Bypass, which allows high flows in the Sacramento River to be diverted into the Yolo Bypass, could be expanded to roughly twice their current width to accommodate increased bypass flows. The existing north levee of the Sacramento Bypass would be degraded and a new levee constructed approximately 1,500 feet in length to the north. The existing Sacramento Weir would be expanded to match the wider bypass.

The new north levee of the Sacramento Bypass would be constructed as per the standard levee section for new construction which includes; Type I Levee Fill, 3H:1V waterside and landside slopes, and a minimum crest width of 20 feet. As both the existing north and south levees have experienced underseepage and slope stability related distress, the new north levee would include a 300-foot wide drained landside seepage berm (5 feet thick at the landside levee toe tapering to 3 feet thick at the berm toe and constructed of random fill with a 1.5-foot thick drainage and filter layer at the base) with a system of relief wells located at least 15 feet landward of the berm toe and spaced at 200-foot intervals. A seepage cutoff wall with tip elevation of 5 feet (35 feet deep) should be constructed beneath the Sacramento Weir.

17.0 PROBABILISTIC ANALYSES

The First-Order-Second-Moment (FOSM) method, as recommended in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies" dated 28 May 1999, was followed during the probabilistic evaluation of each index point. In this approach, the uncertainty in performance is taken to be a function of the uncertainty in model parameters. The standard deviations of a performance function were estimated based on the expected values (means) and the standard deviation of the random variable means. The performance functions considered were underseepage, through-seepage, and slope stability.

Potential sources of levee distress or failure considered in the analyses were underseepage through the levee foundation, through-seepage through the levee embankment, and instability of the landside levee slope under steady state conditions. The levees were evaluated against the above mentioned performance modes at five different water surface elevations (loading conditions), which included; levee crest, levee crest minus three feet, half levee height, toe plus three feet, and landside levee toe where the probability of failure was considered to be zero. Using this method of selecting loading conditions the curves should represent probability of poor performance at multiple flood frequencies.

The probability of poor performance was evaluated by assessing the foundation and embankment materials and assigning values for the probability moments of the random variables considered in the analyses. Random variables for underseepage were considered for the ratio of the horizontal permeability of the aquifer to the vertical permeability of the upper less permeable blanket, blanket thickness, and aquifer thickness. Random variables for through-seepage were considered for critical tractive stress, porosity, and intrinsic permeability of the levee embankment material. Random variables for slope stability were considered for effective friction angle, effective cohesion, and total unit weight of the levee embankment, and effective friction angle and cohesion of the foundation material.

A judgment based conditional probability function for each analyzed cross-section was based on existing conditions of the levee such as encroachments on the levee slopes, vegetation on the levee slopes and in the vicinity of the levee toes, existing cracks and holes due to animal burrows, erosion of the waterside levee slopes and riverbank, and considering the past history of sand boils or slope failures. Generally, past experience with poor performance at utility crossing and rodent activity indicates the risk of failure is somewhat significant in the analyzed areas.

The conditional probability of failure as a function of floodwater elevation has been developed by combining the probability of failure functions for all considered failure modes; underseepage, through-seepage, slope instability, and judgment.

The without project levee performance curves indicate that the levees in ARN Reaches C through F and ARS Reaches D through G would perform unsatisfactorily when minimally loaded. In general, the analyses identified underseepage deficiencies and/or underseepage related slope stability deficiencies. Therefore, the with project levee performance curves considered the proposed improvement measures for each failure mode, as necessary, which resulted in significant reduction in probabilities of poor performance.

17.1 ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 15.0 ft with a coefficient of variation of 96, and a mean aquifer thickness of 24.0 ft with a coefficient of variation of 42. The blanket was comprised of predominantly silty sands. The aquifer was made up of poorly graded sand to silty sand, and silty gravel.

The levee embankment contains an existing cutoff wall which mitigates underseepage, through seepage, and slope stability concerns. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, accounting for 50.0% and 4.0% respectively at the crest. Past performance has indicated significant amounts of erosion of the riverbank, waterside levee slope and foundation. Overall judgment based contributions account for a Pr(f) of 55.3% of the without project combined curve at the levee crest. Figure 17-1 presents the without project conditions combined curve.

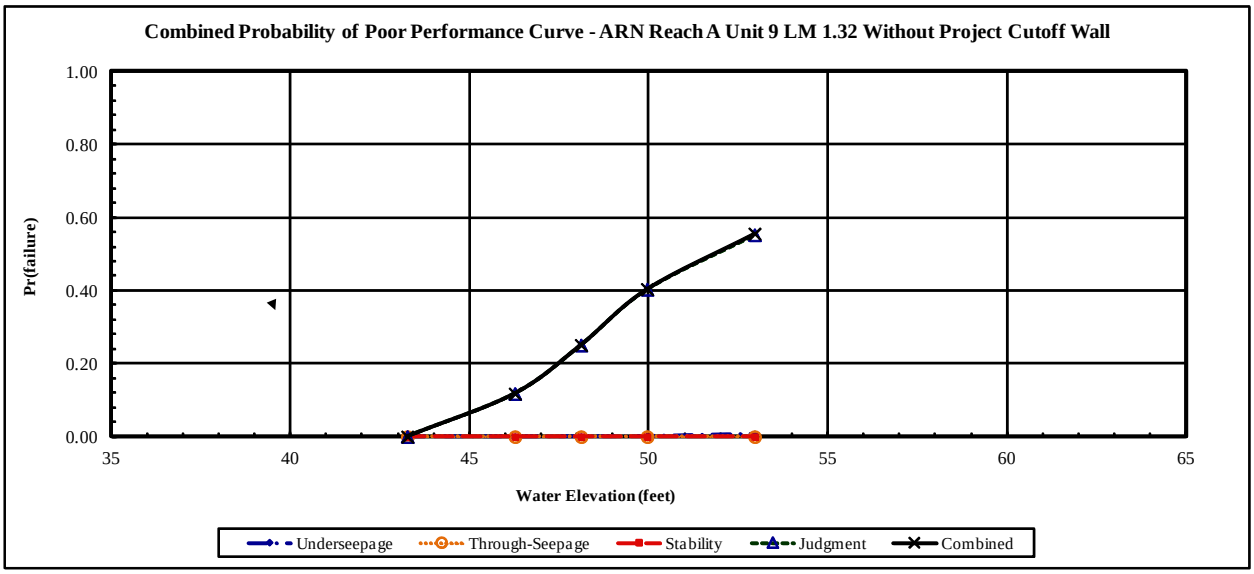

Figure 17-1: Combined Probability of Poor Performance for Without Project Conditions

The remaining probability of failure was primarily attributed to the judgment based failure modes, erosion, which is proposed to be mitigated through the placement riprap erosion protection. With project improvement measures reduce erosion to a Pr(f) of 5.0% at the levee crest. Figure 17-2 presents the with project conditions combined curve.

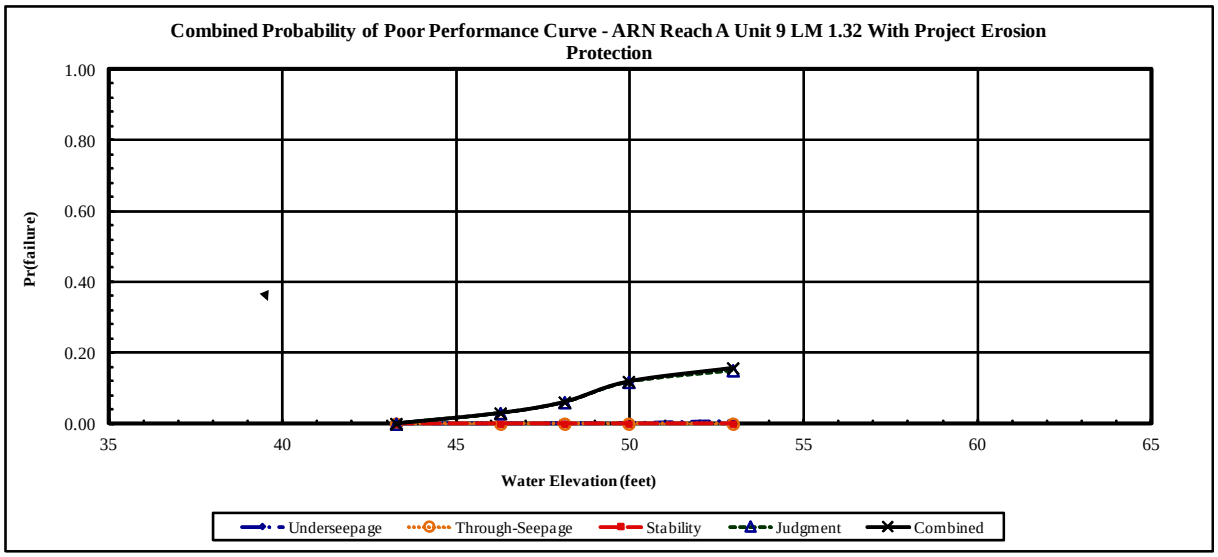

Figure 17-2: Combined Probability of Poor Performance for With Project Conditions

17.2 ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 6.0 ft with a coefficient of variation of 50, and a mean aquifer thickness of 25.0 ft with a coefficient of variation of 36. The blanket was comprised of predominantly lean clay. The aquifer was made up of silty sands, poorly graded sands, and silts.

The without project underseepage analysis resulted in a Pr(f) of 72.4% at the levee crest and landside slope stability analysis resulted in a Pr(f) of 68.1% at the crest. The without project judgment based probability portion of the curve was comprised mainly of utilities and animal burrows both of which account for a Pr(f) of 6.0% at the crest. Overall judgment based contributions account for a Pr(f) of 17.7% of the without project combined curve at the levee crest. Figure 17-3 presents the without project conditions combined curve.

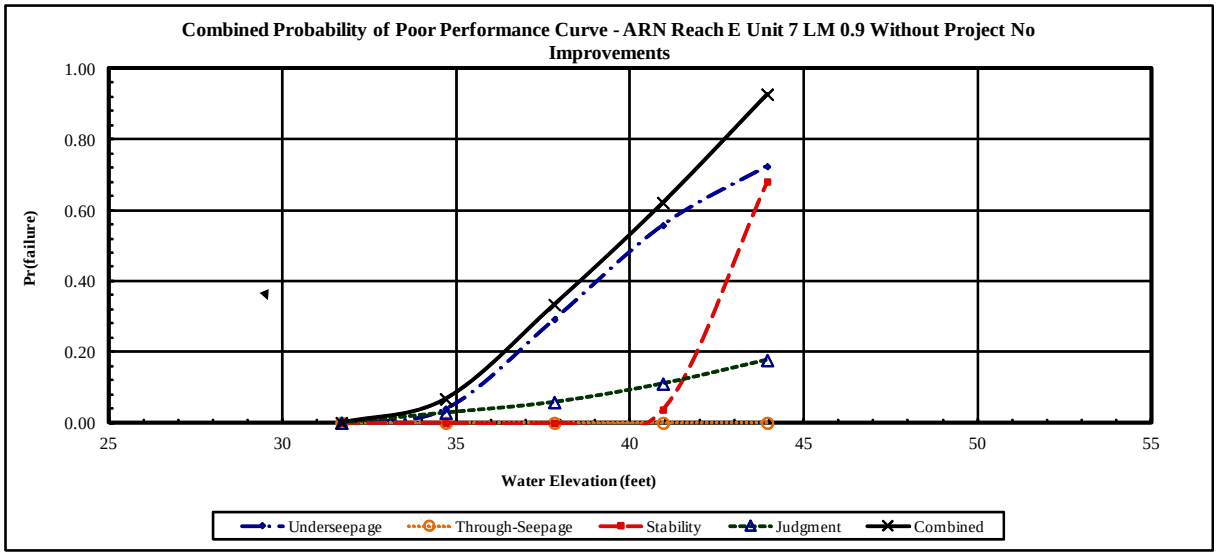

Figure 17-3: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall. This improvement mitigates underseepage and landside slope stability concerns. With project conditions did not provide a reduction to judgment based probabilities of failure. As such the Pr(f) for both utilities and animal burrows remained at 6.0% at the levee crest. Figure 17-4 presents the with project conditions combined curve.

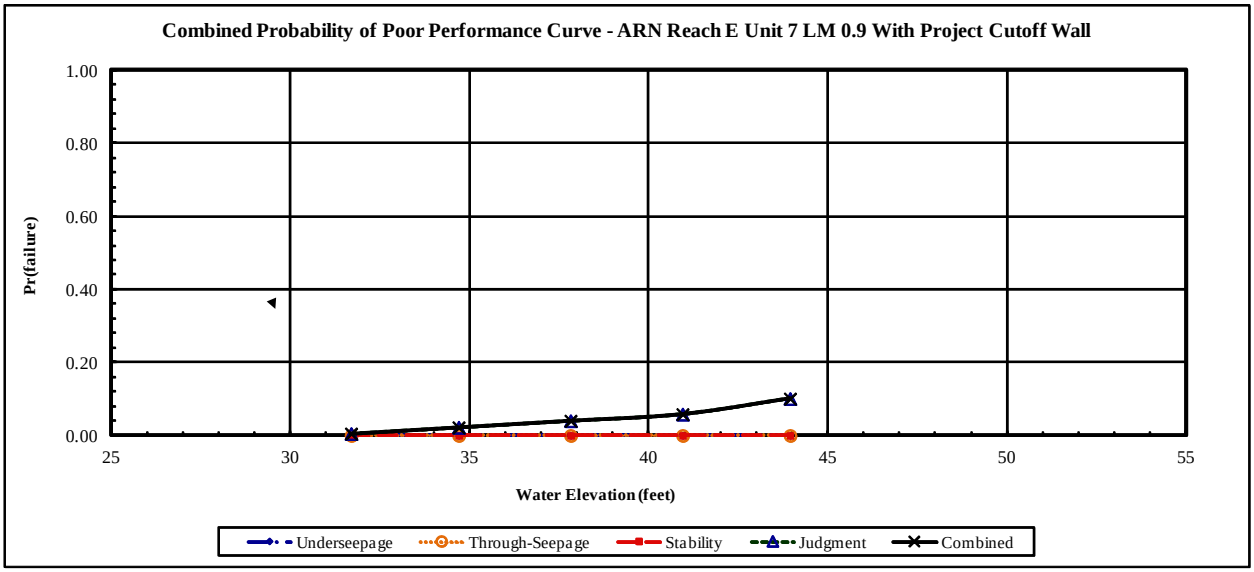

Figure 17-4: Combined Probability of Poor Performance for With Project Conditions

17.3 ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 10.0 ft with a coefficient of variation of 30, and a mean aquifer thickness of 41.0 ft with a coefficient of variation of 24. The blanket was comprised of predominantly silts and lean clays. The aquifer was made up of silty sands and poorly graded sands.

The levee embankment contains an existing cutoff wall which mitigates both underseepage, through seepage, and slope stability concerns. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, which accounted for 60.0% and 4.0% respectively at the crest. Past performance has indicated significant amounts of erosion of the riverbank, waterside levee slope and foundation. The combined without project levee performance curve resulted in a Pr(f) of 65.0% at the levee crest. Figure 17-5 presents the without project conditions combined curve.

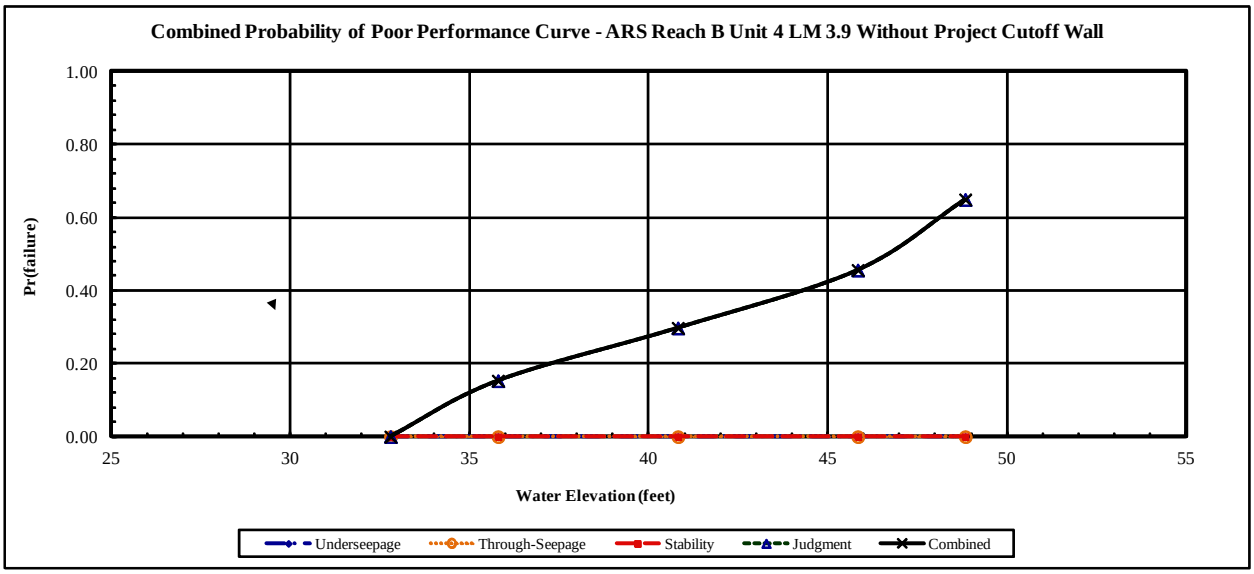

Figure 17-5: Combined Probability of Poor Performance for Without Project Conditions

The high probability of failure was primarily attributed to the erosion portion of the judgment based failure modes, which is proposed to be mitigated through the placement of riprap erosion protection. With project improvement measures reduce erosion to a Pr(f) of 5.0%. Figure 17-6 presents the with project conditions combined curve.

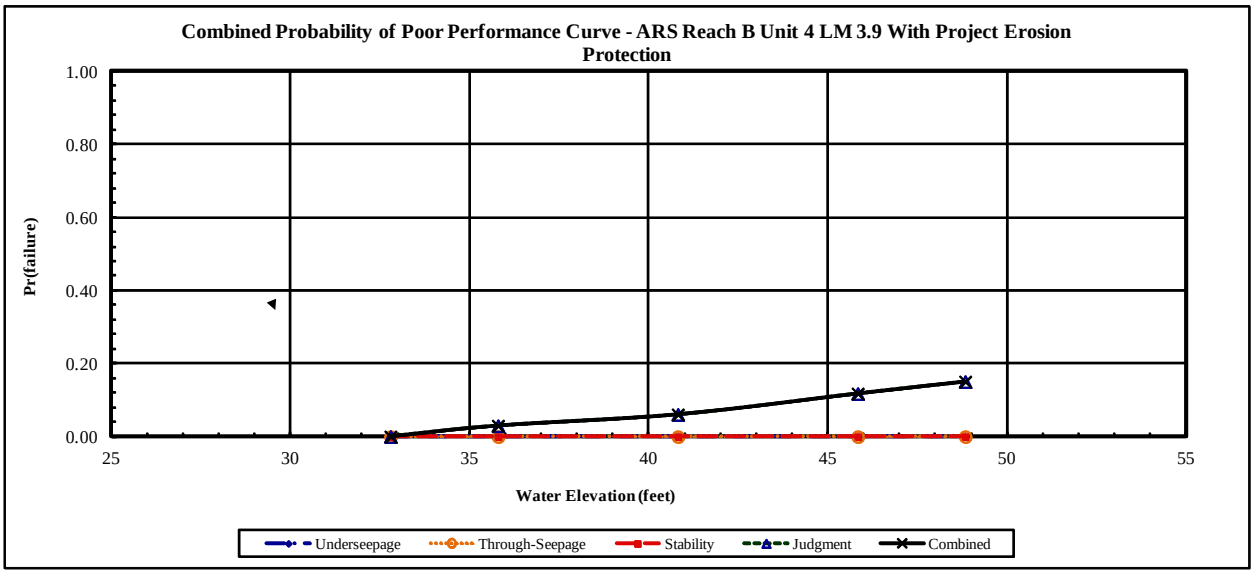

Figure 17-6: Combined Probability of Poor Performance for With Project Conditions

17.4 ARS REACH F – SACRAMENTO RIVER EAST –U1 LM 5.92

Borings chosen to be used in probabilistic analyses resulted in a mean blanket thickness value of 19.0 ft with a coefficient of variation of 47, and a mean aquifer thickness of 83.0 ft with a coefficient of variation of 19. The blanket was comprised of predominantly silts, and lean clays. The aquifer was made up of mainly silty sands, and poorly graded sands.

The without project underseepage analysis resulted in a Pr(f) of 25.8% at the levee crest and landside slope stability analysis resulted in a Pr(f) of 1.9% at the crest. The levee embankment contains an existing shallow cutoff wall which mitigates through seepage concerns. The without project judgment based probability portion of the curve was comprised mainly of erosion, and encroachments, which accounted for 16.0% and 6.0% respectively at the crest. Overall contributions account for a Pr(f) of 28.7% of the without project combined curve at the levee crest. Figure 17-7 presents the without project conditions combined curve.

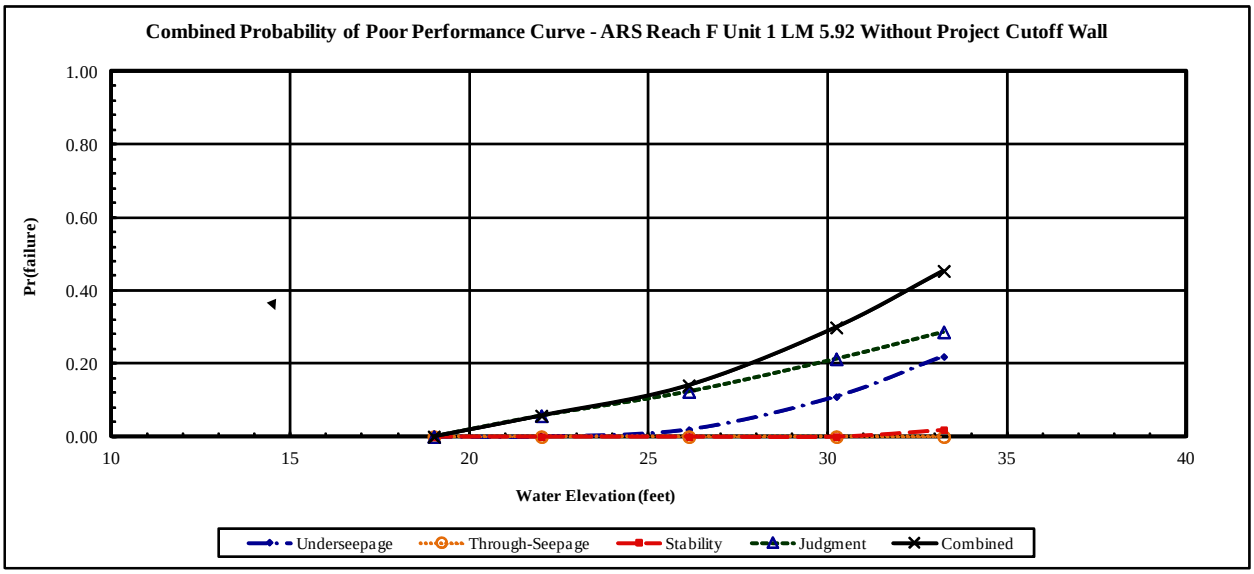

Figure 17-7: Combined Probability of Poor Performance for Without Project Conditions

With project conditions analyses were completed with the incorporation of an underseepage cutoff wall and waterside erosion protection. These improvements mitigated underseepage, landside slope stability, and erosion concerns. With project conditions analysis reduce erosion, encroachments, and utilities to a Pr(f) of 2.0%, 3.5%, and 1.0% as during construction, a portion of existing encroachments and utilities will be removed or relocated to allow for proper inspection and maintenance. Figure 17-8 presents the with project conditions combined curve.

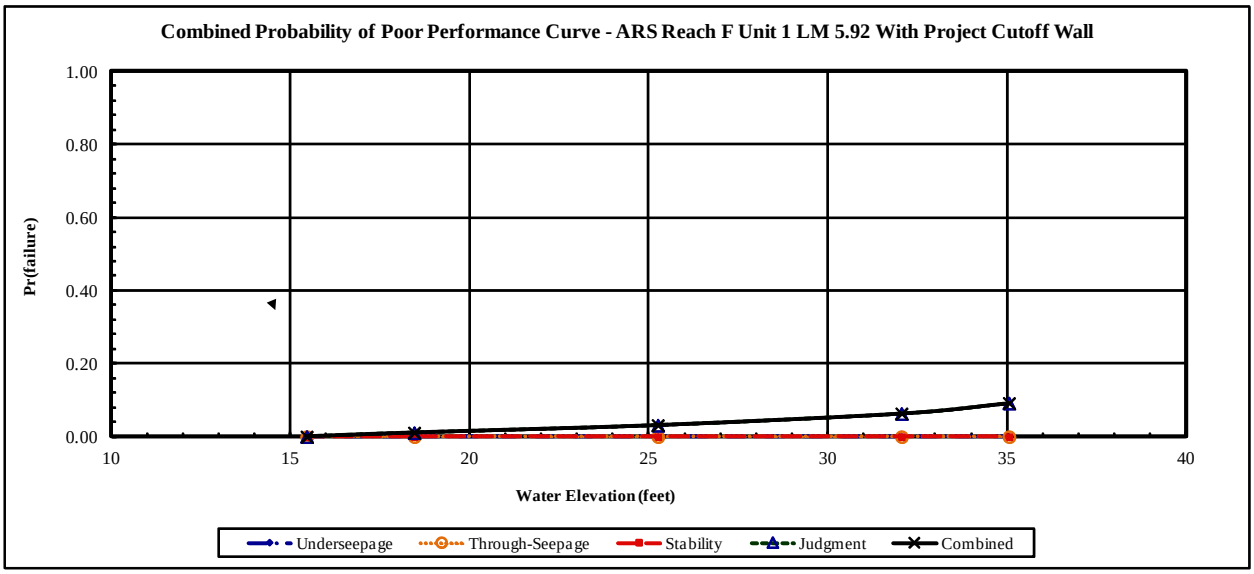

Figure 17-8: Combined Probability of Poor Performance for With Project Conditions

17.5 NAT REACH D – NCC SOUTH –U1 LM 1.30

The NPACR recommended a cutoff wall constructed through the existing levee section for Reach D of Natomas which mitigated underseepage and landside slope stability concerns. The change in Pr(f) for seepage was 4.2% from the design water surface elevation to the top of levee water surface elevation, given the inclusion of the cutoff wall. The judgment based probabilities also added a Pr(f) of 9.3%, comprised mainly of animal burrows and encroachments, which contributed a Pr(f) of 7.0% and 5.0% respectively. Figure 17-9 presents the with project levee performance curve from the NPACR which included a levee raise component. It is also the with project conditions levee performance curve for the ARCF GRR.

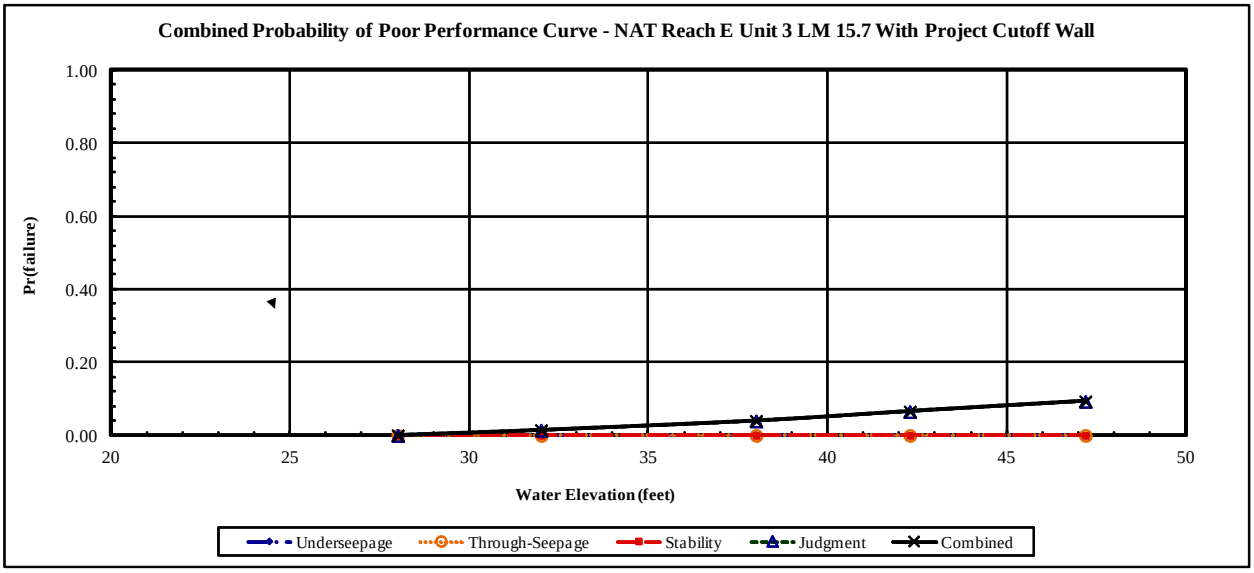

Figure 17-9: Combined Probability of Poor Performance for With Project Conditions

18.0 MATERIAL REQUIREMENTS AND BORROW SITES

It is anticipated that significant quantities of material will be required for construction of the proposed project. Several different improvement measures such as seepage berms, cutoff walls, embankment construction/reconstruction, and erosion protection are proposed. The SOP-03 established the requirements of engineered fill to be used for the construction of the levee embankments.

The material is expected to be sourced from several sites including; newly identified borrow sites within approximately 25 miles of the study area, existing borrow sites identified for the Natomas Basin by SAFCA, the DWSC dredge disposal area, the existing levees, and existing commercial sources. A desktop regional borrow study was performed to identify potential borrow sites, within 25 miles of the study area, where enough soil could be sourced to satisfy the project needs. Plates 4 and 5 show the high confidence and low confidence areas of potential borrow sites. Test pits and laboratory testing on materials collected from test pits were provided by SAFCA as part of the NLIP for borrow sites established for the Natomas Basin. Additionally, the Sacramento District has studied the DWSC spoil areas as a borrow source several time in the past, and a discussion of that borrow source is included below. Typically projects constructed by the Sacramento District utilize commercial borrow sites near the project area.

19.0 CONCLUSIONS

This report presented the results of geotechnical analyses and feasibility level geotechnical design recommendations associated with the various alternatives under consideration to address technical deficiencies in the flood risk management system protecting the study area. The alternatives consisted of a combination of structural measures to mitigate deficiencies with levee height, geometry, erosion, access, vegetation, seepage, and slope stability. They also included, the widening and construction of new levees on the Sacramento Bypass and Weir.

The results of the without project seepage and slope stability analyses indicated that the levees in ARN Reaches C through F and ARS Reaches D through G did not meet minimum criteria. The analyses showed that the levees did not meet criteria at varying flood frequencies typically between the 25 and 200 year events. The with project analyses typically included deep cutoff walls which resulted in the with project levee analyses satisfying criteria.

Two potentially erosion-resistant units were identified in the stratigraphy of the American River: (1) a moderately cohesive silty and sandy interbed of relatively limited lateral and longitudinal extent within a thicker package of loose Holocene sediments (the “upper” unit); and (2) much thicker, more widespread relatively erosion-resistant deposits associated with the Pleistocene-aged Fair Oaks formation (the “lower unit”). Erosion rate testing confirmed that erodibility was related to the geologic unit and that most of the specimens within the Fair Oaks formation could be categorized as Moderate Resistant to Very Resistant and similarly, the layers above erosionally resistant surface could be categorized as Very Erodible to Erodible.

The results of the liquefaction triggering analysis and liquefaction-induced post-earthquake deformation based on limit equilibrium analysis indicated that liquefaction potential is highly

likely at each critical location for all the reaches for Natomas Basin, Reach A of American River North Basin, and Reaches C to G of American River South Basin. Moreover, at these locations, the analysis indicates that the post-earthquake deformation as the result of liquefaction of the material beneath the embankment is a global or structural failure mode that is very likely to compromise the ability to provide flood protection at these critical locations.

Based on analyses at LM 5.92 that incorporated tree fall and scour it was shown that the tree fall and scour did not significantly affect levee performance and that the levee meets USACE seepage and slope stability criteria. Therefore, it was a reasonable conclusion that with a VVR to allow vegetation to remain, the safety, structural integrity, and functionality of the Sacramento River levee would be retained.

The without project levee performance curves indicate that the levees in ARN Reaches C through F and ARS Reaches D through G would perform unsatisfactorily when minimally loaded. In general, the analyses identified underseepage deficiencies and/or underseepage related slope stability deficiencies. Therefore, the with project levee performance curves typically included deep cutoff walls which resulted in significant reduction in probabilities of poor performance.

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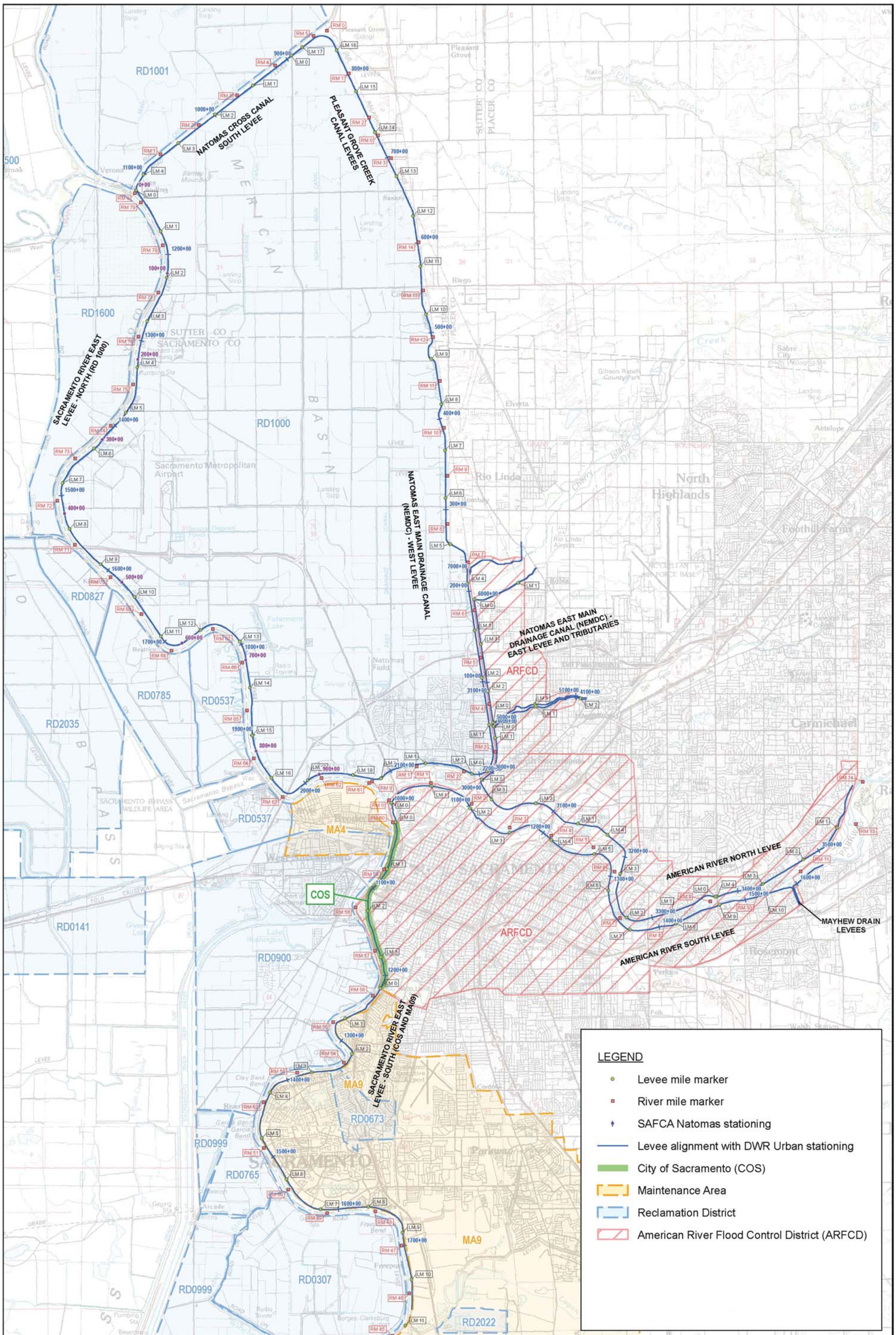

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 1 - ARCF GRR LEVEE MILE AND STATIONING MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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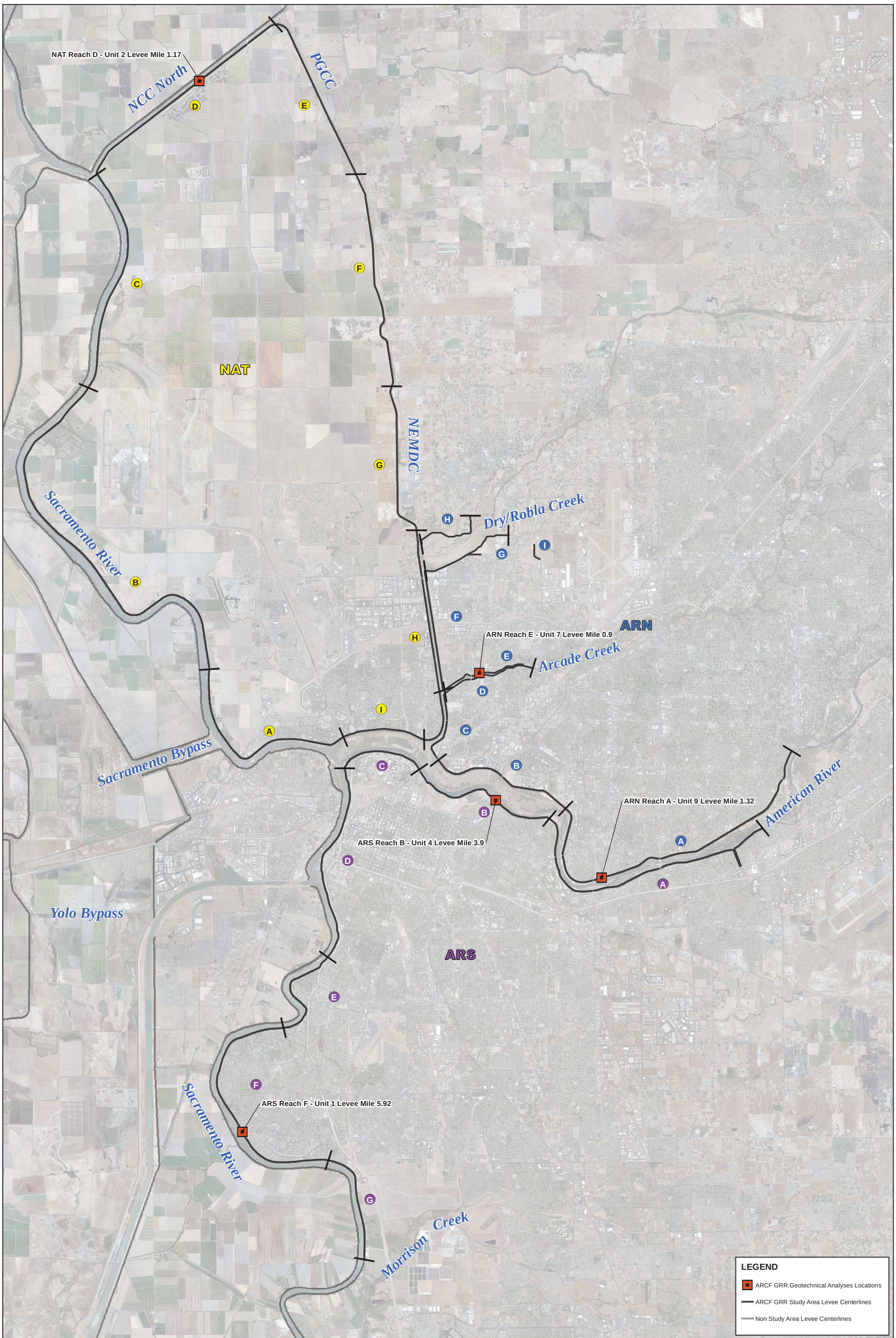

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 2 - ANALYSES SECTION AND INDEX POINT LOCATION MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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10 Oct 2014
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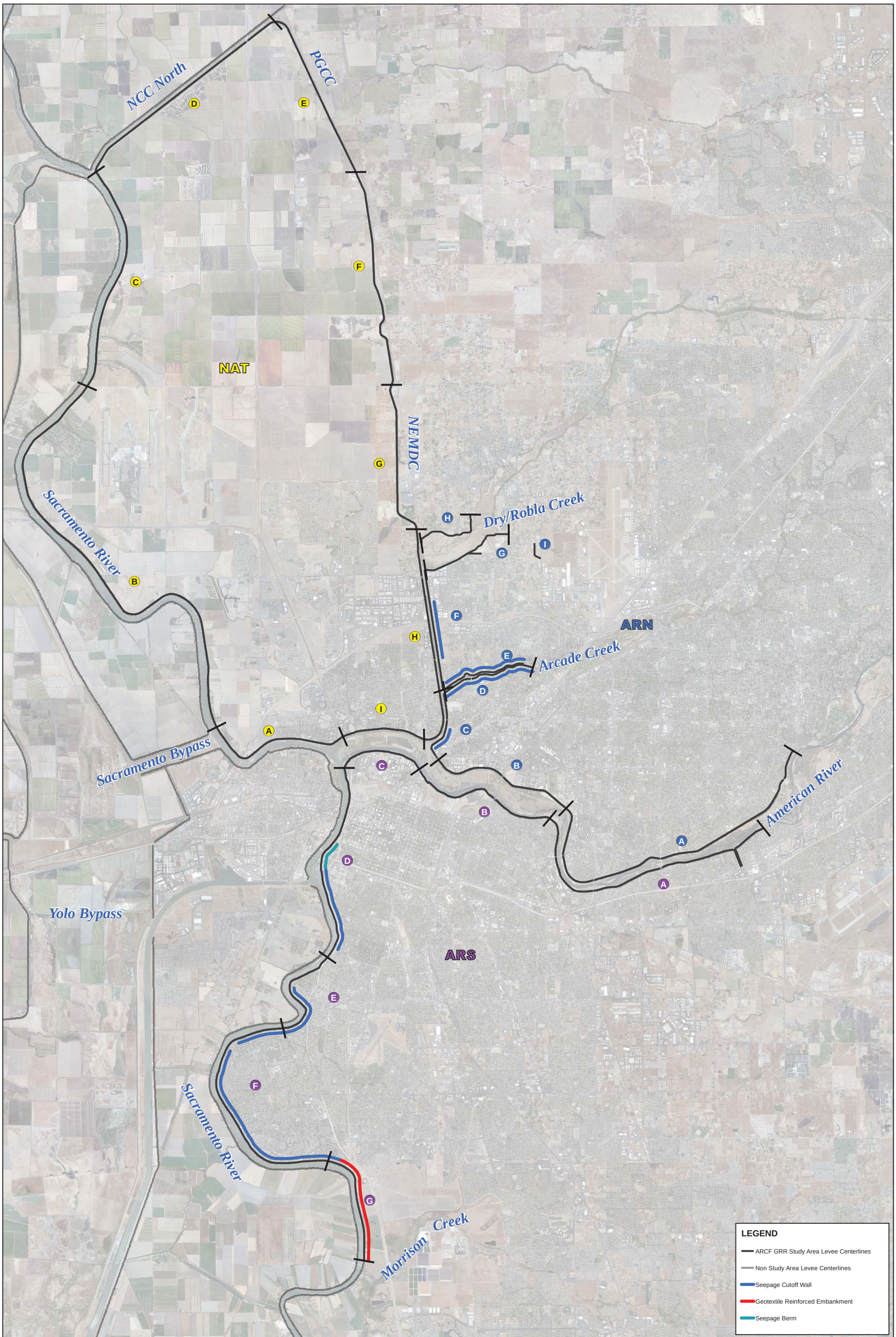

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 3 - GEOTECHNICAL IMPROVEMENTS MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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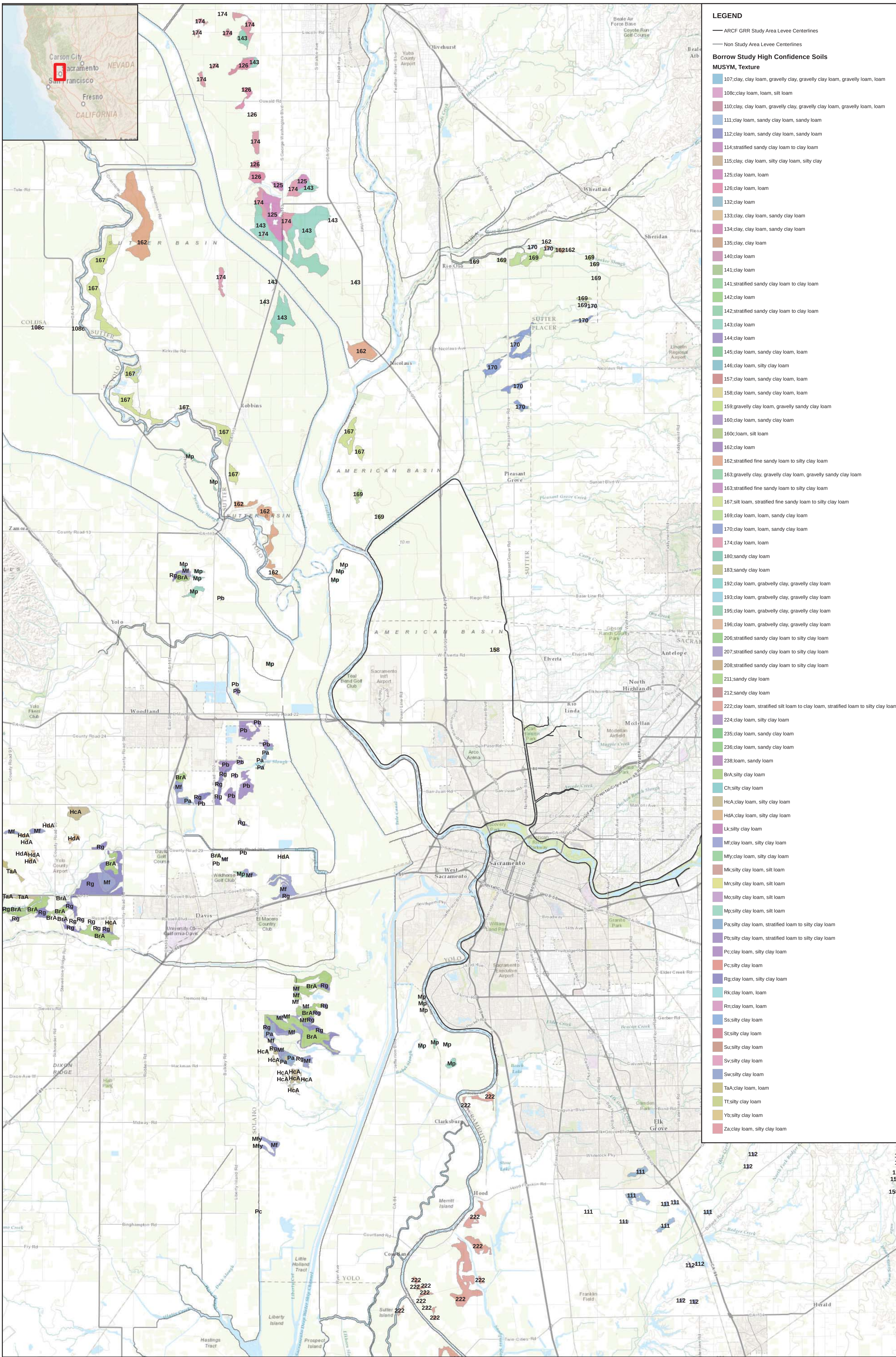

US Army Corps of Engineers.
SACRAMENTO DISTRICT

PLATE 4 - DESKTOP BORROW STUDY HIGH CONFIDENCE LOCATION MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

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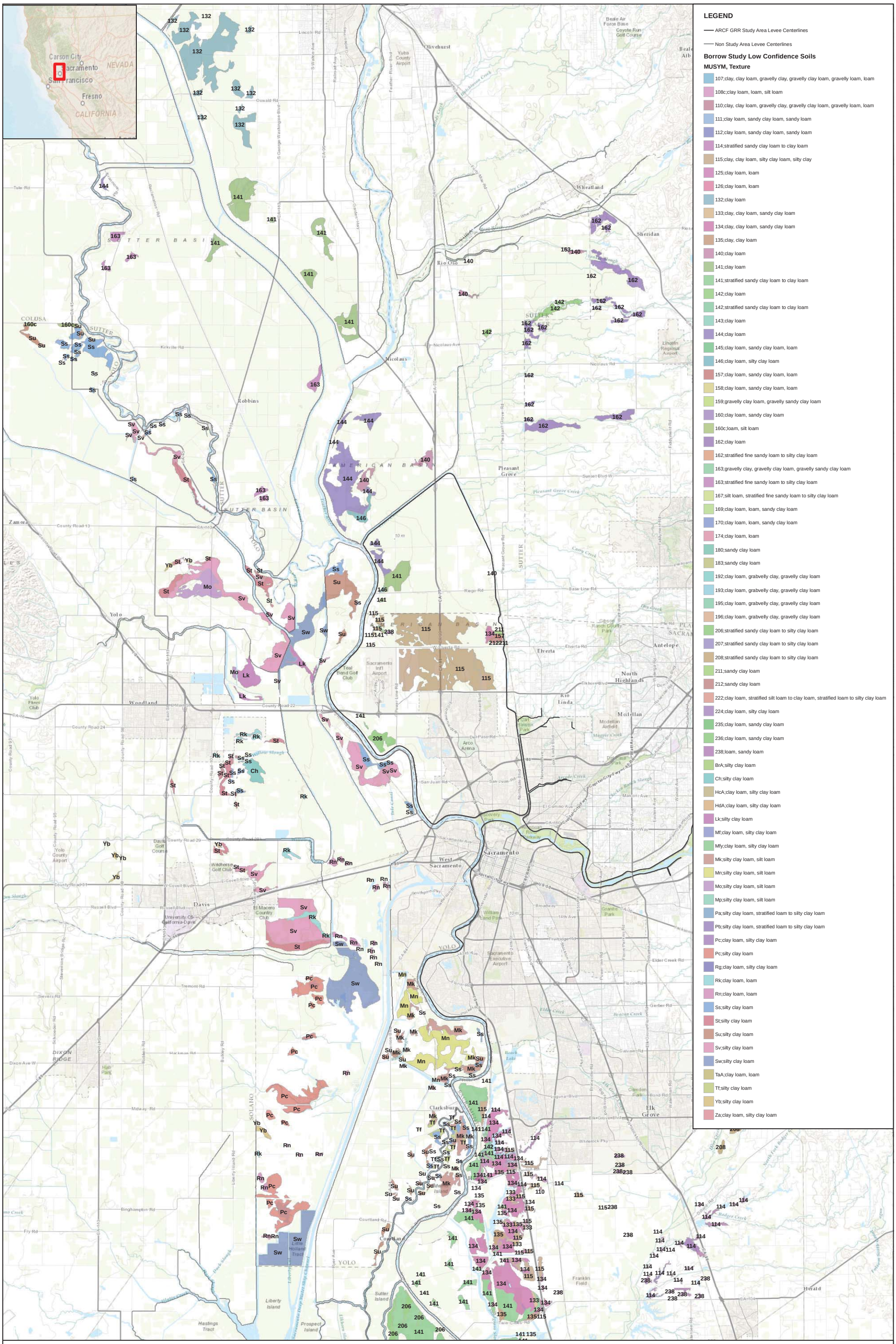

US Army Corps of Engineers
SACRAMENTO DISTRICT

PLATE 5 - DESKTOP BORROW STUDY LOW CONFIDENCE LOCATION MAP
ATTACHMENT C - GEOTECHNICAL REPORT

AMERICAN RIVER COMMON FEATURES
GENERAL REEVALUATION REPORT

N

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AMERICAN RIVER WATERSHED

COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT

ATTACHMENT C – GEOTECHNICAL REPORT

ENCLOSURE 1

ANALYSES CALCULATION PACKAGE

AMERICAN RIVER NORTH BASIN

ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
AMERICAN RIVER NORTH RA U9 LM 1.32
Table F-2-1: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD 88)	Layer ID	Soil Description	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data										Comments
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	Torvane (tsf)	Pocket Penetrometer (tsf)	Average Unit Weight (pcf)	PI	LL	LI	
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	53.01	1	Silty Sand (SM) with Silt (ML) Levee	SM	0.00	8.61	53.01	44.40	8.61		45	16	30								
		2	Silty Sand (SM) with Silty (ML)	ML	8.61	37.11	44.40	15.90	28.50		33	9	21								
		3	Poorly Graded Gravel (GP) with Lean Clay (CL)	GP	37.11	53.61	15.90	-0.60	16.50			76	89								
		4	Poorly Graded Sand with Silty Sand (SP-SM)	SP-SM	53.61	61.87	-0.60	-8.86	8.26		13	48	69								
		5	Lean Clay (CL) with Silt (ML)	CL	61.87	86.41	-8.86	-33.40	24.54			73	64								
		6	Impervious Clay Cap (CL)	CL																	
		7	Cutoff Wall	SB WALL														8	25	17.00	
					Total Depth (ft.)	**86.41**															

Layer ID	Recommended Hydraulic Conductivity					Strenth Coorelations								Strength from Lab Test Data						Recommended Strength Parameters			Comments
	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Total Overburden Pressure at Mid Layer During Drilling (psf)	Effective Overburden Stress at Mid Layer During Drilling (psf)	OCR from N_{60}[3]	OCR from LI[3]	Su from N (psf)[4]	Su/σ'$_o$ from PI (psf)[4]	Calculated Maximum Past Pressure (psf)[5]	Drained Friction Angle[7]	OCR	σ'$_p$ (psf)	Su (psf)	Su/σ'$_o$	Φ'	C' (psf)	Φ'	C' (psf)	γ (pcf)	
1	5.00E-04	4.00	1.25E-04	1.418	0.354	0	-269													33	0	125	
2	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-1426													33	0	125	
3	2.00E-01	4.00	5.00E-02	567.000	141.750	0	-2830													35	0	135	
4	1.00E-03	4.00	2.50E-04	2.835	0.709	0	-3603													33	0	125	
5	1.00E-05	4.00	2.50E-06	0.028	0.007	0	-4626	#VALUE!		9269		#NUM!								28	50	115	
6	1.00E-05	4.00	2.50E-06	0.028	0.007	0	0	#VALUE!	#VALUE!											28	50	115	
7	1.00E-06	4.00	2.50E-07	0.003	0.001															0	50	85	

2F-97-6

STA. 14+165

DEPTH		N	GR	SA	FI	LL	PI	MC	
EL. 15.48 m (50.80') - 0	SC	14	-	-	-	-	-	-	CLAYEY SAND, SC: Firm; moist; dark yellowish-brown; about 85% fine to medium sand; about 15% fines; no reaction with HCl; no odors present
(2.0') 0.61 m	SM	13	0	68	32	-	NP	-	SILTY SAND, SM: Firm; moist; dark yellowish-brown; fine to medium, mostly fine sand; nonplastic fines; no reaction with HCl; no odors present
(3.5') 1.07 m			-	-	-	-	-	-	
(4.0') 1.22 m									
		7	-	-	-	-	-	-	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 80% fine to medium sand; about 20% fines; no reaction with HCl; no odors present
(6.0') 1.83 m									
		29							SILTY SAND, SM: Very firm; moist; dusky yellowish-brown; about 75% fine to medium sand; about 25% fines; no reaction with HCl; no odors present; weak iron oxide staining
			-	-	-	-	-	-	
		19							At 2.6 m (8.5'), as above except firm
(10.3') 3.14 m	SC	22	-	-	-	-	-	-	CLAYEY SAND, SC: Loose; moist; dusky yellowish-brown; about 70% fine to medium sand; about 30% medium plasticity fines; no reaction with HCl; no odors present
(12.0') 3.66 m									
		10	-	-	-	-	-	-	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 80% fine to medium sand; about 20% fines; no reaction with HCl; no odors present
(14.0') 4.27 m									
		5	-	-	-	-	-	-	
(16.5') 5.03 m									
		5	0	59	41	-	NP	-	
(18.0') 5.49 m									
		8							SILTY SAND, SM: Loose; moist; moderate brown; fine to medium, mostly fine sand; nonplastic fines; no reaction with HCl; no odors present
			-	-	-	-	-	-	
		8							At 6.6 m (21.5'), as above except switched to mud rotary
(23.0') 7.01 m	SM	10							
			-	-	-	-	-	-	SILTY SAND, SM: Loose; moist; moderate brown; about 85% fine to medium sand; about 15% fines; no reaction with HCl; no odors present
		10							
(33.0') 10.06 m									

CONTINUED IN NEXT COLUMN

2F-97-6

CONTINUED FROM PREVIOUS COLUMN

DEPTH		N	GR	SA	FI	LL	PI	MC	
(33.0') 10.06 m	SP-SM	10							
			-	-	-	-	-	-	POORLY GRADED SAND WITH SILT, SP-SM: Loose; moist; moderate brown; fine to medium, mostly fine sand; nonplastic fines; no reaction with HCl; no odors present
(38.0') 11.58 m									
		10	0	90	10	-	NP	-	At 11.7 m (38.5'), as above except strong iron oxide staining
(39.5') 12.04 m									
			-	-	-	-	-	-	
(42.0') 12.80 m	GRAVEL AND COBBLES								At 12.8 m (42.0'), gravel and cobbles present; rough drilling; no recovery
			-	-	-	-	-	-	At 16.5 m (54.0'), no gravel and cobbles present; smoother drilling
(58.0') 17.68 m									LEAN CLAY WITH SAND, CL: Hard; moist; pale yellowish-brown; about 85% medium plasticity fines; about 15% fine sand; no reaction with HCl; no odors present
(58.2') 17.74 m	CL								
	SM	36	0	87	13	-	NP	-	
(59.5') 18.14 m									SILTY SAND, SM: Dense; moist; dark yellowish-brown; fine to medium, mostly fine, subangular to subrounded sand; nonplastic fines; no reaction with HCl; no odors present; strong iron oxide staining
			-	-	-	-	-	-	
(63.0') 19.20 m									
	CL	R							
			-	-	-	-	-	-	SANDY LEAN CLAY, CL: Hard; moist; pale yellowish-brown; about 65% medium plasticity fines; about 35% fine sand; no reaction with HCl; no odors present; hard but smooth drilling
(68.0') 20.73 m	SC								CLAYEY SAND, SC: Dense; dark yellowish-brown; about 60% fine to medium sand; about 40% medium plasticity fines; no reaction with HCl; no odors present
		38	-	-	-	-	-	-	
(69.5') 21.18 m									B.O.H.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

NOTES:

1. THE LEGENDS AND NOTES FOR THE 2F-97-# EXPLORATIONS ARE SHOWN ON SHEET B-11.
2. ADDITIONAL LOGS OF EXPLORATIONS ARE SHOWN ON SHEET NOS. B-1 THROUGH B-12 AND B-14 THROUGH B-49.

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved

Designed by: R. IWASA
Dwn by: R. IWASA
Ckd by: SCANDRONE
Reviewed by: M. RAMSOTHAM
Submitted by: Chief, Design Section
Date: 8 FEB 1999
Rev. REV_#
Design file no: AMT – 4 – 783
SPEC. No: 98925
File name: AR-LOG1.DWG
Plot date: 8 FEB 1999
Plot scale: 1 : 1

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

AMERICAN RIVER
AMERICAN RIVER WATERSHED PROJECT
LOWER AMERICAN RIVER
RIGHT (NORTH) BANK LEVEE STRENGTHENING

CALIFORNIA

LOG OF EXPLORATION
2F-97-6

Sheet reference number:
B-13
SEQ. 24

Hole No. DH-7

DRILLING LOG

DIVISION	
INSTALLATION	
SHEET 1 OF 2 SHEETS	
1. PROJECT	American River FCD, Maint. Areas 10 & 11
2. LOCATION (Coordinates or Station)	American River, East Levee site #7
3. DRILLING AGENCY	P.C. Exploration
4. HOLE NO. (As shown on drawing title and file number)	DH-7
5. NAME OF DRILLER	Mike Moore
6. DIRECTION OF HOLE	☑ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	NA
8. DEPTH DRILLED INTO ROCK	NA
9. TOTAL DEPTH OF HOLE	30.0
10. SIZE AND TYPE OF BIT	8 in" Hollow stem augers
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	
12. MANUFACTURER'S DESIGNATION OF DRILL	Mobile B-53
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 6 / UNDISTURBED Ø
14. TOTAL NUMBER CORE BOXES	NA
15. ~~ELEVATION~~ GROUND WATER	
16. DATE HOLE	STARTED 4-22-87 / COMPLETED 4-22-87
17. ELEVATION TOP OF HOLE	NA
18. TOTAL CORE RECOVERY FOR BORING	N.A. %
19. SIGNATURE OF INSPECTOR	Paul F. Schmidt (WA)

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% ~~CORE~~ RECOVERY e	~~BOX NO.~~ SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	10.0	ML	LEVEE 0.0-0.5 Gravel + dirt 0.5-11.2 SANDY SILT: Dk. yel brn (10YR 4/2), ~40-70% fines; non to slight plastic, quick dilatancy, no toughness; ~30-60% sand, very fine-grained, poorly graded, mica flakes; slight charcoal, organic lite; high permeabilities; firm to stiff; moist.			Sampling with a 2.0" (OD) split-spoon sampler, driven by a 140 lb. wire-line hammer, free-falling 30.0 in. per blow.
	2.0			4 / 5 / 10 — 0.8 / 1.5		1.5
				4 / 5 / 7 — 1.5 / 1.5		3.0 Drilling is easy
	4.0			4 / 5 / 6 — 1.5 / 1.5	B-1	4.5
	6.0			5 / 6 / 6 — 1.5 / 1.5		6.0
			7.8-9.2 gray silty sand medium dense	8 / 9 / 14 — 1.2 / 1.5	B-2	7.5
	8.0			7 / 8 / 8 — 1.3 / 1.5	B-3	9.0
	10.0		FOUNDATION 11.2-12.6 SAND: Salt & pepper; <5% fines; >95% fine-grained sand, mica and qtz; loose, dry.	5 / 7 / 7 — 1.5 / 1.5		10.5
		SP		4 / 2 / 3 — 1.4 / 1.5	B-4	12.0
	12.0	ML	12.6-30.0 SANDY SILT: as 0.5-11.2' No changes	3 / 3 / 3 — 1.5 / 1.5		13.5
	14.0			2 / 3 / 3 — 1.5 / 1.5	B-5	15.0
	16.0			2 / 3 / 3 — 1.5 / 1.5		16.5
	18.0			3 / 3 / 4 — 1.4 / 1.5		18.0
				3		19.5

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT [illegible] | HOLE NO. DH-7

Hole No. DH-7

DRILLING LOG	DIVISION	INSTALLATION	SHEET 2 OF 2 SHEETS

1. PROJECT	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL)
3. DRILLING AGENCY	12. MANUFACTURER'S DESIGNATION OF DRILL
4. HOLE NO. (As shown on drawing title and file number)	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN — DISTURBED — UNDISTURBED
5. NAME OF DRILLER	14. TOTAL NUMBER CORE BOXES
	15. ELEVATION GROUND WATER
6. DIRECTION OF HOLE ☐ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.	16. DATE HOLE — STARTED — COMPLETED
7. THICKNESS OF OVERBURDEN	17. ELEVATION TOP OF HOLE
8. DEPTH DRILLED INTO ROCK	18. TOTAL CORE RECOVERY FOR BORING. %
9. TOTAL DEPTH OF HOLE	19. SIGNATURE OF INSPECTOR

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	20.0	ML	12.6 - 30.0 SANDY SILT: (cont.)	3 1.5 / 5 1.5	B-5 (cont)	Drilling continues easy.
				3 / 2 1.2 / 3 1.5		21.0
	22.0					22.5
			22.8 - 23.5 more sandy lens	3 1.2 / 3 1.5 / 3		
	24.0		24.0 color getting reddish.	3 / 4 1.5 / 5 1.5		24.0
						25.5
	26.0			3 1.5 / 3 1.5 / 4	B-6	
						27.0
	28.0			4 1.5 / 4 1.5 / 4		
			28.0 - 30.0 slightly more sandy	5 1.5 / 5 1.5 / 4		28.5
	30.0		Bottom Hole 30.0'			30.0

Terminated boring at 30.0' (required depth) and back-filled hole with cuttings.

DATA ON THIS LOG ARE AN APPROXIMATION OF THE GEOLOGIC AND SUBSURFACE CONDITIONS BECAUSE THE INFORMATION WAS OBTAINED FROM INDIRECT, DISCONTINUOUS, AND POSSIBLY DISTURBED SAMPLING NECESSITATED BY USE OF SMALL-DIAMETER HOLES. ROTARY AND WASH BORING HOLES HAVE FURTHER COMPLICATIONS IN THIS REGARD BECAUSE OF THE NEED TO USE DRILLING FLUID AND/OR CASING IN ADVANCING HOLES.

THIS LOG INDICATES CONDITIONS IN THIS HOLE ONLY ON THE DATE INDICATED AND MAY NOT REPRESENT CONDITIONS AT OTHER LOCATIONS AND ON OTHER DATES. ANY WATER LEVELS SHOWN ARE SUBJECT TO VARIATION.

THIS HOLE WAS LOGGED IN SUCH A WAY AS TO PROVIDE DATA PRIMARILY FOR DESIGN PURPOSES AND NOT NECESSARILY FOR THE PURPOSES OF SPECIFIC CONTRACTORS.

THE STRATIFICATION LINES OR DEPTH INTERVALS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES, AND THE TRANSITIONS MAY BE GRADUAL.

SOIL CLASSIFICATIONS SHOWN ON LOGS ARE FIELD CLASSIFICATIONS BASED ON THE UNIFIED SOILS CLASSIFICATION SYSTEM

Hole No. DH-7A

DRILLING LOG	DIVISION	INSTALLATION	SHEET 1 OF 1 SHEETS

1. PROJECT: American River F.C.D., Maint. Area 10 & 11	10. SIZE AND TYPE OF BIT: 5.0" Hollow stem augers
2. LOCATION (Coordinates or Station): American River East levee, site #7 (toe)	11. DATUM FOR ELEVATION SHOWN (TBM or MSL):
3. DRILLING AGENCY: E.C. Exploration	12. MANUFACTURER'S DESIGNATION OF DRILL: Mobile B-53
4. HOLE NO. (As shown on drawing title and file number): DH-7A	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 2; UNDISTURBED 0
5. NAME OF DRILLER: Mike Moore	14. TOTAL NUMBER CORE BOXES: NA
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ~~ELEVATION~~ GROUND WATER:
7. THICKNESS OF OVERBURDEN: NA	16. DATE HOLE: STARTED 4-22-87; COMPLETED 4-22-87
8. DEPTH DRILLED INTO ROCK: NA	17. ELEVATION TOP OF HOLE: NA
9. TOTAL DEPTH OF HOLE: 20.0	18. TOTAL CORE RECOVERY FOR BORING: NA %
	19. SIGNATURE OF INSPECTOR: Paul F. Schmidt (WA)

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% ~~CORE~~ RECOVERY e	~~BOX OR~~ SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
	0.0	ML	FOUNDATION 0.0 - 20.0 SANDY SILT: Dk yel brn (10YR 4/2) to mod brn (5YR 3/4), ~40-70% Fines, non to slight plastic, no toughness, ~30-60% sand, very fine- to fine-grained, poorly graded, mica flakes; high pervious ness; soft to firm; moist 2.0-2.4 sand lens, clean 3.2-3.5 sand lens 6.9-7.5 sandy lens 8.5-9.0' sand lens 10.5-11.1 sandy lens 12.0-12.3 sandy lens 17.0-17.3 sandy lens 18.5-20.0 more sandy Termination at 20.0	3 1 1 — 1.4/1.5 1 2 2 — 1.4/1.5 2 2 2 — 1.5/1.5 2 2 3 — 1.5/1.5 3 3 3 — 1.5/1.5 3 3 4 — 1.4/1.5 3 3 3 — 1.3/1.5 3 3 3 — 1.2/1.5 3 2 3 — 1.3/1.5 3 4 4 — 1.5/1.5 3 4 3 — 1.3/1.5 2 2 2 — 1.5/1.3	B-1 B-2	Sampling with a 2.0" (OD) split spoon sampler, driven by a 140 lb. wire-line hammer free-falling 30.0" per blow. Drilling is very easy Terminated boring at 20.0' (required depth) and backfilled hole with cuttings

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: [illegible] HOLE NO. DH-7A

DATE STARTED 5/22/08 **DATE COMPLETED** 5/22/08	**GROUND ELEVATION** 52.95 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 75.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	**DRILLER'S NAME** E. Santellan **HELPER'S NAME** R. Ryon	**TOTAL DEPTH OF FILL** 9.8 ft
DRILLING METHOD 0 - 3 ft: HA, 3 - 10 ft: HSA, 10 - 75 ft: Rotary Wash	**DRILL RIG MAKE AND MODEL** MARL M-10 (Gregg Rig No. D-44)	**CONSULTANT COMPANY** GEI Consultants, Inc.
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5-inch drag bit	**DRILLING ROD TYPE AND DIAMETER** 6" HSA, 94mm	**FIELD LOGGER** M. Horse
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** Surface, 6-in., 10 ft	**FIELD LOG REVIEWER** G. Bradner
SAMPLER TYPE(S) Bag, DCore(2.5"), PCore(2.5"), Shelby(2.37"), SPT(1.375")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** Marl, automatic, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 83%
BOREHOLE BACKFILL OR COMPLETION 5% bentonite grout	**GROUNDWATER READING: DURING DRILLING** N/A due to rotary wash drilling method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Gravel Road Base.												
	1		[LEVEE FILL] LEAN CLAY with Sand (CL); yellowish brown (10YR 5/8); moist; 80% medium plasticity, medium dry strength, medium toughness fines; 20% fine sand; 0% gravel.		1										S01A_001_002B
	2				2										S02A_002_003B
50	3		[LEVEE FILL] SILT with Sand (ML); dark brown (10YR 3/3); moist; 85% low plasticity, medium dry strength, rapid dilatancy, low toughness fines; 15% fine sand; 0% gravel.												
	4				3	100									S03A_003_005T Pushed Shelby tube at 400 psi
	5														
	6		[LEVEE FILL] SANDY SILT (ML); medium dense; dark brown (10YR 3/3); moist; 52% medium dry strength, rapid dilatancy, low toughness fines; 48% fine sand; 0% gravel.		4	56	10 10 12 [22]	30	1.25P	16	NP	NP			S04A_005_007S
	7												52	HD	Box 1 Representative S05A_007_008P
45	8				5	100			1.5P						
FILL	9														
	10		[Approximate bottom of Levee Fill at 9.8'].												
	11		4-inch thick Silty Sand (SM) lense; 85% fine sand; 15% fines.		6	44	8 11 9 [20]	28	0.75P						S06B_010_012S S06A_011_012S
	12		SILTY SAND (SM); medium dense; very dark brown (10YR 2/2); wet; 58% fine sand; 42% no plasticity fines; 0% gravel; portion of fines are clay-sized.												S07A_012_013P
40	13				7	57									
	14														
	15														
	16				8	50	4 6 6 [12]	17					42	HD	S08A_015_017S
	17		As above except 70% sand; 30% fines; portion of fines are clay-sized.							20				SG	S09A_017_018P
35	18				9	86									
	19														
	20														

Draft 4 After Final Markups 11/5/2009

Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
Latitude: 38.56228 **Longitude:** -121.40544
Levee Station or Milepost: 3306+35 **Levee Mile:** 1.31
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCNBAR_003B
Sheet 1 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20		SILTY SAND (SM); as above.		10	50	5 6 6 [12]	17					30	HD	S10A_020_022S
	21														
	22		As above except increasing sand; decreasing fines.		11	36									S11_022_023P
30	23														
	24														
	25		SANDY SILT (ML); medium dense; very dark brown (10YR 2/2); moist; 57% low plasticity fines; 43% fine sand; 0% gravel.		12	50	4 5 8 [13]	18	0.5P				57	HD	S12A_025_027S
	26														
	27		As above except decreasing sand; increasing fines. SILTY SAND (SM); medium dense; very dark brown (10YR 2/2); moist; 60% fine sand; 40% low plasticity fines; 0% gravel.		13	50									S13C_027_027P S13B_027_028P S13A_028_029P
25	28														
	29														
	30		As above except 80% sand; 20% no plasticity fines.		14	39	7 8 9 [17]	24							S14A_030_032S
	31														
	32		11-inch Sandy Silt (ML) lense; 30% fine sand; 70% no plasticity fines.		15	60									S15B_032_033P S15A_033_034P
20	33		As above except dark yellowish brown (10YR 3/4); 70% sand; 30% fines; portion of fines are clay-sized.												
	34														
	35				16	44	7 7 8 [15]	21					30	HD	S16A_035_037S
	36														
	37		As above except 80% fine to medium sand; 20% fines.		17	95									S17A_037_037P
15	38														
	39														
	40		SILTY GRAVEL with Sand (GM); very dense; dark yellowish brown (10YR 3/6); moist; 50% fine to coarse, subrounded to rounded gravel, max. 1 in.; 35% fine to medium sand; 15% low plasticity fines.		18	39	23 23 20 [43]	59							S18A_040_042S 40' to 48': Rig chatter
	41														
	42		Gravel, max. 2.5 in.		19	0									No Recovery Gravels present in sampler
10	43														
	44														
	45														

Draft 4 After Final Markups 11/5/2009

Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
Latitude: 38.56228 **Longitude:** -121.40544
Levee Station or Milepost: 3306+35 **Levee Mile:** 1.31
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCNBAR_003B
Sheet 2 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		Gravel; as above.		20	0									No Recovery Gravel fragments in mud cuttings
	46														
	47														S21A_051_051P
5	48		LEAN CLAY (CL); very stiff; olive brown (2.5Y 4/4); moist; 95% medium plasticity, medium toughness fines; 5% fine sand; 0% gravel.		21	19									
	49														
	50		6-inch thick gravel lense.		22	0	50/4"								No Recovery Driller notes gravel
	51								>3.0P						S22A_051_051P Driller notes rock in hole; pushing rock
	52		Gravel.												
0	53				22	16									Rig Chatter
	54														
	55		LEAN CLAY (CL); hard; yellowish brown (10YR 5/8); 90% low plasticity fines; 10% fine sand; 0% gravel; Iron oxide staining.		23	61	17 47 39 [86]	119	>4.5P						S23A_055_057S
	56														
	57		6-inch thick Silt (ML) lense; 10% fine sand; 90% low plasticity fines.												S24C_057_057P S24B_058_058P S24A_059_060P
-5	58		SILTY SAND (SM); dark yellowish brown (10YR 4/6); 60% fine to medium sand; 40% low plasticity fines; 0% gravel.		24	71									
	59		Poorly Graded SAND (SP); dark olive brown (2.5Y 3/3); moist; 95% fine to medium sand; 5% fines; 0% gravel.												
	60														S25B_060_061S S25A_061_062S
	61		1-foot thick Silty Sand (SM) lense; very dense; 60% fine to medium sand; 40% low plasticity fines.		25	50	21 29 31 [60]	83							
	62		Poorly Graded SAND (SP); dark olive brown (2.5Y 3/3); moist; 95% fine to medium sand; 5% low plasticity, slow dilatancy fines; 0% gravel.												Box 2 Representative S26A_062_062P
-10	63				26	43									
	64														
	65		8-inch thick Lean Clay (CL) lense; 5% fine sand; 95% medium plasticity fines.												S27B_065_067S S27A_065_067S
	66		SILT with Sand (ML); very dense; olive brown (2.5Y 4/4); moist; 85% low plasticity, slow dilatancy fines; 15% fine sand; 0% gravel.		27	50	13 19 21 [40]	55							
	67														S28B_067_067P S28A_070_070P
-15	68		LEAN CLAY (CL); hard; olive (5Y 5/4); moist; 95% medium toughness fines; 5% sand; 0% gravel.		28	100									
	69								>4.5P						
	70														

Draft 4 After Final Markups 11/5/2009

Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
Latitude: 38.56228 **Longitude:** -121.40544
Levee Station or Milepost: 3306+35 **Levee Mile:** 1.31
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCNBAR_003B
Sheet 3 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70		LEAN CLAY (CL); as above except very stiff.		29	61	19 21 25 [46]	64	>3.3P	19	25	8			S29A_070_072P
	71														
	72		As above except dark yellowish brown (10YR 4/6); 10% fine sand; 90% fines.		30	26									S30A_072_072P
-20	73														
	74														
	75														
	76		Borehole terminated at 75 feet. Backfilled with 5% bentonite grout.												
	77														
-25	78														
	79														
	80														
	81														
	82														
-30	83														
	84														
	85														
	86														
	87														
-35	88														
	89														
	90														
	91														
	92														
-40	93														
	94														
	95														

Draft 4 After Final Markups 11/5/2009

Borehole Location: North Bank Crest **County:** Sacramento
Coordinates: Northing: 1,967,149.09 **Easting:** 6,731,673.44
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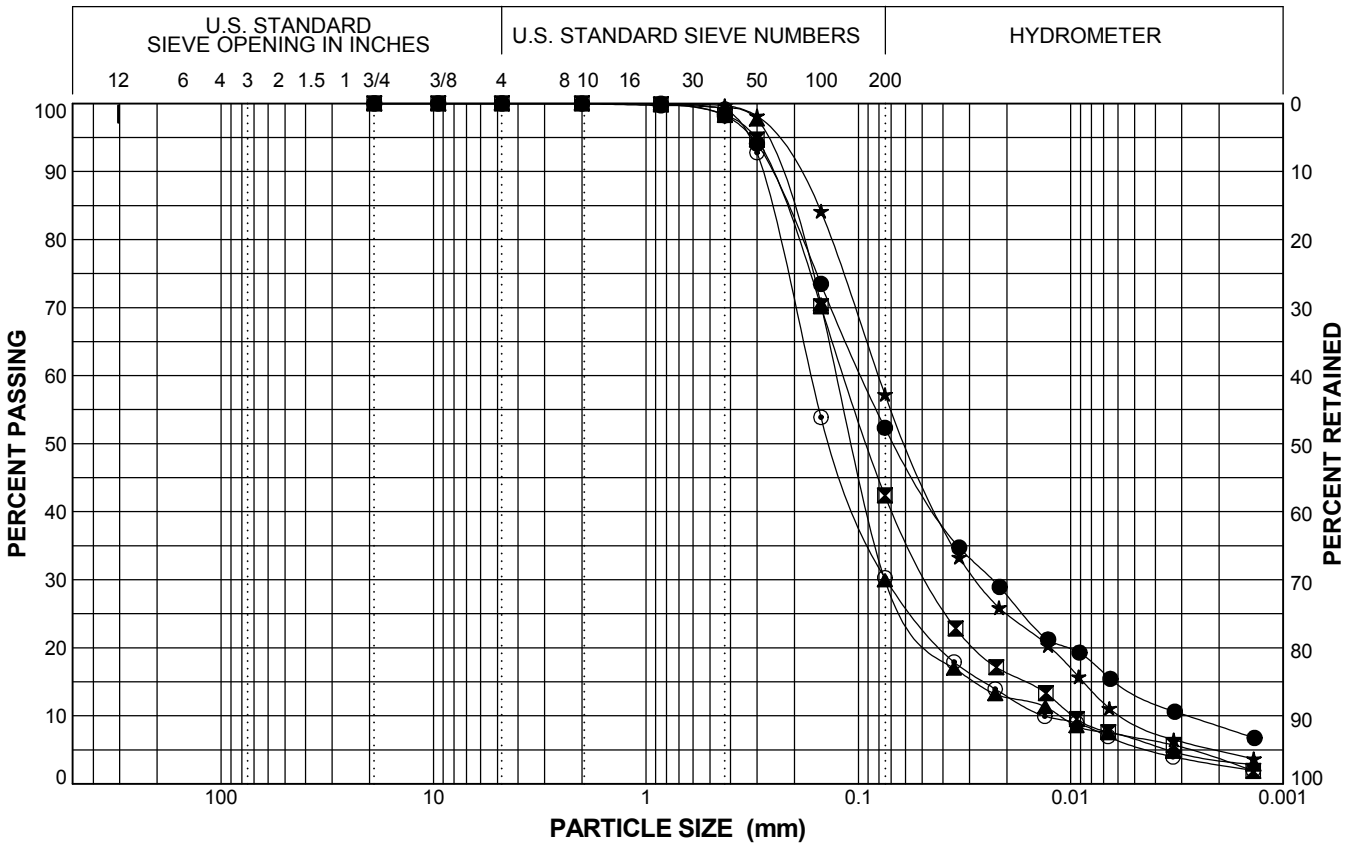
LOG OF BORING
WCNBAR_003B
Sheet 4 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	



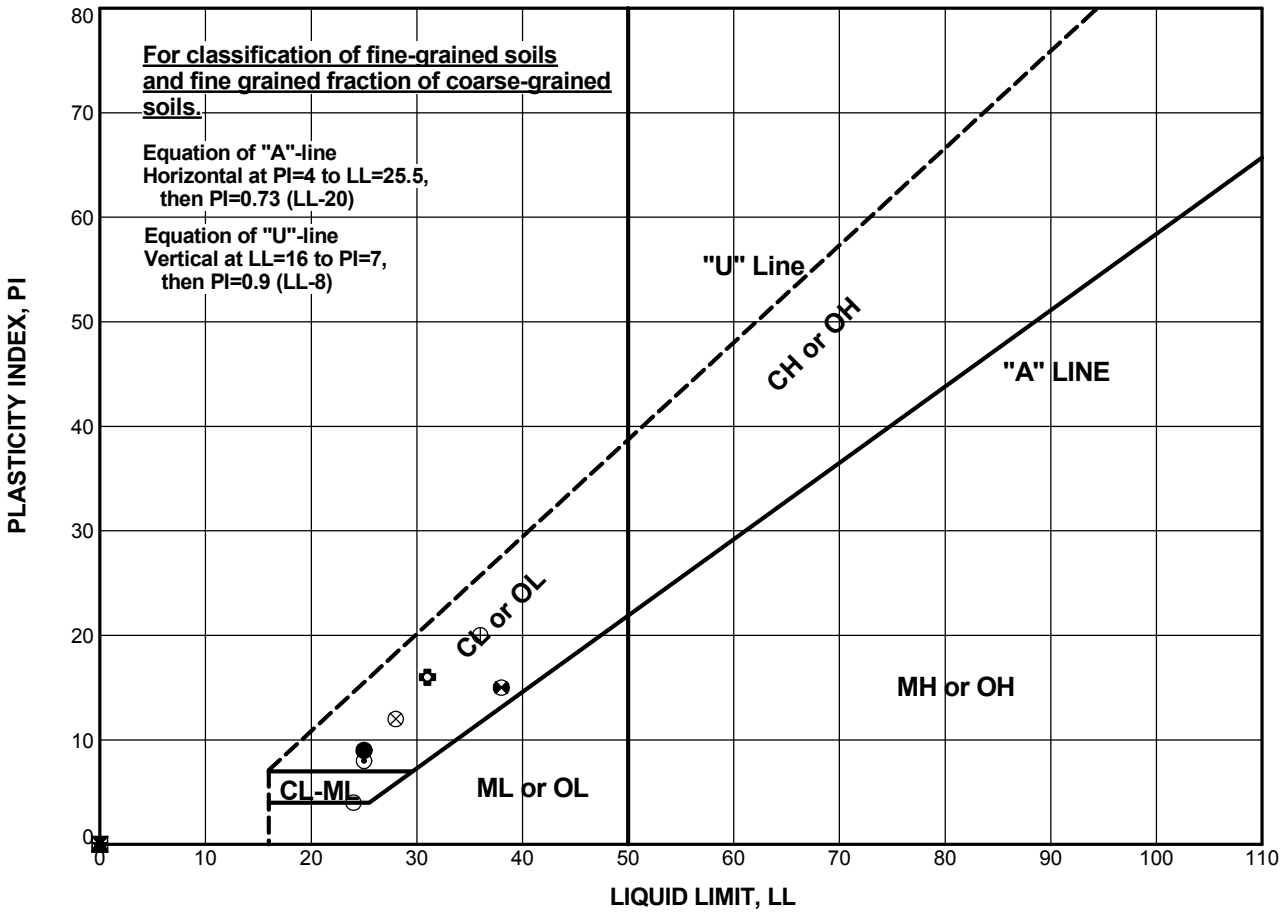
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WCNBAR_003B	S05A_007_008P	7	●	0.0	47.7	52.3	SANDY SILT (ML)
WCNBAR_003B	S08A_015_017S	15	⊠	0.0	57.6	42.4	SILTY SAND (SM)
WCNBAR_003B	S10A_020_022S	20	▲	0.0	70.1	29.9	SILTY SAND (SM)
WCNBAR_003B	S12A_025_027S	25	★	0.0	42.8	57.2	SANDY SILT (ML)
WCNBAR_003B	S16A_035_037S	35	⊙	0.0	69.7	30.3	SILTY SAND (SM)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PARTICLE SIZE DISTRIBUTION CURVES

DWR LEVEE U/NU SIEVE CURVES #200 REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 2/3/10



Boring Number	Sample Number	Depth (feet)	Test Symbol	WC (%)	LL	PL	PI	Classification
WCNBAR_001B	S06A_015_017S	15	●	13.7	25	16	9	CLAYEY SAND (SC)
WCNBAR_002B	S04A_005_007S	5	⊠	17.5	NP	NP	NP	SANDY SILT (ML)
WCNBAR_002B	S08A_015_017S	15	▲		NP	NP	NP	SILTY SAND (SM)
WCNBAR_003B	S04A_005_007S	5	★	15.6	NP	NP	NP	SANDY SILT (ML)
WCNBAR_003B	S29A_070_072S	70	⊙	18.5	25	17	8	LEAN CLAY (CL)
WCNBAR_004B	S02A_002_003B	2	✿	15.9	31	15	16	LEAN CLAY (CL)
WCNBAR_004B	S08A_014_014P	13.5	○	17.6	24	20	4	SANDY SILTY CLAY (CL-ML)
WCNBAR_005B	S08A_010_012S	10	△	10.4	NP	NP	NP	SILTY SAND (SM)
WCNBAR_005B	S16A_036_036S	35	⊗	17.8	28	16	12	LEAN CLAY with Sand (CL)
WCNBAR_005B	S18A_041_042S	40	⊕	16.3	36	16	20	LEAN CLAY with Sand (CL)
WCNBAR_005B	S22A_050_052S	50	□	17.7	NP	NP	NP	SILTY SAND (SM)
WCSBAR_001B	S02A_002_003B	2	⊗	16.8	38	23	15	LEAN CLAY with Sand (CL)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PLASTICITY CHART

DWR LEVEE U/NU ATT. PLOT (U LINE) REV1; AMERICAN RIVER LEVEE BORINGS 11-3-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/3/09

ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
ARCADE CREEK NORTH RN U7 LM 0.90
Table F-2-5: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD88)	Layer ID	Material Type	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data						Recommended Hydraulic Conductivity					Recommended Strength Parameters		
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	PI	LL	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARFC_003B	44.48	1	Sandy Lean Clay Levee	CL	0.00	12.79	44.48	31.69	12.79	12.89	61	10	9	16	14	27	1.00E-05	4.00	2.50E-06	0.028	0.007	24	50	115
		2	Sandy Lean Clay Blanket	CL	12.79	21.64	31.69	22.84	8.85		55	11	12	12	16 12	27 26	1.00E-05	1.00	1.00E-05	0.028	0.028	28	50	115
		3	Poorly Graded Sand	SP	21.64	40.14	22.84	4.34	18.50		12	35	51	38	19	47	5.00E-03	4.00	1.25E-03	14.175	3.544	35	0	130
		4	Silty Sand	SM	40.14	45.64	4.34	-1.16	5.50		22	82	121	82	7	33	1.00E-03	4.00	2.50E-04	2.835	0.709	33	0	125
		5	Sandy Silt	ML	45.64	55.64	-1.16	-11.16	10.00		94	50	74	48			2.00E-04	4.00	5.00E-05	0.567	0.142	30	0	120
		6	Silty Sand	SM	55.64	76.50	-11.16	-32.02	20.86		23	52	76	40	12 5 10 26	41 24 35 49	1.00E-03	4.00	2.50E-04	2.835	0.709	35	0	125
					Total Depth (ft.)	**76.50**																		

DATE STARTED **5/22/07**	DATE COMPLETED **5/23/07**	GROUND ELEVATION **44.48 ft**	ELEVATION BASIS **Survey crew**	TOTAL DEPTH OF BORING **76.5 ft**
DRILLING CONTRACTOR **Westex**		DRILLER'S NAME **K. Jensen**	HELPER'S NAME **T. Seaver/M. Daniels**	TOTAL DEPTH OF FILL **21.5 ft**
DRILLING METHOD **0 - 21.5 ft: Hollow-Stem Auger, 21.5 - 76.5 ft: Rotary Wash**		DRILL RIG MAKE AND MODEL **Mobile B61 HDX (Rig 103)**		CONSULTANT COMPANY **Geomatrix**
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) **10" HSA, 4-3/8" Core Bit**		DRILLING ROD TYPE AND DIAMETER **NWJ 67 mm, HQ Core 94 mm**		FIELD LOGGER **A. Behan**
☒ VERTICAL ☐ INCLINED		CASING TYPE, DIAMETER, INSTALLATION DEPTH **10" HSA to 20'**		FIELD LOG REVIEWER **Y. Ma**
SAMPLER TYPE(S) **Mod Cal (2"), Punch Core (2.25"), Shelby (1.87"), SPT (1.4")**		HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP **Mobile, self compensating auto, 140 lbs/30-inch drop**		HAMMER EFFICIENCY **77%**
BOREHOLE BACKFILL OR COMPLETION **See Termination Notes**		GROUNDWATER READING: DURING DRILLING **N/A due to rotary wash drilling method**	AFTER DRILLING (DATE-TIME)	

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	0		SANDY LEAN CLAY (CL); dark yellowish brown (10YR 4/6) mottled with light brownish gray (10YR 6/2) and very dark grayish brown (10YR 3/2); dry; 61% low plasticity, high dry strength, no dilatancy, medium toughness fines; 39% fine to medium sand; trace coarse sand; (FILL).												
	1														
	2														
	3			▌	1	78	5 8 14	22			15				S01B_003_004M S01A_004_004M
	4														
40	5		Color changes to very dark brown (10YR 2/2) mottled with dark yellowish brown (10YR 4/6), fine sand, slow dilatancy fines at 4.5'.												
	6			▌	2	89	4 4 5	9			15	27	14		S02B_006_006M S02A_006_007M
	7														
	8		6" clayey sand lens at 8'.	╳	3	78	2 3 3	6	8						S03B_008_008S S03A_008_009S
	9														
35	10		Fine to medium sand; fines content varies throughout layer with zones of clayey sand interbedded throughout at 9.5'. 4" silty sand lens at 10.3'.	╳	4	89	1 1 2	3	4						S04A_010_012S
	11		1" silty sand lens at 10.9'. 1" silty sand lens at 11.2'.												
	12														
	13		3" silty sand lense at 12.8'.	╳	5	100	2 3 5	8	10						S05A_013_014S
	14														
30	15														
	16			▌	6	100					16	27	16	61	S06A_015_017T 300 psi
	17														
	18		Color changes to dark brown (10YR 3/3); moist at 17.3'. CLAYEY SAND (SC); dark yellowish brown (10YR 3/6); moist; 52% fine sand; 48% fines; (FILL).	╳	7	89	1 3 4	7	9		15	26	12	48	S07B_018_018S S07A_018_019S
	19		SANDY LEAN CLAY (CL); dark brown (10YR 3/3) mottled with dark yellowish brown (10YR 3/6); moist; 57% low plasticity, high dry strength, slow dilatancy, medium toughness fines; 43% sand; (FILL).												
25	20														

Draft 4 After Final Markups 5/21/2008

Borehole Location: Crest of the Levee
Coordinates: North 1,990,149.70 East 6,717,833.03
Levee Station or Milepost: STA: 5048+89 OFFSET: 2.4 Left
GPS: Latitude 38.62567 Longitude -121.45337
Channel / River Name / Feature: Arcade Creek
County: Sacramento

LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	20														
	21		(BASE OF FILL).		8	78	5 7 8	15			22			57	S08B_021_021M S08A_021_022M
	22		SILTY SAND (SM); brown (7.5YR 4/4); dry; 80% fine sand; 20% fines; (NATIVE).												S09A_022_023P Switched to rotary wash at 21.5'
	23				9	21									
	24		Poorly Graded SAND (SP); medium dense; dark yellowish brown (10YR 4/4); wet; 95% fine to medium sand; 5% fines; no cementation.												
20	25														
	26				10	78	1 4 6	10	13					5	S10A_025_027S
	27														
	28				NR	0									
	29														
15	30														
	31		SANDY SILT (ML); olive brown (2.5Y 4/4); moist; 51% low dry strength, no to slow dilatancy, low toughness fines; 49% fine sand; few concretions.		11	56	6 21 38	59	76		28	47	19	51	S11B_030_031S S11A_031_031S
	32		Poorly Graded SAND with Silt (SP-SM); dense; olive brown (2.5Y 4/4); moist; 88% sand (mostly fine sand, little medium sand, few coarse sand); 12% fines; with few clayey interbeds; few fine gravel; micaceous.												
	33				NR	0									
	34														
10	35		Color changes to light brownish gray (2.5Y 6/2) at 35'.												
	36				12	39	7 13 17	30	39					12	S12A_035_037S
	37														
	38				13	2									
	39														
5	40		2" sandy silt lens at 39.8'.												
	41		SILTY SAND (SM); dense to very dense; olive brown (2.5Y 4/4); moist; 72% fine sand; 28% fines; mostly fine sand, little medium sand, few coarse sand; with few clayey interbeds; few fine gravel; micaceous.		14	33	3 17 22	39	50					28	S13A_040_040P S14A_040_041S
	42														DN: Thickening mud at 41.5' to get better recovery
	43		LEAN CLAY with Sand (CL); olive brown (2.5Y 4/4); moist; 80% medium plasticity, medium dry strength, slow dilatancy, medium toughness fines; 20% fine sand; with concretions.		15	67					31	33	7	88	S15A_043_044P
	44		SILT (ML); olive brown (2.5Y 4/4); moist; 88% low dry strength, rapid dilatancy, low toughness fines; 12% fine sand.												
0	45		SILTY SAND (SM); very dense; light yellowish brown												

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LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	45		(2.5Y 6/3) to grayish brown (2.5Y 5/2); moist; 84% fine sand; 16% fines; weak cementation.		16	60	10 32 50/3"	82/ 9"						16	S16B_045_046S S16A_046_046S
	46		SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 91% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 9% sand.											91	S17A_047_048P
	47														
	48		SILT with Sand (ML); very dense; olive brown (2.5Y 4/4); moist; 73% no dry strength, rapid dilatancy, low toughness fines; 27% fine sand.		17	27									
	49														
-5	50				18	100	23 50/6"	50/ 6"			24	NP	NP	73	S18B_050_051S S18A_051_051S
	51		SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 95% low dry strength, rapid dilatancy, low toughness fines; 5% sand.												
	52		SILTY SAND (SM); olive brown (2.5Y 4/4); moist; 60% fine sand; 40% fines.												S19B_052_053P
	53		SANDY SILT (ML); olive brown (2.5Y 4/4); moist; 60% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 40% fine sand.		19	63									
	54		SILT (ML); very dense; olive brown (2.5Y 4/4); moist; 95% low plasticity, low dry strength, rapid dilatancy, low toughness fines; 5% sand; grades sandy with depth.												S19A_054_054P
-10	55				20	100	22 50/6"	50/ 6"							S20B_055_056S S20A_056_056S
	56		SILTY SAND (SM); very dense; olive brown (2.5Y 4/4); moist; 70% fine sand; 30% fines.												
	57														
	58				NR	0									DN: Thinks low recovery is due to material type and not to drilling fluid thickness
	59														
-15	60				21	75	35 50/6"	50/ 6"							S21A_060_061S
	61		Wet; fine to medium sand at 61'.												
	62														
	63				22	50									
	64		74% sand, 26% fines at 64'.											26	S22B_064_065P S22A_065_065P
-20	65		55% sand, 45% fines, strong cementation, with numerous fine to coarse sand-sized and fine gravel-sized concretions, with oxide staining at 65'.		23	58	22 50/6"	50/ 6"			27	41	12	45	S23A_065_066S
	66														
	67		SANDY SILTY CLAY (CL-ML); olive brown (2.5Y 4/4) mottled with dark yellowish brown (10YR 4/6); wet; 51% low to medium dry strength, slow to rapid dilatancy, low toughness fines; 49% fine sand; with oxide staining.								27	24	5	51	S24C_067_067P
	68		SILTY SAND (SM); olive brown (2.5Y 4/4); moist; 70% fine sand; 30% fines.		24	88									S24B_068_068P
	69		CLAYEY SAND (SC); olive brown (2.5Y 4/4) mottled with dark yellowish brown (10YR 4/6); wet; 85% fine sand; 15% fines; with oxide staining.								36	35	10	58	S24A_069_070P
-25	70		SANDY SILT (ML); very dense; olive brown (2.5Y 4/4);												

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Channel / River Name / Feature: Arcade Creek
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LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations

Elevation, feet	Depth, feet	Material Graphics	FIELD CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in.	Blows per Foot	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	REMARKS
	70		moist; 58% low plasticity, low to medium dry strength, slow dilatancy, low toughness fines; 42% fine sand; with concretions; grades sandier with depth.		25	64	27 50/5"	50/ 5"							S25B_070_071S S25A_071_071S
	71		SILTY SAND (SM); very dense; olive brown (2.5Y 4/4); moist; 85% fine sand; 15% fines.												
	72														
	73				26	49									
	74		70% sand, 30% fines at 74'.											30	S26A_074_075P
-30	75		LEAN CLAY (CL); light olive brown (2.5Y 5/3); dry; 87% high to very high dry strength, no dilatancy, medium to high toughness fines; 13% fine sand; strong cementation.		27	56	5 26 30	56	72		26	49	26	87	S27A_075_076S
	76														
	77		Borehole terminated at 76.5 feet. Backfilled with 5% bentonite grout.												
	78														
	79														
-35	80														
	81														
	82														
	83														
	84														
-40	85														
	86														
	87														
	88														
	89														
-45	90														
	91														
	92														
	93														
	94														
-50	95														

Draft 4 After Final Markups 5/21/2008

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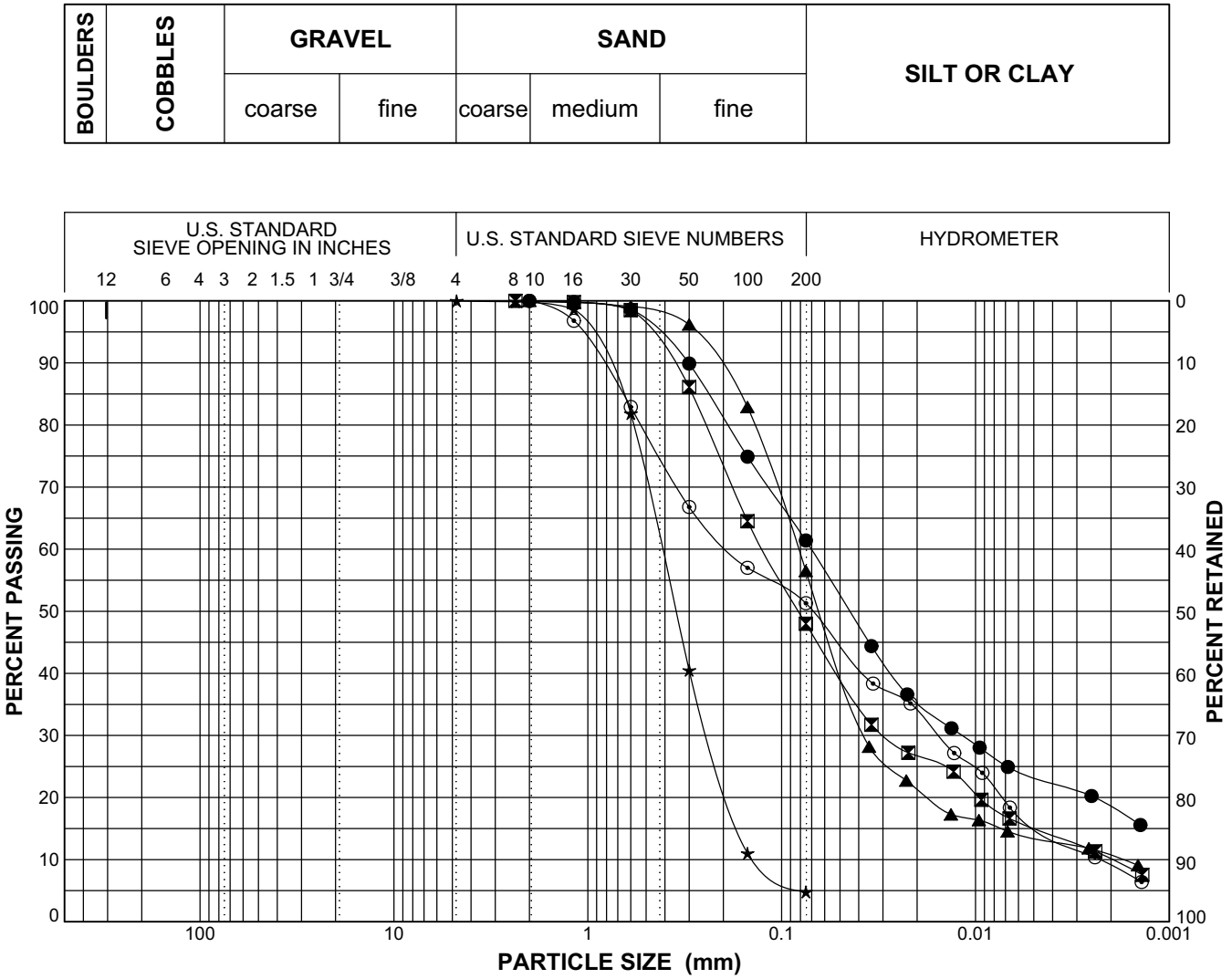
LOG OF BORING
WRARFC_003B

Engineering Support Services
Urban Levee Geotechnical Evaluations



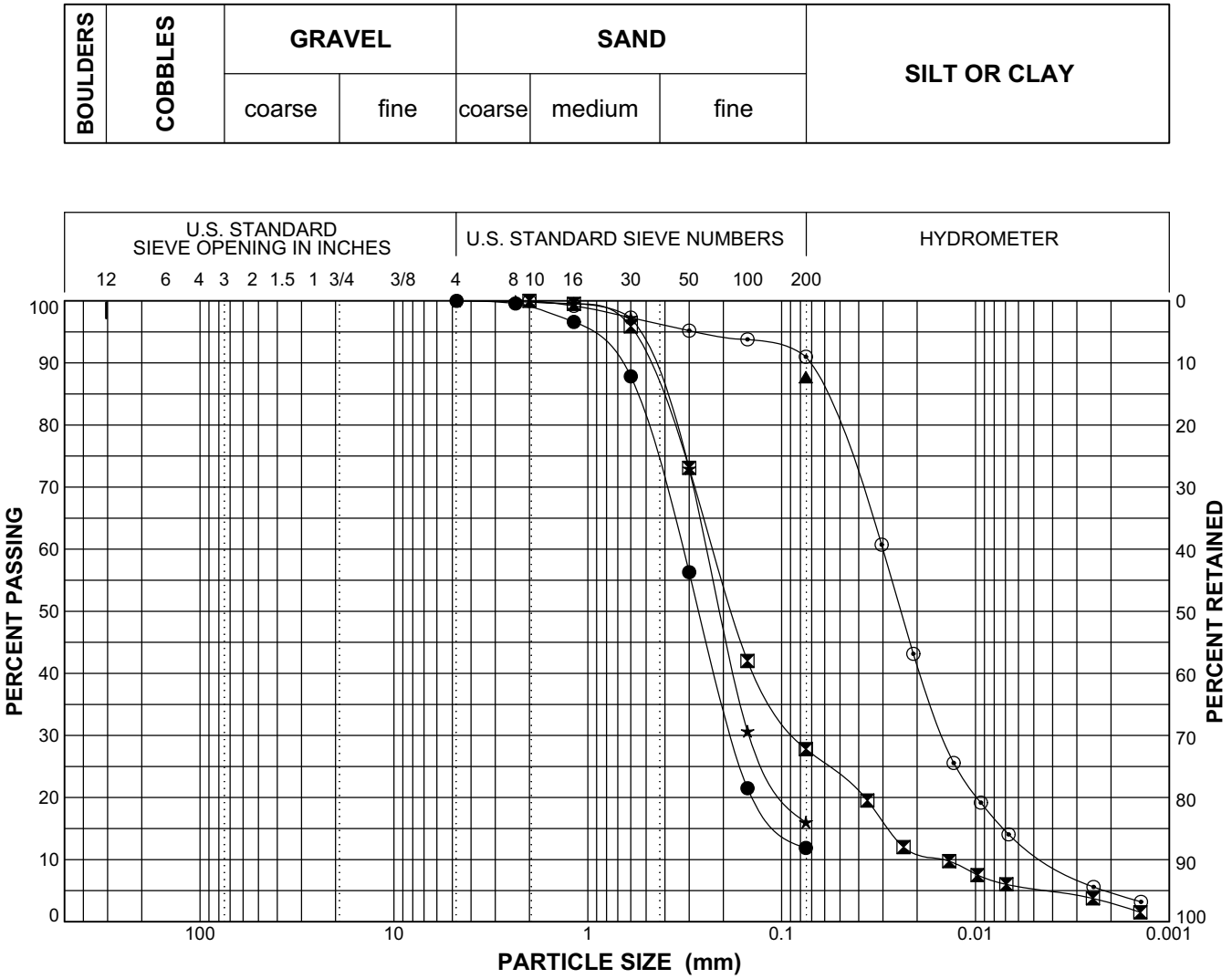
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	6A	15	●	0	39	61	SANDY LEAN CLAY CL
WRARFC_003B	7A	17.8	⊠	0	52	48	CLAYEY SAND SC
WRARFC_003B	8A	21	▲	0	44	57	SANDY LEAN CLAY CL
WRARFC_003B	10A	25	★	0	95	5	Poorly Graded SAND SP
WRARFC_003B	11B	30	⊙	0	49	51	SANDY SILT ML

Engineering Support Services
Urban Levee Geotechnical Evaluations

Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08



Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	12A	35	●	0	88	12	SILTY SAND SM
WRARFC_003B	14A	40	⊠	0	72	28	SILTY SAND SM
WRARFC_003B	15A	43	▲	0	0	88	SILT ML
WRARFC_003B	16B	45	★	0	84	16	SILTY SAND SM
WRARFC_003B	17A	46.5	⊙	0	9	91	SILT ML

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PARTICLE SIZE DISTRIBUTION CURVES

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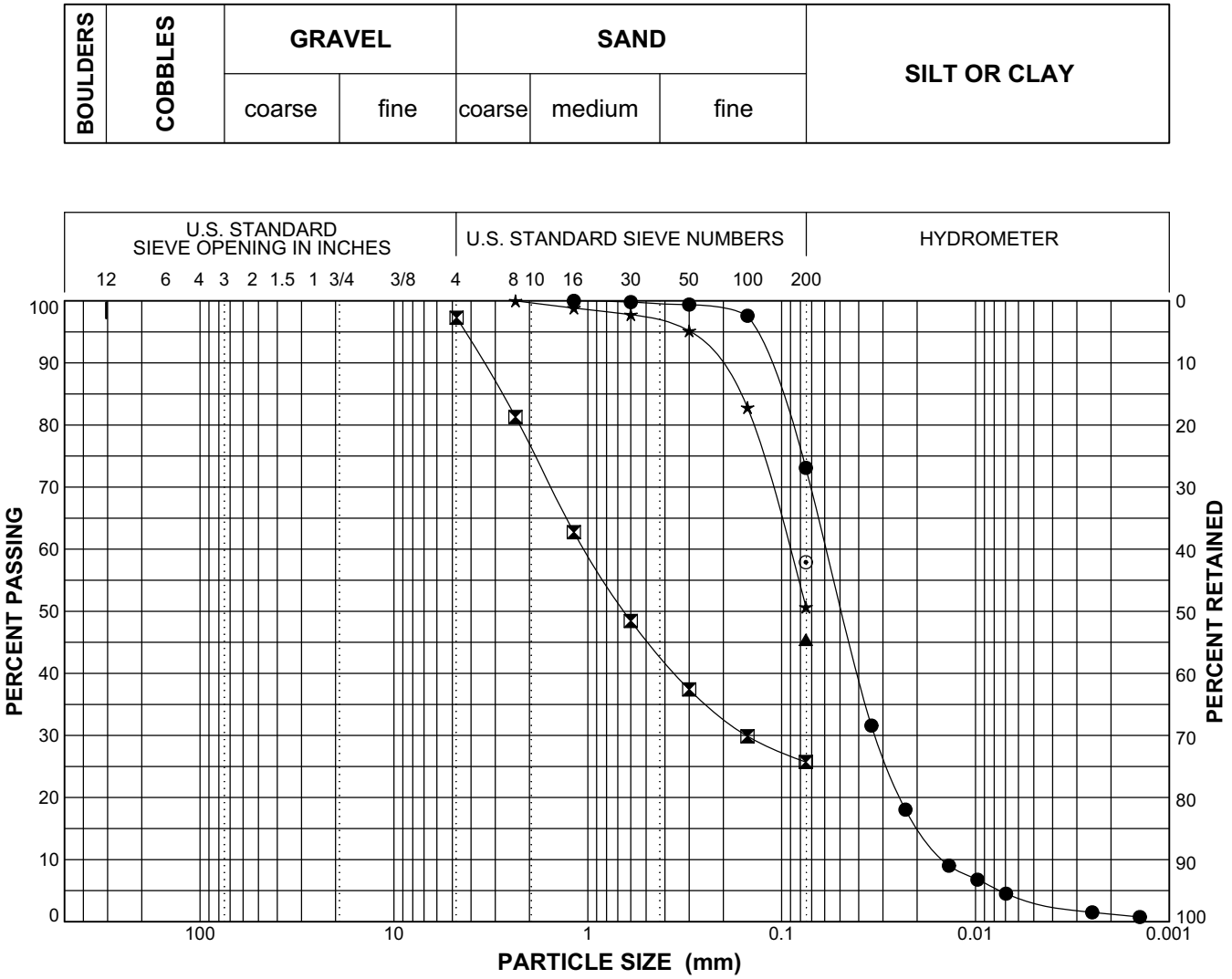

Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	18B	50	●	0	27	73	SILT with Sand ML
WRARFC_003B	22A	64	⊠	0	72	26	SILTY SAND SM
WRARFC_003B	23A	65	▲	0	0	45	SILTY SAND SM
WRARFC_003B	24C	66.5	★	0	49	51	SANDY SILTY CLAY CL-ML
WRARFC_003B	24A	69	⊙	0	0	58	SANDY SILT ML

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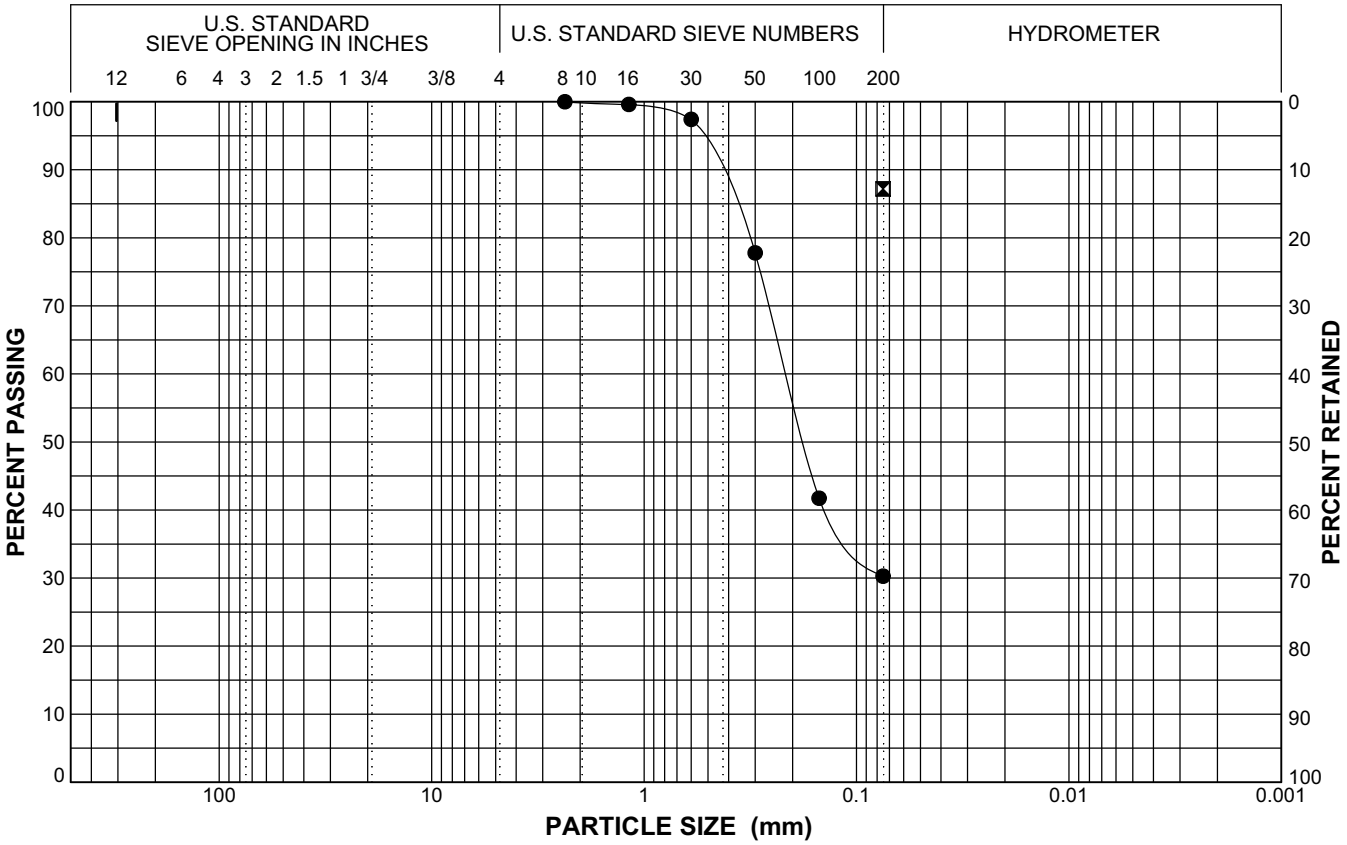
Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	



Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WRARFC_003B	26A	74	●	0	70	30	SILTY SAND SM
WRARFC_003B	27A	75	⊠	0	0	87	LEAN CLAY CL

DWR SIEVE CURVES ALL EXPLORATIONS REV10.GPJ DWR TEST 81507.GDT 5/27/08

Engineering Support Services
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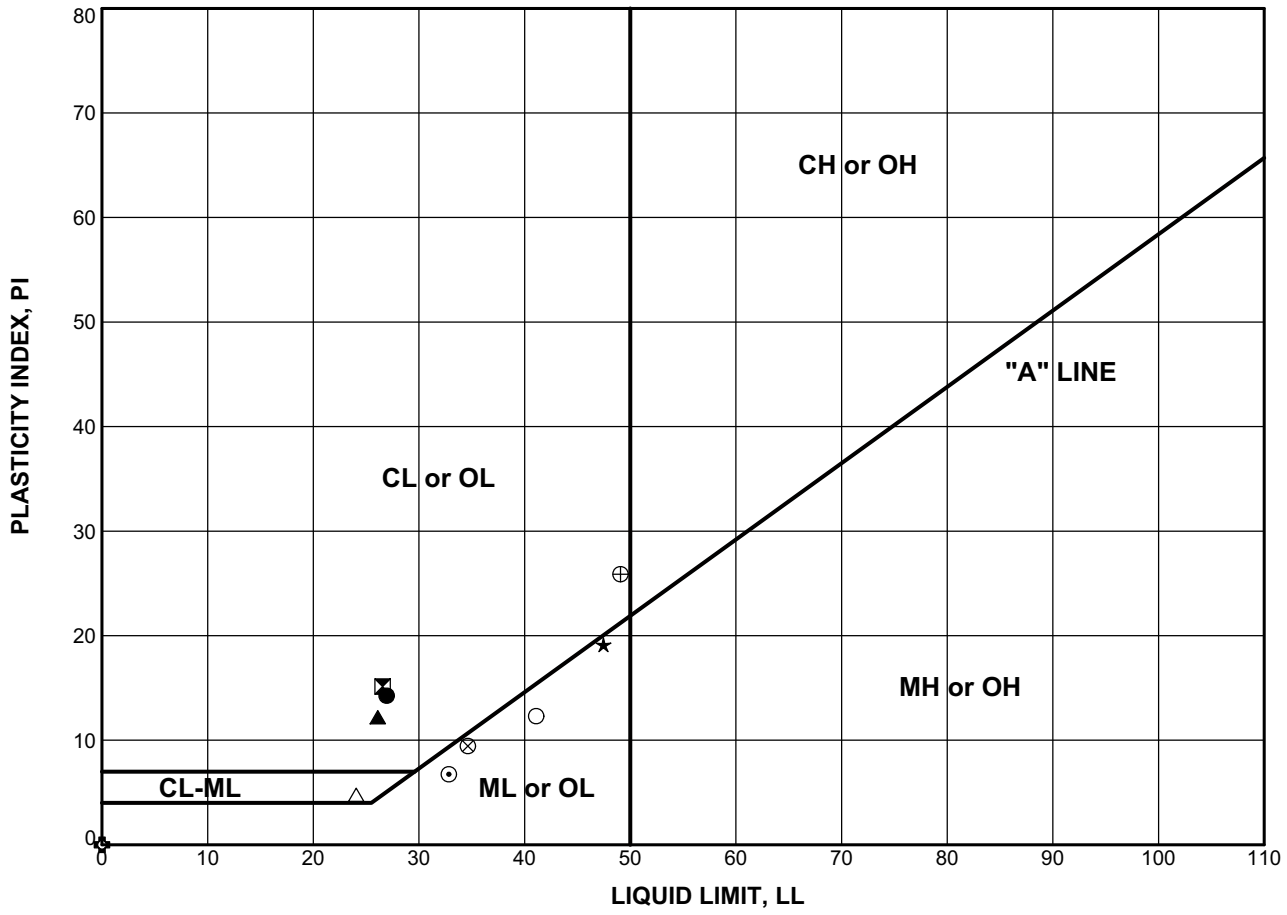
Natomas East Main Drainage Canal

PARTICLE SIZE DISTRIBUTION CURVES



Boring Number	Sample Number	Depth (feet)	Test Symbol	WC (%)	LL	PL	PI	Classification
WRARFC_003B	2A	6	●	14.8	27	13	14	SANDY LEAN CLAY CL
WRARFC_003B	6A	15	⧗	15.7	27	11	16	SANDY LEAN CLAY CL
WRARFC_003B	7A	17.8	▲	15.1	26	14	12	CLAYEY SAND SC
WRARFC_003B	11B	30	★	27.5	47	28	19	SANDY SILT ML
WRARFC_003B	15A	43	⊙	31.0	33	26	7	SILT ML
WRARFC_003B	18B	50	✿	24.4	NP	NP	NP	SILT with Sand ML
WRARFC_003B	23A	65	○	26.5	41	29	12	SILTY SAND SM
WRARFC_003B	24C	66.5	△	27.3	24	19	5	SANDY SILTY CLAY CL-ML
WRARFC_003B	24A	69	⊗	35.7	35	25	10	SANDY SILT ML
WRARFC_003B	27A	75	⊕	25.5	49	23	26	LEAN CLAY CL

DWR ATTERBERG PLOT ALL EXPLORATIONS REV10.GPJ DWR LEVEES 111507.GDT 5/27/08

Engineering Support Services
Urban Levee Geotechnical Evaluations

Natomas East Main Drainage Canal

PLASTICITY CHART

AMERICAN RIVER SOUTH BASIN

ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

STRATIGRAPHY INPUT

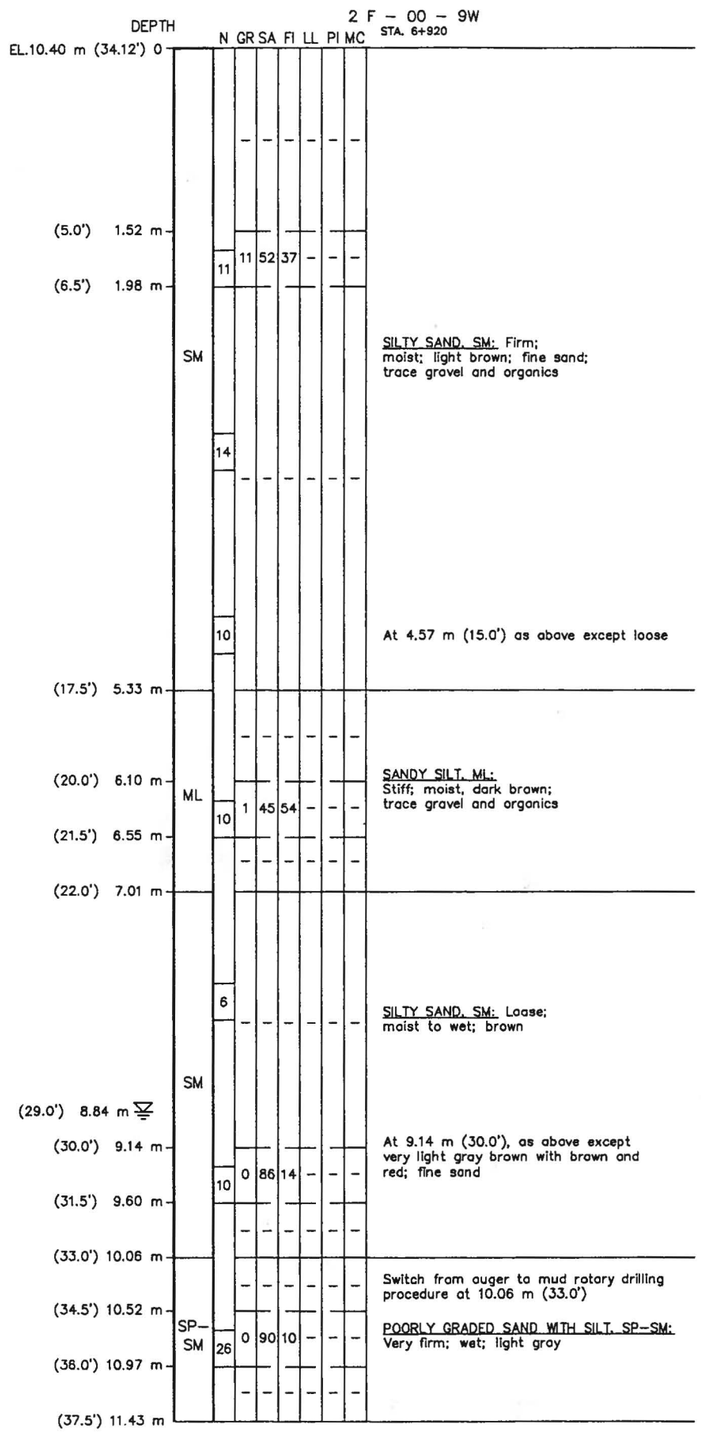
BORING LOGS

LABORATORY TESTING

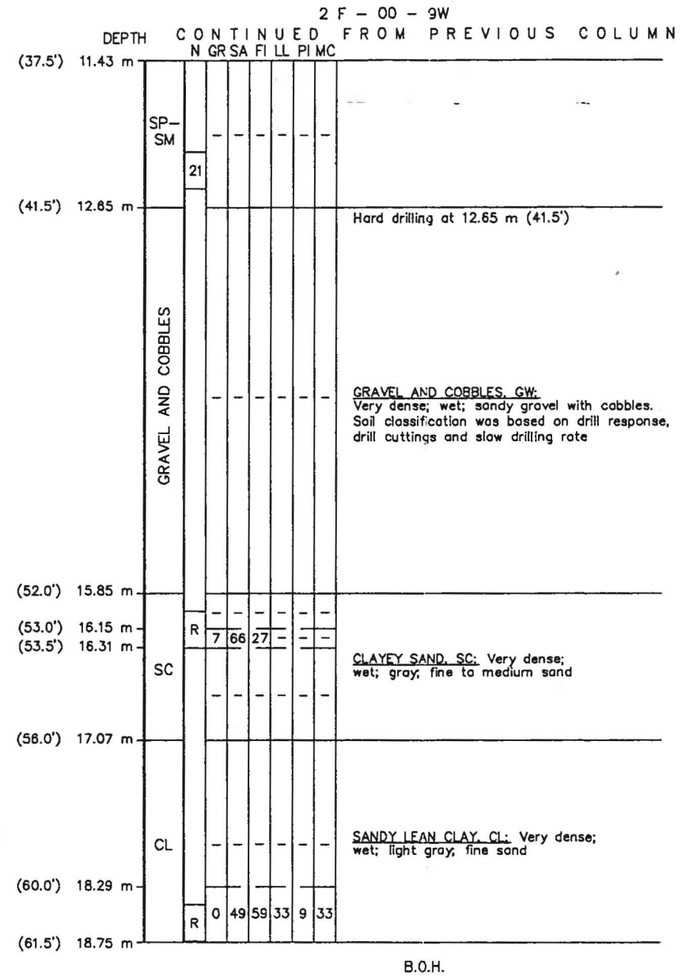
AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
AMERICAN RIVER SOUTH RB U4 LM 3.90
Table F-2-10: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD 88)	Layer ID	Soil Description	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data										Comments
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	Torvane (tsf)	Pocket Penetrometer (tsf)	Average Unit Weight (pcf)	PI	LL	LI	
2F-96-29, 2F-00-9W, 2F-00-114, WCSBAR_003B, 2F-99-17, 2F-97-23	49.70	1	Poorly Graded Sand to Silty Sand (SP-SM)	SP-SM	0.00	22.10	49.70	27.60	22.10	13.30	19	12									
		2	Levee Foundation Silt (ML)	ML	22.10	32.10	27.60	17.60	10.00		54	6									
		3	Poorly Graded Silty Sand (SP-SM) with Clay &	SP-SM	32.10	54.60	17.60	-4.90	22.50		10	13									
		4	Poorly Graded Gravel & Cobbles (GP)	GP	54.60	70.70	-4.90	-21.00	16.10		47	49									
		5	Silt and Clay (CL-ML)	ML	70.70	82.80	-21.00	-33.10	12.10		71	73									
		6	Cut-off Wall	SCB WALL																	
		7	Impervious Clay Cap	CL																	
					Total Depth (ft.)	**82.80**															

Layer ID	Recommended Hydraulic Conductivity					Strenth Coorelations								Strength from Lab Test Data						Recommended Strength Parameters			Comments
	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Total Overburden Pressure at Mid Layer During Drilling (psf)	Effective Overburden Stress at Mid Layer During Drilling (psf)	OCR from N_{60}[3]	OCR from LI[3]	Su from N (psf)[4]	Su/σ'_o from PI (psf)[4]	Calculated Maximum Past Pressure (psf)[5]	Drained Friction Angle[7]	OCR	σ'_p (psf)	Su (psf)	Su/σ'_o	Φ'	C' (psf)	Φ'	C' (psf)	γ (pcf)	
1	1.00E-03	4.00	2.50E-04	2.835	0.709	0	0													33	0	125	
2	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-861													30	0	120	
3	5.00E-03	4.00	1.25E-03	14.175	3.544	0	-1875													33	0	125	
4	1.20E-02	4.00	3.00E-03	34.020	8.505	0	-3079													35	0	135	
5	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-3959													30	0	120	
6	1.00E-06	1.00	1.00E-06	0.003	0.003	0	0													0	50	85	
7	1.00E-05	1.00	1.00E-05	0.028	0.028	0	0	#VALUE!	#VALUE!											28	50	115	



CONTINUED IN NEXT COLUMN



NOTES:

1. SEE FIGURE B–1 FOR LEGEND AND NOTES.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

AMERICAN RIVER WATERSHED PROJECT (COMMON FEATURES), CALIFORNIA LEFT (SOUTH) BANK LEVEE STRENGTHENING CONTRACT 2	DEPARTMENT OF THE ARMY CORPS OF ENGINEERS SACRAMENTO, CALIFORNIA **URS Greiner Woodward Clyde** OAKLAND, CALIFORNIA	DEEP CUTOFF WALL FIELD INVESTIGATION **PIEZOMETER INSTALLATION PROGRAM** LOG OF EXPLORATION 2F–00–9W	FIGURE B–7

2F-00-114

STA. 6+500

DEPTH		N	GR	SA	FI	LL	PI	MC	
EL. 14.0m (45.9') 0	MH	25	–	–	–	–	–	–	SANDY ELASTIC SILT, MH: Dense; moist; brown; about 60% low plasticity fines; about 40% fine sand; trace of organic matter; easy drilling
(3.0') 0.91m	SM	10	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; brown; about 70% fine to medium sand; about 30% low plasticity fines; trace of organic matter (roots); easy drilling
(6.0') 1.83m	SM	8	2	85	13	–	–	–	SILTY SAND, SM: Firm; dry; grayish-brown; fine to medium sand; low plasticity fines; trace of hard, coarse, subrounded, sand; easy drilling
(9.0') 2.74m	SM	8	–	–	–	–	–	–	
	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; brown; about 70% fine to medium sand; about 30% low plasticity fines; trace of organic matter; easy drilling
(15.0') 4.57m	SM	9	0	70	30	–	–	–	SILTY SAND, SM: Firm; moist; olive-gray; mostly fine sand; low plasticity fines; trace of organic matter; easy drilling
▽ (18.0') 5.49m 1:35pm 5/2/00	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; dark grayish-brown; about 70% fine sand; about 30% low plasticity fines; perched water; easy drilling
(19.2') 5.85m	SP-SM		–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP-SM: Firm; moist; dark gray; about 90% fine to medium sand; about 10% low plasticity fines; easy drilling
(21.0') 6.40m	CL	7	–	–	–	–	–	–	LEAN CLAY WITH SAND, CL: Stiff; very moist to almost wet; very dark grayish-brown; about 85% medium plasticity fines; about 15% fine sand; trace of organic matter; easy drilling
(24.0') 7.32m	ML	10	0	47	53	–	–	11	SANDY SILT, ML: Firm; moist; very dark grayish-brown; low plasticity fines; fine sand; easy drilling
▽ (27.0') 8.23m 8:55am 5/2/00	CL	11	–	–	–	–	–	–	LEAN CLAY WITH SAND, CL: Stiff; very moist to almost wet; olive-gray; about 75% medium plasticity fines; about 25% fine sand; perched water; easy drilling
(30.0') 9.14m	ML	8	0	39	61	–	NP	21	SANDY SILT, ML: Stiff; moist; black; non-plastic fines; fine sand; trace of organic matter; easy drilling From 9.5m (31.3') to 9.6m (31.4'), contains sand lens
(33.0') 10.06m	SC	14	–	–	–	–	–	–	CLAYEY SAND, SC: Firm; moist; very dark gray; about 80% fine to medium sand; about 20% medium plasticity fines
(36.0') 10.97 m	SM	14	–	–	–	–	–	–	SILTY SAND, SM: Firm; very moist; very dark gray; about 80% fine sand; about 20% low plasticity fines
▽ (39.0') 11.90m 10:20am 7/21/00	SM	11	–	–	–	–	–	–	At 11.9m (39.0'), as above except wet; flowing sands
(42.0') 12.80m									

(Continued in Next Column)

2F-00-114

(Continued from Previous Column)

DEPTH		N	GR	SA	FI	LL	PI	MC	
(42.0') 12.80m	SP-SM	11	0	92	8	–	NP	–	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; very dark gray; hard, fine to coarse, subrounded sand; nonplastic fines; flowing sands; switched to mud rotary
(44.0') 13.41m	SP	12	–	–	–	–	–	–	POORLY GRADED SAND, SP: Firm; wet; very dark gray; about 95% fine to medium sand; about 5% nonplastic fines
(47.0') 14.33m	SM	12	0	87	13	–	NP	–	SILTY SAND, SM: Firm; wet; very dark gray; fine to medium sand; nonplastic fines
(50.0') 15.2m	SP-SM	12	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; very dark gray; about 90% fine to medium sand; 10% nonplastic fines
(53.0') 16.16m	SP-SM	55	16	77	7	–	NP	–	POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Very dense; wet; dark gray; hard, fine to coarse, subrounded sand; hard, sub-rounded gravel maximum particle size >38mm (1-1/2"); nonplastic fines; very rough, hard and slow drilling; encountered cobbles
(56.0') 17.07m	GRAVEL & COBBLES		–	–	–	–	–	–	At 18.6m (61.0'), flowing sand with clear water At 19.5m (64.0'), gravel and cobbles with abundant water At 21.3m (70.0'), lost circulation, 5 batches of mud mixed and placed down hole At 22.9m (75.0'), bringing up gravel and fine sand, abundant water; flowing sands At 24.4m (80.0'), very fast, easy drilling through fine sand; abundant water and flowing sands
(83.0') 25.30m									

(Continued in Next Column)

2F-00-114

(Continued from Previous Column)

DEPTH		N	GR	SA	FI	LL	PI	MC	
(83.0') 25.30m	GRAVEL & COBBLES								At 26.2m (86.0') bringing up clayey material; no appreciable amount of water; switched to CalMod sampler
(87.5') 26.67m	SM	73	6	52	42	–	NP	32	SILTY SAND, SM: Very dense; moist; dark grayish-brown; mostly fine sand; nonplastic fines; gravel maximum particle size 76mm (3")
(89.0') 27.13m	ML	74	1	36	63	–	NP	29	SANDY SILT, ML: Very dense; moist; dark grayish-brown; nonplastic fines; mostly fine sand; gravel maximum particle size 76mm (3")
(90.4') 27.55m									B.O.H.

STANDARD PENETROMETER DESCRIPTIVE DATA

COHESIONLESS		COHESIVE	
BLOWS*	RELATIVE DENSITY	BLOWS*	CONSISTENCY
0–4	VERY LOOSE	0–1	VERY SOFT
5–10	LOOSE	2–4	SOFT
11–20	FIRM	5–8	FIRM
21–30	VERY FIRM	9–15	STIFF
31–50	DENSE	16–30	VERY STIFF
51+	VERY DENSE	31+	HARD

*BLOWS PER 0.3 m OF PENETRATION OF A 51 mm O.D. AND 35 mm I.D. SAMPLER DRIVEN BY A 63.5 kg HAMMER, WITH A 0.76 m FREEFALL.

LEGEND:

N	NUMBER OF BLOWS WITH THE STANDARD PENETROMETER
GR	GRAVEL, PERCENT BY WEIGHT PASSING THE 76mm (3-INCH) SIEVE AND RETAINED ON THE NO. 4 SIEVE
SA	SAND, PERCENT BY WEIGHT PASSING THE NO. 4 SIEVE AND RETAINED ON THE NO. 200 SIEVE
FI	FINES, PERCENT BY WEIGHT PASSING THE NO. 200 SIEVE
LL	LIQUID LIMIT
PI	PLASTICITY INDEX (LIQUID LIMIT MINUS PLASTIC LIMIT)
MC	LABORATORY DETERMINED MOISTURE CONTENT IN PERCENT OF DRY WEIGHT
NP	NONPLASTIC
SM	COMBINED FIELD VISUAL IDENTIFICATION AND/OR LABORATORY CLASSIFICATION
B.O.H.	BOTTOM OF HOLE
R	REFUSAL WITH THE STANDARD PENETROMETER (SEE NOTE 10)
A	ATTEMPT WITH THE STANDARD PENETROMETER (SEE NOTE 11)
▽	WATER LEVEL
GRAVEL & COBBLES	COBBLES WITH MATRIX MATERIAL (GRAVEL, SAND AND FINES) MATRIX MATERIAL IS CLASSIFIED IN ACCORDANCE WITH ASTM STANDARDS

NOTES:

1. THIS DRAWING IS TO BE USED ONLY FOR APPROXIMATE DESCRIPTIONS OF SUBSURFACE CONDITIONS.
2. SOIL CLASSIFICATIONS AND DESCRIPTIONS ARE BASED ON FIELD LOG DESCRIPTIONS IN ACCORDANCE WITH ASTM D 2488 (DESCRIPTION AND IDENTIFICATION OF SOILS, VISUAL-MANUAL PROCEDURE) AND/OR LABORATORY TEST RESULTS IN ACCORDANCE WITH ASTM D 2487 (CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES).
3. ALL COLORS SHOWN ARE IN ACCORDANCE WITH THE MUNSELL SOIL COLOR CHART.
4. ALL SIEVE SIZES SHOWN ARE METRIC WITH U.S. STANDARD IN PARENTHESES.
5. BORING 2F-00-114 WAS DRILLED BETWEEN 2 MAY AND 21 JULY 2000 USING AN INGERSALL RAND A-400 DRILL RIG UTILIZING A 152mm (6") O.D. AND A 203mm (8") HOLLOW STEM FLIGHT AUGER.
6. WHERE COBBLES WERE ENCOUNTERED, LABORATORY GRADATION DATA REPRESENTS MATERIAL PASSING THE 76mm (3-INCH) SIEVE. PARTICLES LARGER THAN THE INSIDE DIAMETER OF SAMPLER WERE NOT RECOVERED. HENCE, ALL GRAVEL AND COBBLE LAYERS REFERENCED IN SOIL BORINGS CONTAINED LARGER PARTICLES OF GRAVEL AND COBBLES THAT ARE NOT REFLECTED IN THE LABORATORY GRADATION TEST RESULTS SHOWN IN THE SOIL BORING LOGS.
7. STANDARD PENETROMETER DATA WERE OBTAINED IN ACCORDANCE WITH ASTM D 1586 UTILIZING A 610mm LONG STANDARD 51mm O.D. BY 35mm I.D. SPLIT BARREL SAMPLER. THE SPLIT-SPOON PENETROMETER WAS DRIVEN USING AN AUTOMATIC-TRIP, 63.5 KG SAFETY HAMMER. ALL SPT "N" VALUES ARE "FIELD", I.E. UNCORRECTED FOR DEPTH.
8. GROUNDWATER WAS ENCOUNTERED AT THE TIME OF EXPLORATIONS; GROUNDWATER LEVELS CAN BE EXPECTED TO FLUCTUATE IN RESPONSE TO RAINFALL VARIATIONS, PARTICULARLY IN THE VICINITY OF SITE DRAINAGE FEATURES.
9. DEPENDING ON THE SOIL MOISTURE AT THE TIME OF CONSTRUCTION, THE SOIL ENCOUNTERED MAY BE UNSTABLE OR POTENTIALLY UNSTABLE. THE PROBABILITY OF UNSTABLE CONDITIONS IS HIGHEST WHEN THE SOIL MOISTURE IS GREATEST.
10. REFUSAL WITH THE STANDARD PENETROMETER IS DEFINED AS ONE OF THE FOLLOWING:
    A. 10 BLOWS FOR NO APPARENT ADVANCEMENT OF THE SAMPLER; OR
    B. 50 BLOWS FOR LESS THAN 152mm (6") ADVANCEMENT OF THE SAMPLER; OR
    C. 100 BLOWS FOR 152mm (6") TO 457mm (18") ADVANCEMENT OF THE SAMPLER.
11. ATTEMPT WITH THE STANDARD PENETROMETER IS DEFINED AS REFUSAL WITHIN THE FIRST 152mm (6") OF SEATING PENETRATION.
12. △ ADDITIONAL LOGS OF EXPLORATIONS ARE SHOWN ON SHEET NOS. B-4 THROUGH B-17 AND B-19 THROUGH B-21.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Updated title block information — R.S. Ong/BIG

Designed by: J. SCIANDRONE
Dwn by: COE-SOIL
Cad by: R. IWASA
Reviewed by: J. SCIANDRONE
Submitted by: J.S/ KEN PATTERMANN
Date: 05-OCT-2001
Design file no: 1-04-474
SPEC. No.: 1034
File name: 1034B18.dwg
Plot date: 5 OCT 2001
Plot scale: 1:1
Rev.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

AMERICAN RIVER WATERSHED PROJECT
AMERICAN RIVER JET GROUT SECTIONS
CONTRACT 1
CALIFORNIA

LOG OF EXPLORATION
2F-00-114

Sheet reference number:
B-18
SEQ. 24

Soil Design Section Sheet No.: 18 OF 21 △

Reference – Exploration Log File No.: 1-01-486 △

MASTER DESIGN FILE: 1034B18.DWG
PLOT DATE: 05-OCT-2001
PLOT TIME:

2F – 96 – 28

STA. 4+737

EL. 12.8 m (41.9')

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	12.8	SP–SM	44	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Dense; moist; brown; about 90% fine to coarse, angular to subrounded sand; about 10% low plasticity fines
0.61 (2.0')	12.19	SM	40	–	–	–	–	–	–	SILTY SAND, SM: Dense; moist; brown; about 85% fine to coarse, angular to subrounded sand; about 15% low plasticity fines
1.22 (4.0')	11.58	ML	21	–	–	–	–	–	–	SANDY SILT, ML: Very stiff; moist; brown; about 65% low plasticity fines; about 35% fine to medium sand
1.83 (6.0')	10.97	ML	14	–	–	–	–	–	–	SILT WITH SAND, ML: Stiff; moist; very dark gray; about 80% low plasticity fines; about 20% fine to medium sand
2.44 (8.0')	10.36	ML	13	–	–	–	–	–	–	SILT WITH SAND, ML: Stiff; moist; olive–brown; about 75% low plasticity fines; about 25% fine to medium sand
3.05 (10.0')	9.75	SM	22	–	–	–	–	–	–	SILTY SAND, SM: Very firm; moist; dark brown; about 75% fine to coarse, subangular to subrounded sand; about 25% nonplastic fines
4.11 (13.5')	8.69	SC	11	1	66	33	28	8	–	CLAYEY SAND, SC: Firm; moist; olive–brown; fine to coarse, mostly medium, subangular to subrounded sand; low plasticity fines; gravel maximum particle size 19 mm (3/4"); charcoal material present
4.57 (15.0')	8.23									
5.18 (17.0')	7.62	ML	10	–	–	–	–	–	–	SANDY SILT, ML: Stiff; moist; brown; about 55% low plasticity fines; about 45% fine to medium sand
6.25 (20.5')	6.55	ML	8	–	–	–	–	–	–	SANDY SILT, ML: Firm; moist; brown; about 60% low plasticity fines; about 40% fine to medium sand
7.32 (24.0')	5.48	ML	6	–	–	–	–	–	–	SILT, ML: Firm; moist; dark gray; about 90% low plasticity fines; about 10% fine sand
8.38 (27.5')	4.42	SM	8	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; very dark gray; about 60% fine sand; about 40% nonplastic fines
9.45 (31.0')	3.35	ML	10	–	–	–	–	–	–	SANDY SILT, ML: Stiff; moist; very dark gray; about 60% nonplastic fines; about 40% fine sand
10.52 (34.5')	2.28									

CONTINUED IN NEXT COLUMN

2F – 96 – 28

CONTINUED FROM PREVIOUS COLUMN

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
10.52 (34.5')	2.28	SM	10	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; very dark gray; about 85% fine to medium sand; about 15% low plasticity fines
11.58 (38.0')	1.22	SM	14	–	–	–	–	–	–	SILTY SAND, SM: Firm; wet; very dark gray; about 85% fine to medium sand; about 15% low plasticity fine; organic material present
12.65 (41.5')	0.15	SM	9	1	82	17	–	NP	–	SILTY SAND, SM: Loose; wet; very dark gray; fine to medium sand; nonplastic fines; gravel maximum particle size 10 mm (3/8"); organic material present
13.11 (43.0')	0.69	SP–SM	8	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Loose; wet; very dark gray; about 90% fine to coarse, subangular to subrounded sand; about 10% nonplastic fines; organic material present;
13.72 (45.0')	0.00	SP–SM	7	–	–	–	–	–	–	
15.24 (50.0')										B.O.H.

2F – 96 – 29

STA. 8+904

EL. 14.1 m (46.1')

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
0	14.1	SM	59	–	–	–	–	–	–	SILTY SAND WITH GRAVEL, SM: Very dense; moist; yellowish–brown; about 60% fine to coarse, subangular to subrounded sand; about 25% subangular gravel maximum particle size 19 mm (3/4"); about 15% low plasticity fines; no reaction with HCl; easy drilling
0.61 (2.0')	13.49	SM	32	–	–	–	–	–	–	SILTY SAND, SM: Dense; moist; yellowish–brown; about 85% fine to medium sand; about 15% low plasticity to nonplastic fines; trace of gravel maximum particle size 13 mm (1/2"); trace of charcoal present; no reaction with HCl; no odor present; easy drilling
1.22 (4.0')	12.88	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; yellowish–brown; about 85% fine to medium sand; about 15% nonplastic to low plasticity fines; no reaction with HCl; no odor present; easy drilling
1.83 (6.0')	12.27	SM	15	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; yellowish–brown; about 80% fine to medium sand; about 20% low plasticity fines; no reaction with HCl; no odor present; easy drilling
2.44 (8.0')	11.66	SP–SM	14	–	–	–	–	–	–	
3.05 (10.0')	11.05	SP–SM	9	2	92	6	–	NP	–	POORLY GRADED SAND WITH SILT, SP–SM: Firm to loose; moist; brown; fine to coarse, mostly medium sand; nonplastic fines; gravel maximum particle size 19 mm (3/4"); no reaction with HCl; easy drilling
3.51 (11.5')	10.59									
4.11 (13.5')	10.00	SM	9	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; grayish–brown; about 85% fine to medium sand; about 15% nonplastic fines; trace of subrounded gravel present; no reaction with HCl; no odor present; easy drilling
5.18 (17.0')	8.93	SP–SM	15	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Firm; moist; very dark grayish–brown; about 90% fine to coarse, subangular to subrounded sand; about 10% nonplastic fines; no reaction with HCl; no odor present
6.40 (21.0')	7.70	MH	5	–	–	–	–	–	–	ELASTIC SILT, MH: Firm; moist; dark brown; about 90% low plasticity fines; about 10% fine sand; no reaction with HCl; weak iron oxide staining
7.32 (24.0')	6.78	ML	4	0	25	75	33	3	–	SILT WITH SAND, ML: Soft; wet; dark yellowish–brown; nonplastic fines; fine sand; no reaction with HCl
7.77 (25.5')	6.33	SP–SM	4	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Very loose; wet; dark brown; about 90% fine sand; about 10% nonplastic fines; no reaction with HCl
8.38 (27.5')	5.72	MH		–	–	–	–	–	–	ELASTIC SILT, MH: Soft; wet; dark yellowish–brown; about 95% low plasticity fines; about 5% fine sand; no reaction with HCl
8.75 (28.7')	5.35									
9.45 (31.0')	4.65									

CONTINUED IN PREVIOUS COLUMN

2F – 96 – 29

CONTINUED FROM NEXT COLUMN

Depth (m)	Elev. (m)	Symbol	N	GR	SA	FI	LL	PI	MC	Description
9.45 (31.0')	4.65	SM	8	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; dark brown; about 85% fine sand; about 15% nonplastic fines; no reaction with HCl
9.75 (32.0')	4.35	SP–SM	11	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Loose; moist; very dark grayish–brown; about 90% fine to medium sand; about 10% nonplastic fines; no reaction with HCl
10.52 (34.5')	3.58	SP–SM	11	–	–	–	–	–	–	POORLY GRADED SAND WITH SILT, SP–SM: Firm; moist; very dark grayish–brown; about 90% fine to medium sand; about 10% nonplastic fines; no reaction with HCl
11.58 (38.0')	2.52	CL	17	–	–	–	–	–	–	LEAN CLAY WITH SAND, CL: Very stiff; moist; very dark grayish–brown; about 80% medium plasticity fines; about 20% fine to medium sand; no reaction with HCl
12.65 (41.5')	1.45	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; wet; dark brown; about 80% fine to medium with trace of coarse sand; about 20% nonplastic fines; no reaction with HCl; weak iron oxide staining
13.26 (43.5')	0.84	SP–SM	25	0	93	7	–	NP	–	POORLY GRADED SAND WITH SILT, SP–SM: Very firm; wet; dark brown; fine to medium, mostly medium sand; nonplastic fines; no reaction with HCl At 13.56 m (44.5'), as above except very dark grayish–brown
13.72 (45.0')	0.68									
										B.O.H.

NOTES:

1. THE LEGENDS AND NOTES ARE SHOWN ON SHEET B–1.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

REGISTERED PROFESSIONAL ENGINEER — SAID SALAH-MARS — No. C 050445 — Exp. 06/30/01 — CIVIL — STATE OF CALIFORNIA

US Army Corps of Engineers Sacramento District

Symbol	Description	Symbol	Date Approved	Description	Date Approved

Designed by: R. IWASA (USACE) | Date: 18 JAN. 2000 | Rev.
Dwn by: R. AGUIANO | Ckd by: LI. LUSCHER | Design file no: 1-04-477
Reviewed by: S. PUNYAMURTHULA | SPEC. No: 9824 | 1145
Submitted by: Chief, Civil Design Section A | File name: AB98R02.DWG | Plot date: 14 JAN 2000 | Plot scale: 1:1

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

URS Greiner Woodward Clyde
OAKLAND, CALIFORNIA

SAID SALAH-MARS

AMERICAN RIVER WATERSHED PROJECT
AMERICAN RIVER, CALIFORNIA
LEFT (SOUTH) BANK LEVEE STRENGTHENING
CONTRACT 2

CALIFORNIA

LOGS OF EXPLORATIONS
2F–96–28 & 2F–96–29

Sheet reference number:
B–6
SEQ. 61

DATE=10-26-99 08

2F-97-23

STA. 7+1 17

DEPTH		N	GR	SA	FI	LL	PI	MC	Description
EL. 14.2 m (46.5') 0	SM	21	–	–	–	–	–	–	SILTY SAND, SM: Very firm; moist; dark yellowish-brown; about 60% fine to medium sand; about 40% low plasticity fines
(3.0') 0.91 m	SM	10	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 80% fine to medium sand; about 20% low plasticity fines
	SM	5	–	–	–	–	–	–	At 1.7 m (5.5'), as above except lenses of POORLY GRADED SAND, SP and SILTY SAND, SM present
(7.0') 2.13 m	SP	7	–	–	–	–	–	–	POORLY GRADED SAND, SP: Loose; moist; brown; about 95% fine to coarse, subangular to subrounded sand; about 5% fines
	SP	6							
(11.0') 3.35 m	SP	5	0	98	2	–	NP	4	
(12.5') 3.81 m	SP	6	–	–	–	–	–	–	POORLY GRADED SAND, SP: Loose; moist; fine to medium, mostly medium with trace of coarse sand; nonplastic fines
(15.0') 4.57 m	SM	6	–	–	–	–	–	–	SILTY SAND, SM: Loose; moist; dark yellowish-brown; about 65% fine to medium sand; about 35% low plasticity fines
(18.0') 5.49 m	SM	TUBE #1	0	58	42	26	3	14	SILTY SAND, SM: Moist; brown; fine to medium, mostly fine sand; nonplastic to low plasticity fines; easy to push tube
(20.0') 6.10 m			–	–	–	–	–	–	
(21.5') 6.55 m	ML	5	–	–	–	–	–	–	SILT, ML: Firm; moist; dark brown; about 95% low plasticity fines; about 5% fine sand
	ML	7	–	–	–	–	–	–	
(28.5') 8.69 m	ML	6	–	–	–	–	–	–	SILT, ML: Firm; moist; brown; about 90% low plasticity fines; about 10% fine sand
(31.5') 9.60 m	CL	3	–	–	–	–	–	–	LEAN CLAY WITH SAND, CL: Soft; moist; dark brown; about 80% low to medium plasticity fines; about 20% fine sand; mud added to hole in anticipation of flowing sands
(35.0') 10.67 m	CL	8	–	–	–	–	–	–	SANDY LEAN CLAY, CL: Firm; moist; dark brown; about 70% low to medium plasticity fines; about 30% fine sand
(38.5') 11.73 m									

CONTINUED IN NEXT COLUMN

2F-97-23

CONTINUED FROM PREVIOUS COLUMN

		N	GR	SA	FI	LL	PI	MC	Description
(38.5') 11.73 m	SM	13	–	–	–	–	–	–	SILTY SAND, SM: Firm; moist; olive-brown; about 80% fine sand; about 20% low plasticity fines
▽(41.5') 12.65 m									
(43.0') 13.11 m	SP-SM	12	0	88	12	–	NP	27	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; olive-brown; fine to medium sand; nonplastic fines; water elevation varies
(45.0') 13.72 m	SM	9	–	–	–	–	–	–	SILTY SAND, SM: Loose; wet; dark olive-brown; about 60% fine sand; about 40% low plasticity fines
(48.5') 14.78 m	SP-SM	16	0	88	12	–	NP	33	POORLY GRADED SAND WITH SILT, SP-SM: Firm; wet; very dark gray; fine to medium, mostly fine sand; nonplastic fines
(50.0') 15.24 m									
(51.5') 15.70 m	SM	12	–	–	–	–	–	–	SILTY SAND, SM: Firm; wet; very dark gray; about 85% fine to coarse, subangular to subrounded sand; about 15% low plasticity fines; traces of fine, subrounded gravel maximum particle size 13 mm (1/2")
									At 16.3 m (53.5'), as above except gravels present; rough drilling
(55.0') 16.76 m	GRAVEL AND COBBLES	64	84	12	4	–	NP	8	GRAVEL AND COBBLES with a matrix of POORLY GRADED GRAVEL, GP: Very dense; wet; very dark gray; fine to coarse, angular to subrounded gravel maximum particle size 51 mm (2"); fine to coarse, angular to subrounded sand; nonplastic fines; switched to 64 mm (2-1/2") I.D. sampler; rough drilling but good rate of advancement
(56.5') 17.22 m			–	–	–	–	–	–	
(60.0') 18.29 m	GRAVEL AND COBBLES	84*	–	–	–	–	–	–	GRAVEL AND COBBLES with a matrix of POORLY GRADED SAND, SP: Very dense; wet; very dark gray; about 95% fine to coarse, subangular to subrounded sand; about 5% fines; 64 mm (2-1/2") I.D. sampler; rough drilling
									At 19.5 m (64.0'), as above except smooth drilling
(65.0') 19.81 m	GRAVEL AND COBBLES	24	23	66	1	1	NP	20	
(66.5') 20.27 m			–	–	–	–	–	–	GRAVEL AND COBBLES with a matrix of POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: Very firm; wet; olive; fine to coarse, mostly fine, angular to subrounded sand; fine, angular to subangular gravel maximum particle size 25 mm (1"); smooth drilling
(70.0') 21.34 m	ML	A	0	17	83	–	9	34	
(71.5') 21.79 m	ML		–	–	–	–	–	–	SILT WITH SAND, ML: Hard; moist; light olive-brown; low plasticity fines; fine to medium, mostly fine sand
(73.0') 22.25 m	ML								At 22.3 m (73.0'), attempted Shelby tube; rock in tube, no recovery
	ML		–	–	–	–	–	–	At 23.2 m (76.0'), smooth drilling
(78.5') 23.93 m	CL	45	–	–	–	–	–	–	SANDY LEAN CLAY, CL: Hard; moist; olive-brown; about 70% low to medium plasticity fines; about 30% fine to coarse, mostly fine to medium, subangular to subrounded sand
(80.0') 24.38 m									B.O.H.

NOTES:

1. THE LEGENDS AND NOTES ARE SHOWN ON SHEET B-1.

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

REGISTERED PROFESSIONAL ENGINEER — SAID SALAH-MARS — No. C 050445 — Exp. 06/30/01 — CIVIL — STATE OF CALIFORNIA

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved

Designed by: R. IWASA (USACE)
Dwn by: FIA/MI
Ckd by: LL LUSCHER
Revised by: S. FUNYAMURTHULA
Submitted by: Chief, Design Section A
Date: 19 JAN. 2000
Design file no: 1-04-477
SPEC. No: 1140
File name: ABSDRAZ.DWG
File date: 14 JAN. 2000
Plot scale: 1 : 1
Rev.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

URS Greiner Woodward Clyde
OAKLAND, CALIFORNIA

SAID SALAH-MARS

CALIFORNIA
AMERICAN RIVER WATERSHED PROJECT
AMERICAN RIVER WATERSHED (COMMON FEATURES), CALIFORNIA
LEFT (SOUTH) BANK LEVEE STRENGTHENING
CONTRACT 2

LOG OF EXPLORATION
2F-97-23

Sheet reference number:
B-20
SEQ. 75

J:\CADSHARED\ARVRFINAL\CONTRACT2\AR820-02.DWG 14FULL-75SIP.scp

2F-99-17

STA. 6+899

DEPTH	N	GR	SA	FI	LL	PI	MC	Description
EL.14.0 m (45.9') 0								
	6							POORLY GRADED SAND WITH SILT, SP-SM: Loose; moist; light brown; fine to medium sand; trace coarse sand; nonplastic fines
(10.0') 3.05 m	6	1	93	6				At 3.05m (10'), as above but becomes wet
(11.5') 3.51 m								
	7							At 4.57m (15'), as above but becomes moist to wet, gray
(17.5') 5.33 m								
(20.0') 6.10 m	7	0	68	32				
(21.5') 6.55 m	7							SILTY SAND, SM: Loose; moist; brown; fine sand; nonplastic fines; trace mica
	11							At 9.14m (30'), as above but becomes firm and sandier (about 75%-80% fine sand, about 20%-25% silt)
(35.0') 10.67 m								

SP-SM

SM

CONTINUED IN NEXT COLUMN

2F-99-17

CONTINUED FROM PREVIOUS COLUMN

DEPTH	N	GR	SA	FI	LL	PI	MC	Description
(35.0') 10.67 m	9							At 10.67m (35'), as above but becomes loose and wet, 85% fine sand, 15% nonplastic fines
(37.5') 11.43 m								
	9							WELL GRADED SAND WITH SILT, SW-SM: Loose; wet; brown; fine to coarse sand; nonplastic fines; trace mica
(45.0') 13.72 m	10	0	90	10				At 13.72m (45'), as above but becomes dark gray
(46.5') 14.17 m								
(49.0') 14.94 m								
(50.0') 15.24 m	14	34	62	4				POORLY GRADED SAND WITH GRAVEL, SP: Firm; wet; dark gray; fine to coarse sand; fine gravel; nonplastic fines; trace mica
(51.5') 15.70 m								
(52.5') 16.00 m	40							POORLY GRADED GRAVEL AND COBBLES WITH SAND, GP: Dense; wet; gray-brown; about 70% fine gravel; about 30% fine to coarse sand; cobbles
								Between 16.46m (54') and 20.4m (67') several thin layers of fine sand
(70.0') 21.33 m								

SM

SW-SM

SW

GRAVEL AND COBBLES

CONTINUED IN NEXT COLUMN

2F-99-17

CONTINUED FROM PREVIOUS COLUMN

DEPTH	N	GR	SA	FI	LL	PI	MC	Description
(70.0') 21.33 m								
(71.5') 21.79 m								
(75.0') 22.86 m	72	0	15	85				SILT WITH SAND, ML: Hard; wet; greenish-brown; low plasticity fines; fine to coarse sand
(76.5') 23.32 m								
(77.5') 23.62 m								
	62							ELASTIC SILT, MH: Hard wet; greenish brown; medium plasticity fines; trace fine to medium sand
(81.5') 24.84 m								

GRAVEL AND COBBLES

ML

MH

B.O.H.

NOTES:

1. SAMPLERS USED TO RECOVER SOIL SAMPLES IN THE FIELD GENERALLY CONSISTED OF STANDARD PENETRATION AND MODIFIED CALIFORNIA TEST SAMPLERS RAGING FROM 35mm (1 3/8-INCH) TO 64 mm (2 1/2-INCH) INSIDE DIAMETER. THEREFORE, PARTICLES LARGER THAN THE INSIDE DIAMETER OF SAMPLER WERE NOT RECOVERED. HENCE, ALL GRAVEL AND COBBLE LAYERS REFERENCED IN SOIL BORINGS CONTAINED LARGER PARTICLES OF GRAVEL, COBBLES, AND OCCASIONAL BOULDERS THAT ARE NOT REFLECTED IN THE LABORATORY GRADATION TEST RESULTS SHOWN IN THE SOIL BORING LOGS.
2. THE LEGENDS AND NOTES ARE SHOWN ON SHEET B-1.
3. DRILLING METHOD DID NOT ALLOW OBSERVATION OF DEPTH TO GROUNDWATER TABLE.

REGISTERED PROFESSIONAL ENGINEER
SAID SALAH-MARS
No. C 050445
Exp. 06/30/01
CIVIL
STATE OF CALIFORNIA

GRAPHIC SCALE

SCALE 1 : 25 — 0, 0.5, 1, 1.5, 2, 2.5 METERS

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved	Symbol	Description	Date	Approved

Designed by: S. PARYANARTHULA
Dwn by: M. IBRAHIM
Ckd by: L. LIEBSCHER
Reviewed by: S. PARYANARTHULA
Submitted by: Chief, Civil Design section A
Date: 18 JAN. 2000
Design file no: 1-04-477
SPEC. No: 1140
File name: AR99R02.DWG
Plot date: 14 JAN. 2000
Plot scale: 1 : 1
Rev.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

URS Greiner Woodward Clyde
OAKLAND, CALIFORNIA

SAID SALAH-MARS

AMERICAN RIVER
AMERICAN RIVER WATERSHED PROJECT
(COMMON FEATURES), CALIFORNIA
LEFT (SOUTH) BANK LEVEE STRENGTHENING
CONTRACT 2

LOG OF EXPLORATION
2F-99-17

Sheet reference number:
B-39
SEQ. 94

C:\DGN\ARV\ARV\WWW\CONTRACT2\DGN\ARV99R02.DWG 1-FULL-7656P.dwg

DATE STARTED 6/3/08 **DATE COMPLETED** 6/3/08	**GROUND ELEVATION** 48.07 ft **ELEVATION DATUM** NAVD 88	**TOTAL DEPTH OF BORING** 70.0 ft
DRILLING CONTRACTOR Gregg Drilling & Testing, Inc.	**DRILLER'S NAME** E. Santellan **HELPER'S NAME** R. Ryon/M. Ageev	**TOTAL DEPTH OF FILL** 13.2 ft
DRILLING METHOD 0 - 3 ft: HA, 3 - 16.5 ft: HSA, 16.5 - 70 ft: Rotary Wash	**DRILL RIG MAKE AND MODEL** MARL M-10 (Gregg Rig No. D-44)	**CONSULTANT COMPANY** GEI Consultants, Inc.
DRILL BIT SIZE AND TYPE (HOLE DIAMETER) 5-inch drag bit; tricone drill through bit	**DRILLING ROD TYPE AND DIAMETER** 6" HSA, 94mm	**FIELD LOGGER** M. Horse
☒ **VERTICAL** ☐ **INCLINED**	**CASING TYPE, DIAMETER, INSTALLATION DEPTH** Surface, 6-in., 15 ft	**FIELD LOG REVIEWER** G. Bradner
SAMPLER TYPE(S) Bag, DCore(2.5"), MCal(2"), PCore(2.5"), SPT(1.375")	**HAMMER TYPE, MAKE/MODEL, WEIGHT/DROP** Marl, automatic, 140 lbs / 30-inch drop	**HAMMER EFFICIENCY** 83%
BOREHOLE BACKFILL OR COMPLETION 5% bentonite grout	**GROUNDWATER READING: DURING DRILLING** N/A due to rotary wash drilling method	**AFTER DRILLING (DATE-TIME)**

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	0		Gravel Road Base.												
	1		[LEVEE FILL] FAT CLAY (CH); very stiff; greenish black (5G 2.5/1); moist; 95% high plasticity, high dry strength, high toughness fines; 5% sand; 0% gravel.		1				3.0P						S01A_001_002B
	2				2										No Recovery; cobble removed
45	3		1-foot thick Fat Clay with Sand (CH) lense; 5% gravel, max. 1/2 in.; 10% fine to medium sand; 85% high plasticity fines.												S03B_003_004P S03A_004_005P
	4		[LEVEE FILL] SILTY CLAYEY SAND (SC-SM); dense; dark brown (7.5YR 3/4); moist; 75% fine to medium sand; 25% low plasticity fines; 0% gravel.		3	100									
	5				4	44	12 16 13 [29]	40					25	HD	S04A_005_007S
	6														
	7		[LEVEE FILL] Poorly Graded SAND with Silt (SP-SM); medium dense; olive brown (2.5Y 4/4); dry; 91% fine to medium sand; 9% fines; 0% gravel.		5	71				3			9		S05A_007_008P
40	8														
	9				6	0	9 9 10 [19]	26							No Recovery; soft material
	10		As above except moist.												S07A_011_011P Driller notes very soft material
	11														
	12				7	40									Driller notes very easy drilling
FILL .35	13		[Approximate bottom of Levee Fill 13.2'].												
	14														
	15		SANDY SILT (ML); loose; dark yellowish brown (10YR 3/6); moist; 50% fine sand; 50% low plasticity fines; 0% gravel.		8	50	3 3 4 [7]	10					50	HD	S08A_016_016S
	16														
	17				9	0									No Recovery Very soft material; easy drilling
30	18														
	19														
	20														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
Coordinates: Northing: 1,976,188.21 **Easting:** 6,719,198.27
Latitude: 38.58732 **Longitude:** -121.44887
Levee Station or Milepost: 1200+59 **Levee Mile:** 3.79
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCSBAR_003B
Sheet 1 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	20		SANDY SILT (ML); as above except medium dense.		10	0	5 6 6 [12]	17							No Recovery Rock stuck in hole
	21														
	22		SANDY SILT (ML); medium dense; very dark brown (7.5YR 2.5/3); moist; 65% low plasticity fines; 35% fine to medium sand; 0% gravel.		11	0	7 8 11 [19]								No Recovery Sandy Silt observed in cuttings
25	23				12	0	5 4 7 [11]	15							No Recovery Driller notes rock still present in hole
	24														
	25		Poorly Graded SAND with Silt (SP-SM); medium dense; dark brown (7.5YR 3/4); moist; 91% fine to medium sand; 9% low plasticity fines; 0% gravel; predominantly fine sand.		13	100									S13A_025_025P
	26				14	100	7 10 10 [20]						9		2.25-inch cobble fragment on top of sample S14A_025_027M
	27				15	44	5 5 9 [14]	19		11				SG	S15A_027_028S
20	28														S16A_028_029P
	29				16	42									
	30		SILTY CLAYEY SAND (SC-SM); medium dense; dark brown (7.5YR 3/4); moist; 77% fine sand; 23% low plasticity fines; 0% gravel.		17	56	7 5 11 [16]	22					23	HD	S17A_030_032S
	31														
	32				18	50									S18A_032_033P
15	33														
	34														
	35		SILTY SAND (SM); dense; dark yellowish brown (10YR 3/6); moist; 80% fine to medium sand; 20% fines; 0% gravel.		19	56	9 12 13 [25]	35		12			20		S19A_035_037S
	36														
	37				20	79									Box 1 Representative S20A_038_038P
10	38														
	39														
	40		As above except medium dense.		21	61	9 11 11 [22]	30							S21A_040_042P
	41														
	42		As above except very dark greenish gray (5G 3/1).		22	45									S22A_042_043P
5	43														
	44														
	45														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
Coordinates: Northing: 1,976,188.21 **Easting:** 6,719,198.27
Latitude: 38.58732 **Longitude:** -121.44887
Levee Station or Milepost: 1200+59 **Levee Mile:** 3.79
Levee Segment
Survey Method: GIS/LiDAR **Coord. System:** CA State Plane Zone II
Channel / River Name / Feature: American River

LOG OF BORING
WCSBAR_003B
Sheet 2 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	45		SILTY SAND (SM); as above.												
	46				23	67	7 8 8 [16]	22							S23A_045_047S
	47														S24B_047_047P S24A_048_048P
0	48		Well-Graded GRAVEL (GW); dense; dark olive gray (5Y 3/2); moist; 85% fine to coarse, subrounded gravel, max. 2 1/4 in.; 10% fine to medium sand; 5% fines.		24	36									Driller notes change; rig chatter
	49														
	50		3-inch thick Poorly Graded Sand (SP) lense; 96% fine to medium sand; 4% fines.												
	51				25	50	10 11 13 [24]	33		20			4		S25B_050_051S S25A_051_052S
	52														No Recovery Rig chatter and shaking
-5	53				26	0									
	54														
	55		3-inch thick Poorly Graded Sand (SP) lense; 95% fine to medium sand; 5% fines. As above except very dense.												
	56				27	39	32 40 30 [70]	97							S27B_055_056S S27A_056_057S
	57														No Recovery Rig chatter; gravel and cobble fragments present in slough
-10	58				28	0									
	59														
	60		Well-Graded GRAVEL with Sand (GW); very dense; dark olive gray (5Y 3/2); moist; 70% fine to coarse, subrounded gravel; 25% fine to medium sand; 5% fines.		29	67	50/6"								S29A_060_061S
	61														No Recovery Rig chatter and shaking; driller notes gravels/cobbles
	62				30	0									
-15	63														Use tricone bit; rig chatter and shaking; driller notes cobbles
	64														
	65		Gravel and cobble fragments, max. 1 1/2 in., present in slough.		31	0	50/3"								No Recovery
	66														
	67														Driller notes gravels/cobbles
-20	68														
	69														
	70														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
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Channel / River Name / Feature: American River

LOG OF BORING
WCSBAR_003B
Sheet 3 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

Elevation, feet	Depth, feet	Material Graphics	CLASSIFICATION OF MATERIALS (Description)	Sample Location	Sample Number	Recovery, %	Blows per 6 in. [Blows per ft]	N_{60}(ASTM)	PP or TV, tsf	LABORATORY DATA: Water Content, %	Liquid Limit	Plasticity Index	Fines, % < #200	Other Lab Tests	REMARKS
	70														Refusal due to gravel/cobbles
	71		Borehole terminated at 70 feet. Backfilled with 5% bentonite grout.												
	72														
-25	73														
	74														
	75														
	76														
	77														
-30	78														
	79														
	80														
	81														
	82														
-35	83														
	84														
	85														
	86														
	87														
-40	88														
	89														
	90														
	91														
	92														
-45	93														
	94														
	95														

Draft 4 After Final Markups 11/5/2009

Borehole Location: South Bank Crest **County:** Sacramento
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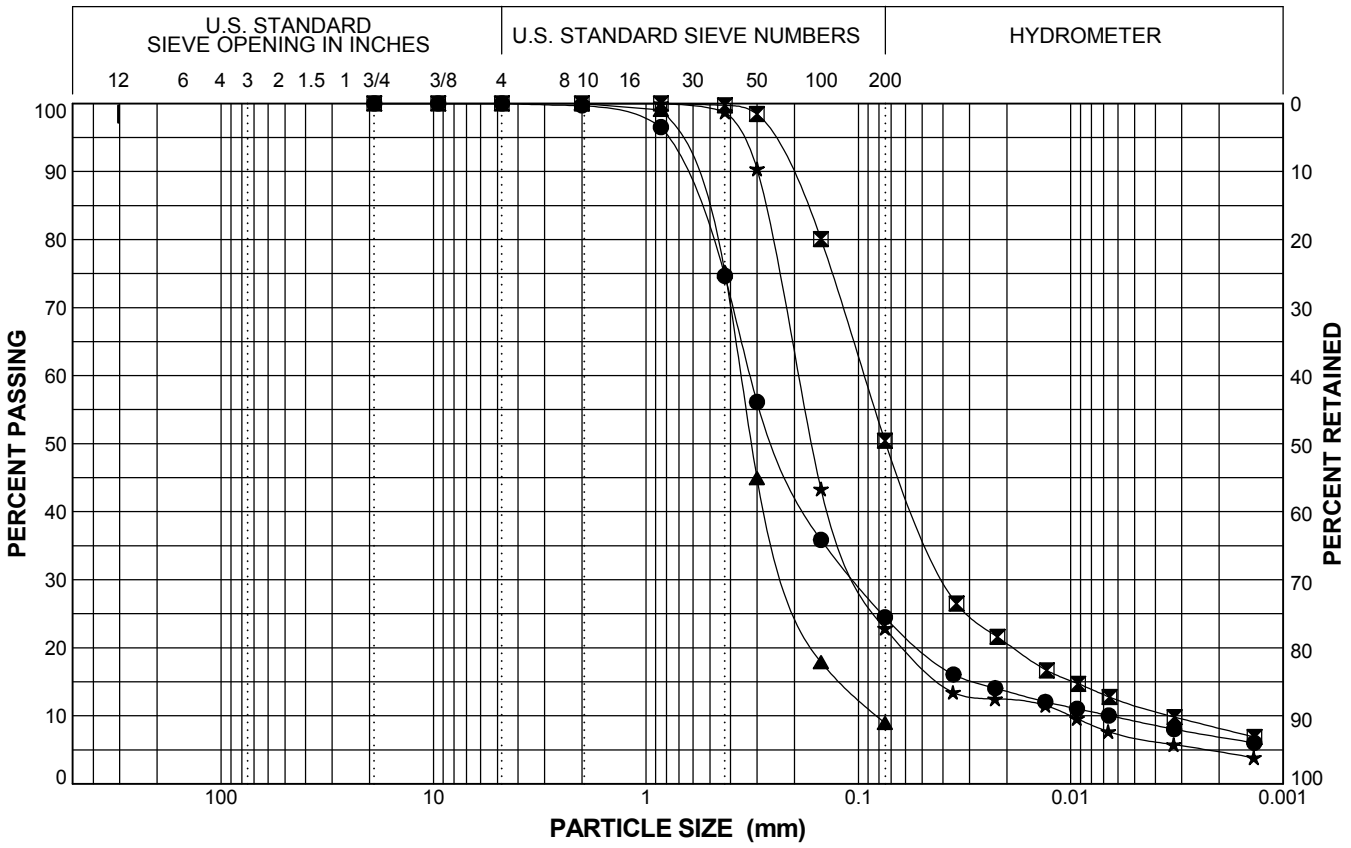
LOG OF BORING
WCSBAR_003B
Sheet 4 of 4

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

DWR LEVEE U/NU SOIL LOG REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/5/09

BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		coarse	fine	coarse	medium	fine	



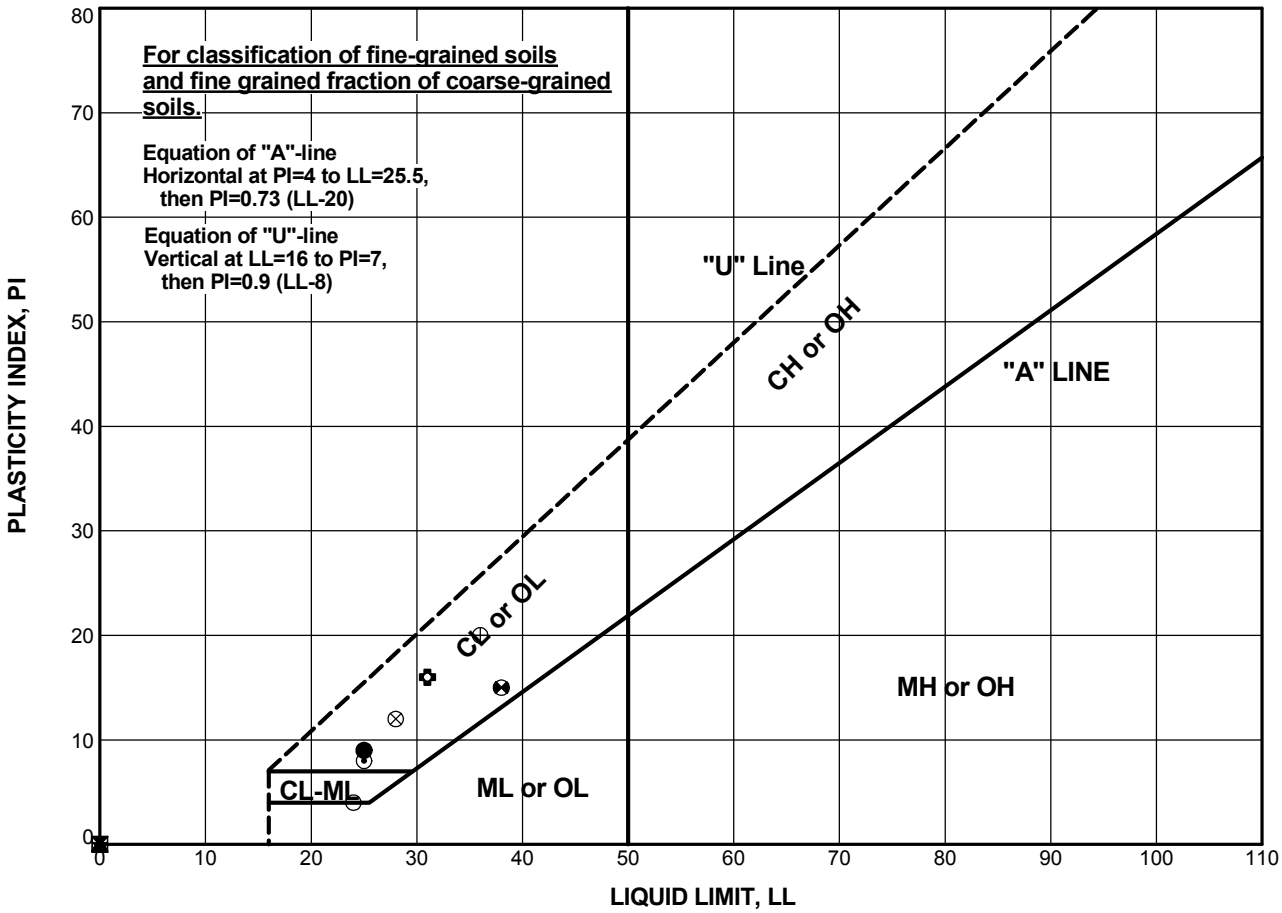
Boring Number	Sample Number	Depth (feet)	Symbol	%G	%S	%F	Classification
WCSBAR_003B	S04A_005_007S	5	●	0.0	75.5	24.5	SILTY CLAYEY SAND (SC-SM)
WCSBAR_003B	S08A_016_016S	15	⊠	0.0	49.6	50.4	SANDY SILT (ML)
WCSBAR_003B	S14A_025_027M	25	▲	0.0	91.0	9.0	Poorly Graded SAND with Silt (SP-SM)
WCSBAR_003B	S17A_030_032S	30	★	0.0	77.1	22.9	SILTY CLAYEY SAND (SC-SM)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PARTICLE SIZE DISTRIBUTION CURVES

DWR LEVEE U/NU SIEVE CURVES #200 REV1; AMERICAN RIVER LEVEE BORINGS 11-5-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 2/3/10



Boring Number	Sample Number	Depth (feet)	Test Symbol	WC (%)	LL	PL	PI	Classification
WCNBAR_001B	S06A_015_017S	15	●	13.7	25	16	9	CLAYEY SAND (SC)
WCNBAR_002B	S04A_005_007S	5	⊠	17.5	NP	NP	NP	SANDY SILT (ML)
WCNBAR_002B	S08A_015_017S	15	▲		NP	NP	NP	SILTY SAND (SM)
WCNBAR_003B	S04A_005_007S	5	★	15.6	NP	NP	NP	SANDY SILT (ML)
WCNBAR_003B	S29A_070_072S	70	⊙	18.5	25	17	8	LEAN CLAY (CL)
WCNBAR_004B	S02A_002_003B	2	✿	15.9	31	15	16	LEAN CLAY (CL)
WCNBAR_004B	S08A_014_014P	13.5	○	17.6	24	20	4	SANDY SILTY CLAY (CL-ML)
WCNBAR_005B	S08A_010_012S	10	△	10.4	NP	NP	NP	SILTY SAND (SM)
WCNBAR_005B	S16A_036_036S	35	⊗	17.8	28	16	12	LEAN CLAY with Sand (CL)
WCNBAR_005B	S18A_041_042S	40	⊕	16.3	36	16	20	LEAN CLAY with Sand (CL)
WCNBAR_005B	S22A_050_052S	50	□	17.7	NP	NP	NP	SILTY SAND (SM)
WCSBAR_001B	S02A_002_003B	2	⊗	16.8	38	23	15	LEAN CLAY with Sand (CL)

Urban Levee Geotechnical Evaluations Program
Engineering Support Services

American River

PLASTICITY CHART

DWR LEVEE U/NU ATT. PLOT (U LINE) REV1; AMERICAN RIVER LEVEE BORINGS 11-3-2009.GPJ; DWR WORKING LIBRARY 092009.GLB; 11/3/09

Vector Engineering Inc.

143E Spring Hill Drive, Grass Valley, CA 95945 (530) 272-2448

LABORATORY SERVICES

WATER CONTENT & MINUS # 200 % with GRAVEL

Client : GEI Consultants

Project No: 061724.0026

Lab Log: **2565**

Project Name: URS/DWR Urban Levee Program-American River TO-44 WO-26

Report Date: July 9, 2008

LSN	Sample ID	Soil Classification **	Water Content (%)	Percent Minus #200	Percent Sand	Percent Gravel
2565BC	WCSBAR_002B_50_S23A_050_052S	Brown Sand w/ Silt (SM)*	20.1	10.2	89.8	0.0
2565BE	WCSBAR_003B_7_S05A_007_008P	Brown Sand w/ Silt (SM)*	3.3	9.5	90.5	0.0
2565BJ	WCSBAR_003B_35_S19A_035_037S	Brown Sand w/ Silt (SM)*	12.3	19.9	80.1	0.0
2565BK	WCSBAR_003B_50_S25B_050_051S	Brown Sand w/ Silt (SM)*	20.2	4.0	96.0	0.0
2565BV	WCSBAR_005B_14_S07A_014_015P	Dark Brown Sandy Silt (ML)	22.9	50.6	49.4	0.0

Notes: ** Classifications are based on ASTM D-2487 when appropriate test results are available and per ASTM D-2488 when visual

These results apply only to the above listed samples. The data and information are proprietary and can not be released without authorization of Vector Engineering Inc. By accepting the data and results represented on this page, Client agrees to limit the liability of Vector Engineering, Inc. from Client and all other parties claims arising out of the use of this data to the cost for the respective test(s) represented here, and Client agrees to indemnify and hold harmless Vector from and against all liability in excess of the aforementioned limit.

Entered By: SK

Rev. By:

Lab Log: **2565**

ARS REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

AMERICAN RIVER WATERSHED - COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT - GEOTECHNICAL ANALYSIS
SACRAMENTO RIVER SOUTH RF2 U9 LM 5.92
Table F-2-14: Permeability and Strength Selection for Analysis

Boring Number	Top of Boring Elevation (ft, NAVD 88)	Layer ID	Soil Description	USCS Soil Classification	Depth to Top of Layer (ft)	Depth to Bottom of Layer (ft)	Elevation of Top of Layer (ft, NAVD 88)	Elevation of Bottom of Layer (ft, NAVD 88)	Layer Thickness (ft)	Average Depth to Groundwater During Drilling	Laboratory and Field Data										Comments
											Average % Fines	Average Field N (blows/ft)	Average N_{60} (blows/ft)[1]	Average Normalized Blow Count, $N_{1,60}$ (blows/ft)[2]	Torvane (tsf)	Pocket Penetrometer (tsf)	Average Unit Weight (pcf)	PI	LL	LI	
2F-05-G4-2, 2F-05-G4-2A	34.00	1	Silty Sand (SM) with Silty (ML) and Poorly Graded	SM	0.00	16.00	34.00	18.00	16.00			16	25								
		2	Silt Blanket (ML)	ML	16.00	21.50	18.00	12.50	5.50		57	6	7								
		3	Silty Sand (SM)	SM	14.49	28.69	12.50	4.80	7.70		44										
		4	Silt (ML) and Lean Clay (CL)	ML	21.50	40.00	4.80	-6.00	10.80		9	19	22								
		5	Silty Sand (SM), Poorly Graded Sand (SP)	SM	40.00	98.00	-6.00	-64.00	58.00		10	57	59								
		6	Poorly Graded Gravel (GP) Poorly Graded	GP	98.00	133.98	-64.00	-99.98	35.98		4	25									
		7	Lean Clay with Silt (CL w/ ML)	CL	133.98	143.00	-99.98	-109.00	9.02												
		8	Impervious Clay Cap (CL)	CL																	
		9	Cutoff Wall	SB WALL																	
					Total Depth (ft.)	**143.00**															

Layer ID	Recommended Hydraulic Conductivity					Strenth Coorelations								Strength from Lab Test Data						Recommended Strength Parameters			Comments
	Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Total Overburden Pressure at Mid Layer During Drilling (psf)	Effective Overburden Stress at Mid Layer During Drilling (psf)	OCR from N_{60}[3]	OCR from LI[3]	Su from N (psf)[4]	Su/σ'_o from PI (psf)[4]	Calculated Maximum Past Pressure (psf)[5]	Drained Friction Angle[7]	OCR	σ'_p (psf)	Su (psf)	Su/σ'_o	Φ'	C' (psf)	Φ'	C' (psf)	γ (pcf)	
1	1.00E-02	4.00	2.50E-03	28.350	7.088	0	-499													34	0	125	Sensitivity run w/ phi= 34. Matching URS Sac River P1GER. Original run at phi=
2	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-1170													28	0	120	Sensitivity run w/ phi= 28. Matching URS Sac River P1GER. Original run at
3	5.00E-04	4.00	1.25E-04	1.418	0.354	0	-1144													30	0	125	
4	2.00E-04	4.00	5.00E-05	0.567	0.142	0	-1679													30	50	120	
5	5.00E-03	4.00	1.25E-03	14.175	3.544	0	-4306													30	0	125	
6	2.50E-02	10.00	2.50E-03	70.875	7.088	0	-7238													35	0	135	

2F-05-G4-2

N 38°29'08.2", W 121°32'55.7"

Levee Crown = 0

Depth	Unified	N	N_{60}	GR	SA	FI	LL	PI	MC	Description
	GW-GC	13	17	-	-	-	-	-	-	AT SURFACE, AGGREGATE MATERIAL, 6" THICK; HOLE LOCATE NEAR LANDSIDE HINGE POINT
1.5'										WELL GRADED GRAVEL WITH SILT AND SAND, GW-GC: FIRM; DRY; DARK GRAYISH-BROWN; 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1/2"; 40% FINE SAND; 10% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
3.0'	SM	28	37							SILTY SAND, SM: FIRM TO DENSE; DRY; DARK GRAYISH-BROWN; 80% FINE SAND; 20% NON-PLASTIC FINES; EASY DRILLING
6.0'	ML	16	21							SANDY SILT, ML: VERY STIFF; DRY; BROWN; 65% LOW PLASTICITY FINES; 35% FINE TO MEDIUM, SUBROUNDED SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP= 3.0 tsf
9.0'	SM	14	19							SILTY SAND, SM: FIRM; DRY; BROWN; 75% FINE SAND; 25% NONPLASTIC FINES; AT 9.0' TO 9.2' A LAYER OF CLAY PRESENT; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
12.0'		25	33							AT 12.0', AS ABOVE EXCEPT DENSE; STREAKS OF IRON OXIDE STAINING; TRACE OF CHARCOAL PRESENT
15.0'										
15.3'	ML	28	37							SILT WITH SAND, ML: HARD; DRY; BROWN; 85% LOW PLASTICITY FINES; 15% FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT STREAKS OF IRON OXIDE STAINING; EASY DRILLING; PP=1.75 tsf
17.0'	SM									SILTY SAND, SM: DENSE TO FIRM; DRY; BROWN; 75% FINE SAND; 25% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; STREAKS OF IRON OXIDE STAINING; TRACE OF PYRITE PRESENT; EASY DRILLING
17.9'		11	15							
18.5'	CL									
19.0'	SM									SILTY SAND, SM: FIRM; DRY; VERY DARK OLIVE-GRAY; 55% FINE SAND; 45% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
19.7'		5	7							
20.1'	CL									LEAN CLAY, CL: STIFF; MOIST; VERY DARK GREENISH-GRAY; MEDIUM PLASTICITY FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP=3.25 tsf
21.0'		4	5							
23.0'										SILTY SAND, SM: LOOSE; DRY; VERY DARK OLIVE-GRAY; 55% FINE SAND; 45% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
		4	5							LEAN CLAY, CL: FIRM; MOIST; VERY DARK GREENISH-GRAY; MEDIUM PLASTICITY FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP=2.25 tsf
▽ 25.0'	SM									
		2	3	-	-	47	25	1	-	LEAN CLAY, CL: FIRM; MOIST; BROWN; MEDIUM PLASTICITY FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT STREAKS OF IRON OXIDE STAINING; EASY DRILLING; PP=1.5 tsf
27.0'										
		3	4							SILTY SAND, SM: LOOSE TO VERY LOOSE; MOIST; BROWN; NONPLASTIC FINES; TRACE OF FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
29.0'										AT 25.0', AS ABOVE EXCEPT WET; GROUND-WATER ENCOUNTERED
30.2'		4	5							AT 29.0', AS ABOVE EXCEPT LOOSE
31.0'										SANDY SILT, ML: FIRM TO SOFT; WET; BROWN; LOW PLASTICITY FINES; FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT STREAKS OF IRON OXIDE STAINING
		3	4	-	-	55	30	4	-	
33.0'										SANDY SILT, ML: SOFT TO FIRM; WET; VERY DARK GREENISH-GRAY; LOW PLASTICITY FINES; FINE SAND; NO ODOR; NO REACTION WITH HCL; EASY DRILLING; PP= 1.25 tsf
		4	5							AT 33.0', AS ABOVE EXCEPT FIRM; STREAKS OF IRON OXIDE STAINING; PP=1.75 tsf
35.0'	ML									
		2	3							SANDY SILT, ML: SOFT TO FIRM; WET; VERY DARK GREENISH-GRAY; 65% NONPLASTIC FINES; 35% FINE SAND; NO ODOR; NO REACTION WITH HCL; ABUNDANT MICA PRESENT; EASY DRILLING; PP= 1.75 tsf
37.0'										AT 37.0', PP=1.0 tsf
		6	8							
39.0'										AT 39.0', PP=1.5 tsf
		6	8							
41.0'										
		8	11							POORLY GRADED SAND WITH SILT, SP-SM: FIRM TO LOOSE; WET; VERY DARK GREENISH-GRAY; FINE SAND; NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; TRACE OF MICA PRESENT; EASY DRILLING
43.0'										
		6	8	-	-	8	-	-	-	
45.0'										AT 45.0', AS ABOVE EXCEPT FIRM;
		10	13							
48.0'	SP-SM									
		13	17							
51.0'										
		13	17							
54.0'										

2F-05-G4-2

(CONTINUED FROM PREVIOUS COLUMN)

Depth	Unified	N	N_{60}	GR	SA	FI	LL	PI	MC	Description
54.0'										
		13	17							
57.0'										
		15	20							SILTY SAND, SM: FIRM TO LOOSE; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% FINES; TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 3/16"; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
60.0'	SM									
		7	9							
63.0'										
		12	16							SILTY SAND, SM: FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO MEDIUM, SUBROUNDED SAND; 25% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
66.0'										
		13	17							SILTY SAND, SM: FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% FINES; TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 3/16"; NO ODOR; NO REACTION WITH HCL; EASY DRILLING
69.0'										
	SP-SM	10	13							POORLY GRADED SAND WITH SILT, SP-SM: FIRM; WET; VERY DARK GREENISH-GRAY; 90% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 10% NONPLASTIC FINES; NO REACTION WITH HCL; EASY DRILLING
72.0'										
		32	43							SILTY SAND, SM: DENSE TO VERY FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% NONPLASTIC FINES; TRACE OF FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 7/8"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
75.0'										AT 75.0', AS ABOVE EXCEPT TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 5/8"
	SM	17	23							
78.0'										
		25	33							SILTY SAND, SM: DENSE; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% FINES; TRACE OF FINE GRAVEL MAXIMUM PARTICLE SIZE 1/2"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
81.0'										
		46	61							POORLY GRADED SAND WITH SILT, SP-SM: VERY DENSE TO DENSE; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NONPLASTIC FINES; TRACE OF FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1/2"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
84.0'										
		25	33	-	-	9	-	-	-	
87.0'										POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: DENSE; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUB-ROUNDED SAND; NONPLASTIC FINES; FINE, SUB-ANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
		26	35							
90.0'	SP-SM									POORLY GRADED SAND WITH SILT, SP-SM: VERY FIRM; WET; VERY DARK GREENISH-GRAY; 75% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 25% NONPLASTIC FINES; TRACE OF FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
		20	27							
93.0'										POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: VERY FIRM; WET; VERY DARK GREENISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUB-ROUNDED SAND; NONPLASTIC FINES; FINE, SUBAN-GULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 7/8"; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
		19	25	16	78	6	-	-	-	
96.0'										POORLY GRADED SAND WITH SILT AND GRAVEL, SP-SM: VERY FIRM; WET; VERY DARK GREEN-ISH-GRAY; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; FINE TO COARSE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; MODE-- RATE DRILLING
		20	27							
99.0'	GM									SILTY GRAVEL WITH SAND, GM: FIRM; WET; VERY DARK GREENISH-GRAY; 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; 35% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 15% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING
99.8'	CL	8	11							
102.0'										LEAN CLAY WITH GRAVEL, CL: STIFF; WET; VERY DARK GREENISH-GRAY; 75% MEDIUM PLASTICITY FINES; 15% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; 10% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NO ODOR; NO REACTION WITH HCL; MODERATE DRILLING; PP=1.25 tsf

(CONTINUED IN NEXT COLUMN)

2F-05-G4-2

(CONTINUED FROM PREVIOUS COLUMN)

Depth	Unified	N	N_{60}	GR	SA	FI	LL	PI	MC	Description
102.0'										
		25	33							SILTY GRAVEL WITH SAND, GM: DENSE TO VERY DENSE; WET; VERY DARK GREENISH-GRAY; 50% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 3/4"; 35% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 15% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING
105.0'	GM									AT 105.0', AS ABOVE EXCEPT 50% FINE, SUBAN-GULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"
		R*	R*							AT 106.5', CONVERT TO CAL-MOD SAMPLER
108.0'										
		A*	A*							
111.0'										
	GW	70*	93*	64	32	4	-	-	-	WELL-GRADED GRAVEL WITH SAND, GW: VERY DENSE; WET; DARK GREENISH-GRAY; FINE TO COARSE, MOSTLY FINE, SUBANGULAR TO SUB-ROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING; DRILLING MUD USED
114.0'										
		R*	R*							
117.0'										
117.4'	SM									SILTY SAND WITH GRAVEL, SM: VERY DENSE; WET; DARK GREENISH-GRAY; 60% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 20% NON-PLASTIC FINES; 20% FINE TO COARSE, SUBANGU-LAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; NO ODOR; NO REACTION WITH HCL; HARD DRILLING
117.7'		83*	R*							
120.0'										SILTY SAND, SM: VERY DENSE; WET; DARK GREENISH-GRAY; 80% FINE TO MEDIUM, SUBANGULAR TO SUBROUNDED SAND; 20% NON-PLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING
		R*	R*							
										WELL-GRADED GRAVEL WITH SAND, GW: VERY DENSE; WET; DARK GREENISH-GRAY; 70% FINE, SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-1/4"; 25% FINE TO COARSE, SUBANGULAR TO SUBROUNDED SAND; 5% NONPLASTIC FINES; NO ODOR; NO REACTION WITH HCL; HARD DRILLING
123.0'		R*	R*							AT 120.0', AS ABOVE EXCEPT GRAVEL MAXIMUM PARTICLE SIZE 1-½"
126.0'	GW									AT 123.0', AS ABOVE EXCEPT GRAVEL MAXIMUM PARTICLE SIZE 2.0"
		R*	R*							
129.0'										
		84*	R*							
132.0'										AT 132.0', AS ABOVE EXCEPT GRAVEL MAXIMUM PARTICLE SIZE 1-¼"; MODERATE DRILLING
		93*	R*							
135.0'										
		R*	R*							LEAN CLAY WITH SAND, CL: HARD; MOIST; DARK GREENISH-GRAY; 85% MEDIUM PLASTICITY FINES; 15% FINE SAND; NO ODOR; STRONG REACTION TO HCL; STREAK OF CALCIUM CARBONATE STAINING; VERY HARD DRILLING; PP=3.25 tsf
138.0'	CL									
		R*	R*							AT 138.0', AS ABOVE EXCEPT HARD DRILLING; PP=3.0 tsf
141.0'										
	ML	58*	77*							SILT WITH SAND, ML: HARD; MOIST; DARK GREENISH-GRAY; 75% LOW PLASTICITY FINES; 25% FINE SAND; NO ODOR; STRONG REACTION TO HCL; VERY HARD DRILLING; PP=2.75 tsf
144.0'										
	B.O.H.									

(CONTINUED IN NEXT COLUMN)

NOTES:

1. LEGEND AND NOTES ARE SHOWN ON SHEET B-1.
2. LOCATION OF EXPLORATIONS ARE SHOWN IN APPENDIX C.

VERTICAL SCALE: 1" = 3'

GRAPHIC SCALE

VERTICAL SCALE 1 : 3 — 0 3 6 9 12 FEET

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Mapping Unit (S/S) No.: MAPPING_UNIT_(S/S)_NO.

Date: 24 Aug 2005 | Rev:
Design File no: | Drawing Code:
Spec No: | File name: 13 | Plot date: | Plot scale: AS NOTED
Designed by: SCANDRONE | Drawn by: PHAM | Reviewed by: EDWARDS | Submitted by: J.J. Section Chief | Ext. Sectorial No.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

SACRAMENTO RIVER AMERICAN RIVER WATERSHED PROJECT (COMMON FEATURES), CALIFORNIA
POCKET AREA FEMA EVALUATION (LEFT BANK)
GEOTECHNICAL SITE 4
LOG OF EXPLORATIONS
G4 - 2

Sheet reference number:
B-24
24 of 50

MAY 2005

Soil Design Section Sheet No.: X of X

Reference - Exploration Log file no.: XXX-01-XXX

Date: Revised 08/30/04, 02/01/03 DWC

2F-05-G4-2A

N XX°XX'XX.X", WXXX°XX'XX.X", ±XX'

DEPTH		N	N_{60}	GR	SA	FI	LL	PI	MC	
Levee Toe = 0										
	ML	11	14	-	-	-	-	-	-	SILT WITH SAND, ML: STIFF TO FIRM; DRY; VERY DARK GRAYISH-BROWN; NONPLASTIC FINES; FINE SAND; TRACE OF SUBANGULAR TO ANGULAR GRAVEL MAXIMUM PARTICLE SIZE 1/2"; TRACE OF IRON OXIDE STAINING; ORGANIC MATERIAL (ROOTS) PRESENT
2.0'										
	ML	5	7	-	-	-	-	-	-	AT 2.0', AS ABOVE EXCEPT DARK YELLOWISH-BROWN
4.0'										AT 4.0', AS ABOVE EXCEPT MOIST
		4	5	-	-	83	33	10	-	
6.0'				-	-	-	-	-	-	
		2	3	-	-	-	-	-	-	
8.0'	SM									SILTY SAND, SM: VERY LOOSE; WET; DARK YELLOWISH-BROWN; FINE SAND; NONPLASTIC FINES
		3	4	-	-	40	23	0	-	
10.0'				-	-	-	-	-	-	
	ML/CL			-	-	-	-	-	-	CLAYEY SILT, ML/CL: FIRM; WET; DARK YELLOWISH-BROWN; NONPLASTIC TO LOW PLASTICITY FINES
11.0'	CL/ML	4	5	-	-	-	-	-	-	SILTY CLAY, CL/ML: FIRM; WET; VERY DARK GRAY; LOW PLASTICITY TO NONPLASTIC, MOSTLY LOW PLASTICITY FINES
12.0'										
		2	3	-	-	53	27	4	-	
14.0'	ML			-	-	-	-	-	-	SANDY SILT, ML: SOFT; WET; DARK YELLOWISH-BROWN; NONPLASTIC FINES; FINE SAND
		3	4	-	-	-	-	-	-	
16.0'										
		2	3	-	-	-	-	-	-	
18.0'	CL/ML									SILTY CLAY, CL/ML: SOFT TO FIRM; WET; VERY DARK GRAY; LOW PLASTICITY TO NONPLASTIC FINES
		4	5	-	-	-	-	-	-	
20.0'										
	ML	4	5	-	-	-	-	-	-	SILT, ML: FIRM; WET; VERY DARK GRAY; NONPLASTIC FINES
22.0'										
		4	5	-	-	-	-	-	-	
24.0'										CLAYEY SILT, ML/CL: FIRM TO SOFT; WET; VERY DARK GRAY; NONPLASTIC TO LOW PLASTICITY FINES
	ML/CL	3	4	-	-	-	-	-	-	
26.0'										AT 26.0', AS ABOVE EXCEPT STIFF
		8	11	-	-	-	-	-	-	
28.0'	ML			-	-	-	-	-	-	SILT, ML: STIFF; WET; VERY DARK GRAY; NONPLASTIC FINES
28.8'		10	13	-	-	-	-	-	-	POORLY GRADED SAND WITH SILT, SP-SM: FIRM; WET; VERY DARK GRAY; 90% FINE TO MEDIUM SAND; 10% NONPLASTIC FINES
30.0'										
		13	17	-	-	-	-	-	-	
32.0'										POORLY GRADED SAND WITH SILT, SP-SM: FIRM TO VERY FIRM; WET; VERY DARK GRAY; FINE TO MEDIUM SAND; NONPLASTIC FINES
		15	20	-	-	-	-	-	-	
34.0'										AT 34.0', AS ABOVE EXCEPT FINE SAND
	SP-SM	16	21	-	-	6	-	-	-	
36.0'				-	-	-	-	-	-	AT 36.0', AS ABOVE EXCEPT FINE TO MEDIUM SAND; TRACE OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1/4"
		17	23	-	-	-	-	-	-	
38.0'										
		21	28	-	-	-	-	-	-	
40.0'										AT 40.0', AS ABOVE EXCEPT NO GRAVEL
		18	24	-	-	-	-	-	-	
42.0'				-	-	-	-	-	-	AT 42.2', AS ABOVE EXCEPT VERY LOOSE
42.2'	CL	3	4	-	-	-	-	-	-	LEAN CLAY, CL: SOFT; WET; VERY DARK GRAY; LOW PLASTICITY FINES
44.0'	SM			-	-	-	-	-	-	SILTY SAND, SM: FIRM; WET; VERY DARK GRAY; 80% FINE TO MEDIUM SAND; 20% NONPLASTIC FINES
44.6'		15	20							
	ML			-	-	-	-	-	-	SILT, ML: VERY STIFF; WET; VERY DARK GRAY; NONPLASTIC FINES
47.0'										
	SM	36	48	-	-	-	-	-	-	SILTY SAND, SM: DENSE; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES
50.0'										

(CONTINUED IN NEXT COLUMN)

2F-05-G4-2A

(CONTINUED FROM PREVIOUS COLUMN)

DEPTH		N	N_{60}	GR	SA	FI	LL	PI	MC	
50.0'										
		13	17	-	-	-	-	-	-	
53.0'										SILTY SAND, SM: FIRM TO LOOSE; WET; VERY DARK GRAY; 85% FINE SAND; 15% NONPLASTIC FINES; MICA PRESENT
		10	13	-	-	-	-	-	-	
56.0'										AT 56.0', AS ABOVE EXCEPT TRACE OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½", MOSTLY SMALLER THAN 1/4"
		7	9	-	-	-	-	-	-	
59.0'										AT 59.0', AS ABOVE EXCEPT FIRM; NO GRAVEL
		9	12	-	-	-	-	-	-	
62.0'										AT 56.0', AS ABOVE EXCEPT TRACE OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"
		12	16	-	-	-	-	-	-	
65.0'	SM									AT 65.0', AS ABOVE EXCEPT NO GRAVEL
		11	14	-	-	18	-	-	-	
68.0'										AT 68.0', AS ABOVE EXCEPT DENSE; 4% OF SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½", MOSTLY SMALLER THAN 1/4"
		27	36	-	-	-	-	-	-	
71.0'										AT 71.0', AS ABOVE EXCEPT VERY FIRM TO DENSE; GRAVEL MAXIMUM PARTICLE SIZE 3/4", MOSTLY SMALLER THAN 1/4"
		21	28	-	-	-	-	-	-	
74.0'				-	-	-	-	-	-	
75.1'		23	31	-	-	-	-	-	-	SILTY SAND WITH GRAVEL, SM: DENSE; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; MICA PRESENT
77.0'										
78.2'		18	24	-	-	-	-	-	-	SILTY SAND, SM: VERY FIRM; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES; TRACE OF GRAVEL MAXIMUM PARTICLE SIZE 3/4", MOSTLY SMALLER THAN 1/4"
80.0'										
81.1'		22	29	-	-	-	-	-	-	SILTY SAND WITH GRAVEL, SM: VERY FIRM; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; MICA PRESENT
83.0'										
83.4'	CL			-	-	-	-	-	-	SILTY SAND, SM: VERY FIRM; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES; TRACE OF GRAVEL MAXIMUM PARTICLE SIZE 3/4", MOSTLY SMALLER THAN 1/4"
84.0'		35	47	-	-	-	-	-	-	SILTY SAND WITH GRAVEL, SM: VERY FIRM; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1.0"; MICA PRESENT
	GP-GC			-	-	-	-	-	-	
86.0'										SILTY SAND, SM: DENSE; WET; VERY DARK GRAY; 60% FINE TO MEDIUM SAND; 40% NONPLASTIC FINES; TRACE OF GRAVEL MAXIMUM PARTICLE SIZE 1/4"
	SM	53	71	-	-	-	-	-	-	
										LEAN CLAY, CL: HARD; WET; VERY DARK GREENISH-GRAY; LOW PLASTICITY TO NONPLASTIC; MOSTLY LOW PLASTICITY FINES
89.0'										POORLY GRADED GRAVEL WITH CLAY AND SAND, GP-GC: DENSE; WET; VERY DARK GREENISH-GRAY; 75% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 15% FINE TO COARSE SAND; 10% LOW PLASTICITY FINES
	GP-GM	50	67	-	-	-	-	-	-	
										SILTY SAND WITH GRAVEL, SM: VERY DENSE; WET; VERY DARK GRAY; 70% FINE TO COARSE SAND; 15% NONPLASTIC FINES; 15% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½", MICA PRESENT
92.0'										
	GP-GC	67	89	-	-	-	-	-	-	POORLY GRADED GRAVEL WITH SILT AND SAND, GP-GM: VERY DENSE; WET; VERY DARK GREENISH-GRAY; 70% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 20% FINE TO COARSE SAND; 10% NONPLASTIC FINES
95.0'	GP-GM			-	-	-	-	-	-	
96.0'		A	A							POORLY GRADED GRAVEL WITH CLAY AND SAND, GP-GC: VERY DENSE; WET; VERY DARK GREENISH-GRAY; 65% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 25% FINE TO COARSE SAND; 10% LOW PLASTICITY FINES
										POORLY GRADED GRAVEL WITH SILT AND SAND, GP-GM: VERY DENSE; WET; VERY DARK GREENISH-GRAY; 70% SUBANGULAR TO SUBROUNDED GRAVEL MAXIMUM PARTICLE SIZE 1-½"; 20% FINE TO COARSE SAND; 10% NONPLASTIC FINES

B.O.H.

NOTES:

1. LEGEND AND NOTES ARE SHOWN ON SHEET B-1.
2. LOCATION OF EXPLORATIONS ARE SHOWN IN APPENDIX C.

VERTICAL SCALE: 1" = 3'

GRAPHIC SCALE

VERTICAL SCALE 1 : 3 — 0 3 6 9 12 FEET

US Army Corps of Engineers
Sacramento District

Symbol	Description	Date	Approved

Mapping Unit (S/S) No.: MAPPING_UNIT_(S/S)_NO.

Date: 24 Aug 2005 | Rev.
Design file no. | Spec. No.
Drawing Code:
File name:
Plot date: 1:1
Dwg scale: AS NOTED

Designed by: SCANDRONE
Dwn by: PHAN
Reviewed by: EDWARDS
Submitted by: JV Section Chief
Chief, Soil Design Sec.

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 J STREET
SACRAMENTO, CA 95814-2922

SACRAMENTO RIVER — CALIFORNIA
AMERICAN RIVER WATERSHED PROJECT
(COMMON FEATURES), CALIFORNIA
POCKET AREA FEMA EVALUATION (LEFT BANK)

GEOTECHNICAL SITE 4
LOG OF EXPLORATIONS
G4 - 2A

Sheet reference number:
B-25
25 of 2005

MAY 2005

Soil Design Section Sheet No.: X of X

Reference - Exploration Log file no.: XXX-01-XXX

SIERRA TESTING LABORATORIES, INC.
GEOTECHNICAL AND MATERIALS TESTING SERVICES

Table 1

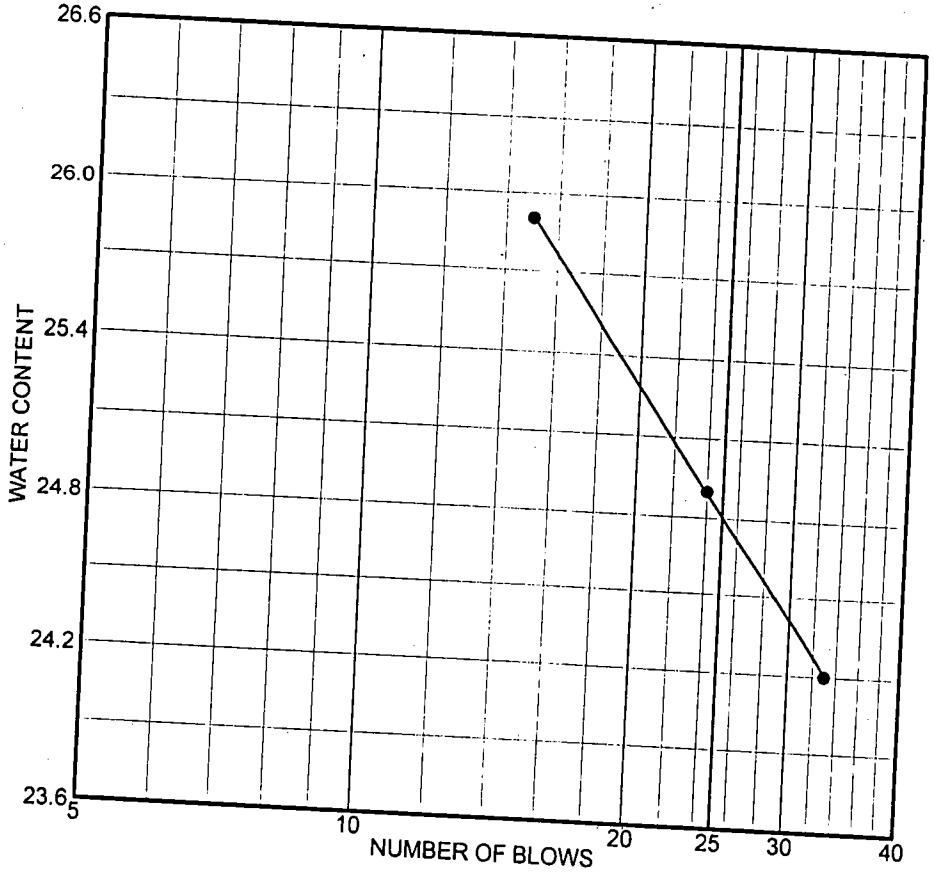
Percent Passing #200 (ASTM D1140)
Sacramento River FEMA –Geotech Sites
(Pocket Area)
STL Job #05-187

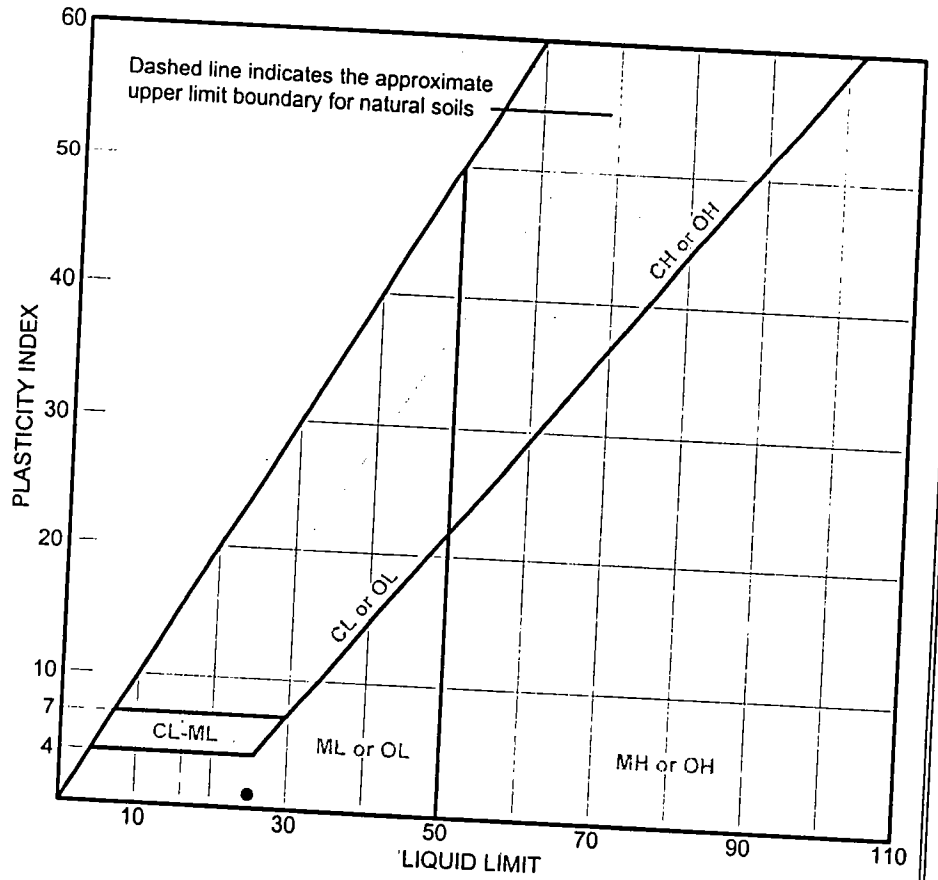
Sample Name	Percent Passing #200
2F-05-G4-2, FS11 25-26.5	47.3
2F-05-G4-2, FS14 31-32.5	55.1
2F-05-G4-2, FS20 43-44.5	7.9
2F-05-G4-2, FS34 84-85.5	8.7

Notes:

5040 Robert J. Mathews Parkway, El Dorado Hills, CA ph: 916-939-3460 fax: 916-939-3507

LIQUID AND PLASTIC LIMITS TEST REPORT





SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
2F-05-G4-2	FS11	25-26.5	4/20/05				25	1

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

(Pocket Area)

Project No. 05-187 | Figure

SIERRA TESTING LABS, INC.

LIQUID AND PLASTIC LIMIT TEST DATA

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites
(Pocket Area)
W91238-05-P-0097
Project Number: 05-187

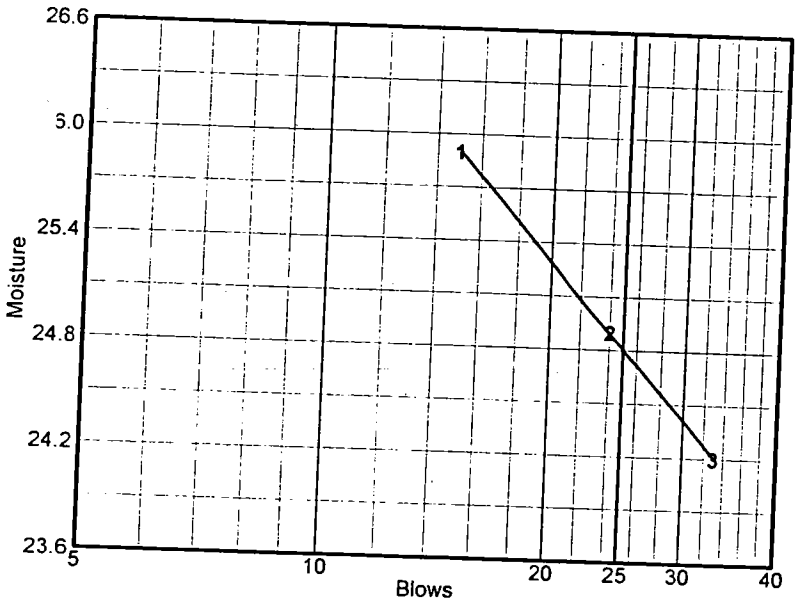
Sample Data

Source: 2F-05-G4-2
Sample No.: FS11
Elev. or Depth: 25-26.5
Location:
Description:
Date: 4/20/05
USCS Class.:
Testing Remarks:

Sample Length(in./cm.):
Natural Moisture:
AASHTO Class.:

Liquid Limit Data

Run No.	1	2	3	4	5	6
Wet+Tare	22.03	25.27	30.93			
Dry+Tare	17.80	20.53	25.18			
Tare	1.45	1.46	1.46			
# Blows	15	24	33			
Moisture	25.9	24.9	24.2			

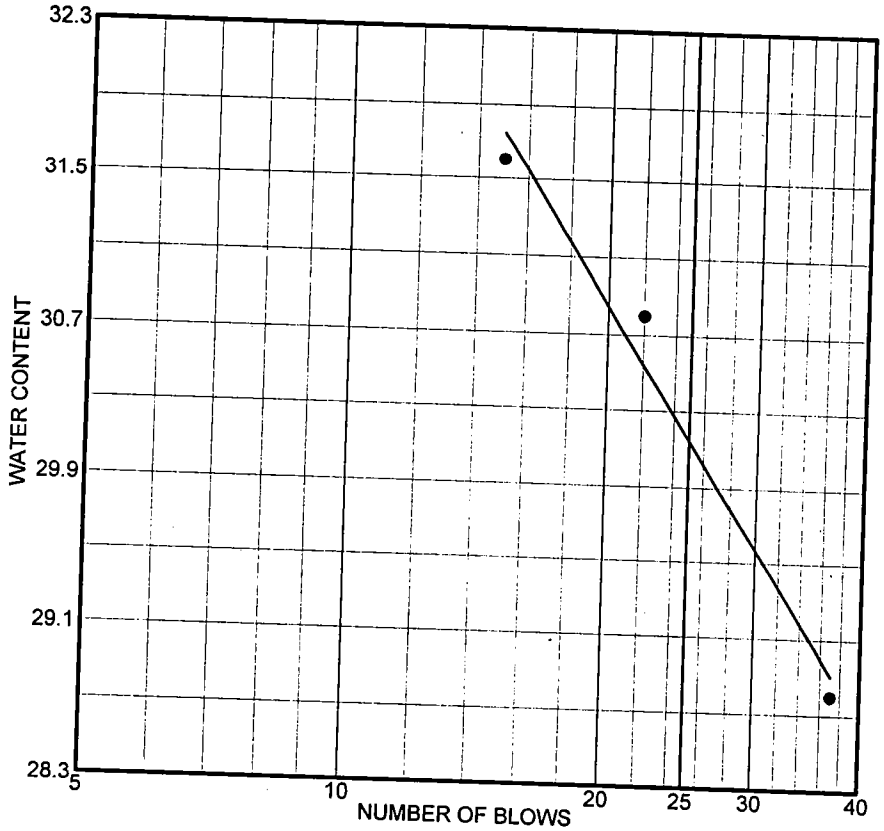


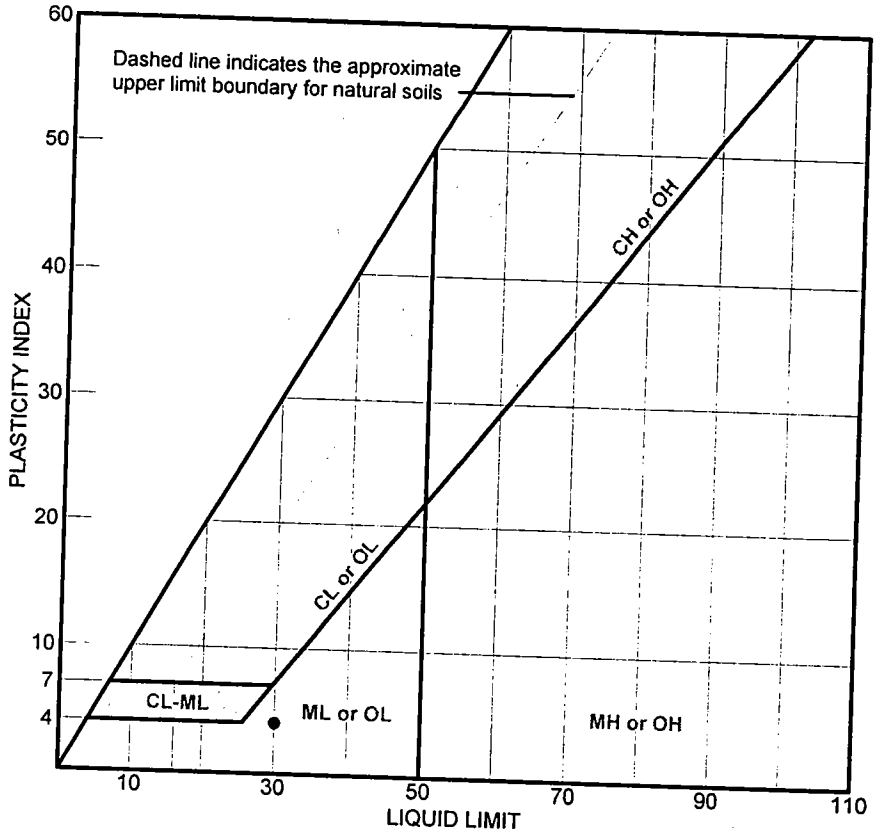
Liquid Limit= 25
Plastic Limit= 24
Plasticity Index= 1

Plastic Limit Data

Run No.	1	2	3	4	
Wet+Tare	4.05	4.95			
Dry+Tare	3.55	4.28			
Tare	1.45	1.46			
Moisture	23.8	23.8			

LIQUID AND PLASTIC LIMITS TEST REPORT





SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
2F-05-G4-2	FS14	31.0-32.5	4/20/05				30	4

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

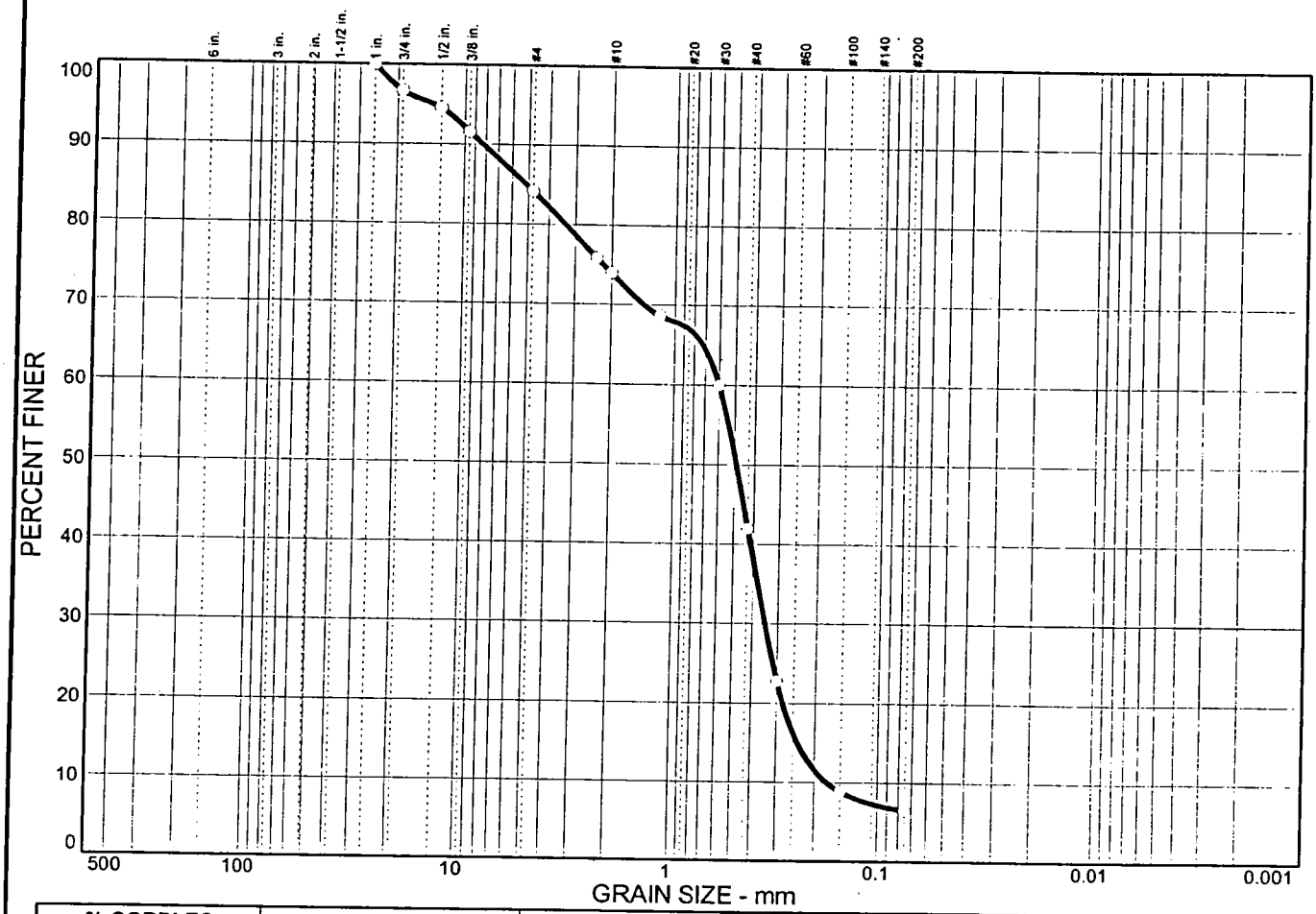
(Pocket Area)

Project No. 05-187 | Figure

SIERRA TESTING LABS, INC.

4.2

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	15.8	77.7	6.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1 in.	100.0		
3/4 in.	96.7		
1/2 in.	94.6		
3/8 in.	91.6		
#4	84.2		
#8	75.9		
#10	74.0		
#16	68.6		
#30	60.0		
#40	42.0		
#50	22.8		
#100	8.9		
#200	6.5		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 5.11 D_{60}= 0.600 D_{50}= 0.487
D_{30}= 0.346 D_{15}= 0.238 D_{10}= 0.174
C_u= 3.45 C_c= 1.15

Classification

USCS= AASHTO=

Remarks

Sample No.: FS37 **Source of Sample:** 2F-05-G4-2 **Date:** 4/20/05
Location: **Elev./Depth:** 93-94.5

SIERRA TESTING LABS, INC.

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites (Pocket Area)
Project No: 05-187 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites
(Pocket Area)
W91238-05-P-0097
Project Number: 05-187

Sample Data

Source: 2F-05-G4-2
Sample No.: FS37
Elev. or Depth: 93-94.5
Location:
Description:
Date: 4/20/05
PL:
USCS Classification:
Testing Remarks:
Sample Length(in./cm.):
LL:
PI:
AASHTO Classification:

Mechanical Analysis Data

	Initial
Dry sample and tare=	317.80
Tare =	0.00
Dry sample weight =	317.80

Sieve tare method

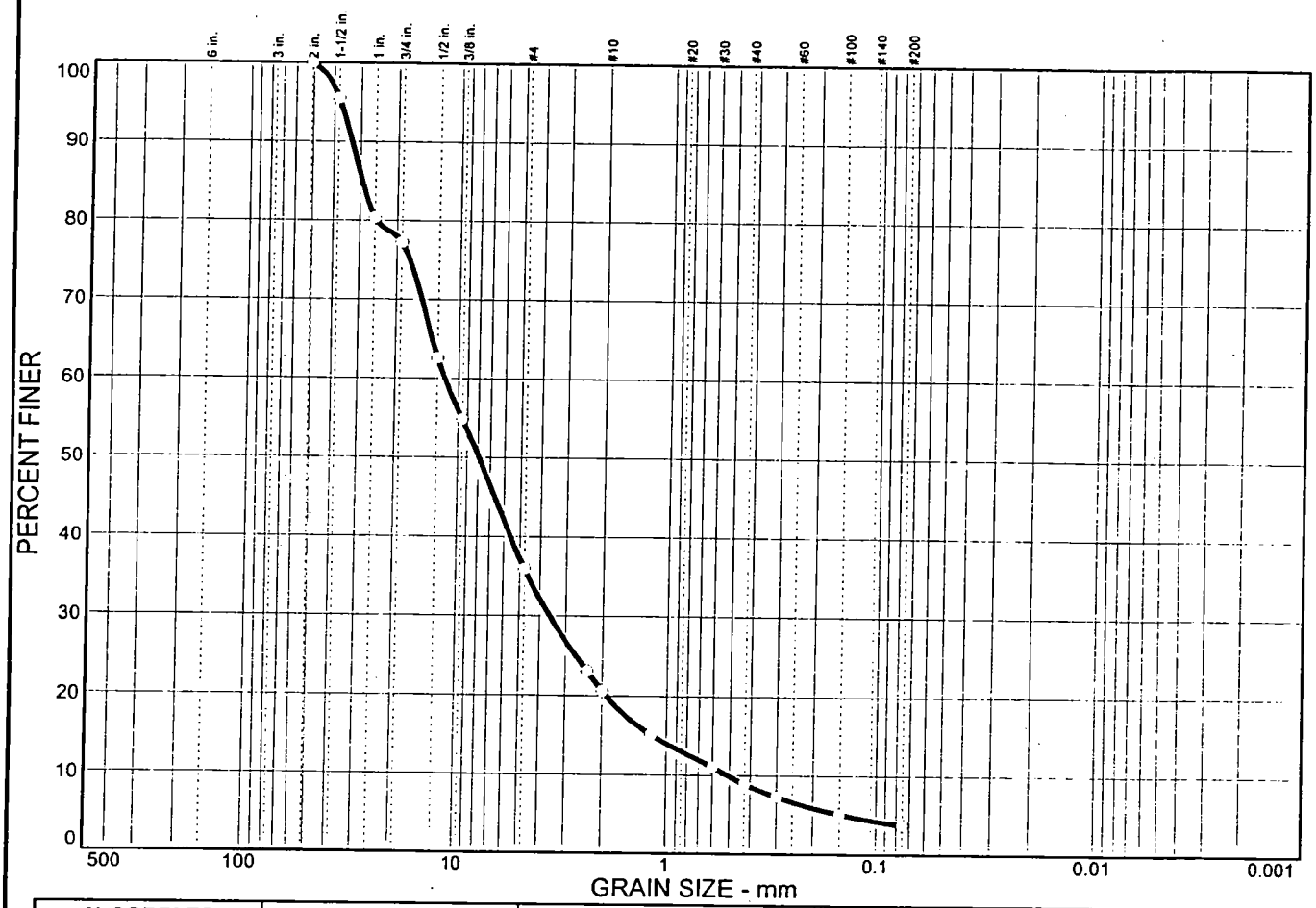
Sieve	Weight retained	Sieve tare	Percent finer
1 inch	0.00	0.00	100.0
3/4 inch	10.50	0.00	96.7
1/2 inch	6.80	0.00	94.6
3/8 inch	9.40	0.00	91.6
# 4	23.60	0.00	84.2
# 8	26.40	0.00	75.9
# 10	5.80	0.00	74.0
# 16	17.20	0.00	68.6
# 30	27.50	0.00	60.0
# 40	57.00	0.00	42.0
# 50	61.20	0.00	22.8
# 100	44.20	0.00	8.9
# 200	7.40	0.00	6.5

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = % GRAVEL = 15.8 % SAND = 77.7
% FINES = 6.5

D_{85}= 5.11 D_{60}= 0.60 D_{50}= 0.49
D_{30}= 0.35 D_{15}= 0.24 D_{10}= 0.17
C_c= 1.1485 C_u= 3.4466

Particle Size Distribution Report



% COBBLES	% GRAVEL	% SAND	% SILT	% CLAY
0.0	64.0	32.3	3.7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
2 in.	100.0		
1-1/2 in.	95.6		
1 in.	80.4		
3/4 in.	77.3		
1/2 in.	62.6		
3/8 in.	54.9		
#4	36.0		
#8	23.1		
#10	20.6		
#16	15.1		
#30	11.0		
#40	8.9		
#50	7.3		
#100	5.1		
#200	3.7		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 29.3 D_{60}= 11.7 D_{50}= 7.90
D_{30}= 3.58 D_{15}= 1.16 D_{10}= 0.511
C_u= 22.89 C_c= 2.14

Classification

USCS= AASHTO=

Remarks

Sample No.: FS43 **Source of Sample:** 2F-05-G4-2 **Date:** 4/20/05
Location: **Elev./Depth:** 111-112.5

SIERRA TESTING LABS, INC.

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites (Pocket Area)
Project No: 05-187 **Figure**

GRAIN SIZE DISTRIBUTION TEST DATA

Client: U.S. Army Corps of Engineers
Project: Sacramento River FEMA - Geotech Sites
(Pocket Area)
W91238-05-P-0097
Project Number: 05-187

Sample Data

Source: 2F-05-G4-2
Sample No.: FS43
Elev. or Depth: 111-112.5
Location:
Description:
Date: 4/20/05 **PL:**
USCS Classification:
Testing Remarks:

Sample Length(in./cm.):
LL: **PI:**
AASHTO Classification:

Mechanical Analysis Data

		Initial
Dry sample and tare	=	1919.80
Tare	=	0.00
Dry sample weight	=	1919.80

Sieve tare method

Sieve	Weight retained	Sieve tare	Percent finer
2 inch	0.00	0.00	100.0
1-1/2 inch	85.00	0.00	95.6
1 inch	290.50	0.00	80.4
3/4 inch	60.50	0.00	77.3
1/2 inch	281.60	0.00	62.6
3/8 inch	148.80	0.00	54.9
# 4	361.40	0.00	36.0
# 8	248.70	0.00	23.1
# 10	47.00	0.00	20.6
# 16	105.90	0.00	15.1
# 30	79.10	0.00	11.0
# 40	41.10	0.00	8.9
# 50	29.80	0.00	7.3
# 100	43.10	0.00	5.1
# 200	26.20	0.00	3.7

Fractional Components

Gravel/Sand based on #4
Sand/Fines based on #200
% COBBLES = % GRAVEL = 64.0 % SAND = 32.3
% FINES = 3.7

D_{85}= 29.29 D_{60}= 11.69 D_{50}= 7.90
D_{30}= 3.58 D_{15}= 1.16 D_{10}= 0.51
C_c= 2.1439 C_u= 22.892

SIERRA TESTING LABORATORIES, INC.
GEOTECHNICAL AND MATERIALS TESTING SERVICES

Table 1

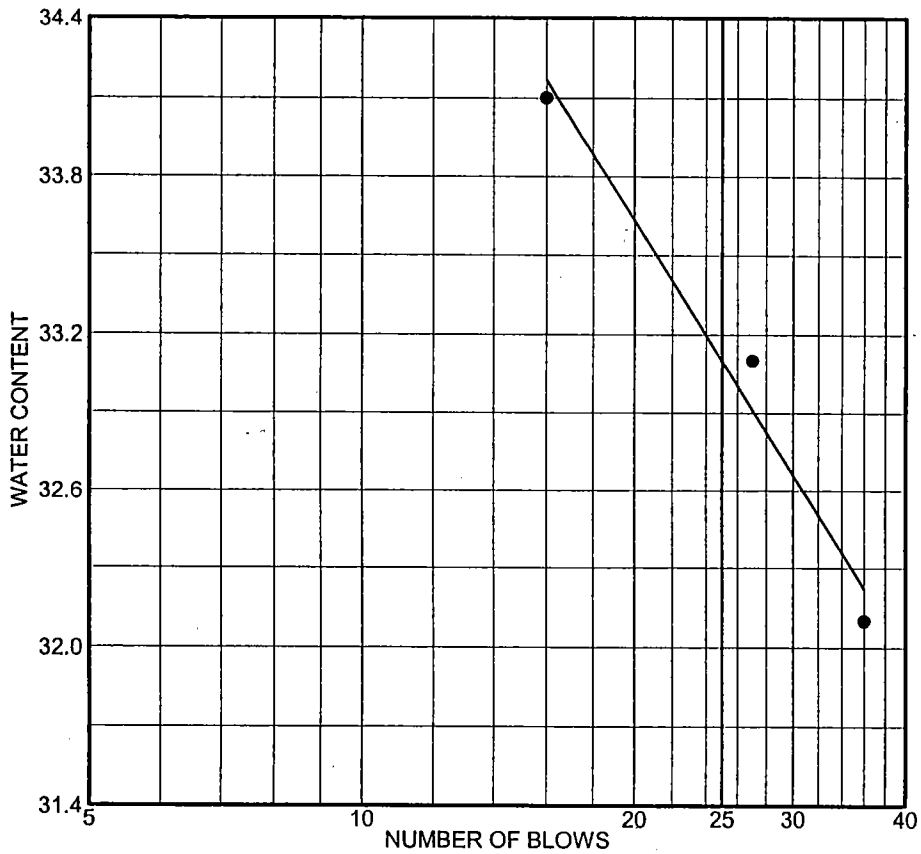
Percent Passing #200 (ASTM D1140)
Sacramento River FEMA-Geotech Sites
(Pocket Area)
STL Job #05-187

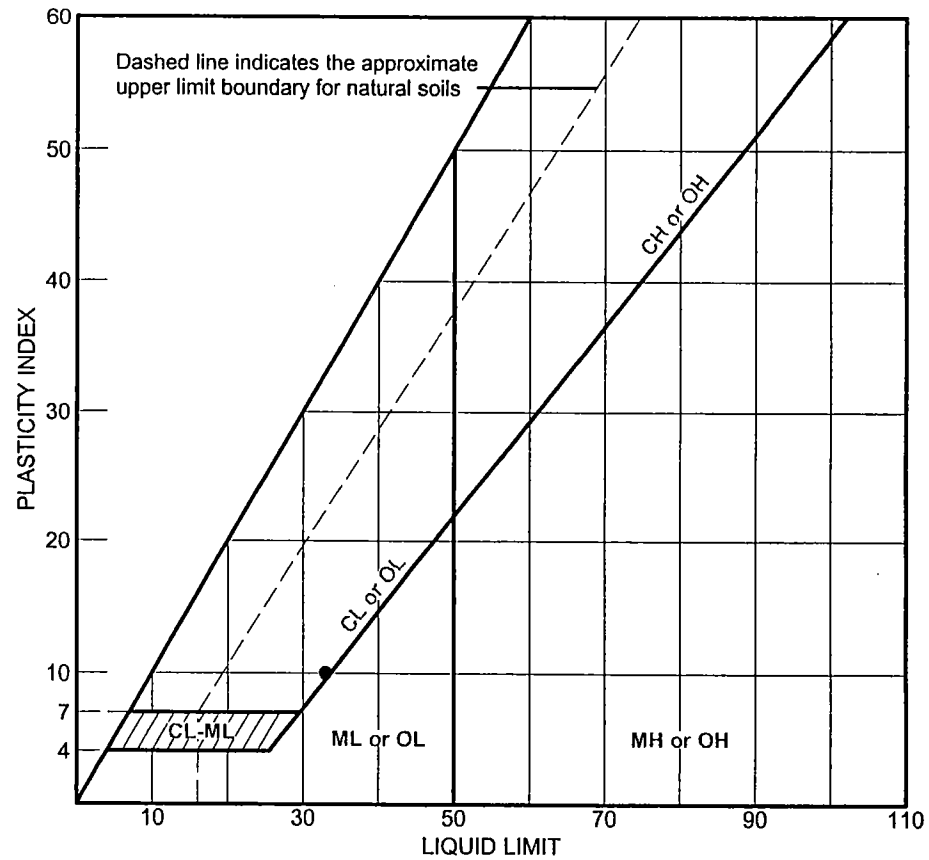
Sample Name	Percent Passing #200
2F-05-G4-2A, FS3 4.0'-5.5'	82.8
2F-05-G4-2A, FS5 8.0'-9.5'	40.4
2F-05-G4-2A, FS8 12.0'-13.5'	53.0
2F-05-G4-2A, FS20 34.0'-35.5'	5.8
2F-05-G4-2A, FS32 65.0'-66.5'	17.7

Notes:

5040 Robert J. Mathews Parkway, El Dorado Hills, CA ph: 916-939-3460 fax: 916-939-3507

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	2F-05-G4-2A	FS3	4.0-5.5	6/22/05				33	10

Client U.S. Army Corps of Engineers

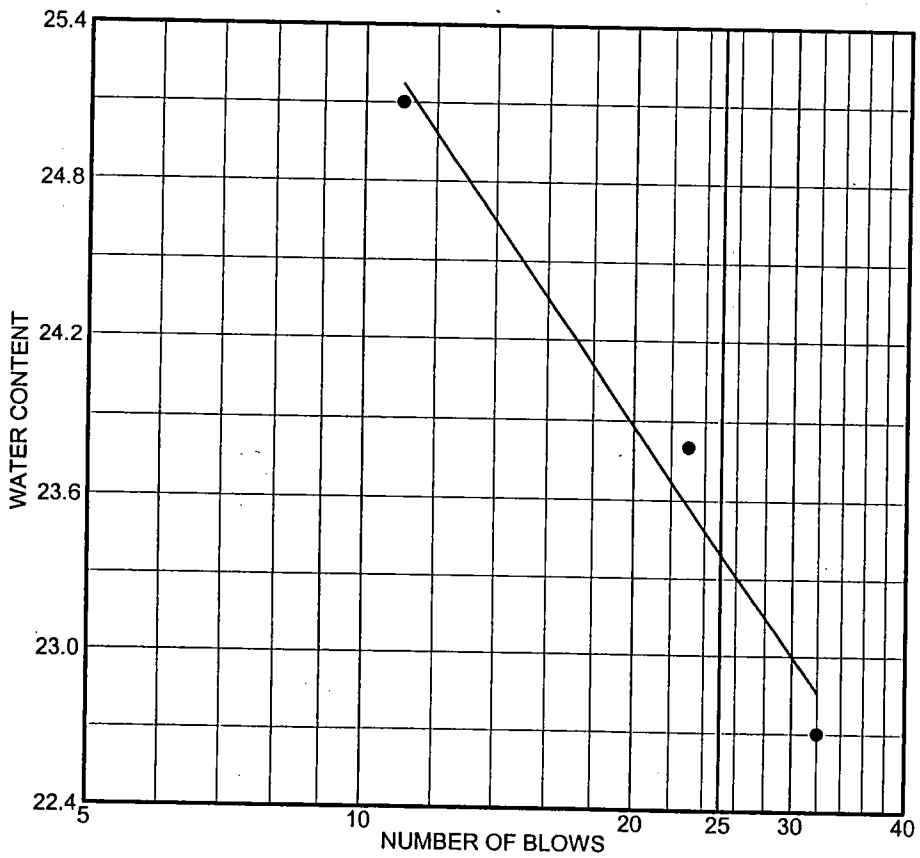
Project Sacramento River FEMA - Geotech Sites

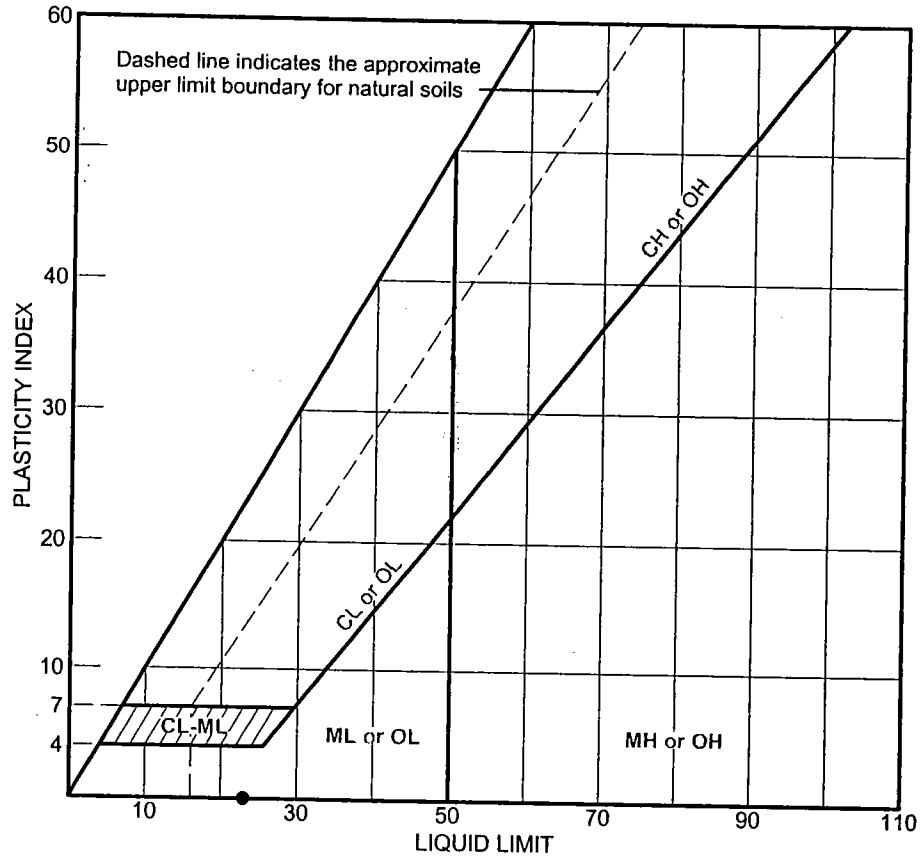
(Pocket Area)

Project No. 05-187 | Figure

SIERRA TESTING LABS, INC.

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	2F-05-G4-2A	FS5	8.0-9.5	6/22/05				23	0

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

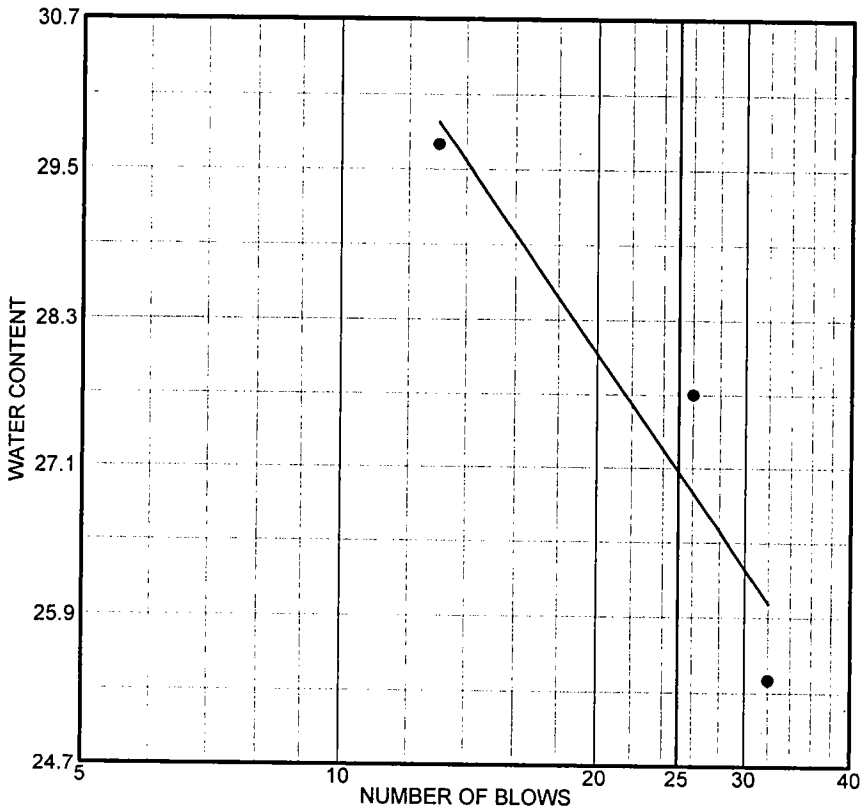
(Pocket Area)

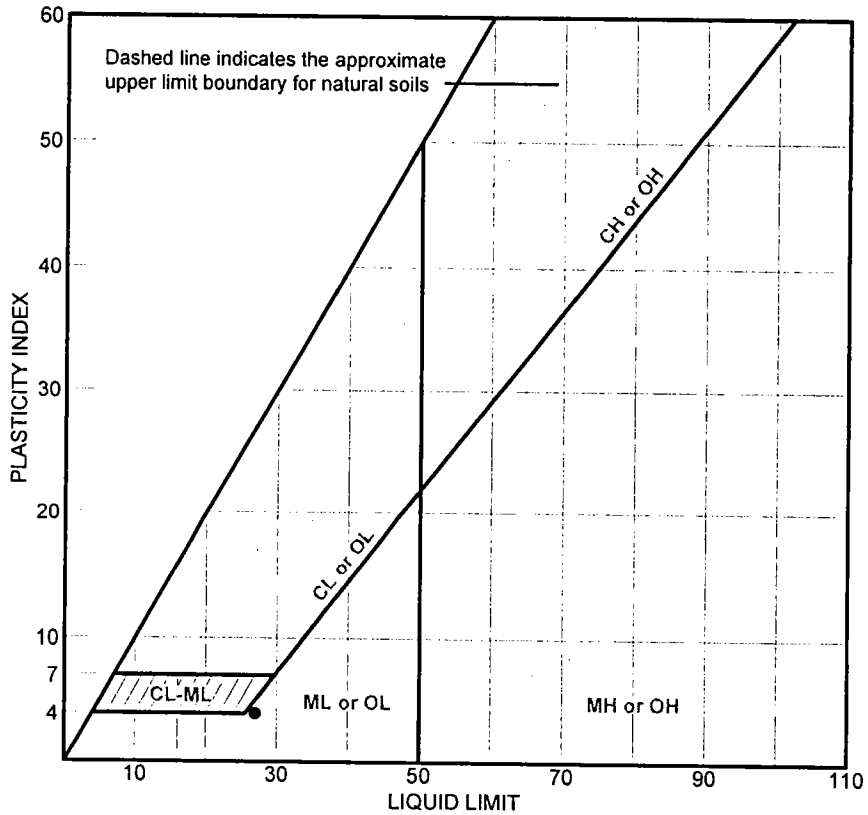
Project No. 05-187 Figure

SIERRA TESTING LABS, INC.

●

LIQUID AND PLASTIC LIMITS TEST REPORT





	SOURCE	SAMPLE #	DEPTH/ELEV.	DATE SAMPLED	USCS	MATERIAL DESCRIPTION	NM %	LL	PI
●	2F-05-G4-2A	FS8	12.0-13.5	6/22/05				27	4

Client U.S. Army Corps of Engineers

Project Sacramento River FEMA - Geotech Sites

(Pocket Area)

Project No. 05-187 Figure

SIERRA TESTING LABS, INC.

●

NATOMAS BASIN

NAT REACH D – NCC SOUTH – U1 LM 1.17

STRATIGRAPHY INPUT

BORING LOGS

LABORATORY TESTING

American River Common Features GRR
Natomas Cross Canal Sta. 956+00 LM 1.17
Table F-2-16: Permeability Selection for Seepage Analysis

Elevation of Levee Crest (NAVD 88)	Boring	Layer ID	USCS Soil Classification	Depth to Top of Layer (ft.)	Depth to Bottom of Layer (ft.)	Elevation of Top of Layer (NAVD 88)	Elevation of Bottom of Layer (NAVD 88)	Layer Thickness (ft.)	Laboratory and Field Data			Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
									% Fines (-Sieve 200) From Field Classification	PI	LL	Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
44.85	NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	0	24.5	44.9	20.4	24.50	35			4.00E-05	4.00	1.00E-05	0.113	0.028	28	50	120
		2	Poorly Graded Sand w/ silt (SP-SM)	24.5	47	20.4	-2.2	22.50				1.00E-03	10.00	1.00E-04	2.835	0.284	33	0	130
		3	Poorly Graded Sand (SP)	47	81.5	-2.2	-36.7	34.50				5.00E-03	10.00	5.00E-04	14.175	1.418	34	0	135
		4	Sandy Fat Clay (CH)	81.5	86.2	-36.7	-41.4	4.70				1.00E-05	10.00	1.00E-06	0.028	0.003	30	50	110
		5	Clay Cap									1.00E-06	4.00	2.50E-07	0.00284	0.00071	28	50	115
		6	Cutoff Wall									1.00E-06	1.00	1.00E-06	0.00284	0.00284	0	50	85
				Total Depth (ft.)	**86.20**														

Landside Toe El **32.42** **(NAVD 88)**
Levee Height **12.4** **(ft.)**

Note:

NCC					NAVD 88			
		10-yr SAC	25-yr SAC	50-yr SAC	100-yr SAC	200-yr SHY	500-yr AMR	Top of Levee
Reach	River Sta	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	W.S. Elev	NLDB Left Bank
Main	**3.23**	**39.00**	**41.11**	**41.88**	**42.84**	**44.23**	**45.16**	**44.85**

Exit Gradient at Toe

Mitigation Height

500-yr +3 Levee Height	200-yr +3 Levee Height
48.16	**47.23**

Surface Conditions:	Levee crown, loose gravel	Date Completed:	6/26/2006
Groundwater:	Groundwater not measured.	Logged By:	Brian Honea
		Total Depth:	91-1/2 feet
Method:	Hollow Stem Auger/Mud Rotary	Boring Diameter:	8 inch/4 inch
Equipment:	CME 75 with 140lb. Automatic Hammer		

Approximate Elevation: 42.5 feet (NGVD29*)
Approximate Northing: 2048063.91 feet
Approximate Easting: 6675533.77 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														LOOSE GRAVEL (GM): (Levee Fill)
														Sandy SILT (ML): Gray brown, moist, firm (Levee Fill)
			1a	4										
			1b	5										
				6										
38	5													
			2a	2										
			2b	2										
				3										**Silty SAND** (SM): Gray, moist, fine sand, about 30% fines, about 30% fines (Levee Fill)
														Sandy FAT CLAY (CH): Gray brown, moist, firm, high plasticity, about 30% fine sand (Levee Fill)
			3a	3										
			3b	3										
				6										
33	10													
			4a	3										
			4b	5				51	29			Atterberg; see Plate B-2		
				6										
			5a	3										
			5b	4										
				6										
28	15													
			6a	2										
			6b	3										
				6										
			7a	2										
			7b	3										
				6										
23	20													
			8a	3										**Sandy FAT CLAY** (CH): Gray brown, moist, firm, high plasticity, about 30% fine sand
			8b	6										
				7										
			9a	3										
			9b	6										
				9										Some charcoal pieces
18	25													
			10a	4										
			10b	8										
				9										Dark gray to black
			11a	9										**Sandy SILT** (ML): Gray brown, moist, firm
			11b	10										
				14										

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

Drafted By: D. Ross
Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3
A-6

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
		FIELD				LABORATORY								
13	30			9										
			12a	14										
			12b	18							55			
				5										**Silty SAND** (SM): Olive brown, moist to wet, fine sand, about 25% fines
			13a	5										
			13b	7							25			
8	35			3										
			14a	7										
			14b	13										
				4										
			15a	5										
			15b	6							44			About 44% fines
3	40			4										**Sandy SILT** (ML): Olive brown, moist to wet, about 39% fine sand
			16a	6										
			16b	7							61			
				2										**Silty SAND** (SM): Gray brown, wet, fine sand, about 35% fines
			17a	5										
			17b	7										
-3	45			3										
			18a	9										
			18b	18							21			About 21% fines
				7										
			19a	13										About 44% fines
			19b	20							44			
-8	50			10										
			20a	15										
			20b	22										**SILT** (ML): Light gray with orange, moist, hard
				6										**Silty SAND** (SM): Gray brown, wet, fine sand, about 35% fines
			21a	11										
			21b	17										
-13	55			7										**Sandy SILT** (ML): Gray with orange, moist, very stiff, fine sand, about 16% fine sand
			22a	12										
			22b	21							84			
				9										
			23a	23										Decreasing sand
			23b	31							54			
														SILT (ML): Olive brown, moist, very hard
-18	60			11										
			24a	23										**Sandy SILT** (ML): Gray brown, moist to wet, very hard, about 47% fine to medium sand
			24b	26							53			
														SILT (ML): Gray with orange, moist, hard, about

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LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 3
A-6

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														5% fine sand
-23	65			7										Firm
			25a	11										
			25b	18										
-28	70			13										Very hard
			26a	24										
			26b	32										
-33	75			8										Gray, about 20% fine sand
			27a	19										
			27b	25										**Silty SAND** (SM): Gray, moist to wet, fine to medium sand, about 25% fines
-38	80			6										
			28a	15										
			28b	21							27			About 27% fines
-43	85			10										**Sandy SILT** (ML): Dark gray, moist, very hard, about 30% fine sand
			29a	22										
			29b	31										Greenish gray
-48	90			14										**Silty SAND** (SM): Dark gray, wet, about 30% fines
			30a	23										
			30b	34							30			
														Boring completed at a depth of 91-1/2 feet below existing site grade.
-53	95													

FIELD | LABORATORY

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

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Date: 6/28/2007
Project No.: 72834/DNCC06
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LOG OF BORING NCCB-6- 4

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
3 of 3
A-6

Surface Conditions:	Levee toe, grassy	Date Completed:	7/5/2006
Groundwater:	Groundwater not measured.	Logged By:	C. Wilhite
		Total Depth:	66-1/2 feet
Method:	Mud Rotary	Boring Diameter:	4 inch
Equipment:	CME 750 with 140lb. Automatic Hammer		

Approximate Elevation: 21.5 feet (NGVD29*)
Approximate Northing: 2048016.25 feet
Approximate Easting: 6675610.83 feet

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
														LEAN CLAY (CL): Brown, dry, firm
			1a 1b	8 9 9										Moist
17	5		2a 2b	4 4 23	1.75									Olive brown
														Sandy SILT (ML): Brown, moist, firm, about 30% fine sand
			3a 3b	17 39 39	>4.5									**Clayey GRAVEL** (GC): Brown to red, moist, fine to coarse gravel, about 30% fines
														SILT (ML): Brown, moist, very hard
12	10		4a 4b	7 10 20										Firm, some red mottling
			5a 5b	7 13 20	>4.5									
7	15		6a 6b	9 15 15										**LEAN CLAY** (CL): Brownish gray, moist, firm
			7a 7b	6 7 8							39			**Silty SAND** (SM): Brown, moist, fine sand, about 39% fines
2	20		8a 8b	3 5 7										Olive brown
			9a 9b	3 5 6							39			
														Sandy SILT (ML): Brown, moist, firm, about 30% fine to medium sand
-4	25		10a 10b	3 6 10							32			**Silty SAND** (SM): Brown, moist, fine to medium sand, about 32% fines
			11a 11b	5 10 18							23			Medium sand, about 23% fines

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LOG OF BORING NCCB-6- 5

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 3
A-7

Elevation (ft., msl)	Depth (feet)	Sample Type	Sample No.	Blows/6 inches	Pocket Penetrometer (tsf)	Dry Density (pcf)	Moisture Content (%)	Liquid Limit	Plasticity Index	Passing #4 Sieve (%)	Passing #200 Sieve (%)	Other Tests	Graphic Log	DESCRIPTION
-9	30			9										**Sandy SILT** (ML): Gray brown, moist, firm, about 30% fine sand
			12a	9										
			12b	11	3.25									
				9										**Silty SAND** (SM): Brown, moist, fine to medium sand, about 25% fines
			13a	17										
			13b	21							25			
-14	35			10										
			14a	11										**SILT With Sand** (ML): Gray brown, moist, firm, about 15% fine sand
			14b	10	1.75									
				11										**Silty SAND** (SM): Brown, moist, fine sand, about 20% fines
			15a	14										
			15b	17	4.0									**LEAN CLAY With Sand And Gravel** (CL): Brown, moist, firm, about 10% fine to coarse sand, about 5% fine gravel
-19	40			7										
			16a	23										**Poorly Graded SAND With Silt** (SP-SM): Brown, moist, about 10% fines
			16b	28							10			
				8										**LEAN CLAY** (CL): Brown, moist, hard
			17a	18										
			17b	17	3.25									
-24	45			7										Firm
			18a	14										
			18b	14	>4.5									
				17										**SILT With Sand** (ML): Olive brown, moist, very hard, about 10% fine sand
			19a	20										
			19b	28	>4.5									
-29	50			10										
			20a	12										
			20b	14										**LEAN CLAY** (CL): Olive brown, moist, firm, about 5% fine sand
				5										**SILT With Sand** (ML): Olive brown, moist, firm, about 10% fine sand
			21a	7										
			21b	11										
-34	55			3							63			**Sandy SILT** (ML): Olive gray, moist to wet, firm, about 37% fine sand
			22a	5										
			22b	7	.25									
				8										
			23a	10	3.25									
			23b	20										
-39	60			13										Very hard
			24a	18										
			24b	25	>4.5									

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

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Date: 6/28/2007
Project No.: 72834/DNCC06
File Number: 72834-DNCC06

LOG OF BORING NCCB-6- 5

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
2 of 3
A-7

Elevation (ft., msl)	Depth (feet)	FIELD: Sample Type	FIELD: Sample No.	FIELD: Blows/6 inches	FIELD: Pocket Penetrometer (tsf)	LABORATORY: Dry Density (pcf)	LABORATORY: Moisture Content (%)	LABORATORY: Liquid Limit	LABORATORY: Plasticity Index	LABORATORY: Passing #4 Sieve (%)	LABORATORY: Passing #200 Sieve (%)	LABORATORY: Other Tests	Graphic Log	DESCRIPTION
														Silty SAND (SM): Brown, moist, fine sand, about 47% fines
-44	65			8										
			25a	12										
			25b	16							47			
														Boring completed at a depth of 66-1/2 feet below existing site grade.
-49	70													
-54	75													
-59	80													
-64	85													
-69	90													
-74	95													

P-LOG_2006 BLOWS PER 6 INCHES 72834-DNCC06.GPJ 6/28/07

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LOG OF BORING NCCB-6- 5

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THROUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
3 of 3
A-7

BORING NO.	SAMPLE DEPTH (ft)	DRY UNIT WEIGHT (pcf)	MOISTURE CONTENT (% of dry weight)	PARTICLE SIZE SIEVE SIZE (percent passing)						ATTERBERG LIMITS		OTHER TESTS
				3"	3/4"	#4	#10	#40	#200	L.L.	P.I.	
CCB-6-1	8.5								41			
NCCB-6-1	16.0								41			
NCCB-6-1	18.5					100	100	99	57			Sieve; see Plate B-3
NCCB-6-1	21.0								34			
NCCB-6-1	23.5								19			
NCCB-6-1	25.5									31	10	Atterberg; see Plate B-2
NCCB-6-1	28.5								93			
NCCB-6-1	46.0								51			
NCCB-6-1	48.5								44			
NCCB-6-1	53.5								40			
NCCB-6-1	61.0								32			
NCCB-6-1	63.5								9			
NCCB-6-1	70.5					100	99	70	11			Sieve; see Plate B-3
NCCB-6-2	11.0								61			
NCCB-6-2	16.0								42			
NCCB-6-2	21.0								51			
NCCB-6-2	26.0									46	19	Atterberg; see Plate B-2
NCCB-6-2	46.0								16			
NCCB-6-2	51.0								11			
NCCB-6-2	53.5					100	100	65	14			Sieve; see Plate B-3
NCCB-6-2	81.0								10			
NCCB-6-3	6.0								49			
CCB-6-3	11.0									46	18	Atterberg; see Plate B-2
NCCB-6-3	16.0								81			
NCCB-6-3	18.5					100	100	99	20			Sieve; see Plate B-3
NCCB-6-3	23.5								59			
NCCB-6-3	36.0								54			
NCCB-6-3	38.5								54			
NCCB-6-3	43.5								48			
NCCB-6-4	11.0									51	29	Atterberg; see Plate B-2
NCCB-6-4	31.0								55			
NCCB-6-4	33.5								25			
NCCB-6-4	38.5								44			
NCCB-6-4	41.0								61			
NCCB-6-4	46.0								21			
NCCB-6-4	48.5								44			
NCCB-6-4	56.0								84			
NCCB-6-4	58.5								54			
NCCB-6-4	61.0								53			
NCCB-6-4	81.0								27			
NCCB-6-4	91.0								30			

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SUMMARY OF LABORATORY TESTS

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THOUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 5
B-1

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2834-DNCC06.GPJ 6/4/08
KA-LAB

BORING NO.	SAMPLE DEPTH (ft)	DRY UNIT WEIGHT (pcf)	MOISTURE CONTENT (% of dry weight)	PARTICLE SIZE SIEVE SIZE (percent passing)						ATTERBERG LIMITS		OTHER TESTS
				3"	3/4"	#4	#10	#40	#200	L.L.	P.I.	
CCB-6- 5	18.5								39			
NCCB-6- 5	23.0								39			
NCCB-6- 5	26.0								32			
NCCB-6- 5	28.5								23			
NCCB-6- 5	33.5								25			
NCCB-6- 5	41.0								10			
NCCB-6- 5	55.0								63			
NCCB-6- 5	66.0								47			
NCCB-6- 6	15.5								49			
NCCB-6- 6	28.5									61	38	Atterberg; see Plate B-2
NCCB-6- 6	43.5					100	100	49	9			Sieve; see Plate B-3
NCCB-6- 6	46.0								12			
NCCB-6- 6	53.5								60			
NCCB-6- 6	56.0								47			
NCCB-6- 6	61.0					100	100	90	16			Sieve; see Plate B-3
NCCB-6- 6	66.0					100	100	93	5			Sieve; see Plate B-3
NCCB-6- 6	86.0								58			
NCCB-6- 7	12.5									55	37	Atterberg; see Plate B-2
NCCB-6- 7	33.5								49			
NCCB-6- 7	36.0								34			
NCCB-6- 7	41.0								26			
NCCB-6- 7	55.5								90			
CCB-6- 8	31.0									53	37	Atterberg; see Plate B-2
NCCB-6- 8	58.5								41			
NCCB-6- 8	61.0								21			
NCCB-6- 8	81.0								61			
NCCB-6- 8	86.0								7			
NCCB-6- 8	91.0								7			
NCCB-6- 9	11.0								26			
NCCB-6- 9	16.0									54	34	Atterberg; see Plate B-2
NCCB-6- 9	31.0								65			
NCCB-6- 9	33.5								34			
NCCB-6- 9	36.0					100	99	31	6			Sieve; see Plate B-3
NCCB-6- 9	38.5								6			
NCCB-6- 9	41.0								21			
NCCB-6- 9	46.0								4			
NCCB-6-10	15.5								13			
NCCB-6-10	18.0								44			
NCCB-6-10	23.0								21			
NCCB-6-10	30.5								12			
NCCB-6-10	41.0								26			

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SUMMARY OF LABORATORY TESTS

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THOUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
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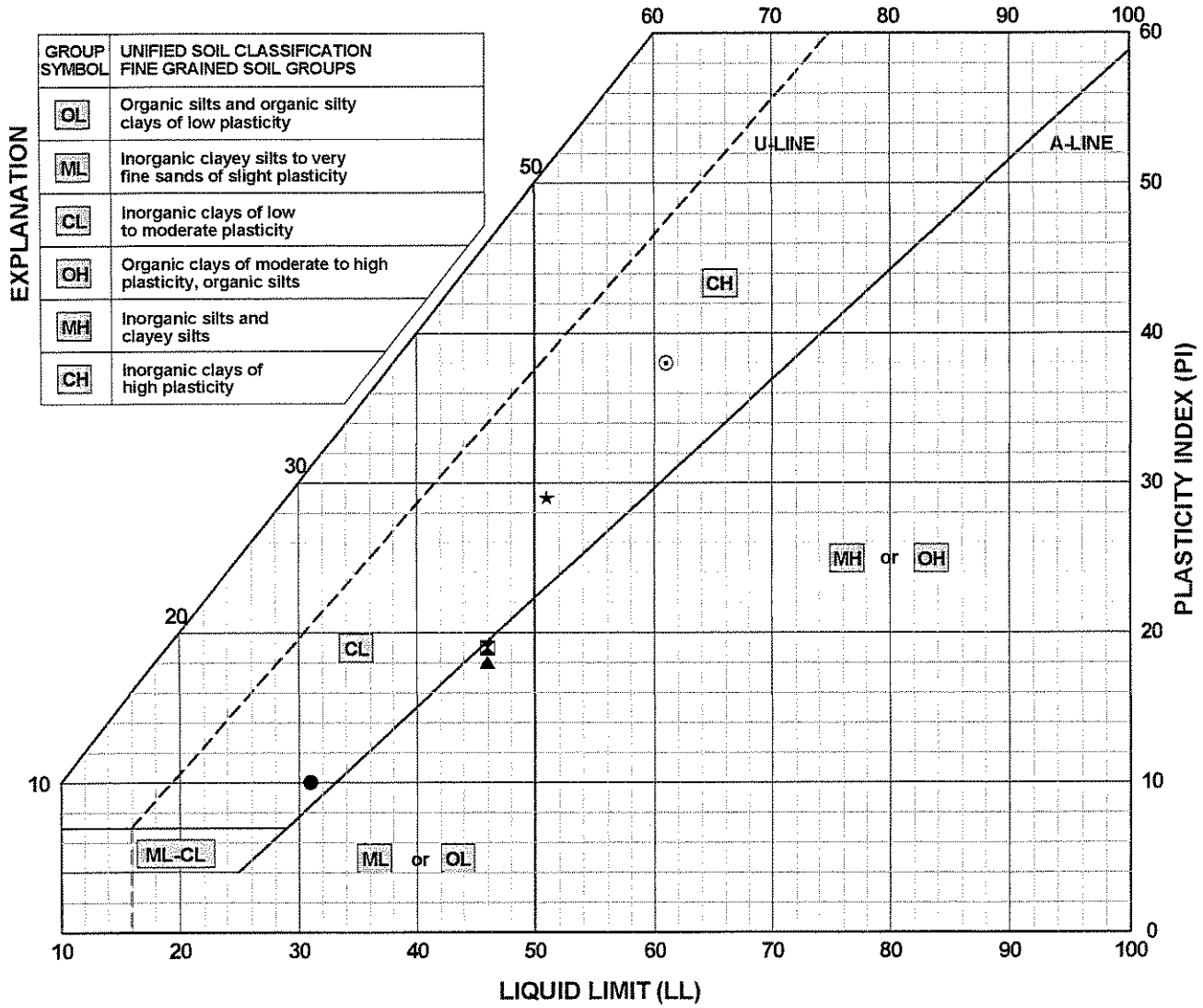

LEGEND:	SOURCE	DEPTH (ft)	LL	PL	PI	DESCRIPTION
●	NCCB-6-1	25.5	31	21	10	Lean CLAY (CL)
⊠	NCCB-6-2	26.0	46	27	19	Lean CLAY (CL)
▲	NCCB-6-3	11.0	46	28	18	Sandy CLAY (CL)
★	NCCB-6-4	11.0	51	22	29	Sandy Fat CLAY (CH)
⊙	NCCB-6-6	28.5	61	23	38	Fat CLAY (CH)

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PLASTICITY CHART

NATOMAS CROSS CANAL SOUTH LEVEE
REACHES 1 THOUGH 4
NATOMAS BASIN EVALUATION
SUTTER COUNTY, CALIFORNIA

PLATE
1 of 4
B-2

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G 72834-DNCC06.GPJ 6/4/08
KA_AT

AMERICAN RIVER WATERSHED

COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT

ATTACHMENT C – GEOTECHNICAL REPORT

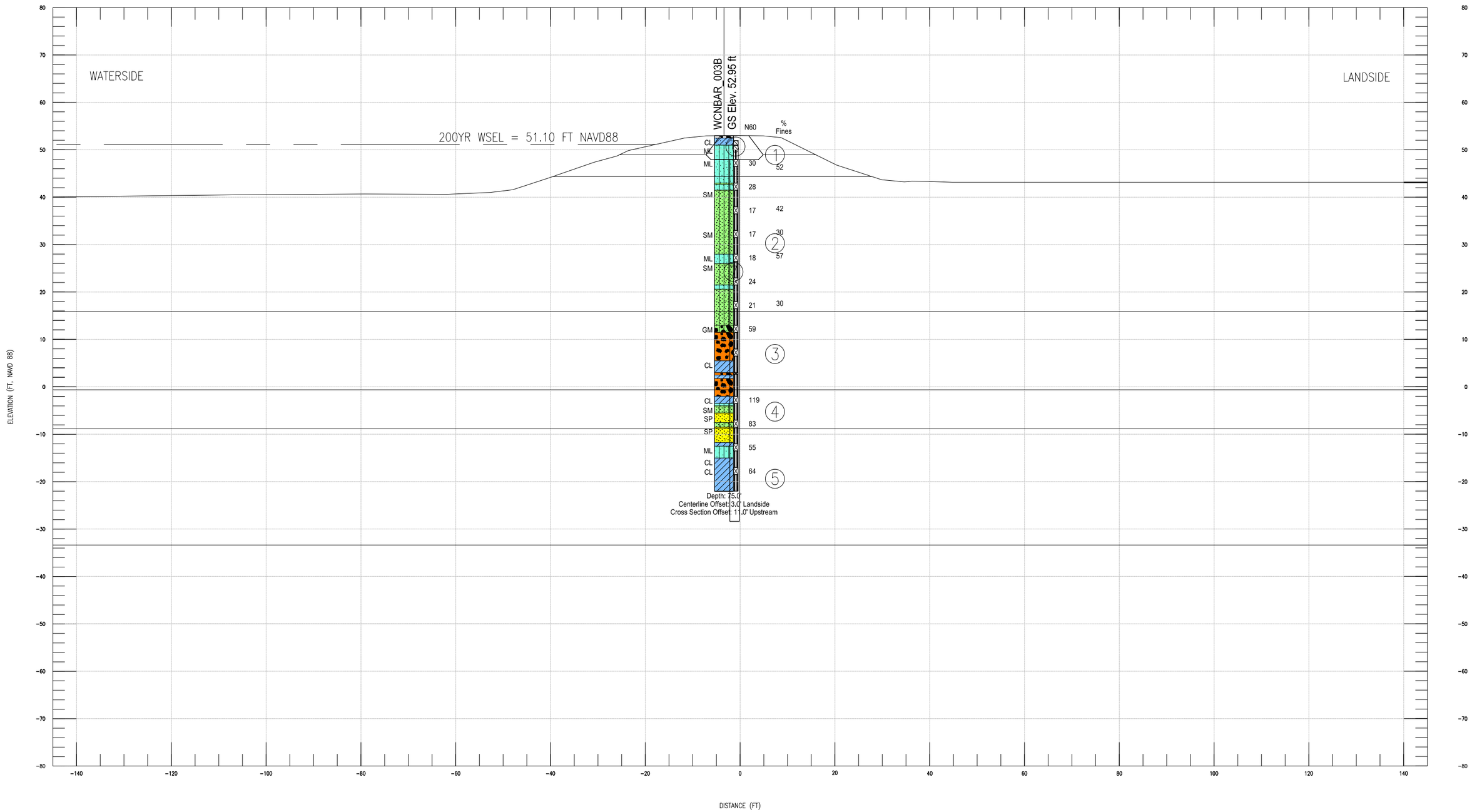
ENCLOSURE 2

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS

AMERICAN RIVER NORTH BASIN

ARN REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

DEPARTMENT OF THE ARMY
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SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 10 SCALE
ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: I2EDGAJD - May 22, 2013 - 4:10:20pm
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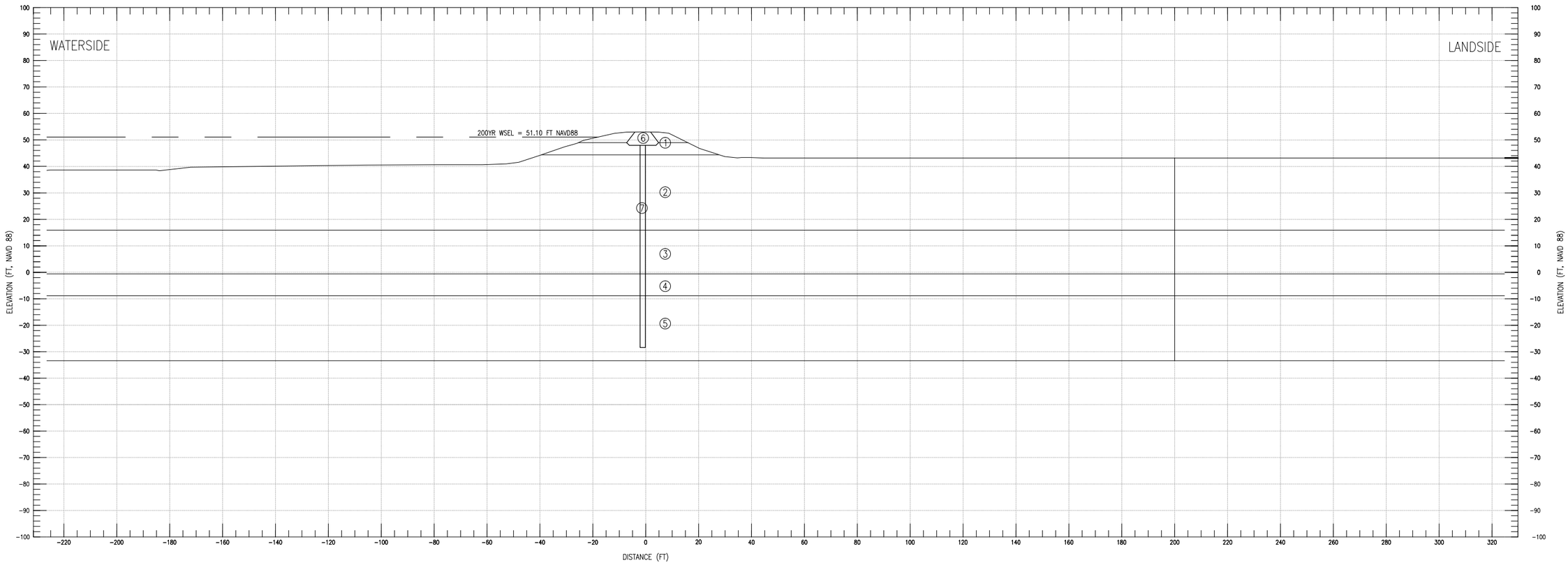

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

SECTION STRATIGRAPHY – 20 SCALE

ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: L2EDGAJD - May 22, 2013 - 4:10:25pm
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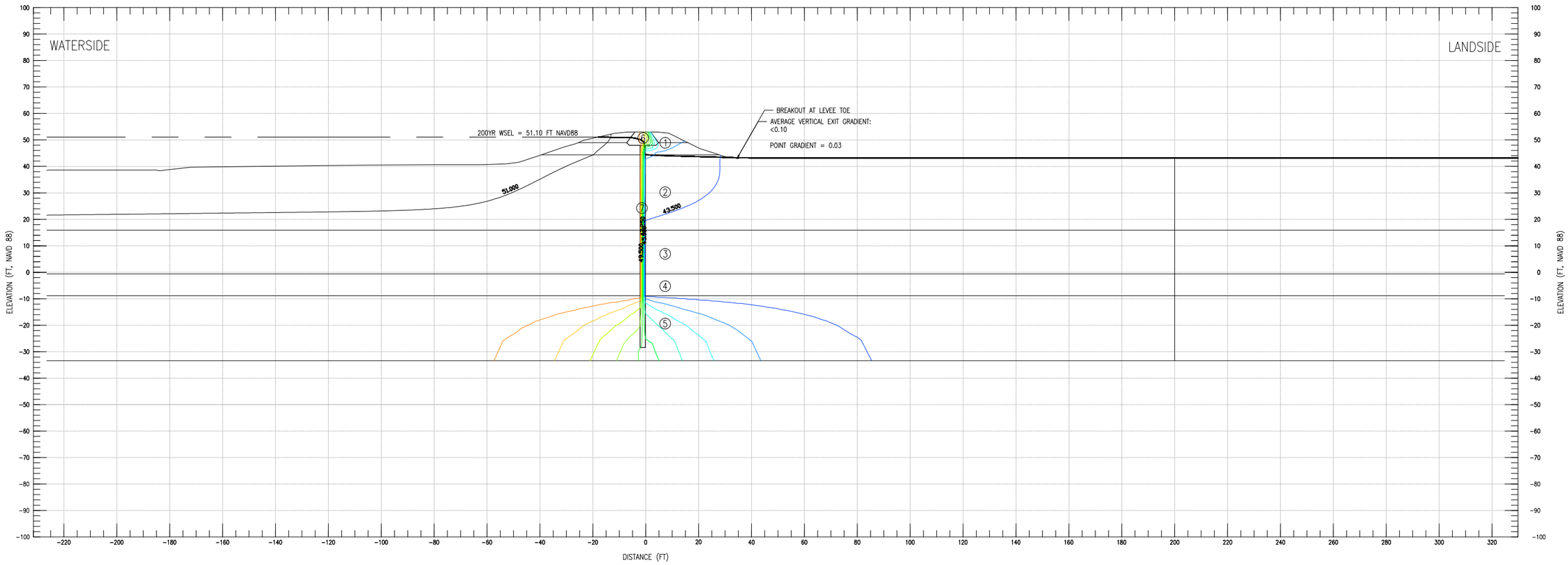

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	3

PLOT BY: L2EDGAJD - May 22, 2013 - 4:10:30pm
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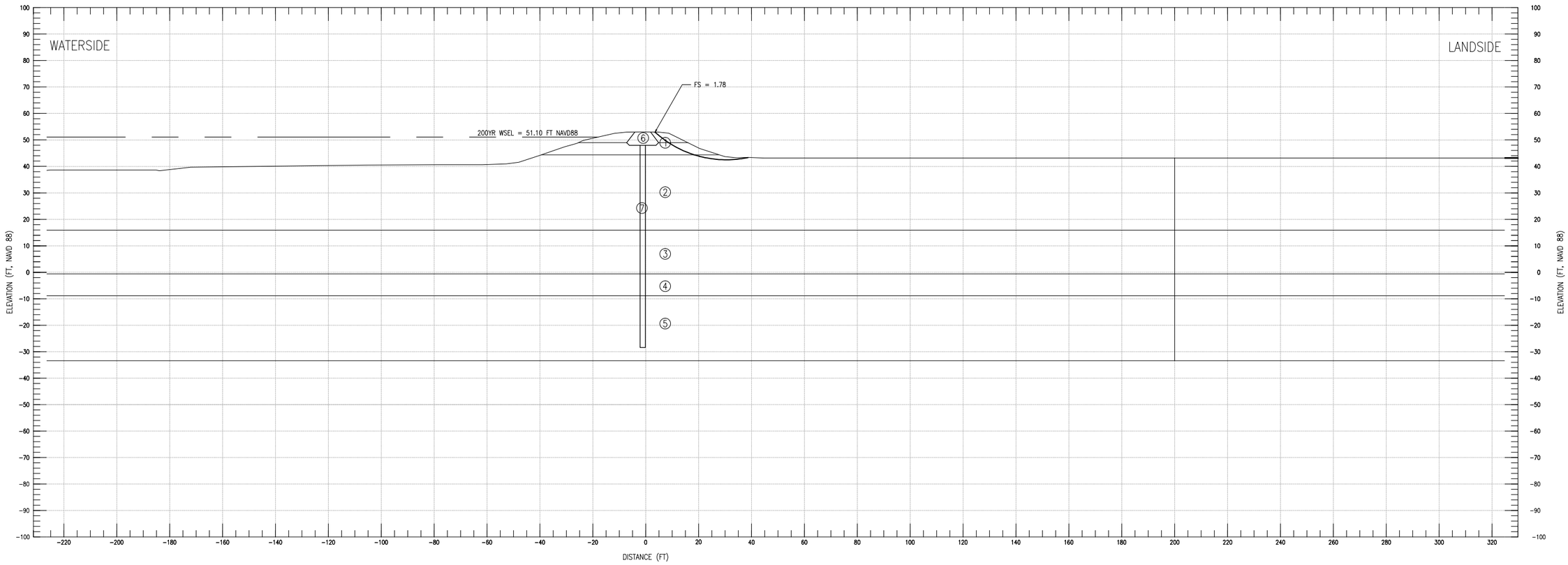

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WNCBAR_003B, 2F-97-6, DH-7, DH-7A	1	Silty Sand (SM) with Silt (ML) Levee Embankment	5.00E-04	4	1.25E-04	1.4175	0.3544	33	0	125
	2	Silty Sand (SM) with Silty (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	33	0	125
	3	Poorly Graded Gravel (GP) with Lean Clay (CL)	2.00E-01	4	5.00E-02	567.0000	141.7500	35	0	135
	4	Poorly Graded Sand with Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	5	Lean Clay (CL) with Silt (ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	6	Impervious Clay Cap (CL)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	7	Cutoff Wall	1.00E-06	4	2.50E-07	0.0028	0.0007	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARN – REACH A – AMERICAN RIVER NORTH – U9 LM 1.32

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: L2EDGAJD - May 22, 2013 - 4:10:36pm
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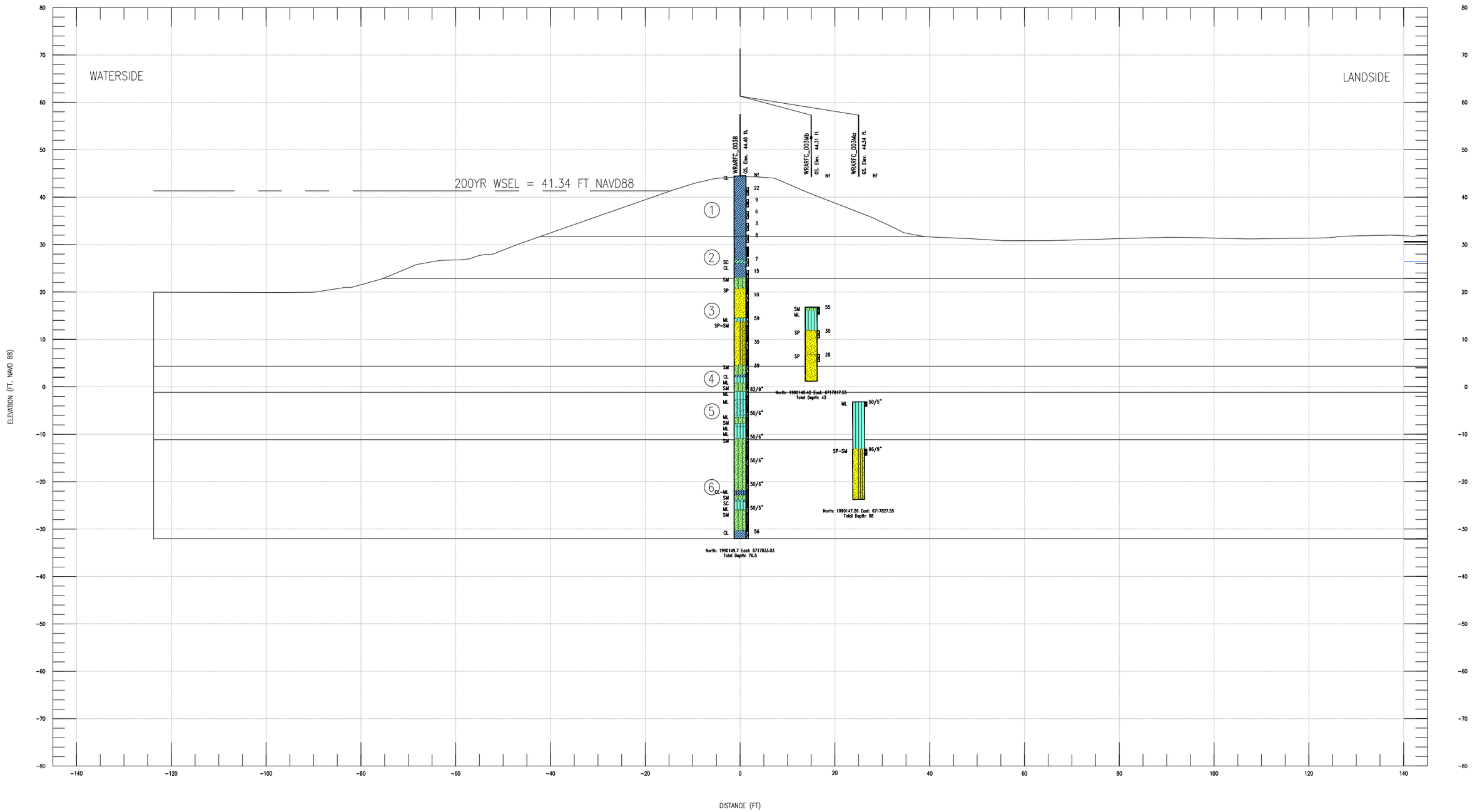
ARN REACH E – ARCADE CREEK NORTH – U7 LM 0.90

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARFC_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
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AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 10 SCALE
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: L2EDGAJD - May 22, 2013 - 4:56:12pm
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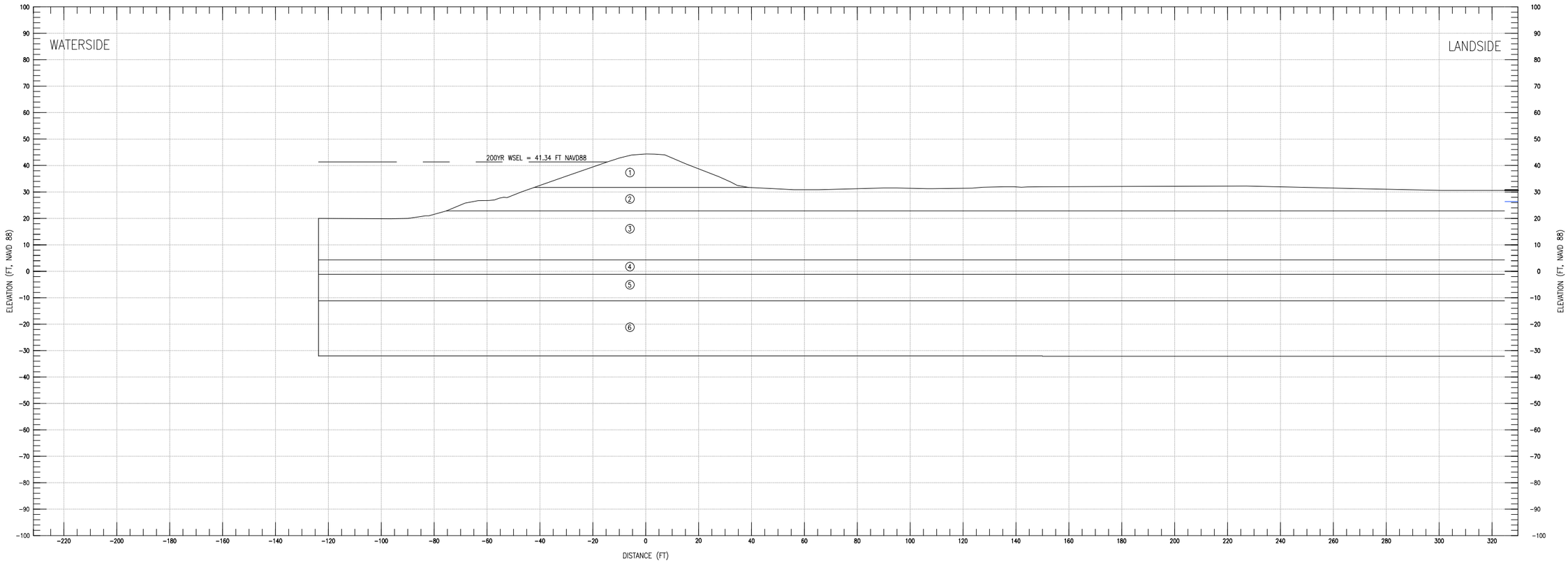

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	35	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

SECTION STRATIGRAPHY – 20 SCALE
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: I2EDGAJD - May 22, 2013 - 4:56:17pm
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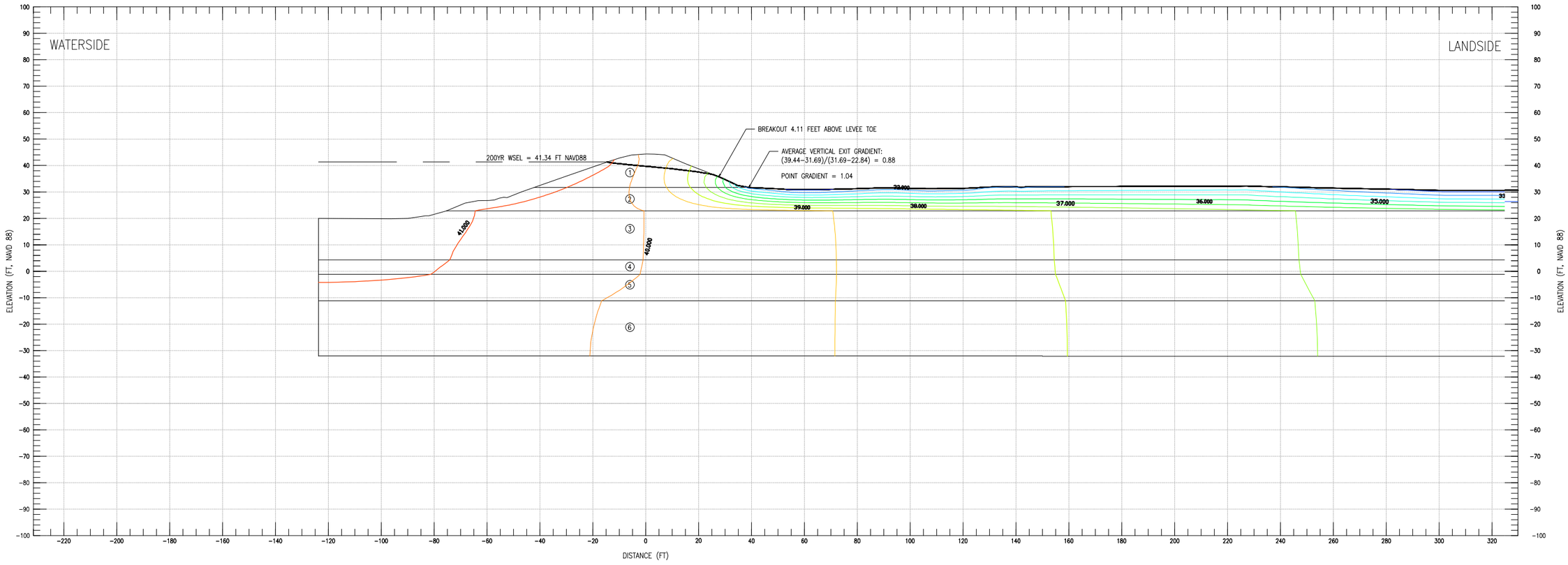

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
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	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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SACRAMENTO, CALIFORNIA

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	3

PLOT BY: I2EDGAJD - May 22, 2013 - 4:56:22pm
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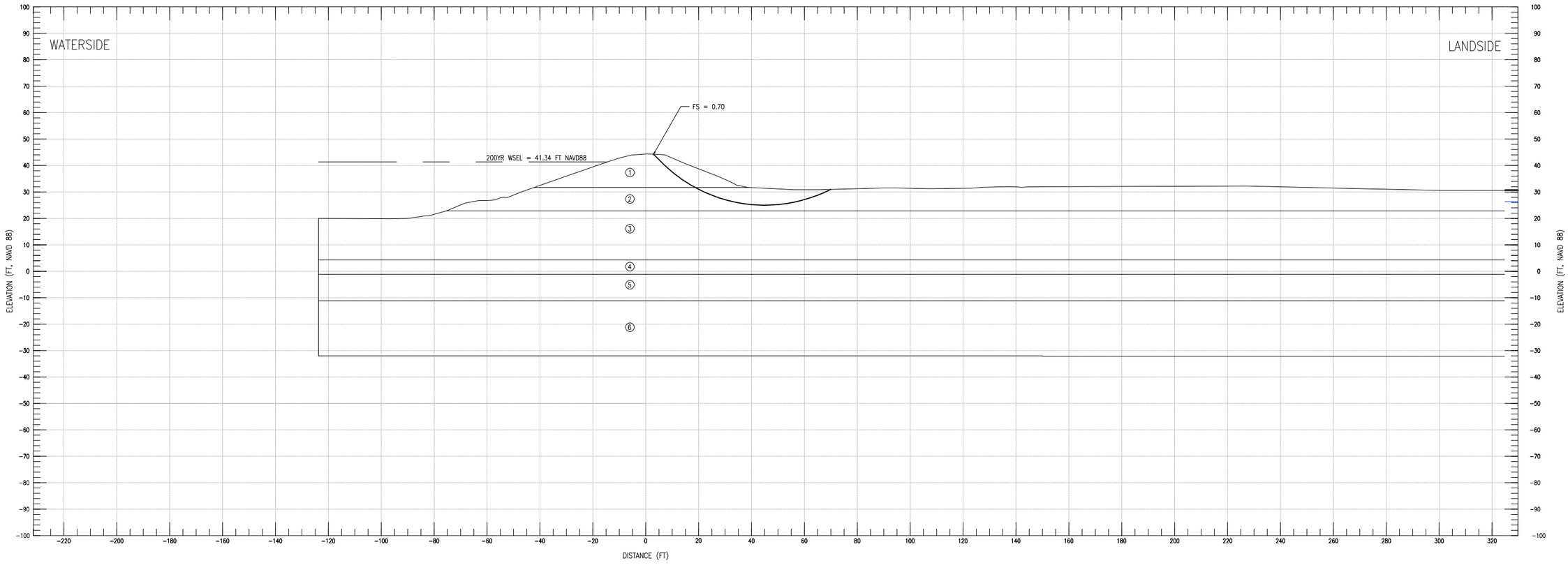

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
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0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
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SACRAMENTO, CALIFORNIA

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: LZEDGAJD - May 22, 2013 - 4:56:28pm
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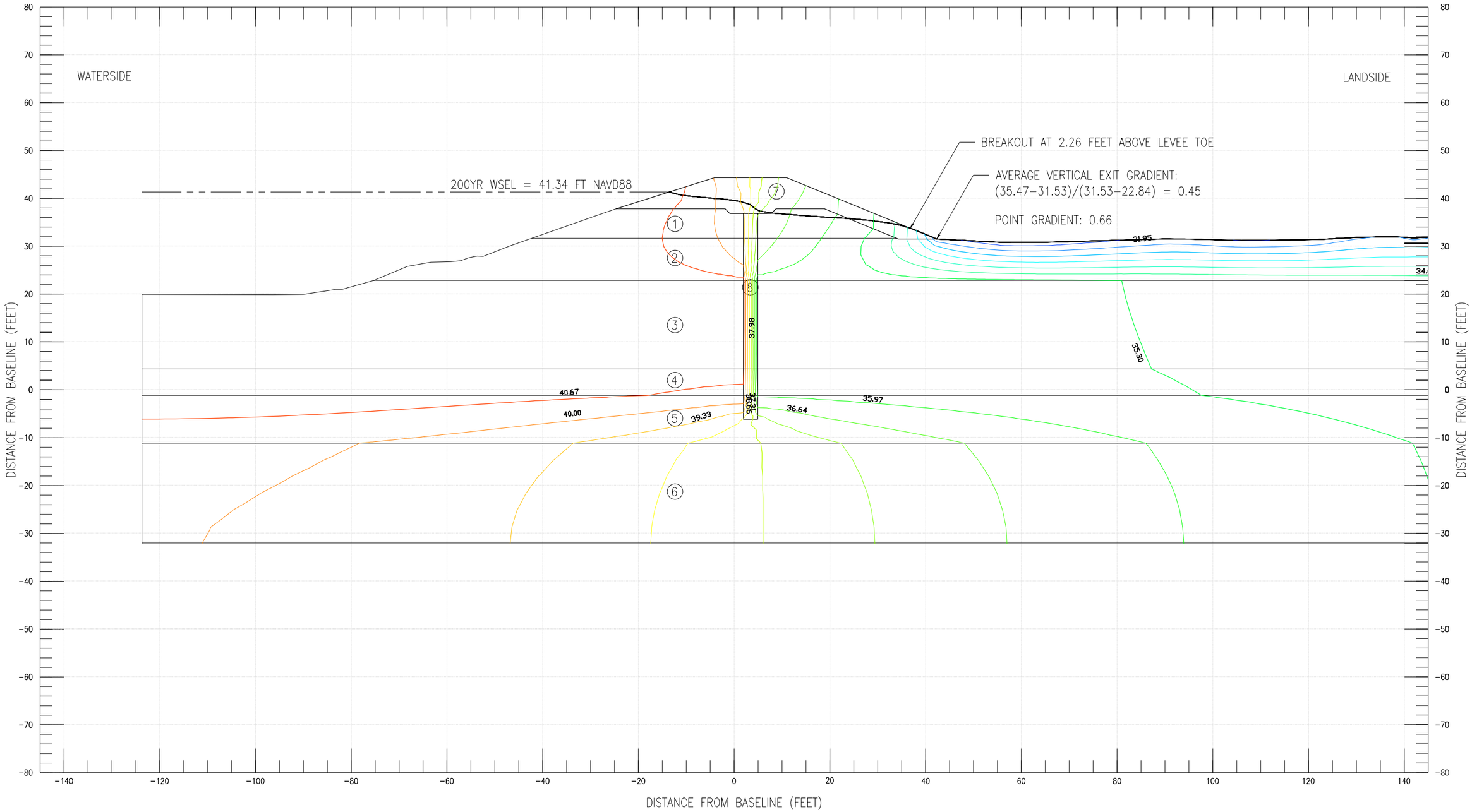

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
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WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
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	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125
	7	Engineered Fill (SC)	1.00E-05	1.00	1.00E-05	0.028	0.028	32	50	125
	8	Cutoff Wall	1.00E-05	1.00	1.00E-05	0.028	0.028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
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GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-HEAD CONTOURS-WITH PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	5

PLOT BY: L2EDGAJD - Feb 27, 2013 - 11:57:04am
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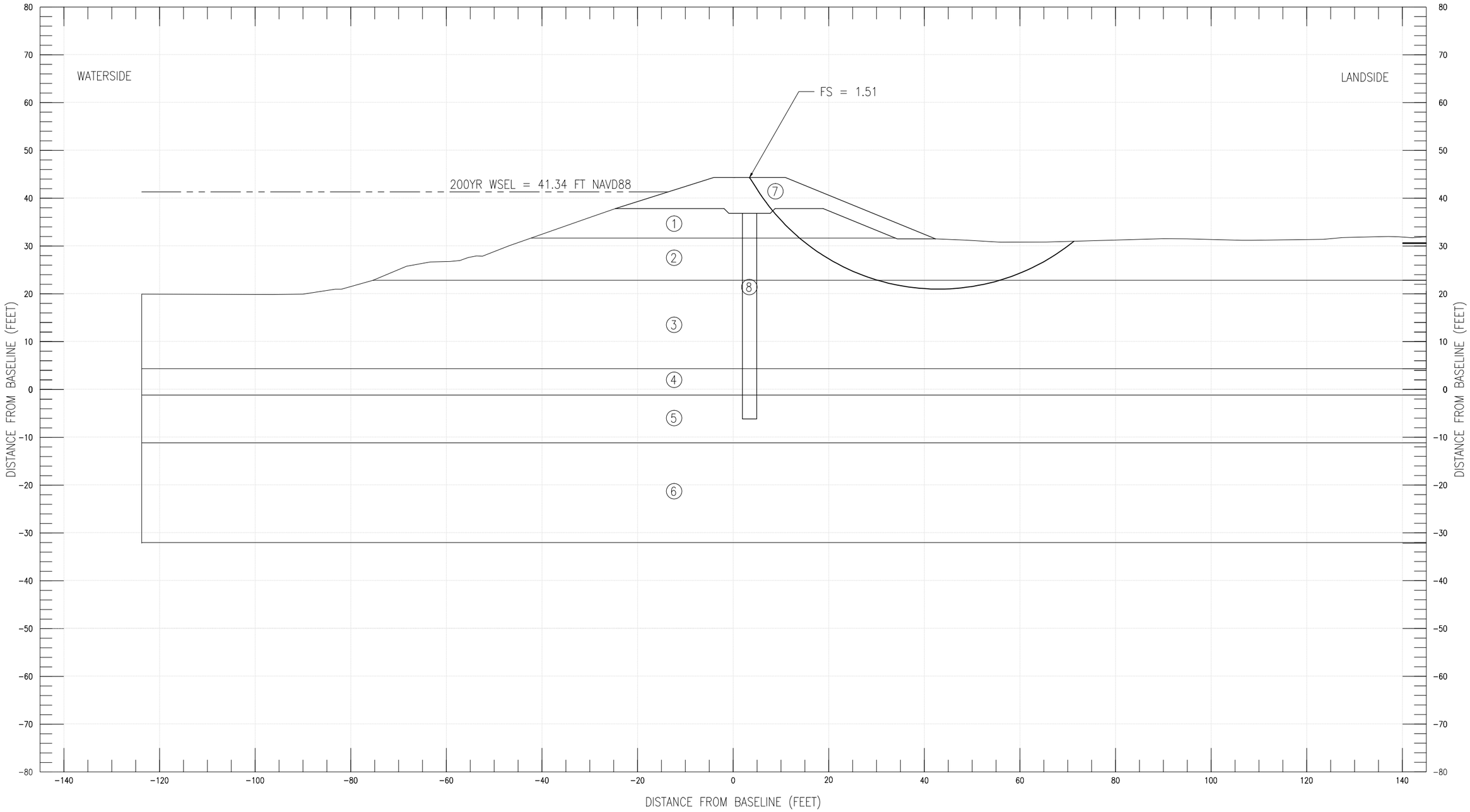

Boring Number	Layer ID	Material Type	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
WRARF C_003B	1	Sandy Lean Clay Levee	1.00E-05	4	2.50E-06	0.028	0.007	24	50	115
	2	Sandy Lean Clay Blanket	1.00E-05	1	1.00E-05	0.028	0.028	28	50	115
	3	Poorly Graded Sand	5.00E-03	4	1.25E-03	14.175	3.544	36	0	130
	4	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	33	0	125
	5	Sandy Silt	2.00E-04	4	5.00E-05	0.567	0.142	30	0	120
	6	Silty Sand	1.00E-03	4	2.50E-04	2.835	0.709	35	0	125
	7	Engineered Fill (SC)	1.00E-05	1.00	1.00E-05	0.028	0.028	32	50	125
	8	Cutoff Wall	1.00E-05	1.00	1.00E-05	0.028	0.028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

200YR WSEL-CRITICAL SHEAR SURFACE-WITH PROJECT
ARN – REACH E – ARCADE CREEK NORTH – U7 LM 0.90

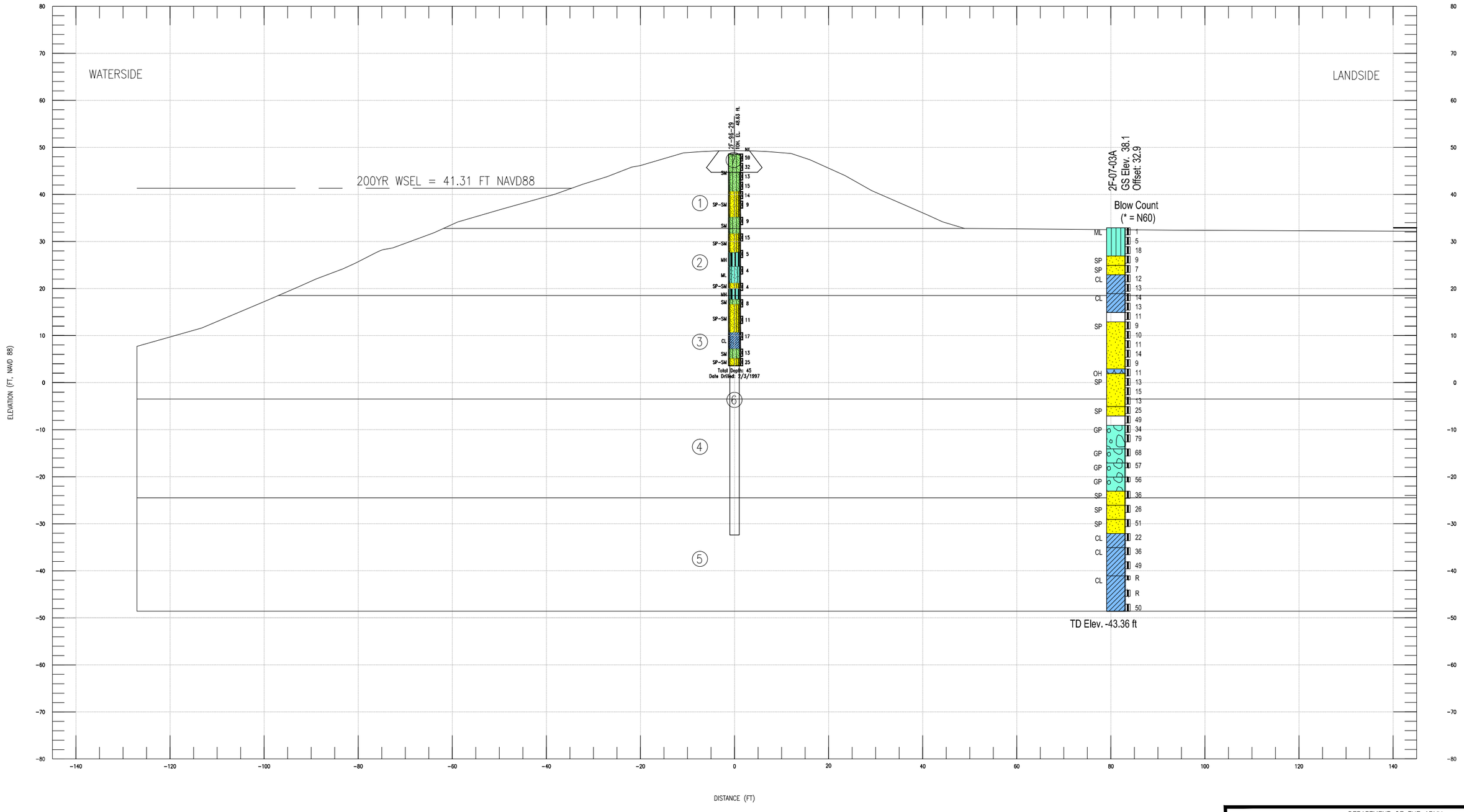
DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	6

PLOT BY: I2EDGAJD - Feb 27, 2013 - 11:57:12am
DRAWING: X:\SOIL\Sccommon features grr\4 - cf grr\15 - submittals\arcf grr geotechnical report\arcf geotechnical appendix\grr appendix plates\ACN_RE_U7_LM_0.90(F4).dwg

AMERICAN RIVER SOUTH BASIN

ARS REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29,	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
2F-00-9W,	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
2F-00-114,	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
WCSBAR_0	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
03B, 2F-99-	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
17, 2F-97-	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
23	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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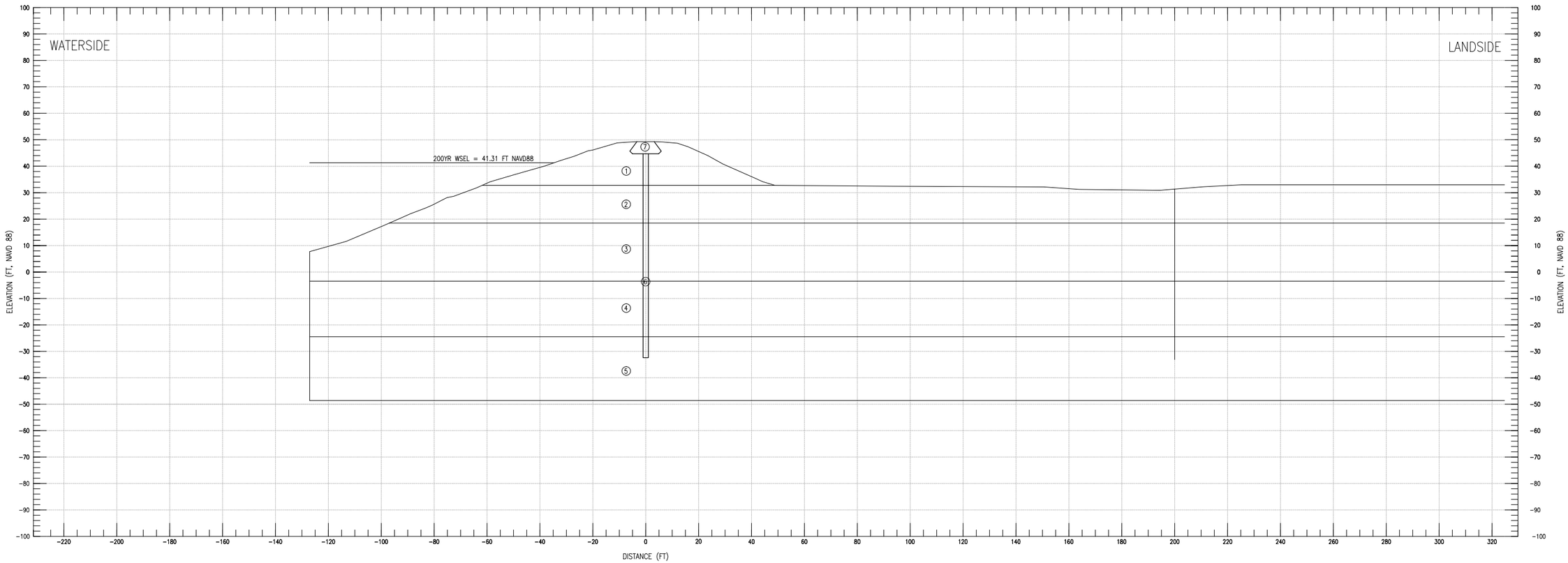
AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 10 SCALE
ARS – REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: LZEDGAJD - May 23, 2013 - 9:42:06am
DRAWING: X:\SOILS\Common Features GRR\4 - CF GRR\15 - Submittals\ARCF GRR Geotechnical Report\ARCF Geotechnical Appendix\GRR Appendix Plates\200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT.dwg



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29, 2F-00-9W, 2F-00-114, WCSBAR_0 03B, 2F-99-17, 2F-97-23	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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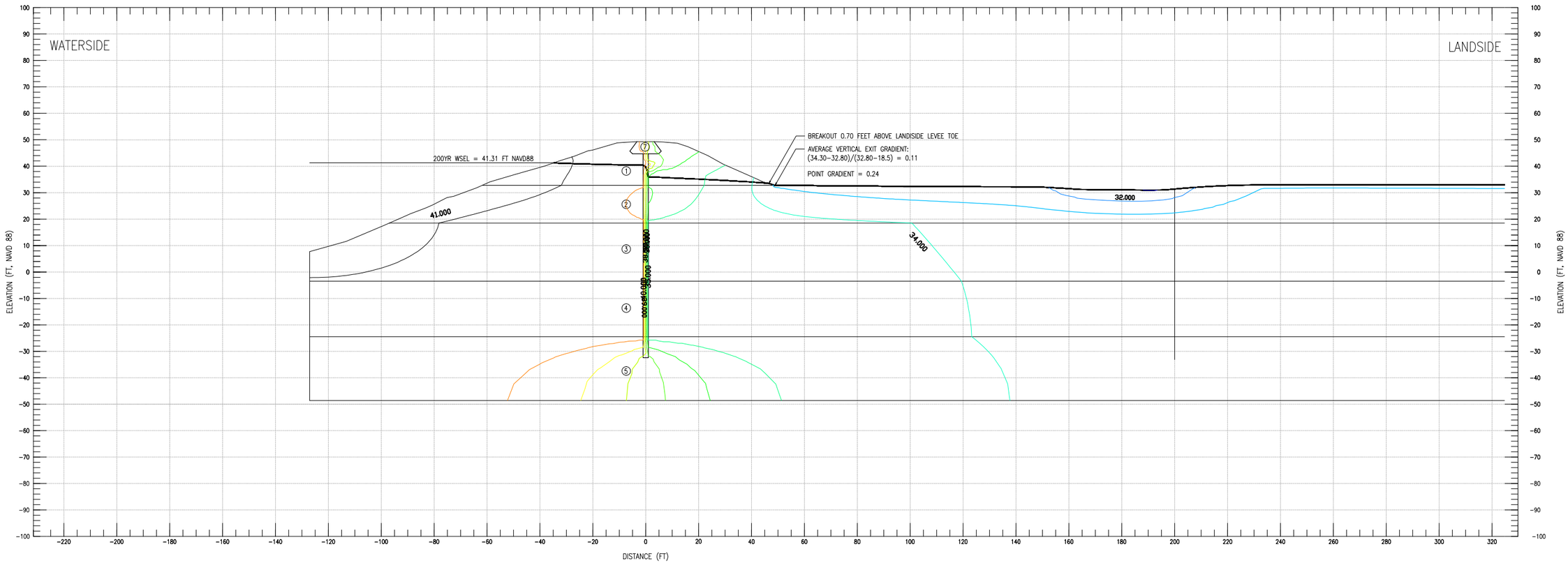
AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
SECTION STRATIGRAPHY – 20 SCALE
ARS – REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: LZEDGAJD - May 23, 2013 - 9:42:13am
DRAWING: X:\SOILS\Common Features GRR\4 - CF GRR\15 - Submittals\ARCF GRR Geotechnical Report\ARCF Geotechnical Appendix\GRR Appendix Plates\200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT.dwg



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29,	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
2F-00-9W,	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
2F-00-114,	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
WCSBAR_0	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
03B, 2F-99-	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
17, 2F-97-	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
23	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARS - REACH B - AMERICAN RIVER SOUTH - U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	

PLOT BY: L2EDGAJD - May 23, 2013 - 5:12:10pm
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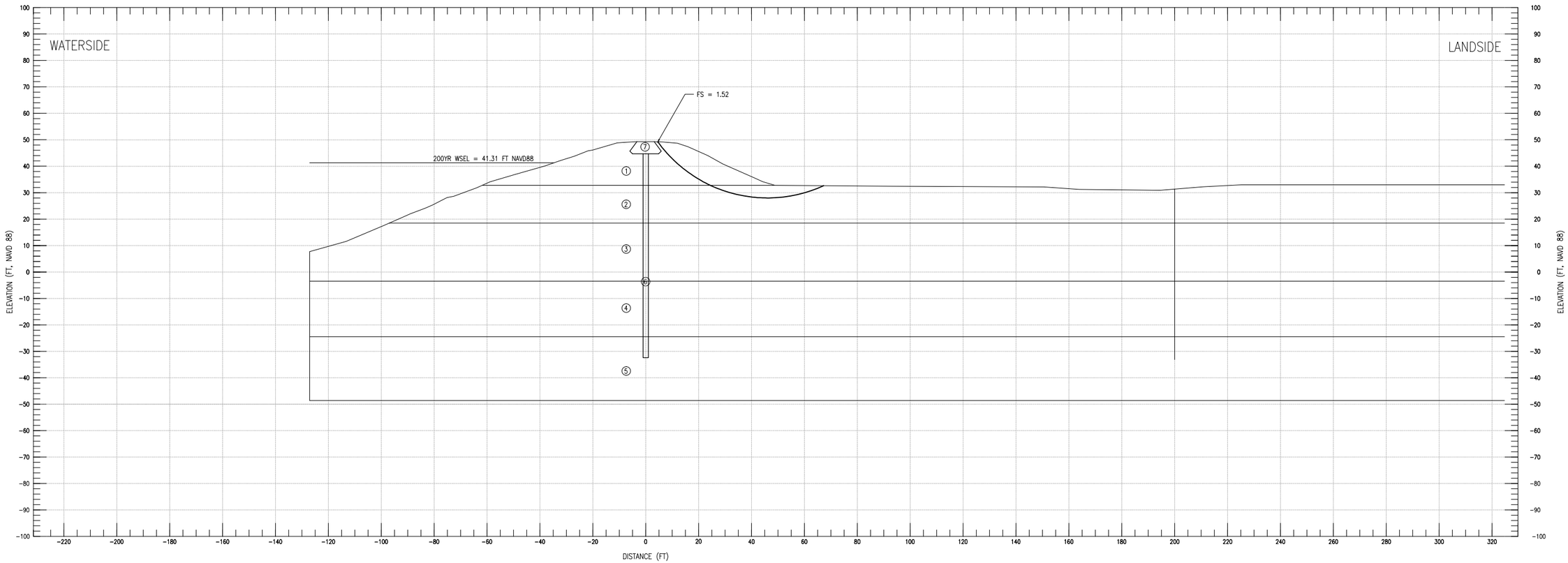

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-96-29, 2F-00-9W, 2F-00-114, WCSBAR_0 03B, 2F-99-17, 2F-97-23	1	Poorly Graded Sand to Silty Sand (SP-SM)	1.00E-03	4	2.50E-04	2.8350	0.7088	33	0	125
	2	Levee Foundation Silt (ML)	2.00E-04	4.0	5.00E-05	0.5670	0.1418	30	0	120
	3	Poorly Graded Silty Sand (SP-SM) with Clay & Silt	5.00E-03	4	1.25E-03	14.1750	3.5438	33	0	125
	4	Poorly Graded Gravel & Cobbles (GP)	1.20E-02	4	3.00E-03	34.0200	8.5050	35	0	135
	5	Silt and Clay (CL-ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	0	120
	6	Cut-off Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85
	7	Impervious Clay Cap	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARS – REACH B – AMERICAN RIVER SOUTH – U4 LM 3.90

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: LZEDGAJD - May 23, 2013 - 5:12:21pm
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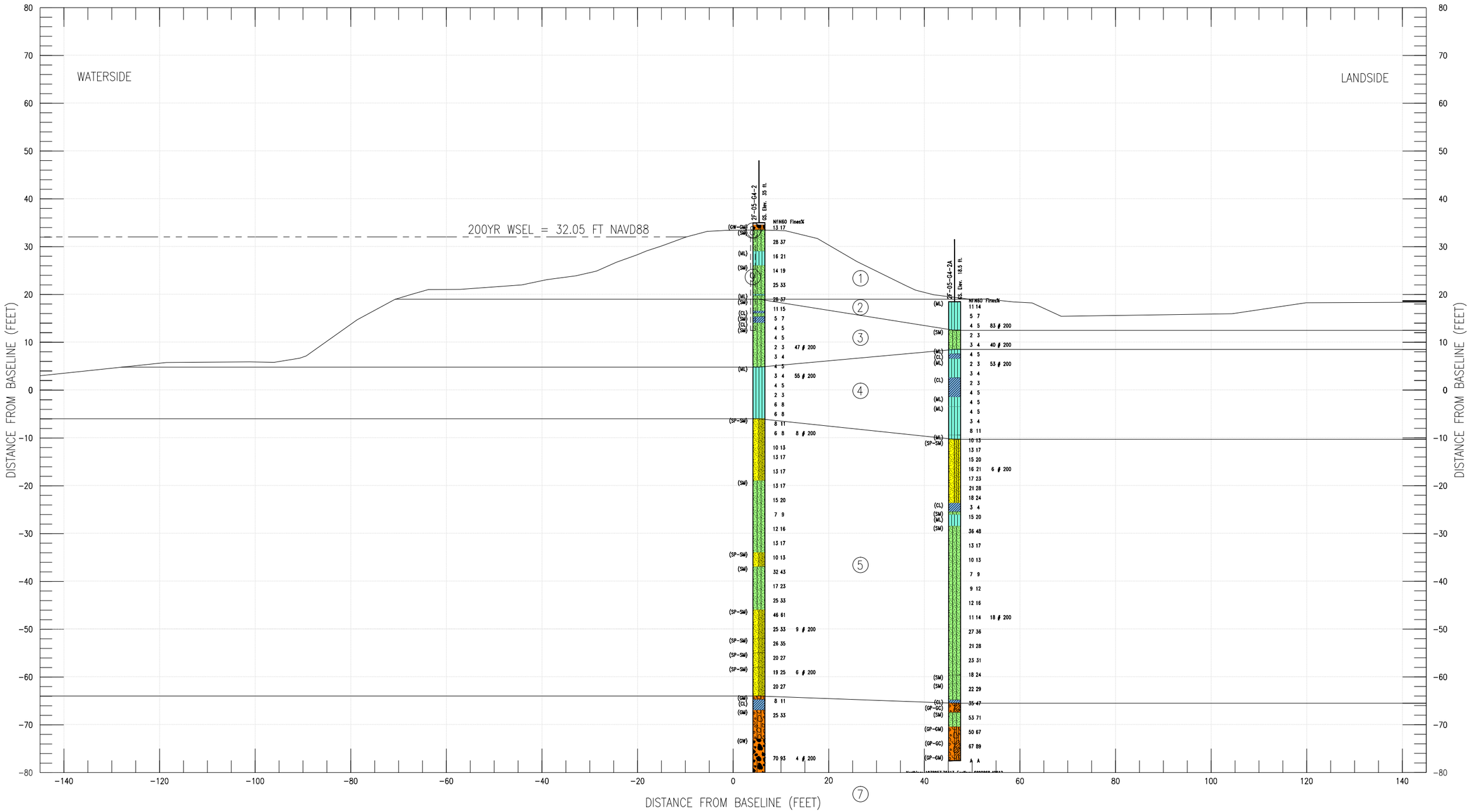
ARS REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

SECTION STRATIGRAPHY– 10 SCALE

ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: L2EDGJAD - May 23, 2013 - 5:41:29pm
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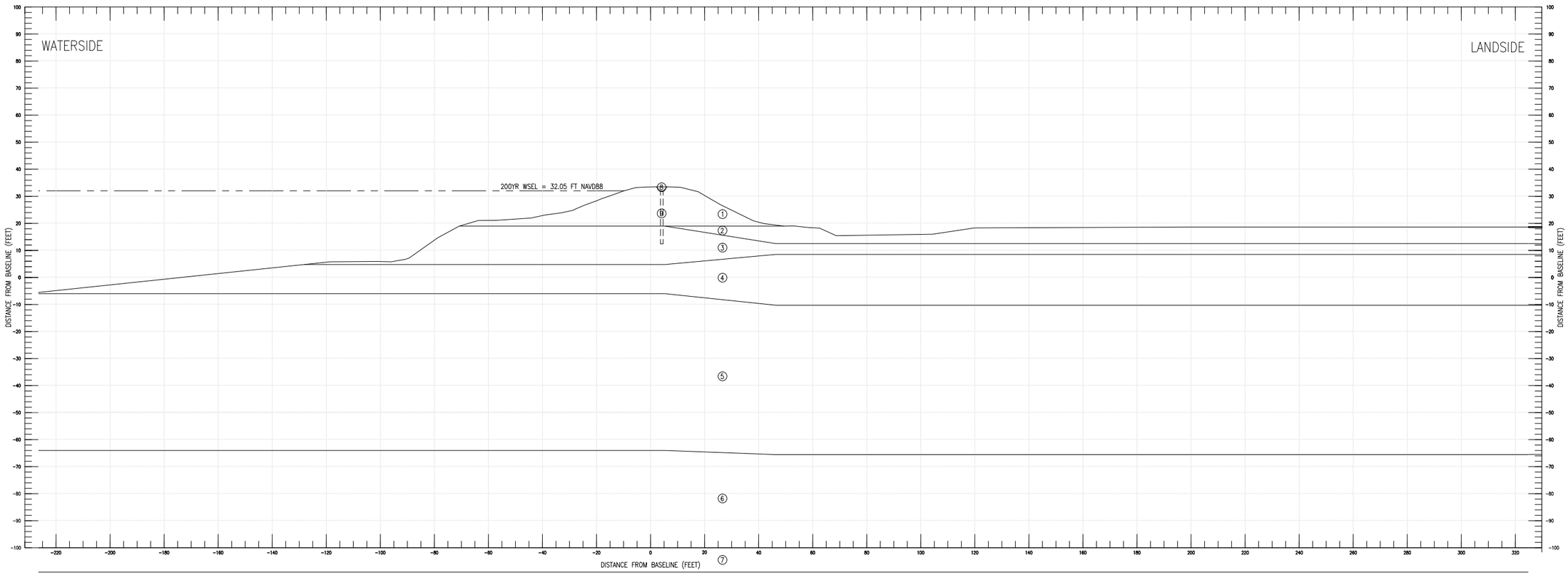

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

SECTION STRATIGRAPHY– 20 SCALE

ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	2

PLOT BY: L2EDGAJD - May 23, 2013 - 5:41:33pm
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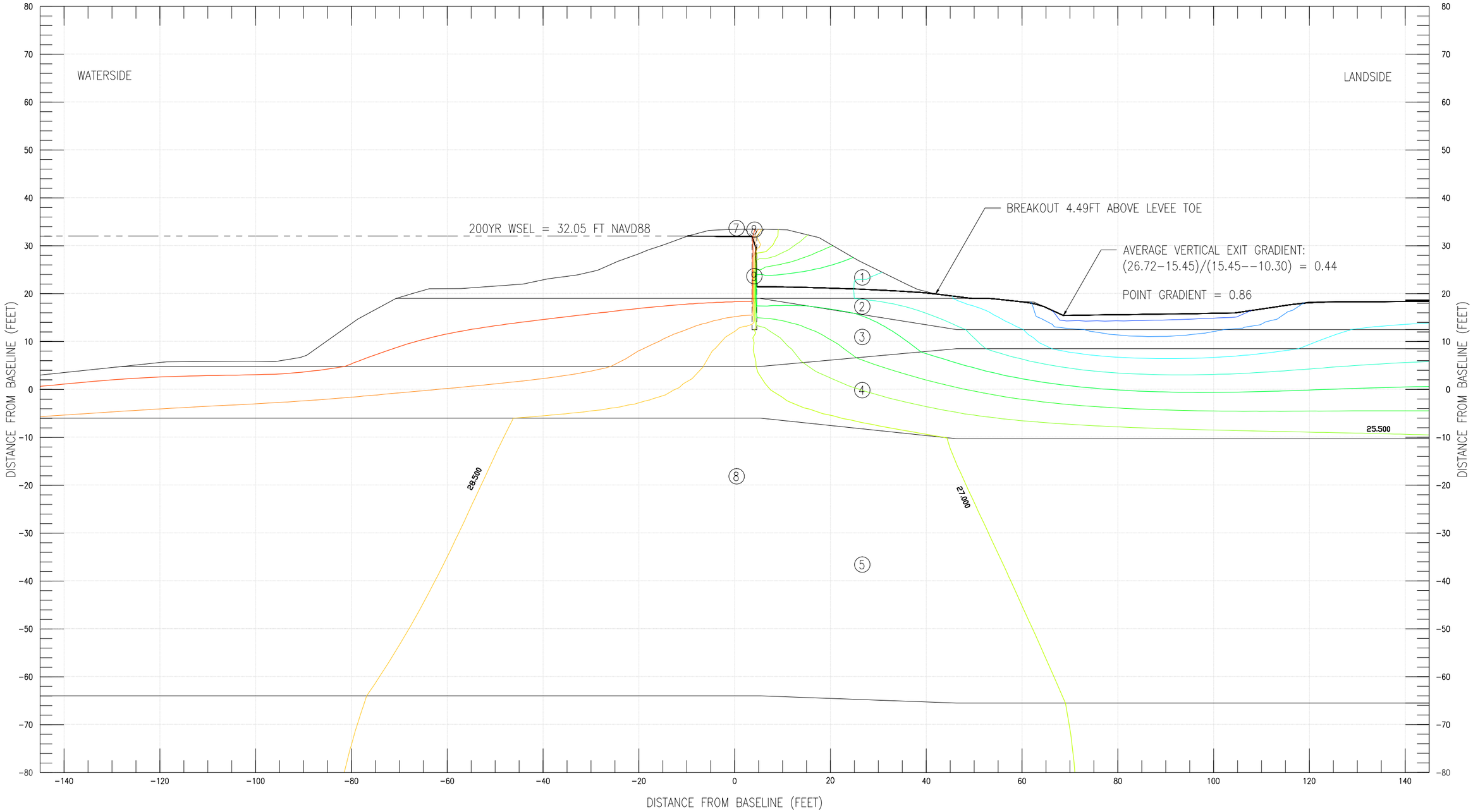

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CLw/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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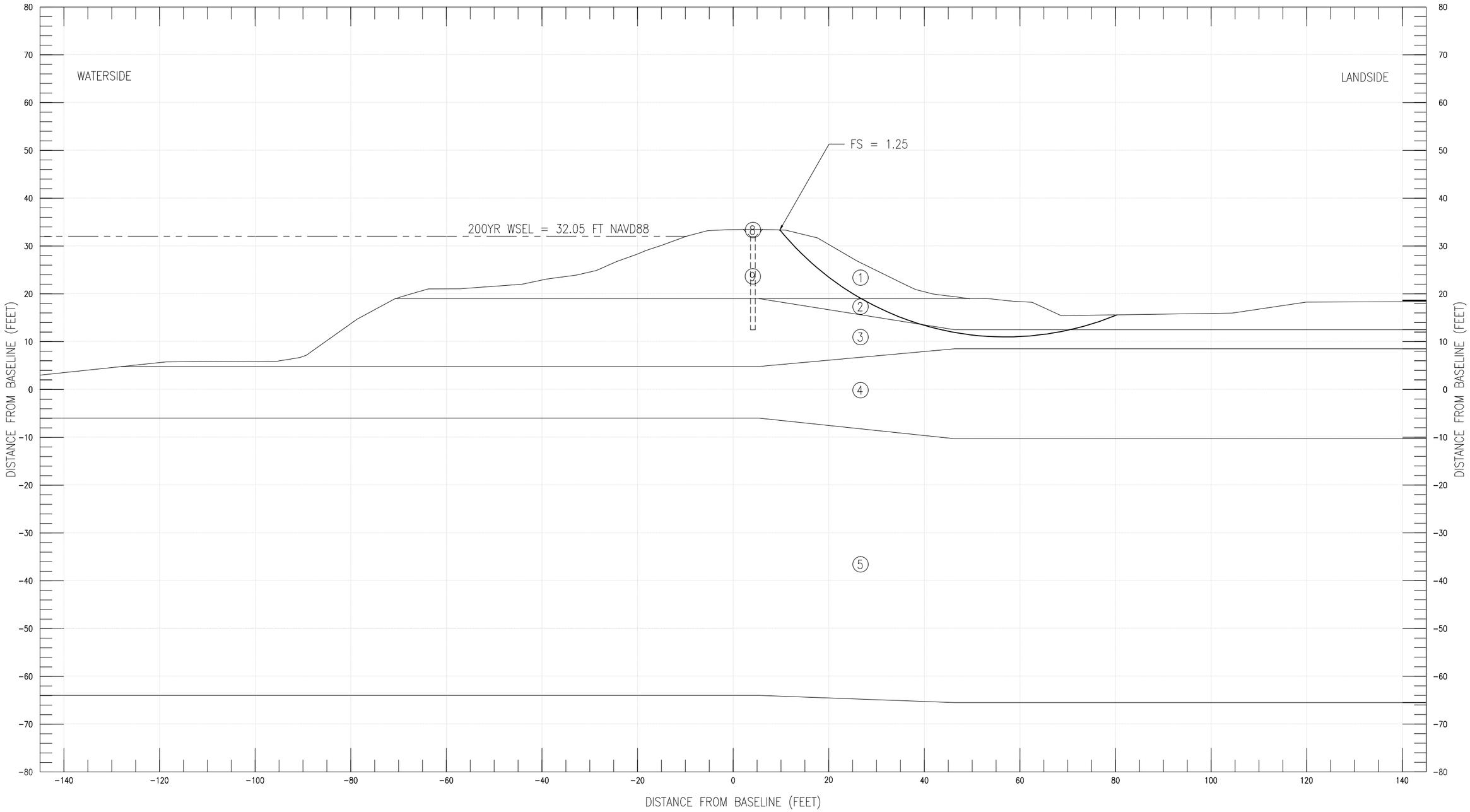
AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

200YR WSEL-HEAD CONTOURS-WITHOUT PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	3

PLOT BY: I:2EDGAJD - May 23, 2013 - 5:41:42pm
DRAWING: X:\SOILS\Common Features GRR14 - CF GRR\15 - Submittals\ARCF GRR Geotechnical Report\ARCF Geotechnical Appendix\GRR Appendix Plates\200YR WSEL-CRITICAL SHEAR SURFACE- M1.dwg



Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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SACRAMENTO CALIFORNIA

AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3
200YR WSEL-CRITICAL SHEAR SURFACE-WITHOUT PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

PLOT BY: LZEDGAJD - May 23, 2013 - 5:41:50pm
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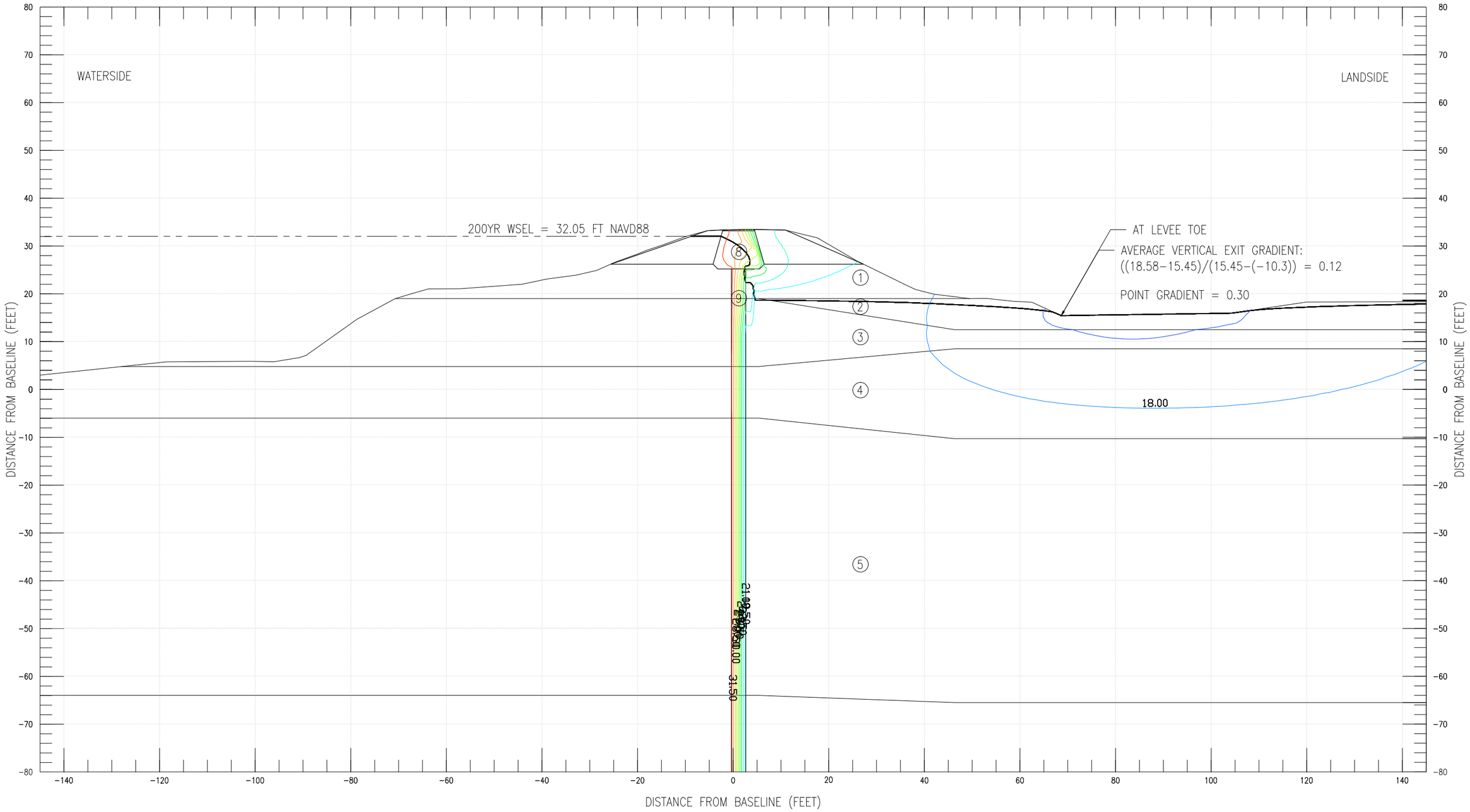

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

200YR WSEL–HEAD CONTOURS– WITH PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	5

PLOT BY: I2EDGAJD - May 23, 2013 - 5:41:59pm
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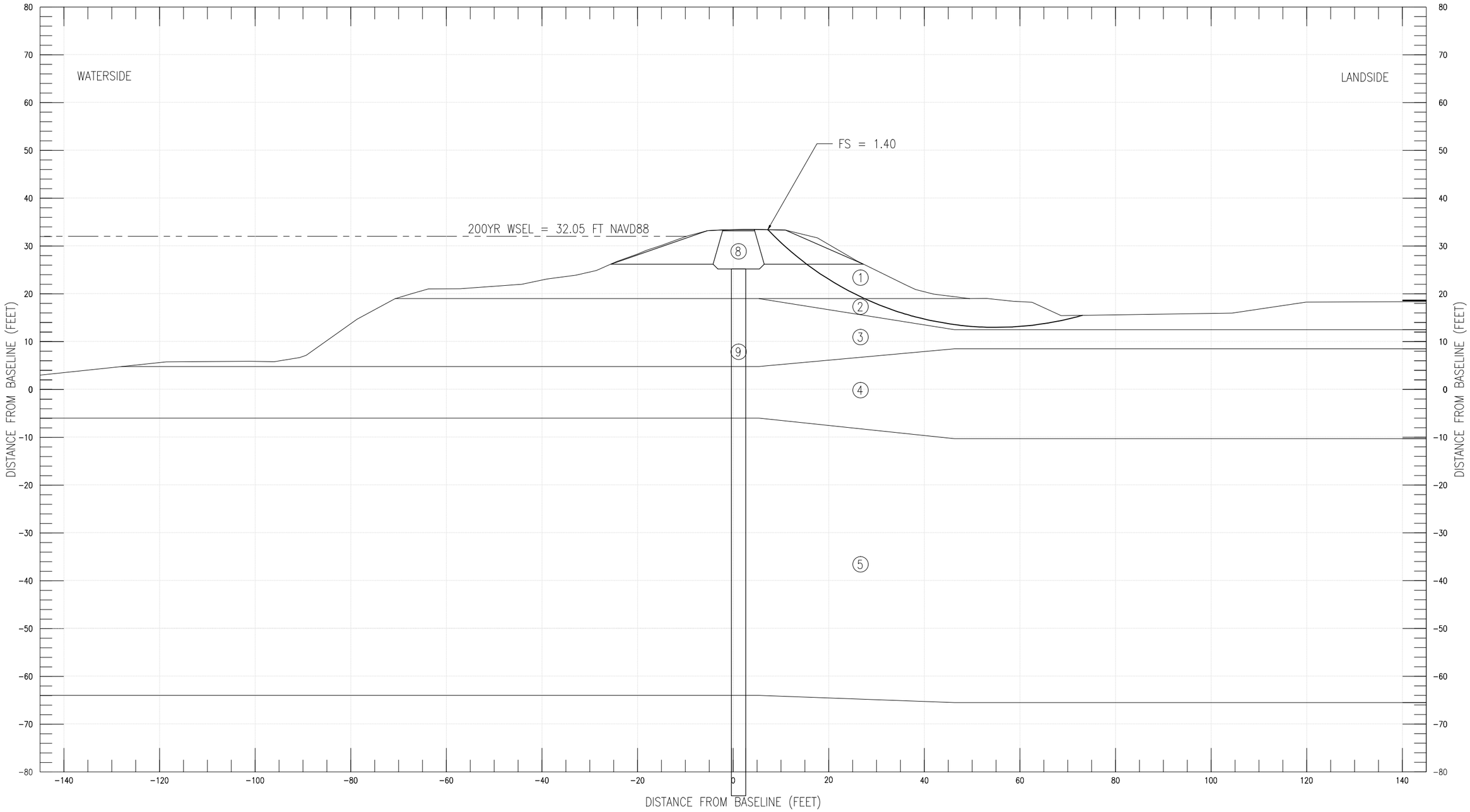

Boring Number	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal kh (kx) cm/sec	Anisotropy Ratio kh/kv	Vertical kv (ky) cm/sec	Horizontal kh (kx) ft/day	Vertical kv (ky) ft/day	Φ'	C' (psf)	γ (pcf)
2F-05-G4-2, 2F-05-G4-2A	1	Silty Sand (SM) with Silty (ML) and Poorly Graded Sand (SP) Levee Embankment	1.00E-02	4	2.50E-03	28.3500	7.0875	34	0	125
	2	Silt Blanket (ML)	2.00E-04	4	5.00E-05	0.5670	0.1418	28	0	120
	3	Silty Sand (SM)	5.00E-04	4	1.25E-04	1.4175	0.3544	30	0	125
	4	Silt (ML) and Lean Clay (CL)	2.00E-04	4	5.00E-05	0.5670	0.1418	30	50	120
	5	Silty Sand (SM), Poorly Graded Sand (SP)	5.00E-03	4	1.25E-03	14.1750	3.5438	30	0	125
	6	Poorly Graded Gravel (GP) Poorly Graded Sand (SP)	2.50E-02	10	2.50E-03	70.8750	7.0875	35	0	135
	7	Lean Clay with Silt (CL w/ ML)	1.00E-05	4	2.50E-06	0.0284	0.0071	28	50	115
	8	Impervious Clay Cap (CL)	1.00E-05	1	1.00E-05	0.0284	0.0284	28	50	115
	9	Cutoff Wall	1.00E-06	1	1.00E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ENCLOSURE - F3

200YR WSEL–CRITICAL SHEAR SURFACE– WITH PROJECT
ARS – REACH F – SACRAMENTO RIVER EAST – U1 LM 5.92

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	6

PLOT BY: LZEDGAJD - May 23, 2013 - 5:42:08pm
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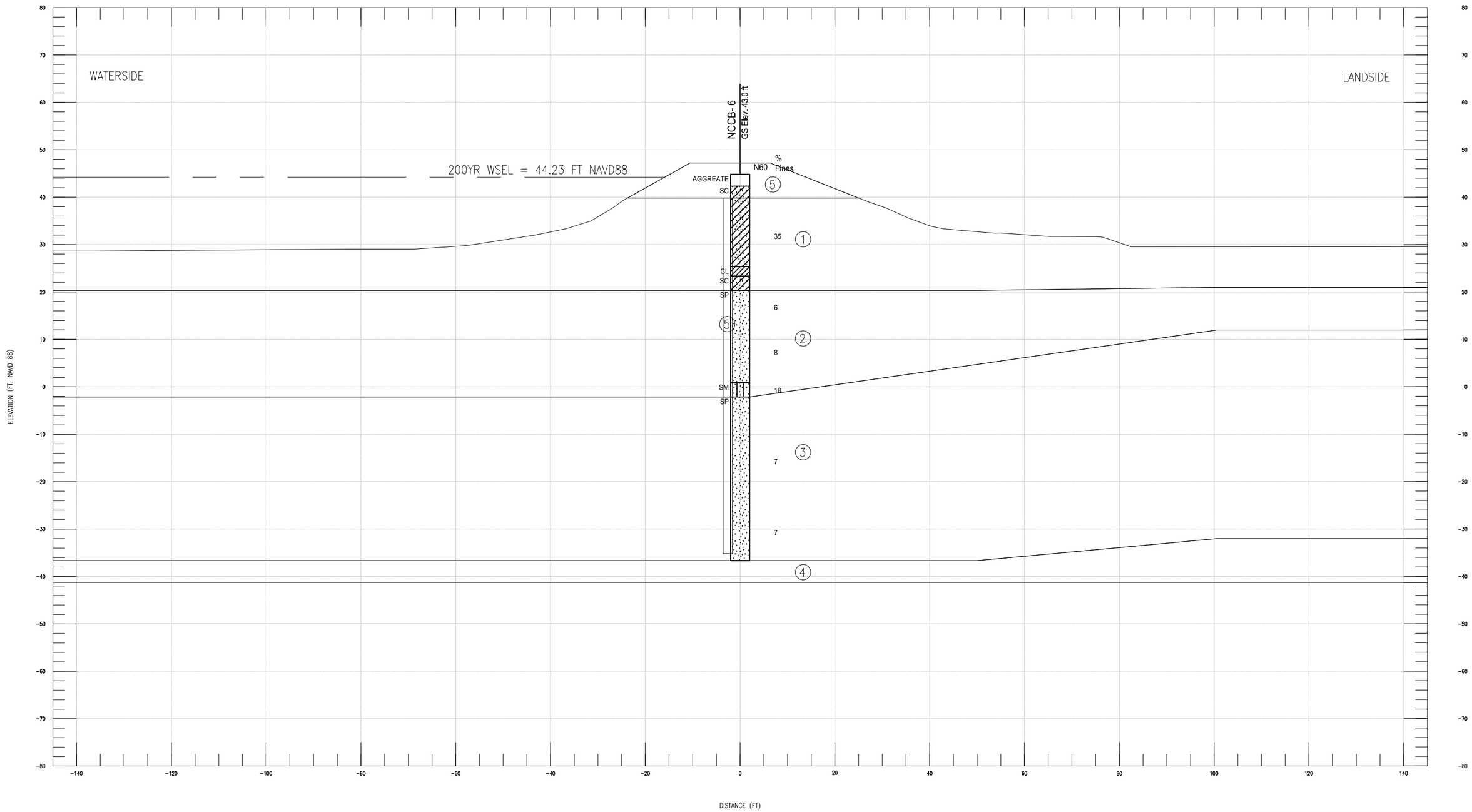
NATOMAS BASIN

NAT REACH D – NCC SOUTH – U1 LM 1.17

STEADY STATE SEEPAGE AND LANDSIDE SLOPE STABILITY ANALYSES RESULTS



Natomas Cross Canal Sta. 956+00 LM 1.17										
Boring	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	4.0E-05	4	1.0E-05	0.113	0.028	28	50	120
	2	Poorly Graded Sand w/ silt (SP-SM)	1.0E-03	10	1.0E-04	2.835	0.284	33	0	130
	3	Poorly Graded Sand (SP)	5.0E-03	10	5.0E-04	14.175	1.418	34	0	135
	4	Sandy Fat Clay (CH)	1.0E-05	10	1.0E-06	0.028	0.003	30	50	110
	5	Clay Cap	1.0E-06	4	2.5E-07	0.0028	0.0007	28	50	115
	6	Cutoff Wall	1.0E-06	1	1.0E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

NAT REACH D UNIT 1 LM 1.17–SECTION STRATIGRAPHY–10 SCALE
NATOMAS BASIN

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	1

PLOT BY: L2EDGAJD - Jan 31, 2013 - 4:12:56pm
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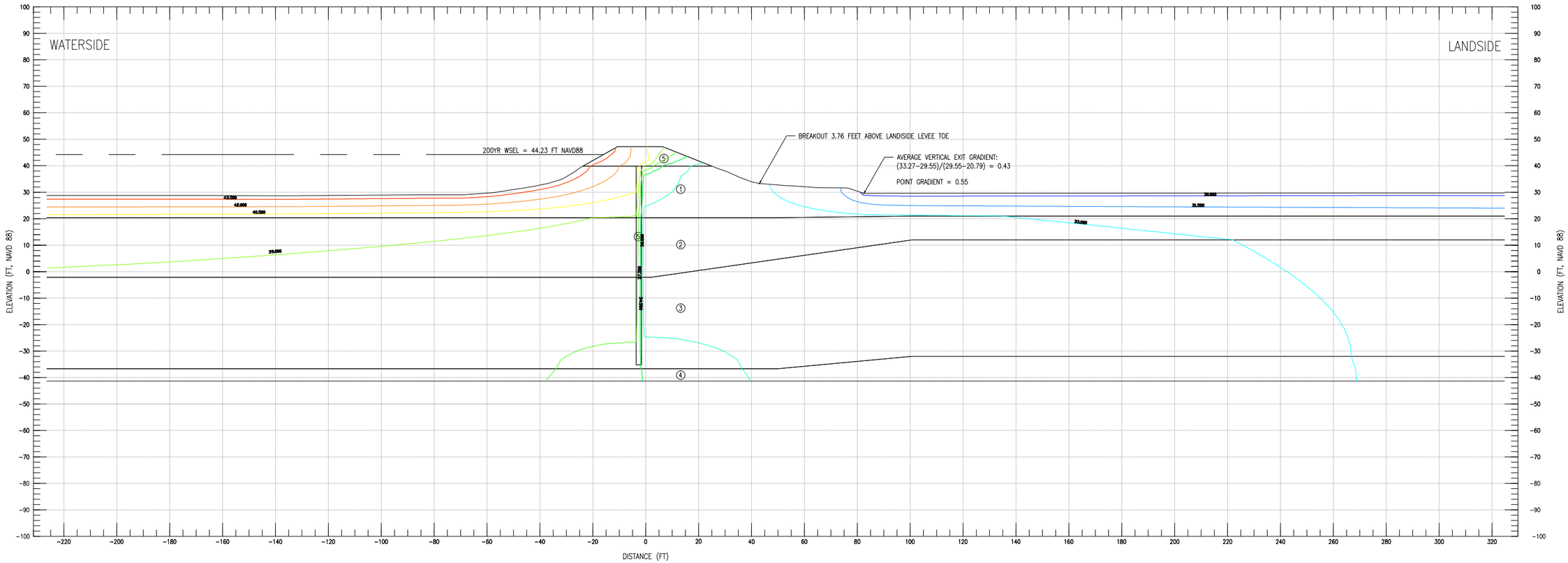

Natomas Cross Canal Sta. 956+00 LM 1.17										
Boring	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	4.0E-05	4	1.0E-05	0.113	0.028	28	50	120
	2	Poorly Graded Sand w/ silt (SP-SM)	1.0E-03	10	1.0E-04	2.835	0.284	33	0	130
	3	Poorly Graded Sand (SP)	5.0E-03	10	5.0E-04	14.175	1.418	34	0	135
	4	Sandy Fat Clay (CH)	1.0E-05	10	1.0E-06	0.028	0.003	30	50	110
	5	Clay Cap	1.0E-06	4	2.5E-07	0.0028	0.0007	28	50	115
	6	Cutoff Wall	1.0E-06	1	1.0E-06	0.0028	0.0028	0	50	85

0 20' 40'
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AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
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GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT

NAT REACH D UNIT 1 LM 1.17-200YR WSEL-HEAD CONTOURS
NATOMAS BASIN

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	

PLOT BY: L2EDGAJD - Jan 31, 2013 - 4:13:00pm
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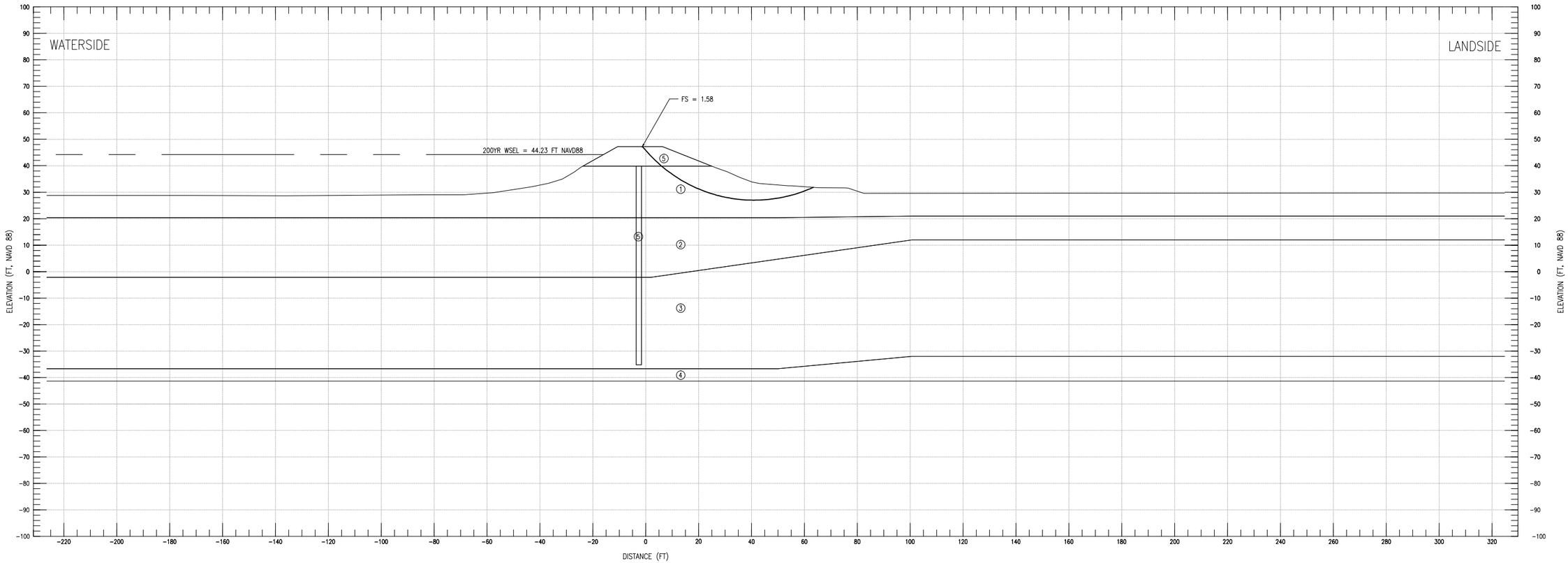

Natomas Cross Canal Sta. 956+00 LM 1.17										
Boring	Layer ID	USCS Soil Classification	Estimated Permeability for Seepage Analysis					Estimated Strength Parameters		
			Horizontal k_h (k_x) cm/sec	k_h/k_v	Vertical k_v (k_y) cm/sec	Horizontal k_h (k_x) ft/day	Vertical k_v (k_y) ft/day	Φ	C	γ
NCCB-6, NCCB-6-49	1	Clayey Sand (SC)	4.0E-05	4	1.0E-05	0.113	0.028	28	50	120
	2	Poorly Graded Sand w/ silt (SP-SM)	1.0E-03	10	1.0E-04	2.835	0.284	33	0	130
	3	Poorly Graded Sand (SP)	5.0E-03	10	5.0E-04	14.175	1.418	34	0	135
	4	Sandy Fat Clay (CH)	1.0E-05	10	1.0E-06	0.028	0.003	30	50	110
	5	Clay Cap	1.0E-06	4	2.5E-07	0.0028	0.0007	28	50	115
	6	Cutoff Wall	1.0E-06	1	1.0E-06	0.0028	0.0028	0	50	85

0 20' 40'
HORIZONTAL SCALE: 1"=20'
AT ORIGINAL D-SIZE DRAWING

0 20' 40'
VERTICAL SCALE: 1"=20'
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AMERICAN RIVER WATERSHED - COMMON FEATURES
GENERAL REEVALUATION REPORT
GEOTECHNICAL ATTACHMENT
NAT REACH D UNIT 1 LM 1.17-200YR WSEL-CRITICAL SHEAR SURFACE
NATOMAS BASIN

DATE:	SCALE:	SHEET NO.
29-Jan-13	AS SHOWN	4

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AMERICAN RIVER WATERSHED

COMMON FEATURES PROJECT

GENERAL REEVALUATION REPORT

ATTACHMENT C – GEOTECHNICAL REPORT

ENCLOSURE 3

PROBABILISTIC ANALYSES AND LEVEE PERFORMANCE CURVES

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCNBAR_03B	20					15					SM	0.709	GM	34	48				
2F-97-06	22.7					30					SM	0.709	SP-SM/GM	24.8	35				
2F-99-08A	24					10					SM	0.709	SP-SM/GM	28	39				
2F-99-15A	6					39					SM	0.709	SP-SM/GM	30.92	44				
2F-02-17	10	15	8	96	53	24	24	10	214	42	SM	0.709	SP-SM/GM	27.33	39	41	4	456	10
2F-07-18A	10					26					SM	0.709	SP/GP	28.62	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCNBAR_03B	SM	20	0.709				20	GM	15	34							34
2F-97-06	SM	22.7	0.709				22.7	SP-SM	13.8	14	GM	16.2	34				24.8
2F-99-08A	SM	24	0.709				24	SP-SM	3	14	GM	7	34				28
2F-99-15A	SM	6	0.709				6	SP-SM	6	14	GM	33	34				30.92
2F-02-17	SM	10	0.709				10	SP-SM	8	14	GM	16	34				27.33
2F-07-18A	SM	10	0.709				10	SP	7	14	GP	19	34				28.62

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

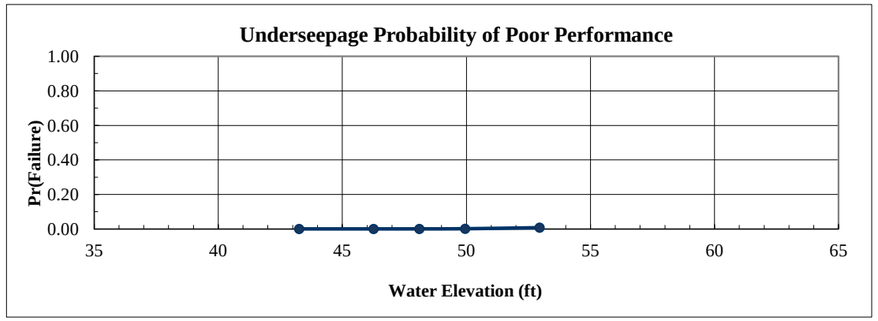
Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	41	4	10
Blanket Thickness (z)	15	8	53
Aquifer Thickness (d)	24	10	42

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	265	85	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.0000
Half Height	4.85	48.11	0.0002
Crest-3ft	6.69	49.95	0.0010
Crest	9.69	52.95	0.0076

Crest	Rh
Head = 9.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	3.62	0.24		
2	45	15.00	24.00	123.38	127.28	0.0715	3.67	0.24	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	3.57	0.24		
4	41	23.00	24.00	141.81	150.44	0.0636	3.86	0.17	0.021025	98.94
5	41	7.00	24.00	82.71	82.99	0.0957	3.21	0.46		
6	41	15.00	34.00	137.38	144.60	0.0926	3.82	0.25	0.000225	1.06
7	41	15.00	14.00	92.18	92.79	0.0519	3.33	0.22		
								Total	0.021250	100.00

E[I] = 0.240000
Var[I]= 0.021250
σ[I]= 0.145774
V(I) = 0.607391

E[ln I] = -1.584129
σ [ln I] = 0.560379

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.826888
F(z) =	0.992423
Pr(f) % =	0.757681

Crest-3ft	Rh
Head = 6.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	2.50	0.17		
2	45	15.00	24.00	123.38	127.28	0.0715	2.54	0.17	0.000025	0.24
3	37	15.00	24.00	113.10	115.41	0.0766	2.46	0.16		
4	41	23.00	24.00	141.81	150.44	0.0636	2.67	0.12	0.010000	97.56
5	41	7.00	24.00	82.71	82.99	0.0957	2.21	0.32		
6	41	15.00	34.00	137.38	144.60	0.0926	2.64	0.18	0.000225	2.20
7	41	15.00	14.00	92.18	92.79	0.0519	2.30	0.15		
								Total	0.010250	100.00

E[I] = 0.170000
Var[I]= 0.010250
σ[I]= 0.101242
V(I) = 0.595543

E[ln I] = -1.923736
σ [ln I] = 0.550962

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.491597
F(z) =	0.998988
Pr(f) % =	0.101233

Half Height	Rh
Head = 4.85	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.81	0.12		
2	45	15.00	24.00	123.38	127.28	0.0715	1.84	0.12	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	1.78	0.12		
4	41	23.00	24.00	141.81	150.44	0.0636	1.93	0.08	0.005625	98.25
5	41	7.00	24.00	82.71	82.99	0.0957	1.60	0.23		
6	41	15.00	34.00	137.38	144.60	0.0926	1.91	0.13	0.000100	1.75
7	41	15.00	14.00	92.18	92.79	0.0519	1.67	0.11		
								Total	0.005725	100.00

E[I] = 0.120000
Var[I]= 0.005725
σ[I]= 0.075664
V(I) = 0.630531

E[ln I] = -2.287631
σ [ln I] = 0.578563

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.953991
F(z) =	0.999820
Pr(f) % =	0.017965

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.12	0.07		
2	45	15.00	24.00	123.38	127.28	0.0715	1.14	0.08	0.000025	1.20
3	37	15.00	24.00	113.10	115.41	0.0766	1.10	0.07		
4	41	23.00	24.00	141.81	150.44	0.0636	1.20	0.05	0.002025	97.59
5	41	7.00	24.00	82.71	82.99	0.0957	0.99	0.14		
6	41	15.00	34.00	137.38	144.60	0.0926	1.18	0.08	0.000025	1.20
7	41	15.00	14.00	92.18	92.79	0.0519	1.03	0.07		
								Total	0.002075	100.00

E[I] = 0.070000
Var[I]= 0.002075
σ[I]= 0.045552
V(I) = 0.650745

E[ln I] = -2.835809
σ [ln I] = 0.594220

Ic= 0.80
ln(I crit) = -0.223144

β =	-4.772323
F(z) =	0.999995
Pr(f) % =	0.000549

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

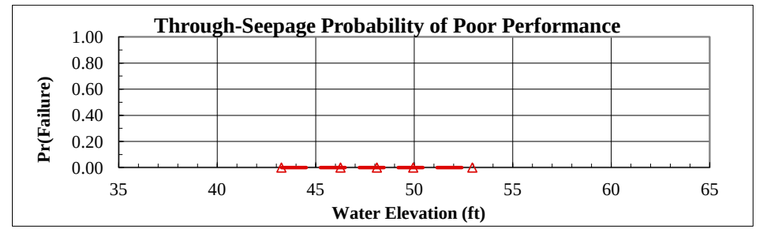
Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Silty Sand (SM) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	1	0.1	10.00
Initial Porosity (n)	0.5	0.05	10.00
Intrinsic Permeability (Ko)	1.00E-07	3.00E-08	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest | **Head =** 9.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 6.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 4.85 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

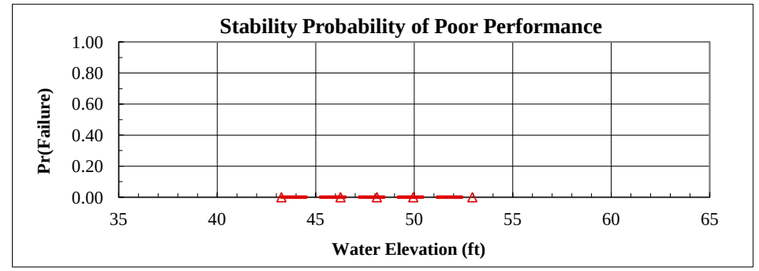
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case Without Project Cutoff Wall

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	33	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest	Head =	9.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.76		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Head =	6.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.79		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	4.85	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.80		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.81		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

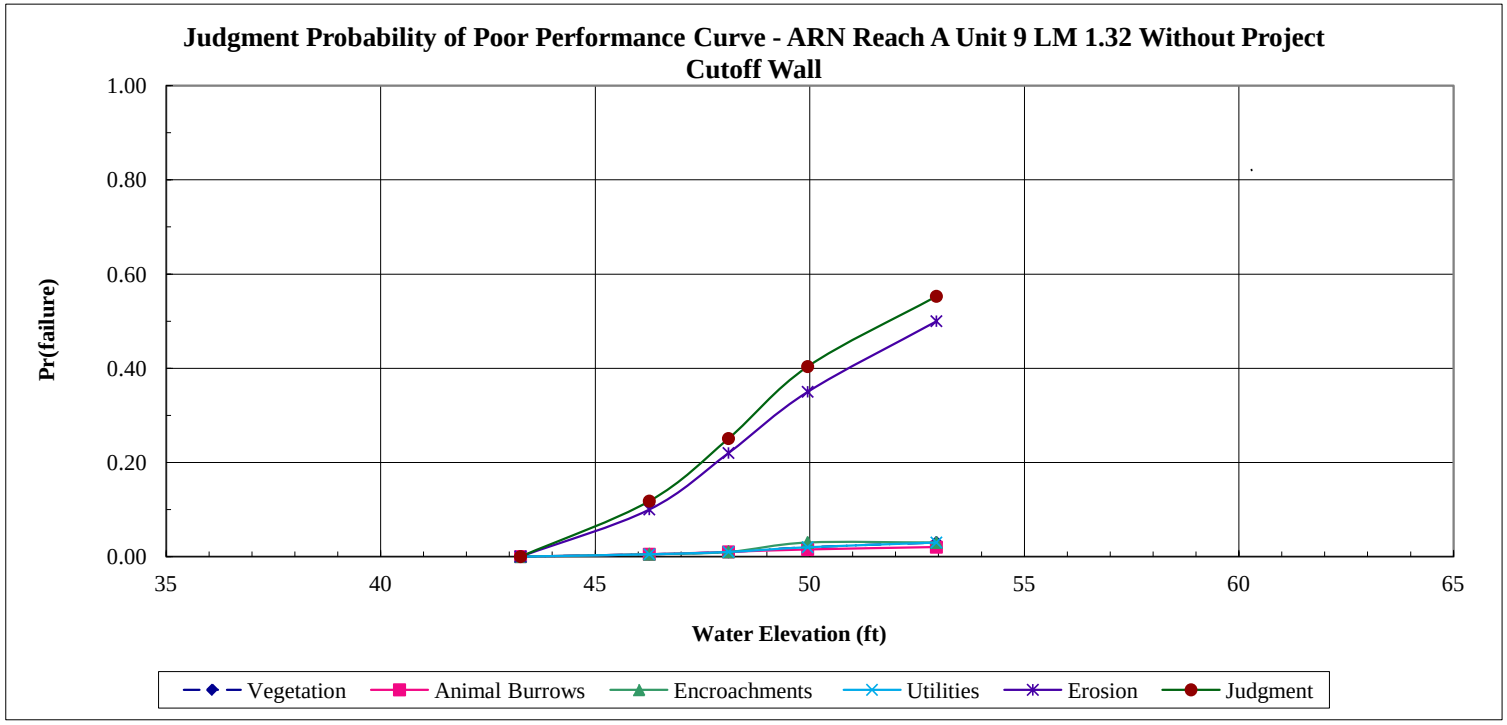
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	40.62	**Date:**	4/29/2011

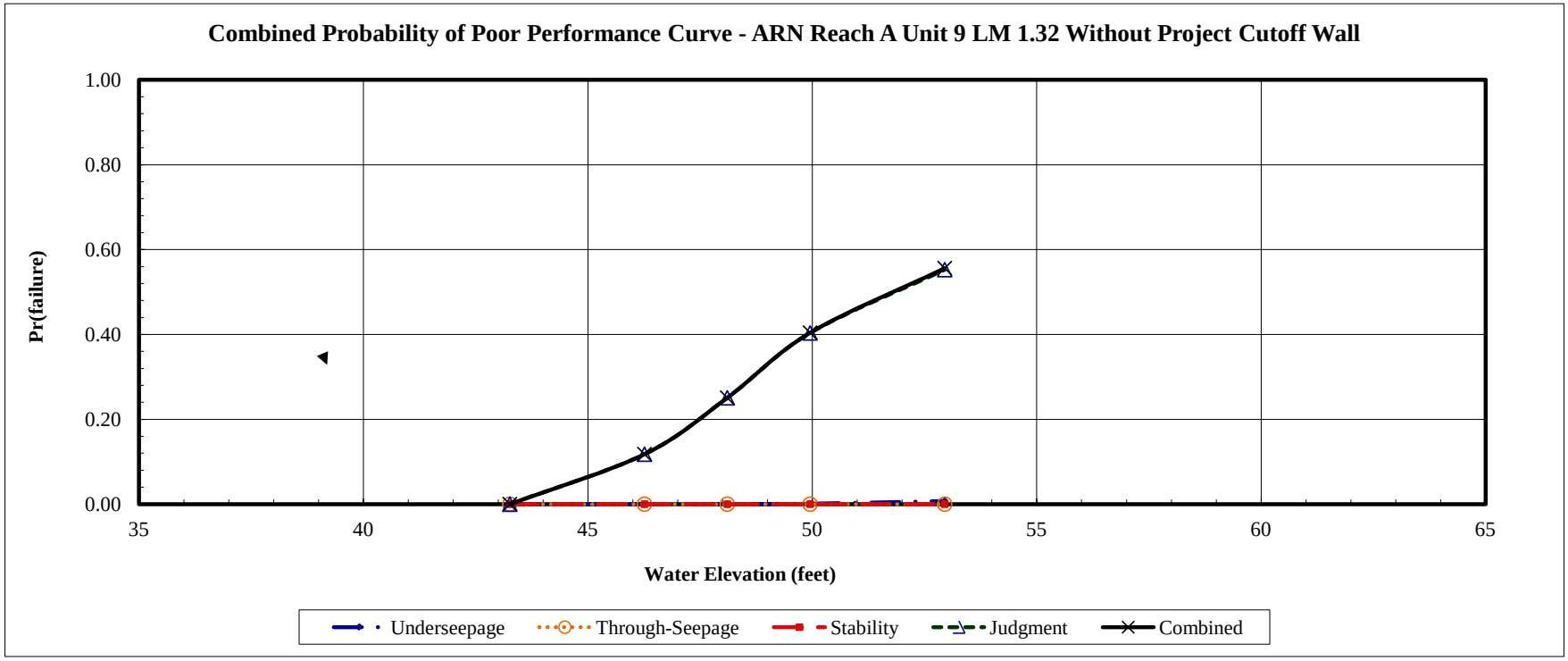
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.0000	1.0000
46.26	0.00500	0.9950	0.00500	0.9950	0.00500	0.9950	0.00500	0.9950	0.10000	0.9000	0.1179	0.8821
48.11	0.01000	0.9900	0.01000	0.9900	0.01000	0.9900	0.01000	0.9900	0.22000	0.7800	0.2507	0.7493
49.95	0.02000	0.9800	0.01500	0.9850	0.03000	0.9700	0.02000	0.9800	0.35000	0.6500	0.4036	0.5964
52.95	0.03000	0.9700	0.02000	0.9800	0.03000	0.9700	0.03000	0.9700	0.50000	0.5000	0.5528	0.4472



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	40.62	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1179	0.8821	0.1179	0.8821
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.2507	0.7493	0.2509	0.7491
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.4036	0.5964	0.4042	0.5958
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.5528	0.4472	0.5562	0.4438



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCNBAR_03B	20					15					SM	0.709	GM	34	48				
2F-97-06	22.7					30					SM	0.709	SP-SM/GM	24.8	35				
2F-99-08A	24					10					SM	0.709	SP-SM/GM	28	39				
2F-99-15A	6					39					SM	0.709	SP-SM/GM	30.92	44				
2F-02-17	10	15	8	96	53	24	24	10	214	42	SM	0.709	SP-SM/GM	27.33	39	41	4	456	10
2F-07-18A	10					26					SM	0.709	SP/GP	28.62	40				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCNBAR_03B	SM	20	0.709				20	GM	15	34							34
2F-97-06	SM	22.7	0.709				22.7	SP-SM	13.8	14	GM	16.2	34				24.8
2F-99-08A	SM	24	0.709				24	SP-SM	3	14	GM	7	34				28
2F-99-15A	SM	6	0.709				6	SP-SM	6	14	GM	33	34				30.92
2F-02-17	SM	10	0.709				10	SP-SM	8	14	GM	16	34				27.33
2F-07-18A	SM	10	0.709				10	SP	7	14	GP	19	34				28.62

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

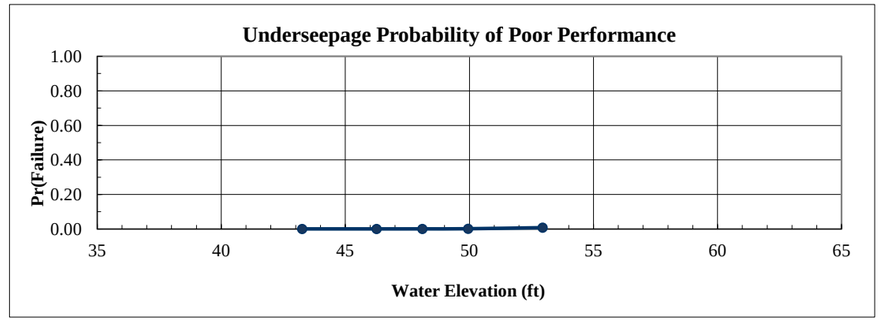
Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	41	4	10
Blanket Thickness (z)	15	8	53
Aquifer Thickness (d)	24	10	42

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	265	85	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.0000
Half Height	4.85	48.11	0.0002
Crest-3ft	6.69	49.95	0.0010
Crest	9.69	52.95	0.0076

Crest	Rh
Head = 9.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	3.62	0.24		
2	45	15.00	24.00	123.38	127.28	0.0715	3.67	0.24	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	3.57	0.24		
4	41	23.00	24.00	141.81	150.44	0.0636	3.86	0.17	0.021025	98.94
5	41	7.00	24.00	82.71	82.99	0.0957	3.21	0.46		
6	41	15.00	34.00	137.38	144.60	0.0926	3.82	0.25	0.000225	1.06
7	41	15.00	14.00	92.18	92.79	0.0519	3.33	0.22		
								Total	0.021250	100.00

E[I] = 0.240000
Var[I]= 0.021250
σ[I]= 0.145774
V(I) = 0.607391

E[ln I] = -1.584129
σ [ln I] = 0.560379

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.826888
F(z) =	0.992423
Pr(f) % =	0.757681

Crest-3ft	Rh
Head = 6.69	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	2.50	0.17		
2	45	15.00	24.00	123.38	127.28	0.0715	2.54	0.17	0.000025	0.24
3	37	15.00	24.00	113.10	115.41	0.0766	2.46	0.16		
4	41	23.00	24.00	141.81	150.44	0.0636	2.67	0.12	0.010000	97.56
5	41	7.00	24.00	82.71	82.99	0.0957	2.21	0.32		
6	41	15.00	34.00	137.38	144.60	0.0926	2.64	0.18	0.000225	2.20
7	41	15.00	14.00	92.18	92.79	0.0519	2.30	0.15		
								Total	0.010250	100.00

E[I] = 0.170000
Var[I]= 0.010250
σ[I]= 0.101242
V(I) = 0.595543

E[ln I] = -1.923736
σ [ln I] = 0.550962

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.491597
F(z) =	0.998988
Pr(f) % =	0.101233

Half Height	Rh
Head = 4.85	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.81	0.12		
2	45	15.00	24.00	123.38	127.28	0.0715	1.84	0.12	0.000000	0.00
3	37	15.00	24.00	113.10	115.41	0.0766	1.78	0.12		
4	41	23.00	24.00	141.81	150.44	0.0636	1.93	0.08	0.005625	98.25
5	41	7.00	24.00	82.71	82.99	0.0957	1.60	0.23		
6	41	15.00	34.00	137.38	144.60	0.0926	1.91	0.13	0.000100	1.75
7	41	15.00	14.00	92.18	92.79	0.0519	1.67	0.11		
								Total	0.005725	100.00

E[I] = 0.120000
Var[I]= 0.005725
σ[I]= 0.075664
V(I) = 0.630531

E[ln I] = -2.287631
σ [ln I] = 0.578563

Ic= 0.80
ln(I crit) = -0.223144

β =	-3.953991
F(z) =	0.999820
Pr(f) % =	0.017965

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	41	15.00	24.00	118.43	121.49	0.0739	1.12	0.07		
2	45	15.00	24.00	123.38	127.28	0.0715	1.14	0.08	0.000025	1.20
3	37	15.00	24.00	113.10	115.41	0.0766	1.10	0.07		
4	41	23.00	24.00	141.81	150.44	0.0636	1.20	0.05	0.002025	97.59
5	41	7.00	24.00	82.71	82.99	0.0957	0.99	0.14		
6	41	15.00	34.00	137.38	144.60	0.0926	1.18	0.08	0.000025	1.20
7	41	15.00	14.00	92.18	92.79	0.0519	1.03	0.07		
								Total	0.002075	100.00

E[I] = 0.070000
Var[I]= 0.002075
σ[I]= 0.045552
V(I) = 0.650745

E[ln I] = -2.835809
σ [ln I] = 0.594220

Ic= 0.80
ln(I crit) = -0.223144

β =	-4.772323
F(z) =	0.999995
Pr(f) % =	0.000549

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

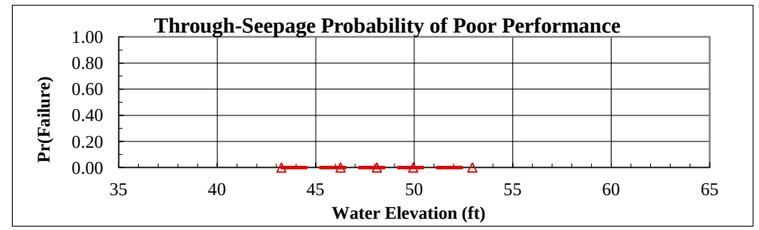
Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables - Silty Sand (SM) Levee			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Tractive Stress (Tc)	1	0.1	10.00
Initial Porosity (n)	0.5	0.05	10.00
Intrinsic Permeability (Ko)	1.00E-07	3.00E-08	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest | **Head =** 9.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 6.69 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 4.85 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.00	0.50	1.00E-07	0.81			
2	0.90	0.50	1.00E-07	0.73			
3	1.10	0.50	1.00E-07	0.89			
4	1.00	0.45	1.00E-07	0.76			
5	1.00	0.55	1.00E-07	0.85			
6	1.00	0.50	7.00E-08	0.96			
7	1.00	0.50	1.30E-07	0.71			

E[FS] =
Var[FS]=
σ[FS]=
V(FS) =
FS req'd = 1.00

E[ln FS] =
σ[ln FS]=
ln(FS req'd) = 0.000000

Total

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

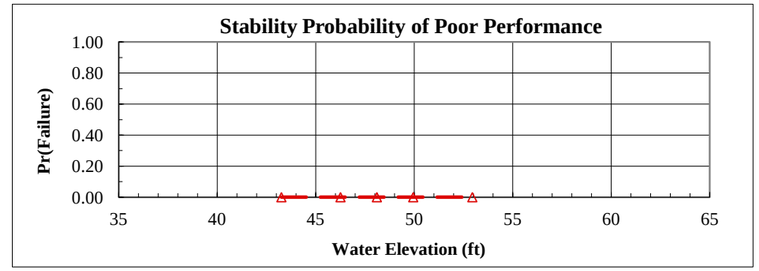
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case With Project Erosion Protection

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	33	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	43.26	0.0000
Toe+3ft	3.00	46.26	0.000000
Half Height	4.85	48.11	0.000000
Crest-3ft	6.69	49.95	0.000000
Crest	9.69	52.95	0.000000

Crest	Head =	9.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.76		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Head =	6.69	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.79		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	4.85	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.80		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	33	0	1.81		
2	29	0	125	33	0			
3	37	0	125	33	0			
4	33	0	125	33	0			
5	33	0	125	33	0			
6	33	0	116	33	0			
7	33	0	134	33	0			
8	33	0	125	29	0			
9	33	0	125	37	0			
10	33	0	125	33	0			
11	33	0	125	33	0			

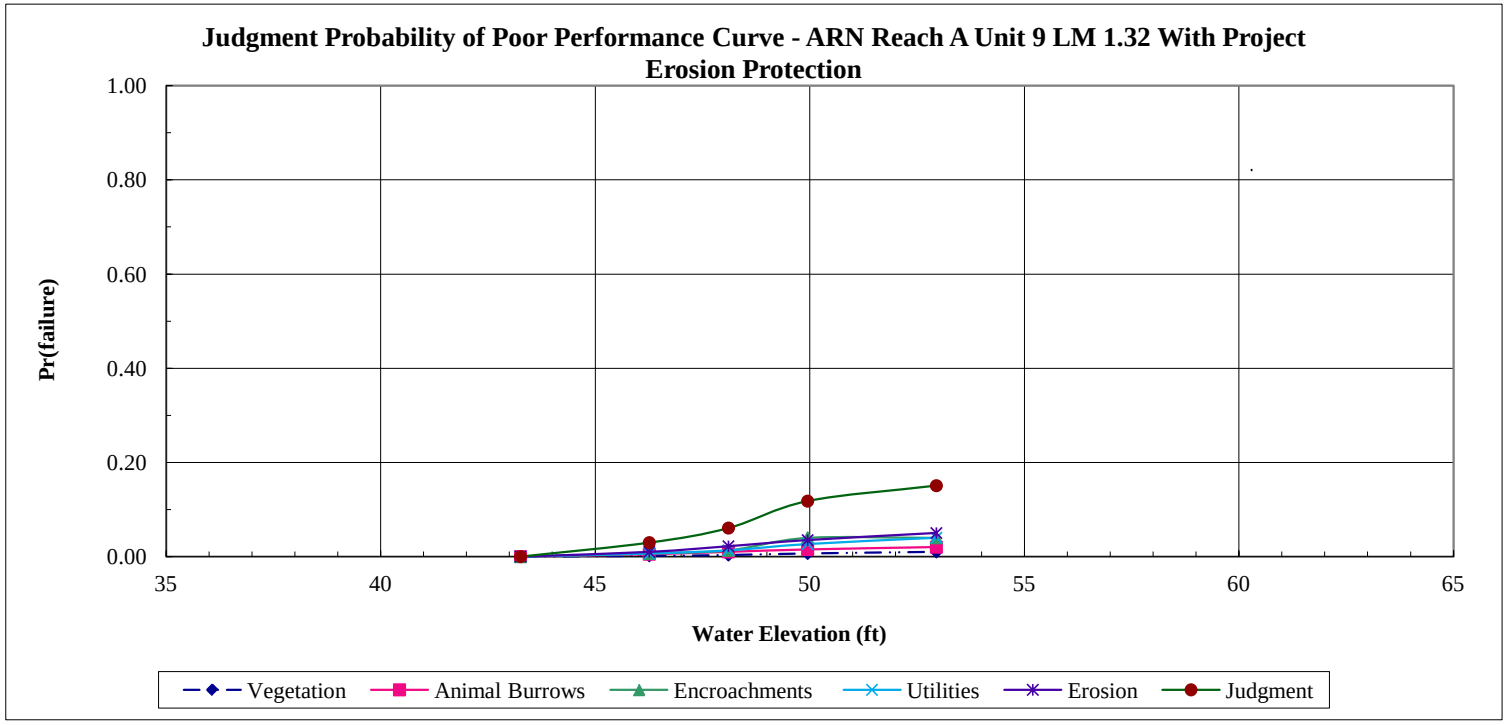
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	A. Deus
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	With Project Erosion Protect	**W/S Toe Elev.:**	40.62	**Date:**	7/5/2012

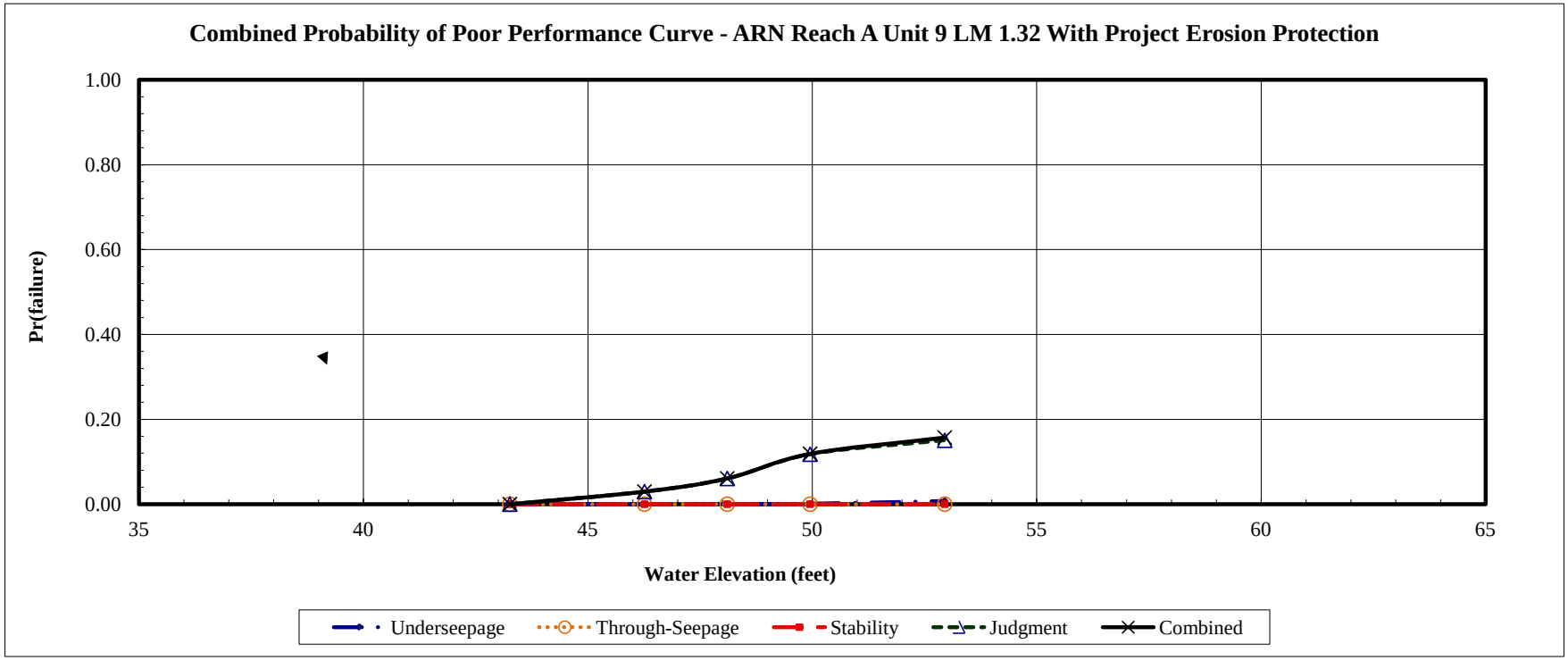
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.0000	1.0000
46.26	0.00167	0.9983	0.00500	0.9950	0.00667	0.9933	0.00667	0.9933	0.01000	0.9900	0.0297	0.9703
48.11	0.00333	0.9967	0.01000	0.9900	0.01333	0.9867	0.01333	0.9867	0.02200	0.9780	0.0606	0.9394
49.95	0.00667	0.9933	0.01500	0.9850	0.04000	0.9600	0.02667	0.9733	0.03500	0.9650	0.1178	0.8822
52.95	0.01000	0.9900	0.02000	0.9800	0.04000	0.9600	0.04000	0.9600	0.05000	0.9500	0.1506	0.8494



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	1.32	**Crest Elev.:**	52.95	**Analysis By:**	A. Deus
Study Area:	American River	**River Mile:**	7.82	**L/S Toe Elev.:**	43.26	**Checked By:**	H. Mulder
River Section:	ARN Reach A Unit 9	**Analysis Case:**	With Project Erosion Protection	**W/S Toe Elev.:**	40.62	**Date:**	7/5/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.0606	0.9394	0.0607	0.9393
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.1178	0.8822	0.1186	0.8814
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.1506	0.8494	0.1570	0.8430



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Arcade Creek North
Basin and Reach: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WRARFC_024S	5					27.5					CL	0.28	SM/ML	1.54	6				
WRARFC_003B	9					15.45					CL	0.028	SP	28	1000				
K94a_BA4	4					33.5					CL	0.28	ML/SM/SP	3.05	11				
		6	3	10	50		25	9	170	36						339	573	99649	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WRARFC_024S	CL	5	0.28				5	SM	12	2.8	ML	15.5	0.57				1.54
WRARFC_003B	CL	9	0.028				9	SP	15.45	28							28
K94a_BA4	CL	4	0.28				4	ML	7.5	0.57	SM	25	2.8	SP	1	28	3.05

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

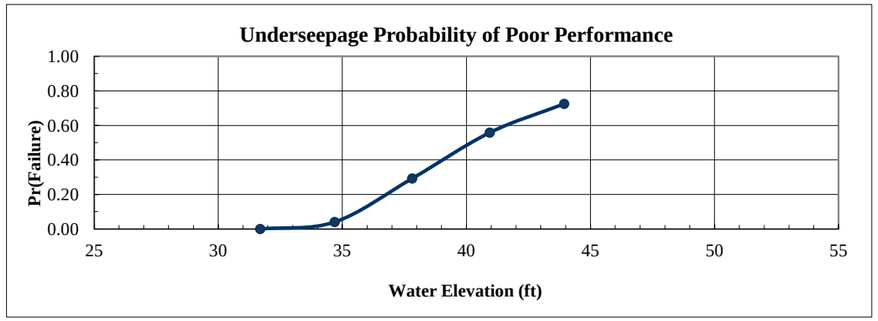
Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	339	332	98
Blanket Thickness (z)	6	3	50
Aquifer Thickness (d)	25	9	36

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	10	100	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.0403
Half Height	6.13	37.82	0.2925
Crest-3ft	9.25	40.94	0.5580
Crest	12.25	43.94	0.7245

Crest	Rh
Head = 12.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	8.23	1.37		
2	671	6.00	25.00	10.00	317.31	0.0585	9.10	1.52	0.280900	34.52
3	7	6.00	25.00	9.68	31.89	0.1766	2.76	0.46		
4	339	9.00	25.00	10.00	276.18	0.0647	8.76	0.97	0.525625	64.59
5	339	3.00	25.00	9.99	159.45	0.0928	7.25	2.42		
6	339	6.00	34.00	10.00	262.98	0.0912	8.64	1.44	0.007225	0.89
7	339	6.00	16.00	9.99	180.40	0.0551	7.61	1.27		
								Total	0.813750	100.00

E[I] = 1.370000
Var[I]= 0.813750
σ[I]= 0.902081
V(I) = 0.658453

E[ln I] = 0.134730
σ [ln I] = 0.600134

Ic= 0.80
ln(I crit) = -0.223144

β =	0.224500
F(z) =	0.275480
Pr(f) % =	72.452008

Crest-3ft	Rh
Head = 9.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	6.22	1.04		
2	671	6.00	25.00	10.00	317.31	0.0585	6.87	1.15	0.160000	35.10
3	7	6.00	25.00	9.68	31.89	0.1766	2.08	0.35		
4	339	9.00	25.00	10.00	276.18	0.0647	6.62	0.74	0.291600	63.97
5	339	3.00	25.00	9.99	159.45	0.0928	5.47	1.82		
6	339	6.00	34.00	10.00	262.98	0.0912	6.52	1.09	0.004225	0.93
7	339	6.00	16.00	9.99	180.40	0.0551	5.75	0.96		
								Total	0.455825	100.00

E[I] = 1.040000
Var[I]= 0.455825
σ[I]= 0.675148
V(I) = 0.649181

E[ln I] = -0.136613
σ [ln I] = 0.593016

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.230370
F(z) =	0.441994
Pr(f) % =	55.800618

Half Height	Rh
Head = 6.13	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	4.12	0.69		
2	671	6.00	25.00	10.00	317.31	0.0585	4.55	0.76	0.070225	34.86
3	7	6.00	25.00	9.68	31.89	0.1766	1.38	0.23		
4	339	9.00	25.00	10.00	276.18	0.0647	4.38	0.49	0.129600	64.34
5	339	3.00	25.00	9.99	159.45	0.0928	3.62	1.21		
6	339	6.00	34.00	10.00	262.98	0.0912	4.32	0.72	0.001600	0.79
7	339	6.00	16.00	9.99	180.40	0.0551	3.81	0.64		
								Total	0.201425	100.00

E[I] = 0.690000
Var[I]= 0.201425
σ[I]= 0.448804
V(I) = 0.650441

E[ln I] = -0.547473
σ [ln I] = 0.593985

Ic= 0.80
ln(I crit) = -0.223144

β =	-0.921694
F(z) =	0.707475
Pr(f) % =	29.252520

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	2.02	0.34		
2	671	6.00	25.00	10.00	317.31	0.0585	2.23	0.37	0.016900	35.26
3	7	6.00	25.00	9.68	31.89	0.1766	0.68	0.11		
4	339	9.00	25.00	10.00	276.18	0.0647	2.15	0.24	0.030625	63.90
5	339	3.00	25.00	9.99	159.45	0.0928	1.78	0.59		
6	339	6.00	34.00	10.00	262.98	0.0912	2.12	0.35	0.000400	0.83
7	339	6.00	16.00	9.99	180.40	0.0551	1.86	0.31		
								Total	0.047925	100.00

E[I] = 0.340000
Var[I]= 0.047925
σ[I]= 0.218918
V(I) = 0.643876

E[ln I] = -1.252225
σ [ln I] = 0.588923

Ic= 0.80
ln(I crit) = -0.223144

β =	-2.126297
F(z) =	0.959716
Pr(f) % =	4.028435

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

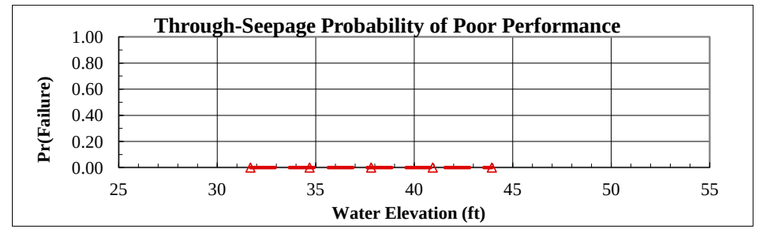
Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Clay (CL) and Clayey Sand (SC) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.4	0.0	10.00
Initial Porosity (n)	0.7	0.07	10.00
Intrinsic Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.000000
Crest	12.25	43.94	0.000000

Crest | **Head =** 12.25 | **Horizontal Gradient (Ix) =** 0.500

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	24.13		
2	0.36	0.70	1.00E-10	10.86	21.72	5.824342	26.44
3	0.44	0.70	1.00E-10	13.27	26.55		
4	0.40	0.63	1.00E-10	11.45	22.90	1.459744	6.63
5	0.40	0.77	1.00E-10	12.66	25.31		
6	0.40	0.70	7.00E-11	14.42	28.85	14.740321	66.93
7	0.40	0.70	1.30E-10	10.58	21.17		

E[FS] = 24.133673 | E[ln FS] = 3.165050 | Total 22.024406 | 100.00
Var[FS]= 22.024406
σ[FS]= 4.693017 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	16.428361
F(z) =	0.000000
Pr(f) % =	0.000000

Crest-3ft | **Head =** 9.25 | **Horizontal Gradient (Ix) =** 0.470

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	25.67		
2	0.36	0.70	1.00E-10	10.86	23.11	6.591605	26.44
3	0.44	0.70	1.00E-10	13.27	28.24		
4	0.40	0.63	1.00E-10	11.45	24.36	1.652042	6.63
5	0.40	0.77	1.00E-10	12.66	26.93		
6	0.40	0.70	7.00E-11	14.42	30.69	16.682119	66.93
7	0.40	0.70	1.30E-10	10.58	22.52		

E[FS] = 25.674120 | E[ln FS] = 3.226925 | Total 24.925765 | 100.00
Var[FS]= 24.925765
σ[FS]= 4.992571 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	16.749528
F(z) =	0.000000
Pr(f) % =	0.000000

Half Height | **Head =** 6.13 | **Horizontal Gradient (Ix) =** 0.400

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	30.17		
2	0.36	0.70	1.00E-10	10.86	27.15	9.100534	26.44
3	0.44	0.70	1.00E-10	13.27	33.18		
4	0.40	0.63	1.00E-10	11.45	28.62	2.280850	6.63
5	0.40	0.77	1.00E-10	12.66	31.64		
6	0.40	0.70	7.00E-11	14.42	36.06	23.031751	66.93
7	0.40	0.70	1.30E-10	10.58	26.46		

E[FS] = 30.167091 | E[ln FS] = 3.388193 | Total 34.413135 | 100.00
Var[FS]= 34.413135
σ[FS]= 5.866271 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	17.586599
F(z) =	0.000000
Pr(f) % =	0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.230

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07	52.46		
2	0.36	0.70	1.00E-10	10.86	47.22	27.525245	26.44
3	0.44	0.70	1.00E-10	13.27	57.71		
4	0.40	0.63	1.00E-10	11.45	49.77	6.898601	6.63
5	0.40	0.77	1.00E-10	12.66	55.03		
6	0.40	0.70	7.00E-11	14.42	62.71	69.661250	66.93
7	0.40	0.70	1.30E-10	10.58	46.01		

E[FS] = 52.464507 | E[ln FS] = 3.941578 | Total 104.085096 | 100.00
Var[FS]= 104.085096
σ[FS]= 10.202210 | σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 | ln(FS req'd) = 0.000000

β =	20.458975
F(z) =	0.000000
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

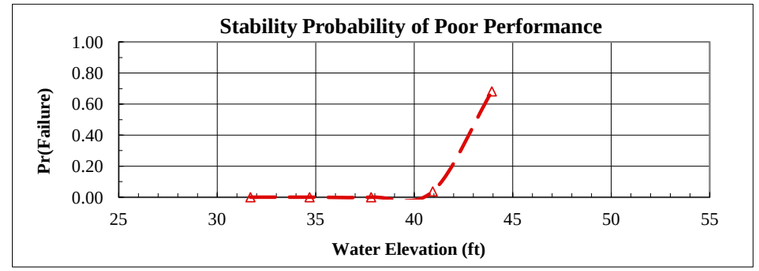
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case Without Project No Improvements

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	28	4	13.00
Levee Cohesion	50	20	40.00
Levee γ	115	8	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	50	20	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.037401
Crest	12.25	43.94	0.681442

Crest	Head =	12.25	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	0.92		
2	24	50	115	28	50	0.73	0.018225	37.73
3	32	50	115	28	50	1.00		
4	28	30	115	28	50	0.85	0.000025	0.05
5	28	70	115	28	50	0.86		
6	28	50	107	28	50	0.75	0.011025	22.83
7	28	50	123	28	50	0.96		
8	28	50	115	24	50	0.76	0.009025	18.69
9	28	50	115	32	50	0.95		
10	28	50	115	28	30	0.75	0.010000	20.70
11	28	50	115	28	70	0.95		

E[FS] = 0.920000 E[ln FS] = -0.111130 Total 0.048300 100.00
Var[FS]= 0.048300
σ[FS]= 0.219773 σ[ln FS]= 0.235577
V(FS) = 0.238883
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	-0.471735
F(z) =	0.681442
Pr(f) % =	68.144204

Crest-3ft	Head =	9.25	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	1.18		
2	24	50	115	28	50	1.08	0.005625	49.02
3	32	50	115	28	50	1.23		
4	28	30	115	28	50	1.12	0.002025	17.65
5	28	70	115	28	50	1.21		
6	28	50	107	28	50	1.12	0.000100	0.87
7	28	50	123	28	50	1.14		
8	28	50	115	24	50	1.11	0.002500	21.79
9	28	50	115	32	50	1.21		
10	28	50	115	28	30	1.15	0.001225	10.68
11	28	50	115	28	70	1.22		

E[FS] = 1.180000 E[ln FS] = 0.161411 Total 0.011475 100.00
Var[FS]= 0.011475
σ[FS]= 0.107121 σ[ln FS]= 0.090595
V(FS) = 0.090781
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	1.781680
F(z) =	0.037401
Pr(f) % =	3.740068

Half Height	Head =	6.13	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	1.40		
2	24	50	115	28	50			
3	32	50	115	28	50			
4	28	30	115	28	50			
5	28	70	115	28	50			
6	28	50	107	28	50			
7	28	50	123	28	50			
8	28	50	115	24	50			
9	28	50	115	32	50			
10	28	50	115	28	30			
11	28	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	28	50	115	28	50	1.52		
2	24	50	115	28	50			
3	32	50	115	28	50			
4	28	30	115	28	50			
5	28	70	115	28	50			
6	28	50	107	28	50			
7	28	50	123	28	50			
8	28	50	115	24	50			
9	28	50	115	32	50			
10	28	50	115	28	30			
11	28	50	115	28	70			

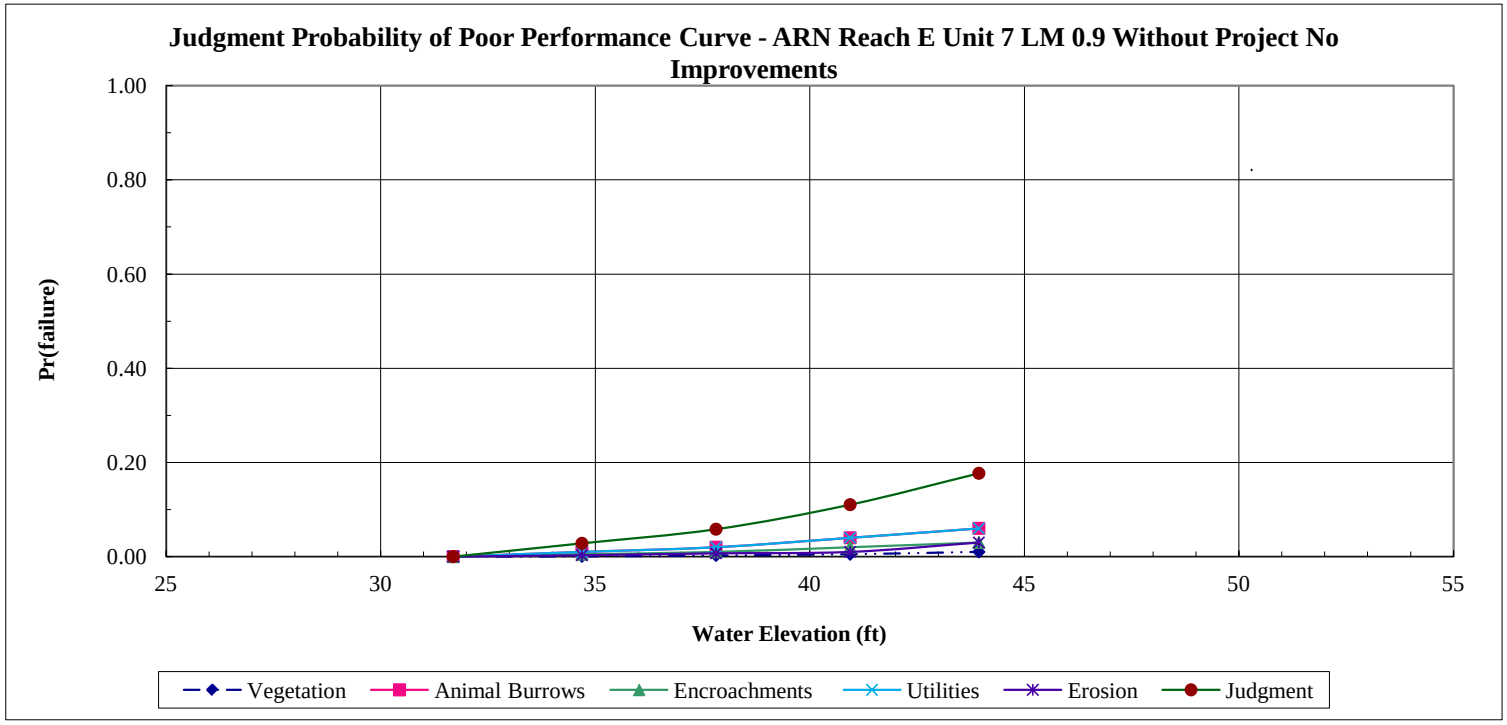
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	0.90	**Crest Elev.:**	43.94	**Analysis By:**	M. Kynett
Study Area:	Arcade Creek North	**River Mile:**	0.88	**L/S Toe Elev.:**	31.69	**Checked By:**	H. Mulder
River Section:	ARN Reach E Unit 7	**Analysis Case:**	Without Project No Improver	**W/S Toe Elev.:**	26.77	**Date:**	4/29/2011

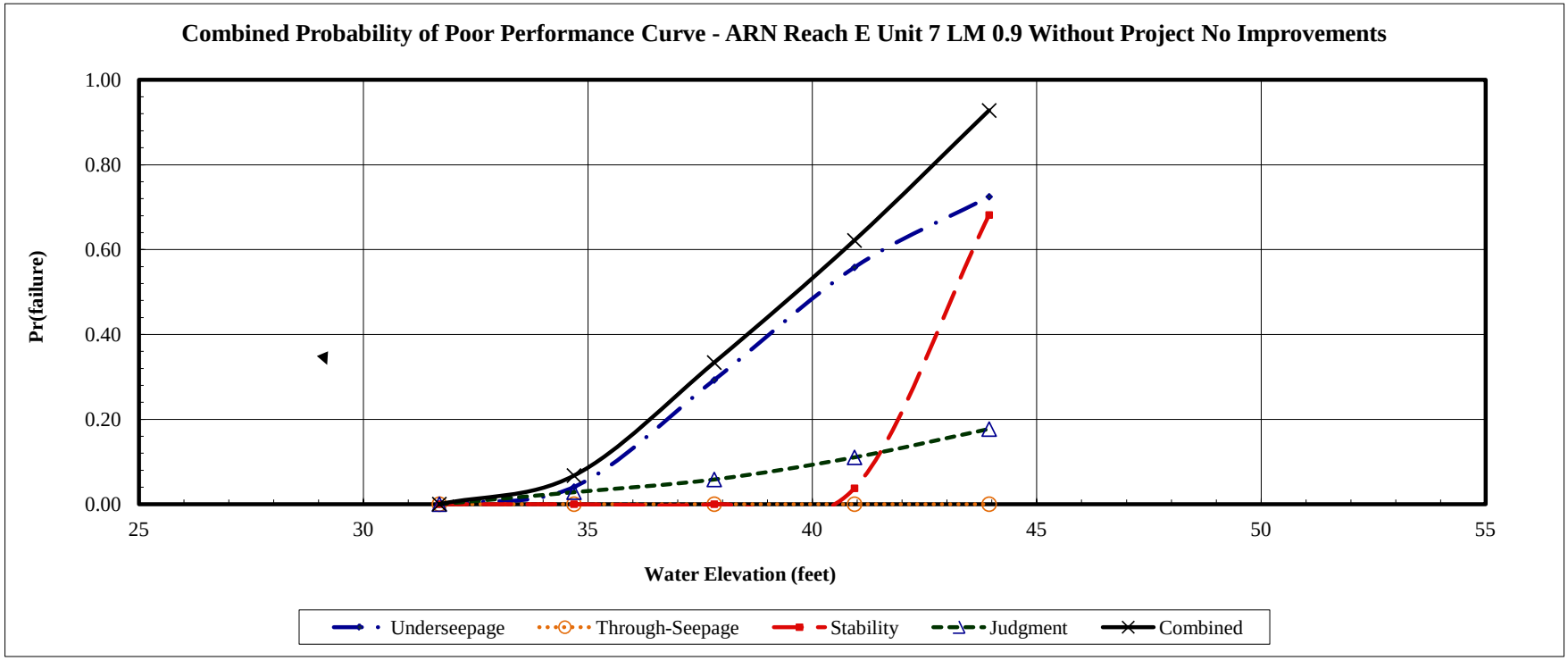
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.69	0.0005	0.9995	0.0100	0.9900	0.0050	0.9950	0.0100	0.9900	0.0030	0.9970	0.0282	0.9718
37.82	0.0025	0.9975	0.0200	0.9800	0.0100	0.9900	0.0200	0.9800	0.0070	0.9930	0.0582	0.9418
40.94	0.0050	0.9950	0.0400	0.9600	0.0200	0.9800	0.0400	0.9600	0.0100	0.9900	0.1103	0.8897
43.94	0.0100	0.9900	0.0600	0.9400	0.0300	0.9700	0.0600	0.9400	0.0300	0.9700	0.1769	0.8231



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	0.90	**Crest Elev.:**	43.94	**Analysis By:**	M. Kynett
Study Area:	Arcade Creek North	**River Mile:**	0.88	**L/S Toe Elev.:**	31.69	**Checked By:**	H. Mulder
River Section:	ARN Reach E Unit 7	**Analysis Case:**	Without Project No Improvements	**W/S Toe Elev.:**	26.77	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.69	0.0403	0.9597	0.0000	1.0000	0.0000	1.0000	0.0282	0.9718	0.0674	0.9326
37.82	0.2925	0.7075	0.0000	1.0000	0.0000	1.0000	0.0582	0.9418	0.3337	0.6663
40.94	0.5580	0.4420	0.0000	1.0000	0.0374	0.9626	0.1103	0.8897	0.6215	0.3785
43.94	0.7245	0.2755	0.0000	1.0000	0.6814	0.3186	0.1769	0.8231	0.9278	0.0722



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Arcade Creek North
Basin and Reach: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WRARFC_024S	5					27.5					CL	0.28	SM/ML	1.54	6				
WRARFC_003B	9					15.45					CL	0.028	SP	28	1000				
K94a_BA4	4					33.5					CL	0.28	ML/SM/SP	3.05	11				
		6	3	10	50		25	9	170	36						339	573	99649	98

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WRARFC_024S	CL	5	0.28				5	SM	12	2.8	ML	15.5	0.57				1.54
WRARFC_003B	CL	9	0.028				9	SP	15.45	28							28
K94a_BA4	CL	4	0.28				4	ML	7.5	0.57	SM	25	2.8	SP	1	28	3.05

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

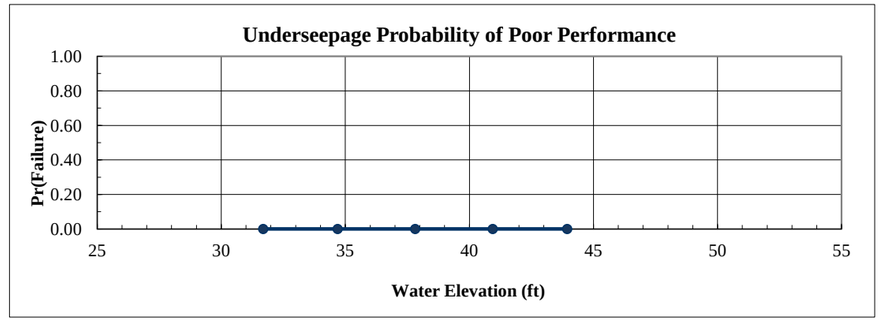
Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	339	332	98
Blanket Thickness (z)	6	3	50
Aquifer Thickness (d)	25	9	36

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	10	100	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.0000
Half Height	6.13	37.82	0.0000
Crest-3ft	9.25	40.94	0.0000
Crest	12.25	43.94	0.0000

Crest	Rh
Head = 12.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	8.23			
2	671	6.00	25.00	10.00	317.31	0.0585	9.10			
3	7	6.00	25.00	9.68	31.89	0.1766	2.76			
4	339	9.00	25.00	10.00	276.18	0.0647	8.76			
5	339	3.00	25.00	9.99	159.45	0.0928	7.25			
6	339	6.00	34.00	10.00	262.98	0.0912	8.64			
7	339	6.00	16.00	9.99	180.40	0.0551	7.61			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Rh
Head = 9.25	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	6.22			
2	671	6.00	25.00	10.00	317.31	0.0585	6.87			
3	7	6.00	25.00	9.68	31.89	0.1766	2.08			
4	339	9.00	25.00	10.00	276.18	0.0647	6.62			
5	339	3.00	25.00	9.99	159.45	0.0928	5.47			
6	339	6.00	34.00	10.00	262.98	0.0912	6.52			
7	339	6.00	16.00	9.99	180.40	0.0551	5.75			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Rh
Head = 6.13	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	4.12			
2	671	6.00	25.00	10.00	317.31	0.0585	4.55			
3	7	6.00	25.00	9.68	31.89	0.1766	1.38			
4	339	9.00	25.00	10.00	276.18	0.0647	4.38			
5	339	3.00	25.00	9.99	159.45	0.0928	3.62			
6	339	6.00	34.00	10.00	262.98	0.0912	4.32			
7	339	6.00	16.00	9.99	180.40	0.0551	3.81			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	339	6.00	25.00	9.99	225.50	0.0745	2.02			
2	671	6.00	25.00	10.00	317.31	0.0585	2.23			
3	7	6.00	25.00	9.68	31.89	0.1766	0.68			
4	339	9.00	25.00	10.00	276.18	0.0647	2.15			
5	339	3.00	25.00	9.99	159.45	0.0928	1.78			
6	339	6.00	34.00	10.00	262.98	0.0912	2.12			
7	339	6.00	16.00	9.99	180.40	0.0551	1.86			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

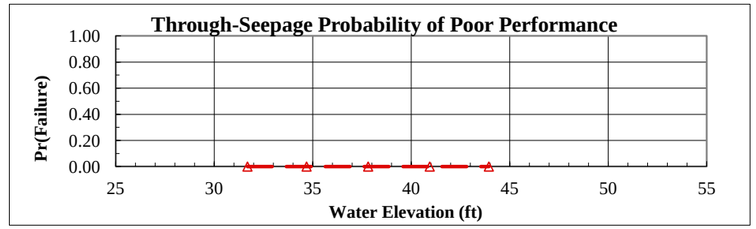
Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Clay (CL) and Clayey Sand (SC) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.4	0.0	10.00
Initial Porosity (n)	0.7	0.07	10.00
Intrinsic Permeability (Ko)	1.00E-10	3.00E-11	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.000000
Crest	12.25	43.94	0.000000

Crest | **Head =** 12.25 | **Horizontal Gradient (Ix) =** 0.500

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 9.25 | **Horizontal Gradient (Ix) =** 0.470

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 6.13 | **Horizontal Gradient (Ix) =** 0.400

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.230

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.40	0.70	1.00E-10	12.07			
2	0.36	0.70	1.00E-10	10.86			
3	0.44	0.70	1.00E-10	13.27			
4	0.40	0.63	1.00E-10	11.45			
5	0.40	0.77	1.00E-10	12.66			
6	0.40	0.70	7.00E-11	14.42			
7	0.40	0.70	1.30E-10	10.58			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

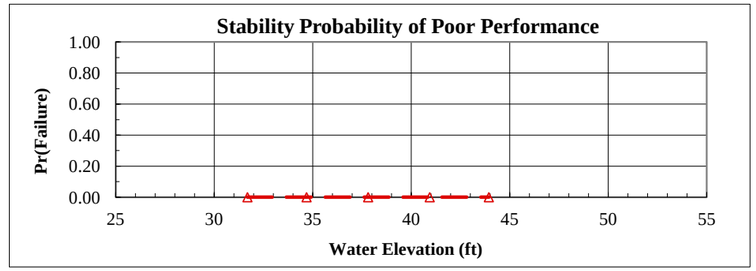
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Levee Φ	24	3	13.00
Levee Cohesion	50	20	40.00
Levee γ	115	8	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	50	20	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	31.69	0.0000
Toe+3ft	3.00	34.69	0.000000
Half Height	6.13	37.82	0.000000
Crest-3ft	9.25	40.94	0.000000
Crest	12.25	43.94	0.000000

Crest	Head =	12.25	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.37		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	9.25	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.51		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	6.13	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.54		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	24	50	115	28	50	1.61		
2	21	50	115	28	50			
3	27	50	115	28	50			
4	24	30	115	28	50			
5	24	70	115	28	50			
6	24	50	107	28	50			
7	24	50	123	28	50			
8	24	50	115	24	50			
9	24	50	115	32	50			
10	24	50	115	28	30			
11	24	50	115	28	70			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

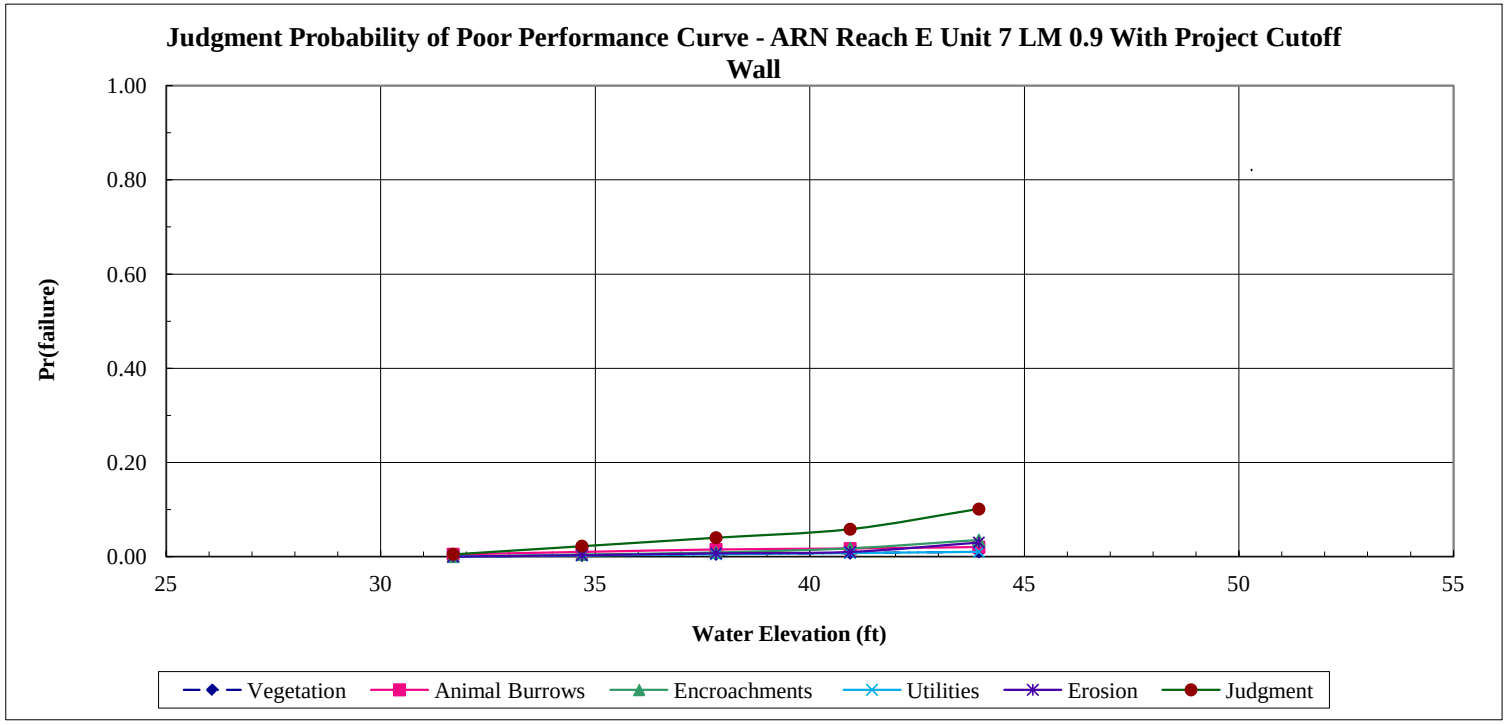
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0050	0.9950	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0050	0.9950
34.69	0.0025	0.9975	0.0100	0.9900	0.0044	0.9956	0.0025	0.9975	0.0030	0.9970	0.0222	0.9778
37.82	0.0050	0.9950	0.0150	0.9850	0.0088	0.9913	0.0050	0.9950	0.0070	0.9930	0.0401	0.9599
40.94	0.0075	0.9925	0.0170	0.9830	0.0175	0.9825	0.0075	0.9925	0.0100	0.9900	0.0581	0.9419
43.94	0.0100	0.9900	0.0200	0.9800	0.0350	0.9650	0.0100	0.9900	0.0300	0.9700	0.1009	0.8991



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

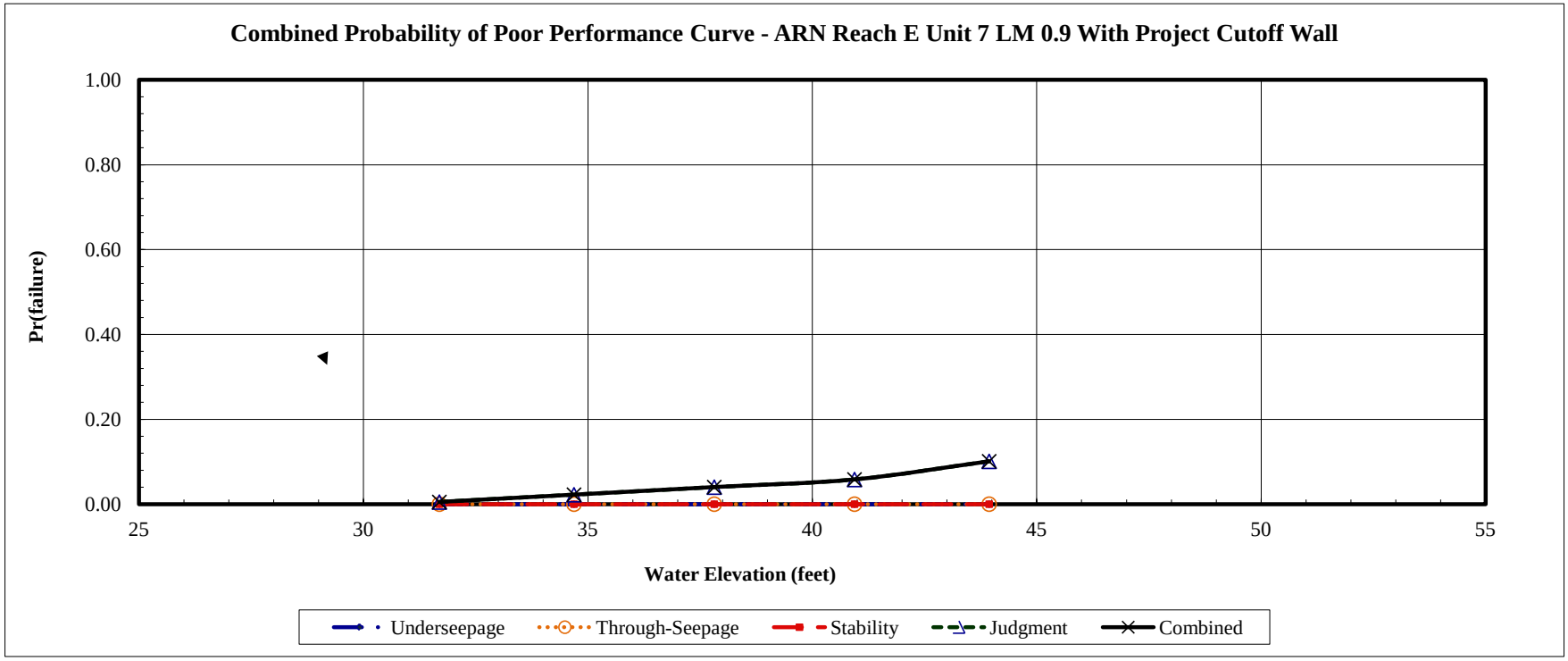
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: With Project Cutoff Wall

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0050	0.9950	0.0050	0.9950
34.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0222	0.9778	0.0222	0.9778
37.82	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0401	0.9599	0.0401	0.9599
40.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0581	0.9419	0.0581	0.9419
43.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1009	0.8991	0.1009	0.8991



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCSBAR-003B	9.5					45.5					ML	0.14	SM/SP-SM/GW	19.58	140				
2F-00-9W	7.96					30					ML/SM	0.14	SM/SP-SM/GW	16.89	121				
2F-97-23	9					31.2					CL/ML/SM	0.028	SM/SP-SM/GW	20.08	717				
2F-00-114	10.5					53					CL/SC/ML	0.035	SM/SP-SM/GW	20.84	595				
2F-99-17	20	12	4	44	33	34	40	9	427	23	SM	0.709	SW-SM/GW	25.18	36	661	1000	769160	98
2F-08-03	14.5					43					ML	0.14	SP/GP	23.77	170				
2F-07-03A	10.51					45					CL/ML	0.00709	SP/GP	20.22	2852				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCSBAR-003B	ML	9.5	0.14				9.5	SM	17.5	2.8	SP-SM	5.5	14	GW	22.5	34	19.58
2F-00-9W	ML	4.5	0.14	SM	17.5	0.709	7.96	SM	11	2.8	SP-SM	8.5	14	GW	10.5	34	16.89
2F-97-23	CL	7	0.028	ML/SM	10	0.14	9	SM	9.85	2.8	SP-SM	6.35	14	GW	15	34	20.08
2F-00-114	CL/SC	9	0.035	ML	6	0.14	10.5	SM	10.5	2.8	SP-SM	18.5	14	GW	24	34	20.84
2F-99-17	SM	20	0.709				20	SW-SM	15	14	GW	19	34				25.18
2F-08-03	ML	14.5	0.14				14.5	SP	22	14	GP	21	34				23.77
2F-07-03A	CL	10	0.00709	ML	10	0.14	10.51	SP	31	14	GP	14	34				20.22

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

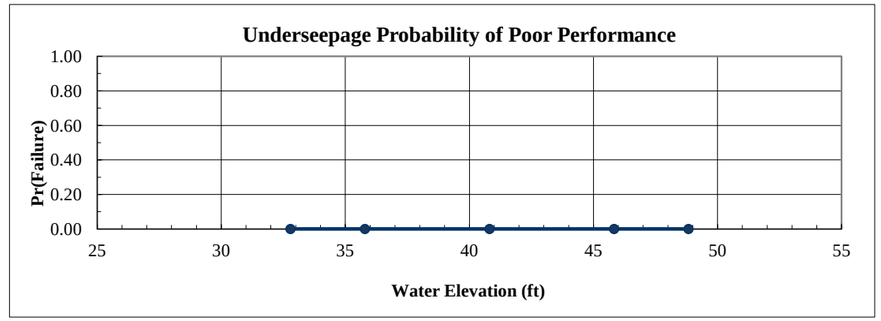
Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	661	648	98
Blanket Thickness (z)	12	4	33
Aquifer Thickness (d)	40	9	23

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	0	125	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.0000
Half Height	8.02	40.81	0.0000
Crest-3ft	13.04	45.83	0.0000
Crest	16.04	48.83	0.0000

Crest	Rh
Head = 16.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	13.13			
2	1309	12.00	40.00	0.00	792.60	0.0436	13.85			
3	13	12.00	40.00	0.00	79.66	0.1954	6.24			
4	661	16.00	40.00	0.00	650.42	0.0516	13.45			
5	661	8.00	40.00	0.00	459.91	0.0684	12.61			
6	661	12.00	49.00	0.00	623.43	0.0655	13.36			
7	661	12.00	31.00	0.00	495.87	0.0499	12.81			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Rh
Head = 13.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	10.67			
2	1309	12.00	40.00	0.00	792.60	0.0436	11.26			
3	13	12.00	40.00	0.00	79.66	0.1954	5.08			
4	661	16.00	40.00	0.00	650.42	0.0516	10.94			
5	661	8.00	40.00	0.00	459.91	0.0684	10.25			
6	661	12.00	49.00	0.00	623.43	0.0655	10.86			
7	661	12.00	31.00	0.00	495.87	0.0499	10.41			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Rh
Head = 8.02	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	6.56			
2	1309	12.00	40.00	0.00	792.60	0.0436	6.93			
3	13	12.00	40.00	0.00	79.66	0.1954	3.12			
4	661	16.00	40.00	0.00	650.42	0.0516	6.73			
5	661	8.00	40.00	0.00	459.91	0.0684	6.31			
6	661	12.00	49.00	0.00	623.43	0.0655	6.68			
7	661	12.00	31.00	0.00	495.87	0.0499	6.41			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	661	12.00	40.00	0.00	563.28	0.0581	2.46			
2	1309	12.00	40.00	0.00	792.60	0.0436	2.59			
3	13	12.00	40.00	0.00	79.66	0.1954	1.17			
4	661	16.00	40.00	0.00	650.42	0.0516	2.52			
5	661	8.00	40.00	0.00	459.91	0.0684	2.36			
6	661	12.00	49.00	0.00	623.43	0.0655	2.50			
7	661	12.00	31.00	0.00	495.87	0.0499	2.40			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

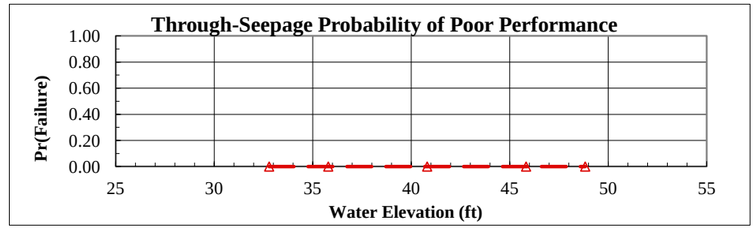
Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	1.2	0.1	10.00
Initial Porosity (n)	0.25	0.03	10.00
Intrinsic Permeability (Ko)	1.50E-07	4.50E-08	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest | **Head =** 16.04 | **Horizontal Gradient (Ix) =** 0.120

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	4.65		
2	1.08	0.25	1.50E-07	0.50	4.19	0.216679	26.44
3	1.32	0.25	1.50E-07	0.61	5.12		
4	1.20	0.23	1.50E-07	0.53	4.42	0.054306	6.63
5	1.20	0.28	1.50E-07	0.59	4.88		
6	1.20	0.25	1.05E-07	0.67	5.56	0.548375	66.93
7	1.20	0.25	1.95E-07	0.49	4.08		

E[FS] = 4.654883 E[ln FS] = 1.519358 Total 0.819360 100.00
Var[FS]= 0.819360
σ[FS]= 0.905185 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	7.886311
F(z) =	0.000000
Pr(f) % =	0.000000

Crest-3ft | **Head =** 13.04 | **Horizontal Gradient (Ix) =** 0.090

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	6.21		
2	1.08	0.25	1.50E-07	0.50	5.59	0.385208	26.44
3	1.32	0.25	1.50E-07	0.61	6.83		
4	1.20	0.23	1.50E-07	0.53	5.89	0.096544	6.63
5	1.20	0.28	1.50E-07	0.59	6.51		
6	1.20	0.25	1.05E-07	0.67	7.42	0.974889	66.93
7	1.20	0.25	1.95E-07	0.49	5.44		

E[FS] = 6.206511 E[ln FS] = 1.807040 Total 1.456641 100.00
Var[FS]= 1.456641
σ[FS]= 1.206914 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	9.379541
F(z) =	0.000000
Pr(f) % =	0.000000

Half Height | **Head =** 8.02 | **Horizontal Gradient (Ix) =** 0.040

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	13.96		
2	1.08	0.25	1.50E-07	0.50	12.57	1.950114	26.44
3	1.32	0.25	1.50E-07	0.61	15.36		
4	1.20	0.23	1.50E-07	0.53	13.25	0.488754	6.63
5	1.20	0.28	1.50E-07	0.59	14.65		
6	1.20	0.25	1.05E-07	0.67	16.69	4.935375	66.93
7	1.20	0.25	1.95E-07	0.49	12.25		

E[FS] = 13.964650 E[ln FS] = 2.617971 Total 7.374243 100.00
Var[FS]= 7.374243
σ[FS]= 2.715556 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	13.588718
F(z) =	0.000000
Pr(f) % =	0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.010

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	55.86		
2	1.08	0.25	1.50E-07	0.50	50.27	31.201831	26.44
3	1.32	0.25	1.50E-07	0.61	61.44		
4	1.20	0.23	1.50E-07	0.53	52.99	7.820057	6.63
5	1.20	0.28	1.50E-07	0.59	58.58		
6	1.20	0.25	1.05E-07	0.67	66.76	78.966003	66.93
7	1.20	0.25	1.95E-07	0.49	48.99		

E[FS] = 55.858599 E[ln FS] = 4.004265 Total 117.987891 100.00
Var[FS]= 117.987891
σ[FS]= 10.862223 σ[ln FS]= 0.192658
V(FS) = 0.194459
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	20.784354
F(z) =	0.000000
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

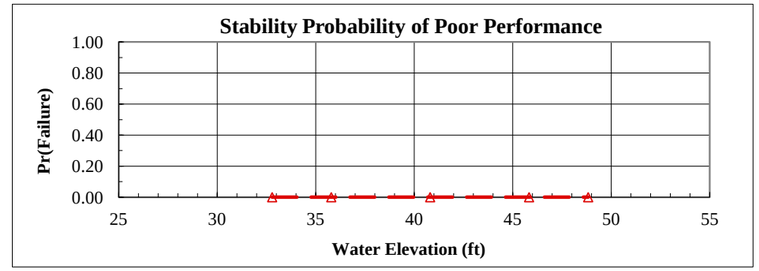
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case Without Project Cutoff Wall

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest	Head =	16.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.58		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft	Head =	13.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.59		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	8.02	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.61		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.67		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

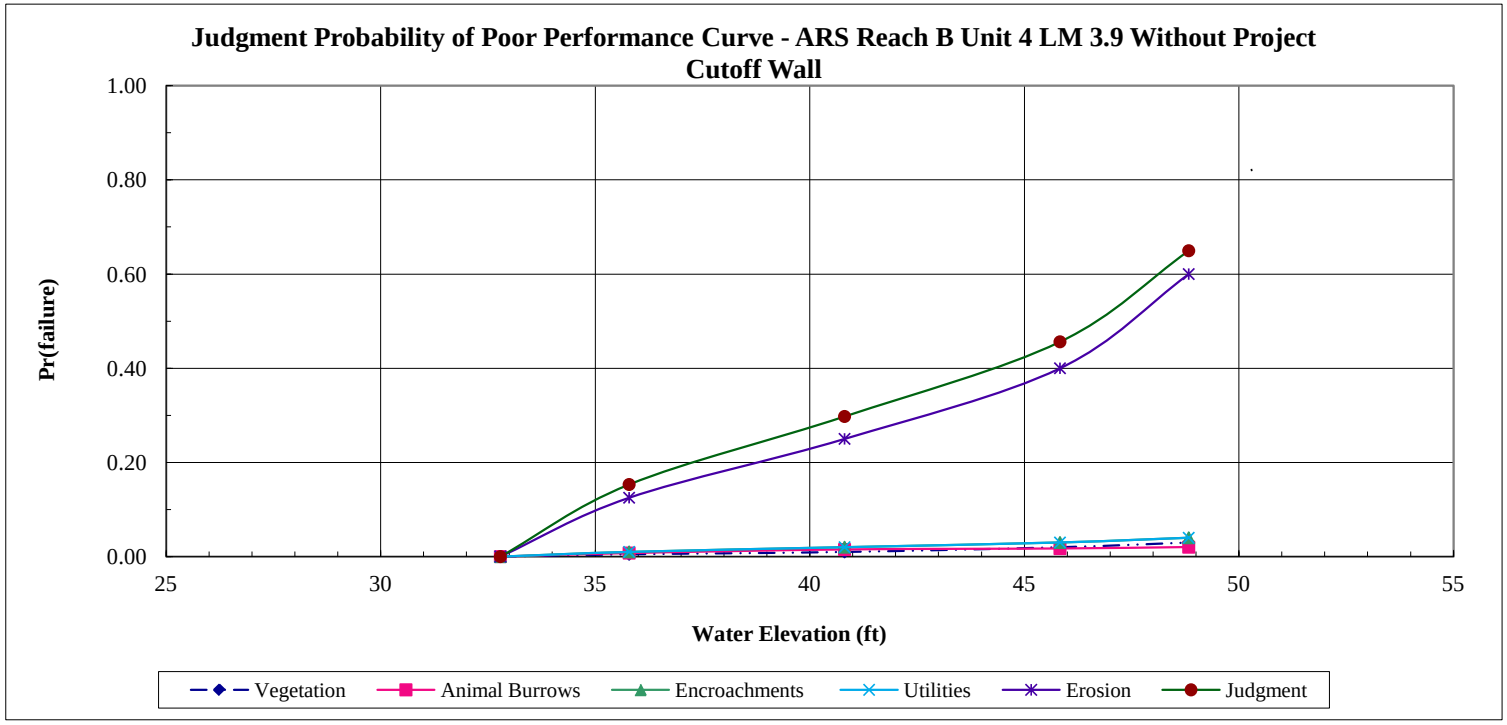
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	3.90	**Crest Elev.:**	48.83	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	3.94	**L/S Toe Elev.:**	32.79	**Checked By:**	H. Mulder
River Section:	ARS Reach B Unit 4	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	28.64	**Date:**	4/29/2011

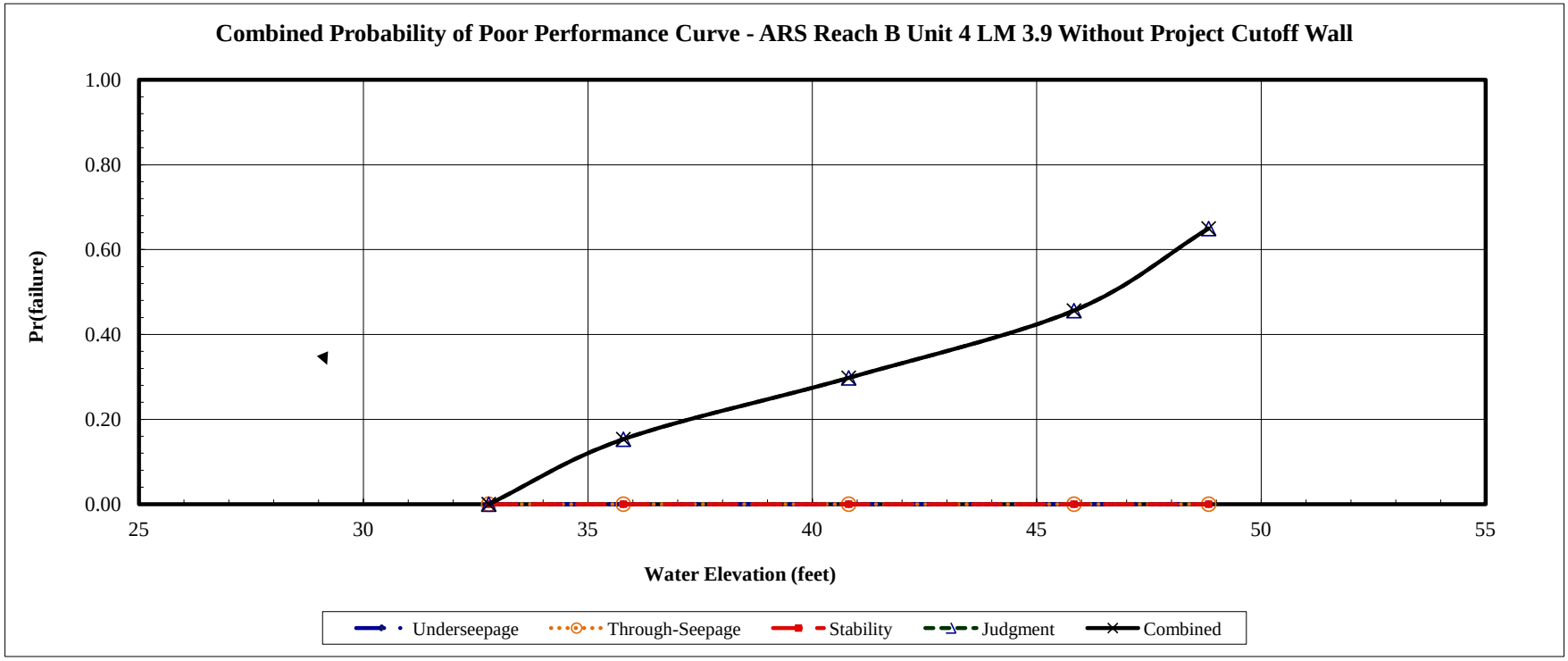
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.79	0.0050	0.9950	0.0075	0.9925	0.0100	0.9900	0.0100	0.9900	0.1250	0.8750	0.1531	0.8469
40.81	0.0100	0.9900	0.0150	0.9850	0.0200	0.9800	0.0200	0.9800	0.2500	0.7500	0.2976	0.7024
45.83	0.0200	0.9800	0.0170	0.9830	0.0300	0.9700	0.0300	0.9700	0.4000	0.6000	0.4562	0.5438
48.83	0.0300	0.9700	0.0200	0.9800	0.0400	0.9600	0.0400	0.9600	0.6000	0.4000	0.6496	0.3504



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	3.90	**Crest Elev.:**	48.83	**Analysis By:**	M. Kynett
Study Area:	American River	**River Mile:**	3.94	**L/S Toe Elev.:**	32.79	**Checked By:**	H. Mulder
River Section:	ARS Reach B Unit 4	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	28.64	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1531	0.8469	0.1531	0.8469
40.81	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.2976	0.7024	0.2976	0.7024
45.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.4562	0.5438	0.4562	0.5438
48.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.6496	0.3504	0.6496	0.3504



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: American River
Basin and Reach: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
WCSBAR-003B	9.5					45.5					ML	0.14	SM/SP-SM/GW	19.58	140				
2F-00-9W	7.96					30					ML/SM	0.14	SM/SP-SM/GW	16.89	121				
2F-97-23	9					31.2					CL/ML/SM	0.028	SM/SP-SM/GW	20.08	717				
2F-00-114	10.5					53					CL/SC/ML	0.035	SM/SP-SM/GW	20.84	595				
2F-08-03	14.5	10	3	32	30	43	41	10	499	24	ML	0.14	SP/GP	23.77	170	349	285	69780	82

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
WCSBAR-003B	ML	9.5	0.14				9.5	SM	17.5	2.8	SP-SM	5.5	14	GW	22.5	34	19.58
2F-00-9W	ML	4.5	0.14	SM	17.5	0.709	7.96	SM	11	2.8	SP-SM	8.5	14	GW	10.5	34	16.89
2F-97-23	CL	7	0.028	ML/SM	10	0.14	9	SM	9.85	2.8	SP-SM	6.35	14	GW	15	34	20.08
2F-00-114	CL/SC	9	0.035	ML	6	0.14	10.5	SM	10.5	2.8	SP-SM	18.5	14	GW	24	34	20.84
2F-08-03	ML	14.5	0.14				14.5	SP	22	14	GP	21	34				23.77

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

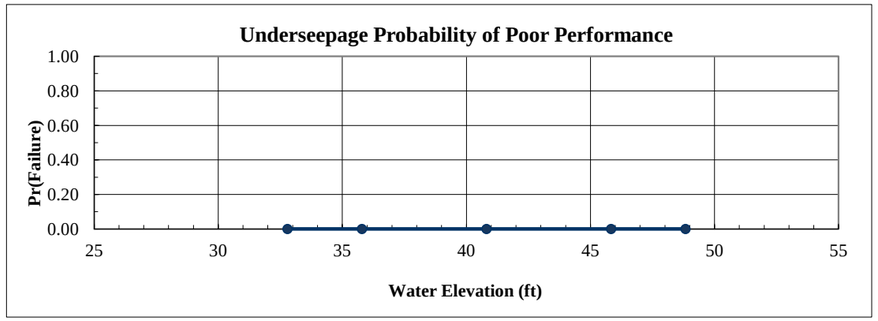
Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	349	285	82
Blanket Thickness (z)	10	3	30
Aquifer Thickness (d)	41	10	24

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	0	125	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.0000
Half Height	8.02	40.81	0.0000
Crest-3ft	13.04	45.83	0.0000
Crest	16.04	48.83	0.0000

Crest	Rh
Head = 16.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	12.06			
2	634	10.00	41.00	0.00	509.84	0.0646	12.88			
3	64	10.00	41.00	0.00	161.99	0.1429	9.05			
4	349	13.00	41.00	0.00	431.30	0.0737	12.44			
5	349	7.00	41.00	0.00	316.49	0.0929	11.50			
6	349	10.00	51.00	0.00	421.89	0.0933	12.37			
7	349	10.00	31.00	0.00	328.92	0.0683	11.62			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Rh
Head = 13.04	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	9.80			
2	634	10.00	41.00	0.00	509.84	0.0646	10.47			
3	64	10.00	41.00	0.00	161.99	0.1429	7.36			
4	349	13.00	41.00	0.00	431.30	0.0737	10.11			
5	349	7.00	41.00	0.00	316.49	0.0929	9.35			
6	349	10.00	51.00	0.00	421.89	0.0933	10.06			
7	349	10.00	31.00	0.00	328.92	0.0683	9.45			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Rh
Head = 8.02	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	6.03			
2	634	10.00	41.00	0.00	509.84	0.0646	6.44			
3	64	10.00	41.00	0.00	161.99	0.1429	4.53			
4	349	13.00	41.00	0.00	431.30	0.0737	6.22			
5	349	7.00	41.00	0.00	316.49	0.0929	5.75			
6	349	10.00	51.00	0.00	421.89	0.0933	6.19			
7	349	10.00	31.00	0.00	328.92	0.0683	5.81			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	349	10.00	41.00	0.00	378.27	0.0815	2.25			
2	634	10.00	41.00	0.00	509.84	0.0646	2.41			
3	64	10.00	41.00	0.00	161.99	0.1429	1.69			
4	349	13.00	41.00	0.00	431.30	0.0737	2.33			
5	349	7.00	41.00	0.00	316.49	0.0929	2.15			
6	349	10.00	51.00	0.00	421.89	0.0933	2.31			
7	349	10.00	31.00	0.00	328.92	0.0683	2.17			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic= 0.80

ln(I crit) = -0.223144

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

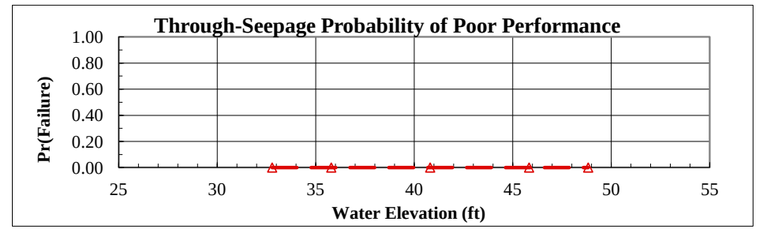
Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	1.2	0.1	10.00
Initial Porosity (n)	0.25	0.03	10.00
Intrinsic Permeability (Ko)	1.50E-07	4.50E-08	30.00

Pr(f)=0
NO



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest	Head =	16.04	Horizontal Gradient (Ix) =	0.120

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	4.65		
2	1.08	0.25	1.50E-07	0.50	4.19	0.216679	26.44
3	1.32	0.25	1.50E-07	0.61	5.12		
4	1.20	0.23	1.50E-07	0.53	4.42	0.054306	6.63
5	1.20	0.28	1.50E-07	0.59	4.88		
6	1.20	0.25	1.05E-07	0.67	5.56	0.548375	66.93
7	1.20	0.25	1.95E-07	0.49	4.08		

E[FS] =	4.654883	E[ln FS] =	1.519358	Total	0.819360	100.00
Var[FS]=	0.819360				
σ[FS]=	0.905185	σ[ln FS]=	0.192658	β =	7.886311
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Crest-3ft	Head =	13.04	Horizontal Gradient (Ix) =	0.090

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	6.21		
2	1.08	0.25	1.50E-07	0.50	5.59	0.385208	26.44
3	1.32	0.25	1.50E-07	0.61	6.83		
4	1.20	0.23	1.50E-07	0.53	5.89	0.096544	6.63
5	1.20	0.28	1.50E-07	0.59	6.51		
6	1.20	0.25	1.05E-07	0.67	7.42	0.974889	66.93
7	1.20	0.25	1.95E-07	0.49	5.44		

E[FS] =	6.206511	E[ln FS] =	1.807040	Total	1.456641	100.00
Var[FS]=	1.456641				
σ[FS]=	1.206914	σ[ln FS]=	0.192658	β =	9.379541
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Half Height	Head =	8.02	Horizontal Gradient (Ix) =	0.040

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	13.96		
2	1.08	0.25	1.50E-07	0.50	12.57	1.950114	26.44
3	1.32	0.25	1.50E-07	0.61	15.36		
4	1.20	0.23	1.50E-07	0.53	13.25	0.488754	6.63
5	1.20	0.28	1.50E-07	0.59	14.65		
6	1.20	0.25	1.05E-07	0.67	16.69	4.935375	66.93
7	1.20	0.25	1.95E-07	0.49	12.25		

E[FS] =	13.964650	E[ln FS] =	2.617971	Total	7.374243	100.00
Var[FS]=	7.374243				
σ[FS]=	2.715556	σ[ln FS]=	0.192658	β =	13.588718
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Horizontal Gradient (Ix) =	0.010

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	1.20	0.25	1.50E-07	0.56	55.86		
2	1.08	0.25	1.50E-07	0.50	50.27	31.201831	26.44
3	1.32	0.25	1.50E-07	0.61	61.44		
4	1.20	0.23	1.50E-07	0.53	52.99	7.820057	6.63
5	1.20	0.28	1.50E-07	0.59	58.58		
6	1.20	0.25	1.05E-07	0.67	66.76	78.966003	66.93
7	1.20	0.25	1.95E-07	0.49	48.99		

E[FS] =	55.858599	E[ln FS] =	4.004265	Total	117.987891	100.00
Var[FS]=	117.987891				
σ[FS]=	10.862223	σ[ln FS]=	0.192658	β =	20.784354
V(FS) =	0.194459			F(z) =	0.000000
FS req'd =	1.00	ln(FS req'd) =	0.000000	Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

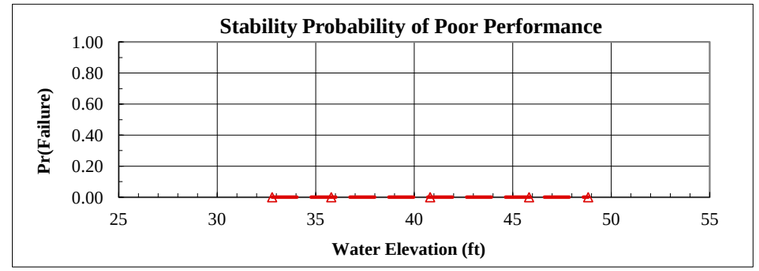
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	32.79	0.0000
Toe+3ft	3.00	35.79	0.000000
Half Height	8.02	40.81	0.000000
Crest-3ft	13.04	45.83	0.000000
Crest	16.04	48.83	0.000000

Crest	Head =	16.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.58		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft	Head =	13.04	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.59		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height	Head =	8.02	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.61		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.67		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

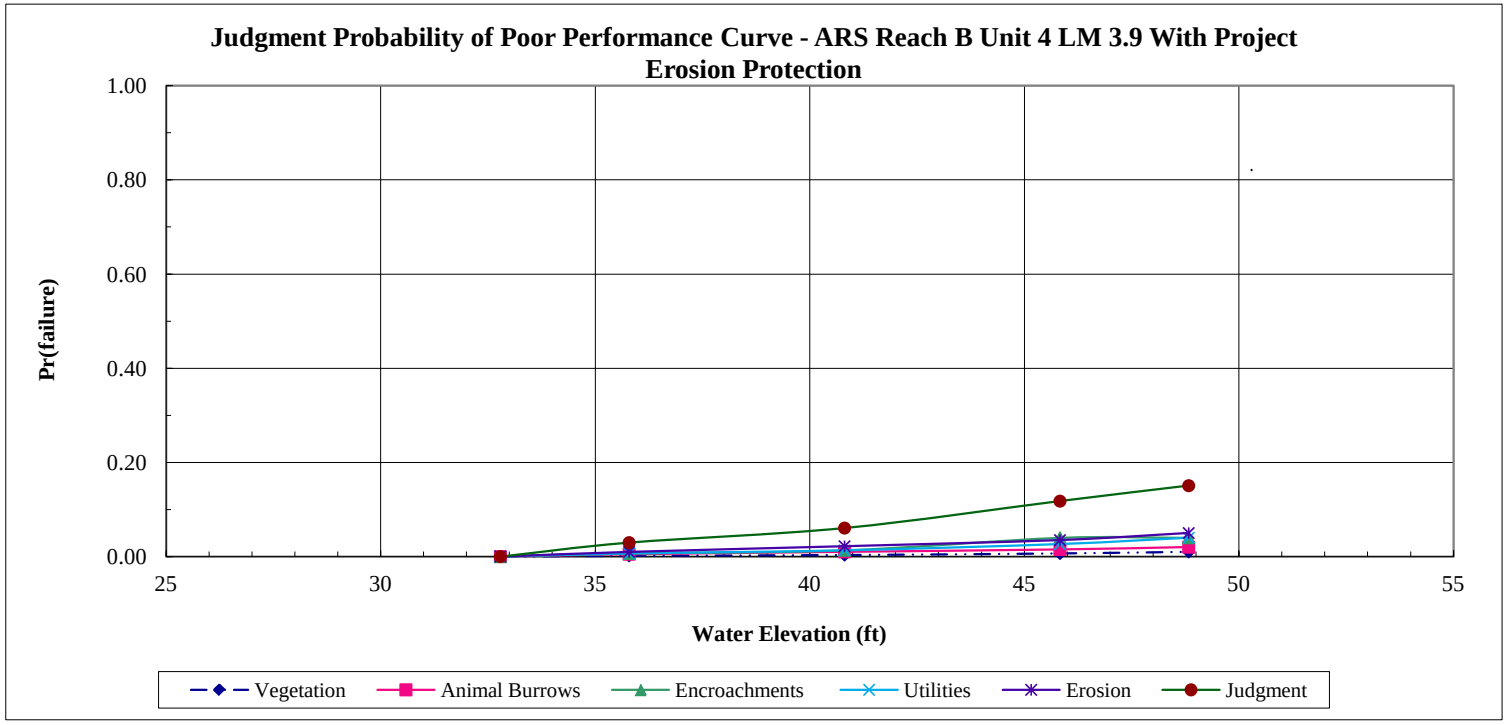
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case: With Project Erosion Protect

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.00000	1.0000	0.0000	1.0000
35.79	0.00167	0.9983	0.00500	0.9950	0.00667	0.9933	0.00667	0.9933	0.01000	0.9900	0.0297	0.9703
40.81	0.00333	0.9967	0.01000	0.9900	0.01333	0.9867	0.01333	0.9867	0.02200	0.9780	0.0606	0.9394
45.83	0.00667	0.9933	0.01500	0.9850	0.04000	0.9600	0.02667	0.9733	0.03500	0.9650	0.1178	0.8822
48.83	0.01000	0.9900	0.02000	0.9800	0.04000	0.9600	0.04000	0.9600	0.05000	0.9500	0.1506	0.8494



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

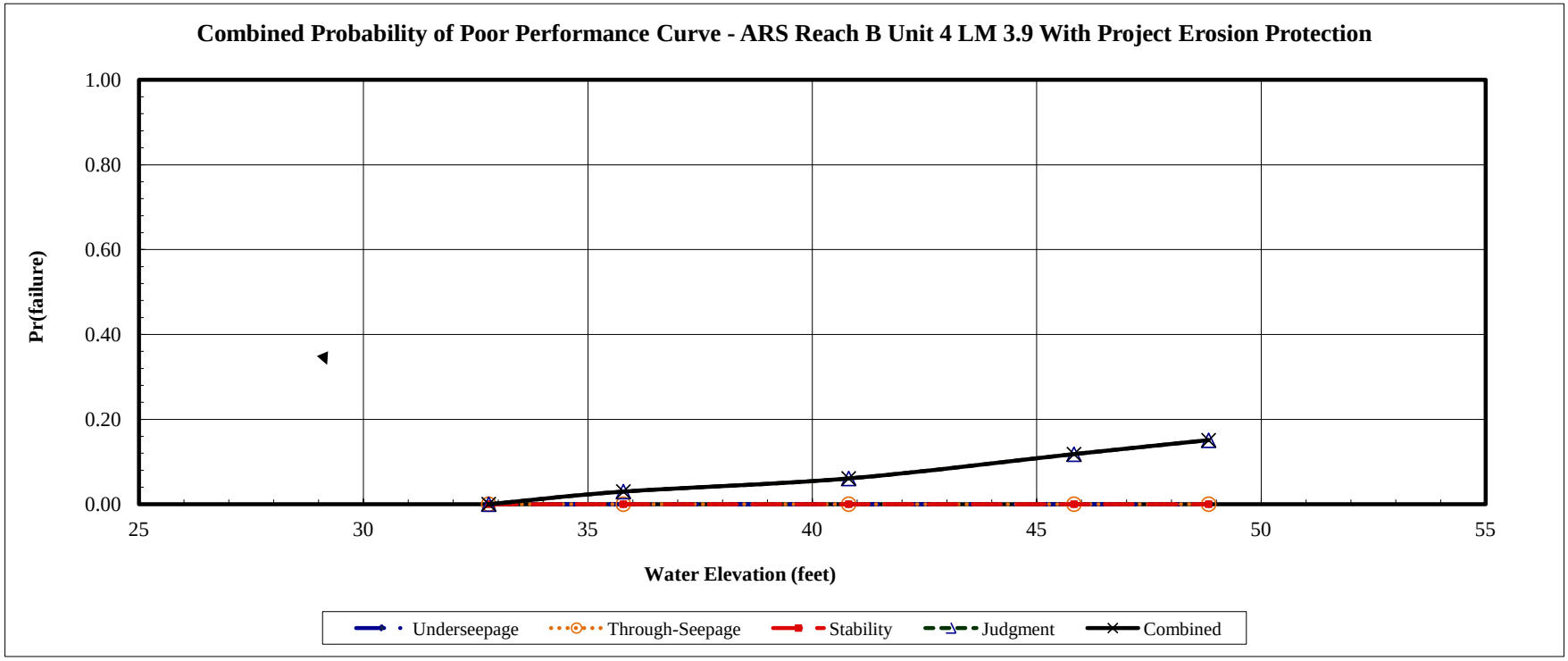
Project: American River Common Features GRR
Study Area: American River
River Section: ARS Reach B Unit 4

Levee Mile: 3.90
River Mile: 3.94
Analysis Case: With Project Erosion Protection

Crest Elev.: 48.83
L/S Toe Elev.: 32.79
W/S Toe Elev.: 28.64

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
35.79	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
40.81	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0606	0.9394	0.0606	0.9394
45.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1178	0.8822	0.1178	0.8822
48.83	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1506	0.8494	0.1506	0.8494



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Sacramento River
Basin and Reach: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-05-G4-1	32					57.4					ML	0.14	SP/ML	25.13	180				
2F-05-G4-1A	32					63.5					ML	0.14	L/SM/SP/GP-G	24.85	178				
2F-05-G4-2	13.11					94					ML/SM	0.14	SM/SP/GW	20.88	149				
2F-05-G4-2A	16					67.2					ML	0.14	SM/SP/GP-GM	12.47	89				
K-S-4	9.75	20	9	118	45	95.25	83	16	911	19	CL/ML/ML/SM	0.028	SP/GP	29.51	1054	289	361	124190	98
2F-05-G4-3	26					96.8					ML	0.14	SM/SP/GP	22.23	159				
2F-05-G4-3A	8.5					90					CL	0.028	SM/SP/GP-GM	20.99	750				
K-S-2	28					91					SM	0.709	SM/SP-SM/GP	15.12	21				
K-S-3	18.5					93.5					SM	0.709	SM/SP-SM/GM	13.54	19				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-05-G4-1	ML	32	0.14				32	SP	51.4	28	ML	6	0.57				25.13
2F-05-G4-1A	ML	32	0.14				32	ML/SM	9	2.8	SP	50	28	GP-GM	4.5	34	24.85
2F-05-G4-2	ML	10.8	0.14	SM	11.7	0.709	13.11	SM	33	2.8	SP	34	28	GW	27	34	20.88
2F-05-G4-2A	ML	16	0.14				16	SM	43.8	2.8	SP	13.4	28	GP-GM	10	34	12.47
K-S-4	CL/ML	6	0.028	ML/SM	18.75	0.14	9.75	SP	71.25	28	GP	24	34				29.51
2F-05-G4-3	ML	26	0.14				26	SM	33	2.8	SP	18.3	28	GP	45.5	34	22.23
2F-05-G4-3A	CL	8.5	0.028				8.5	SM	31	2.8	SP	34	28	GP-GM	25	34	20.99
K-S-2	SM	28	0.709				28	SM	15	2.8	SP-SM	62.5	14	GP	13.5	34	15.12
K-S-3	SM	18.5	0.709				18.5	SM	19	2.8	SP-SM	66	14	GM	8.5	34	13.54

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

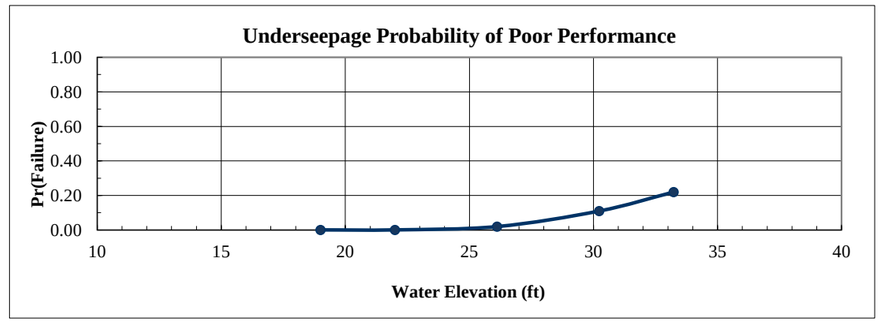
Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	289	283	98
Blanket Thickness (z)	20	9	45
Aquifer Thickness (d)	83	16	19

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
NO	7A	20	95	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	19.00	0.0000
Toe+3ft	3.00	22.00	0.0001
Half Height	7.12	26.12	0.0193
Crest-3ft	11.23	30.23	0.1094
Crest	14.23	33.23	0.2194

Crest	Rh
Head = 14.23	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	12.20	0.61		
2	572	20.00	83.00	20.00	974.62	0.0762	12.73	0.64	0.024025	19.48
3	6	20.00	83.00	19.73	97.95	0.3903	6.55	0.33		
4	289	29.00	83.00	20.00	834.04	0.0875	12.51	0.43	0.099225	80.44
5	289	11.00	83.00	19.99	513.67	0.1320	11.63	1.06		
6	289	20.00	99.00	20.00	756.45	0.1136	12.35	0.62	0.000100	0.08
7	289	20.00	67.00	19.99	622.30	0.0909	12.01	0.60		
								Total	0.123350	100.00

E[I] = 0.610000
Var[I]= 0.123350
σ[I]= 0.351212
V(I) = 0.575758

E[ln I] = -0.637448
σ [ln I] = 0.535074

Ic= 0.80
ln(I crit) = -0.223144

β = -1.191328
F(z) = 0.780622
Pr(f) % = 21.937828

Crest-3ft	Rh
Head = 11.23	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	9.63	0.48		
2	572	20.00	83.00	20.00	974.62	0.0762	10.04	0.50	0.014400	19.32
3	6	20.00	83.00	19.73	97.95	0.3903	5.17	0.26		
4	289	29.00	83.00	20.00	834.04	0.0875	9.87	0.34	0.060025	80.54
5	289	11.00	83.00	19.99	513.67	0.1320	9.18	0.83		
6	289	20.00	99.00	20.00	756.45	0.1136	9.75	0.49	0.000100	0.13
7	289	20.00	67.00	19.99	622.30	0.0909	9.48	0.47		
								Total	0.074525	100.00

E[I] = 0.480000
Var[I]= 0.074525
σ[I]= 0.272993
V(I) = 0.568735

E[ln I] = -0.874094
σ [ln I] = 0.529385

Ic= 0.80
ln(I crit) = -0.223144

β = -1.651148
F(z) = 0.890583
Pr(f) % = 10.941717

Half Height	Rh
Head = 7.12	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	6.10	0.31		
2	572	20.00	83.00	20.00	974.62	0.0762	6.36	0.32	0.006400	21.02
3	6	20.00	83.00	19.73	97.95	0.3903	3.28	0.16		
4	289	29.00	83.00	20.00	834.04	0.0875	6.25	0.22	0.024025	78.90
5	289	11.00	83.00	19.99	513.67	0.1320	5.81	0.53		
6	289	20.00	99.00	20.00	756.45	0.1136	6.18	0.31	0.000025	0.08
7	289	20.00	67.00	19.99	622.30	0.0909	6.01	0.30		
								Total	0.030450	100.00

E[I] = 0.310000
Var[I]= 0.030450
σ[I]= 0.174499
V(I) = 0.562901

E[ln I] = -1.308807
σ [ln I] = 0.524641

Ic= 0.80
ln(I crit) = -0.223144

β = -2.494672
F(z) = 0.980743
Pr(f) % = 1.925683

Toe+3ft	Rh
Head = 3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	289	20.00	83.00	19.99	692.63	0.1028	2.57	0.13		
2	572	20.00	83.00	20.00	974.62	0.0762	2.68	0.13	0.000900	17.56
3	6	20.00	83.00	19.73	97.95	0.3903	1.38	0.07		
4	289	29.00	83.00	20.00	834.04	0.0875	2.64	0.09	0.004225	82.44
5	289	11.00	83.00	19.99	513.67	0.1320	2.45	0.22		
6	289	20.00	99.00	20.00	756.45	0.1136	2.60	0.13	0.000000	0.00
7	289	20.00	67.00	19.99	622.30	0.0909	2.53	0.13		
								Total	0.005125	100.00

E[I] = 0.130000
Var[I]= 0.005125
σ[I]= 0.071589
V(I) = 0.550685

E[ln I] = -2.172653
σ [ln I] = 0.514650

Ic= 0.80
ln(I crit) = -0.223144

β = -4.221614
F(z) = 0.999924
Pr(f) % = 0.007592

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

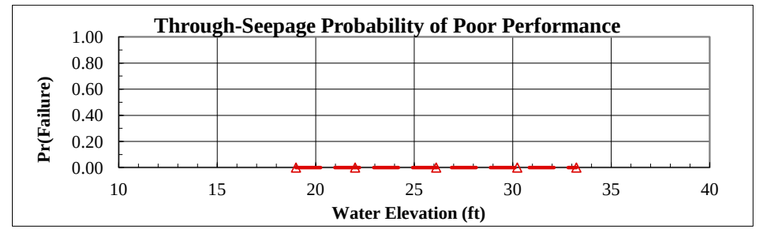
Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.8	0.1	10.00
Initial Porosity (n)	0.35	0.04	10.00
Intrinsic Permeability (Ko)	5.00E-07	1.50E-07	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	19.00	0.0000
Toe+3ft	3.00	22.00	0.000000
Half Height	7.12	26.12	0.000000
Crest-3ft	11.23	30.23	0.000000
Crest	14.23	33.23	0.000000

Crest | **Head =** 14.23 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 11.23 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 7.12 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

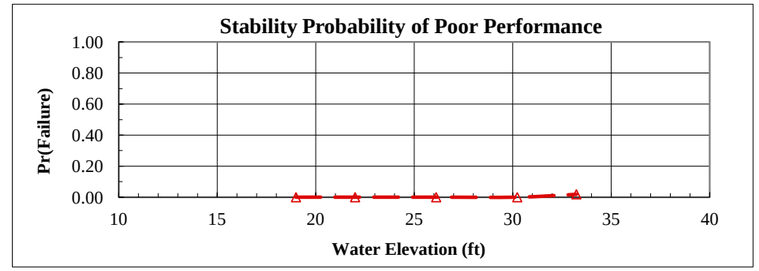
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case Without Project Cutoff Wall

Crest Elev.: 33.23
L/S Toe Elev.: 19.00
W/S Toe Elev.: 22.00

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	33	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	30	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	19.00	0.0000
Toe+3ft	3.00	22.00	0.000000
Half Height	7.12	26.12	0.000000
Crest-3ft	11.23	30.23	0.000000
Crest	14.23	33.23	0.019060

Crest	Head =	14.23	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.28		
2	29	0	125	30	0	1.21	0.010000	45.20
3	37	0	125	30	0	1.41		
4	33	0	125	30	0	1.28	0.000000	0.00
5	33	0	125	30	0	1.28		
6	33	0	116	30	0	1.33	0.000025	0.11
7	33	0	134	30	0	1.32		
8	33	0	125	26	0	1.21	0.012100	54.69
9	33	0	125	34	0	1.43		
10	33	0	125	30	0	1.28	0.000000	0.00
11	33	0	125	30	0	1.28		

E[FS] = 1.280000 E[ln FS] = 0.240153 Total 0.022125 100.00
Var[FS]= 0.022125
σ[FS]= 0.148745 σ[ln FS]= 0.115817
V(FS) = 0.116207
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	2.073551
F(z) =	0.019060
Pr(f) % =	1.906050

Crest-3ft	Head =	11.23	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.32		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	7.12	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.40		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	33	0	125	30	0	1.46		
2	29	0	125	30	0			
3	37	0	125	30	0			
4	33	0	125	30	0			
5	33	0	125	30	0			
6	33	0	116	30	0			
7	33	0	134	30	0			
8	33	0	125	26	0			
9	33	0	125	34	0			
10	33	0	125	30	0			
11	33	0	125	30	0			

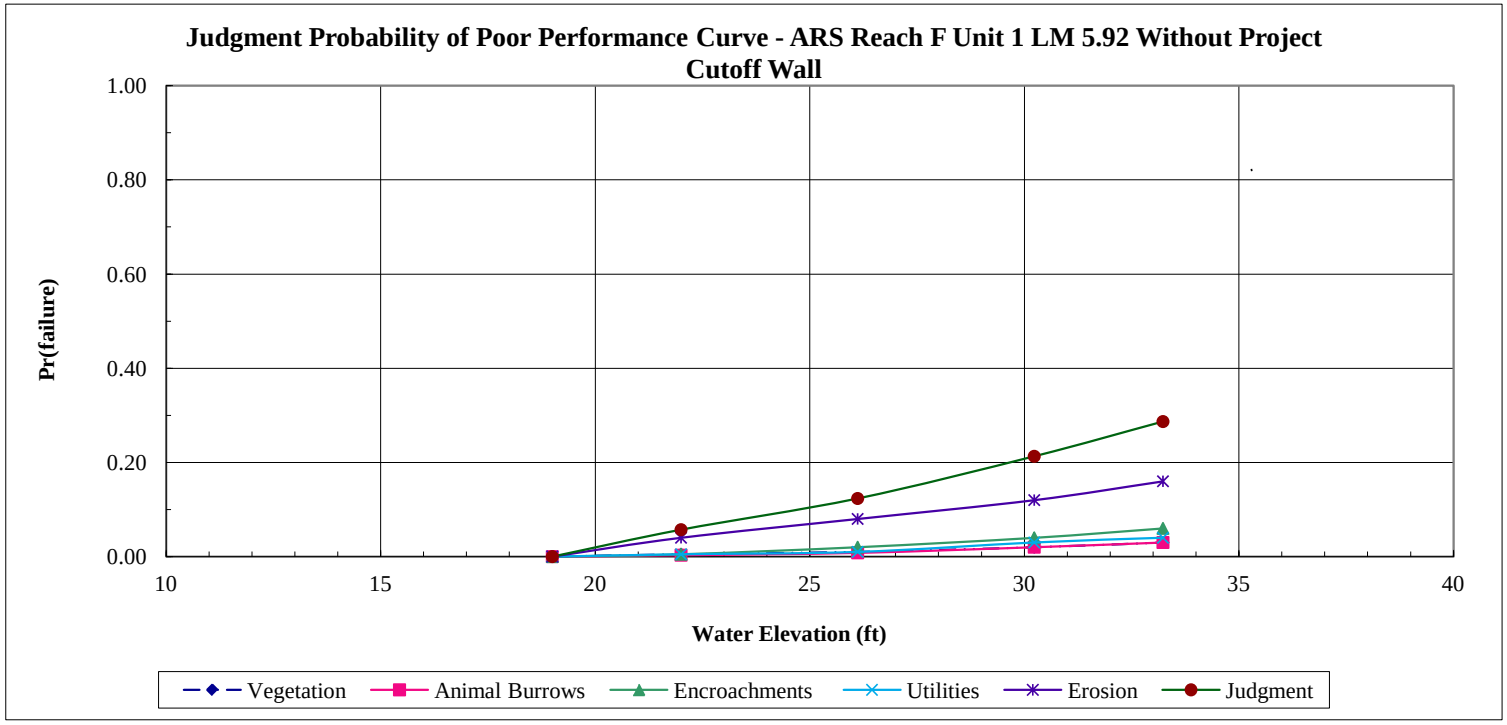
E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	5.92	**Crest Elev.:**	33.23	**Analysis By:**	M. Kynett
Study Area:	Sacramento River	**River Mile:**	50.21	**L/S Toe Elev.:**	19.00	**Checked By:**	H. Mulder
River Section:	ARS Reach F Unit 1	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	22.00	**Date:**	4/29/2011

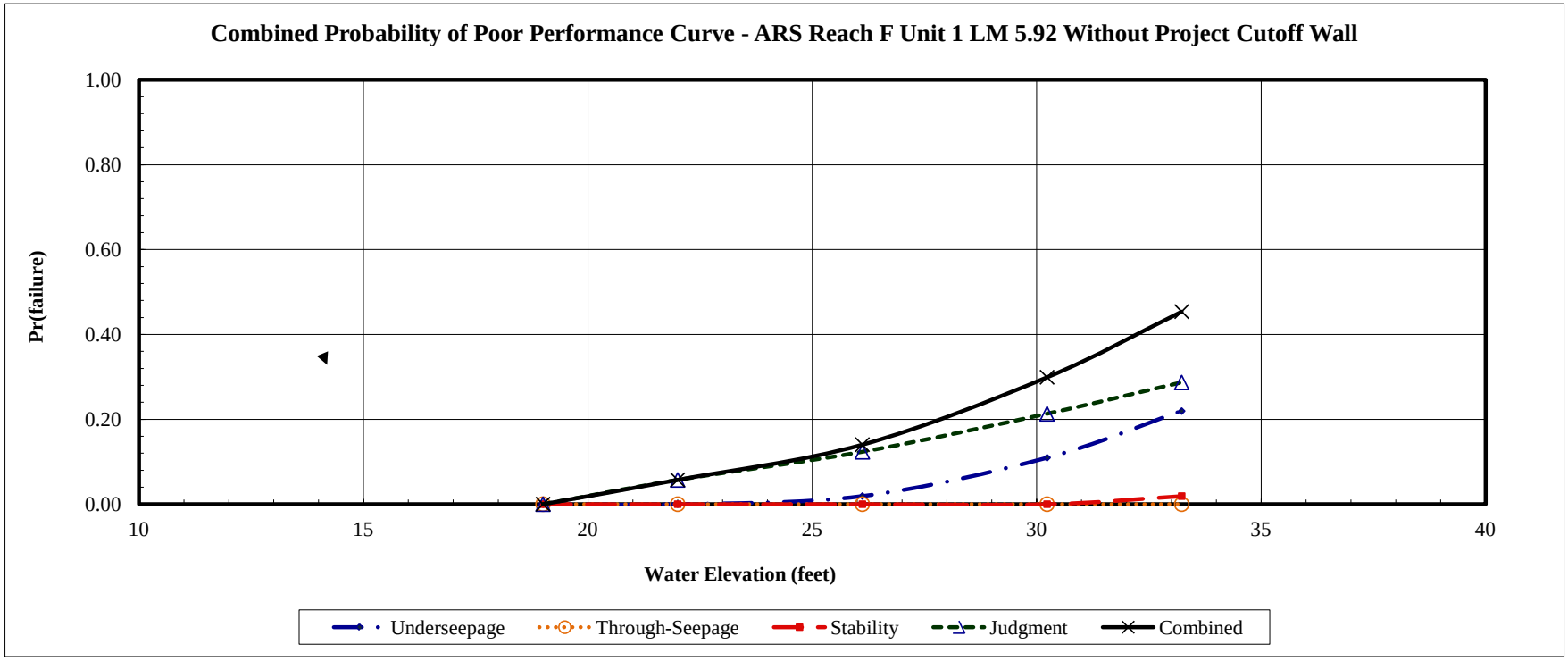
Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
22.00	0.0050	0.9950	0.0030	0.9970	0.0050	0.9950	0.0050	0.9950	0.0400	0.9600	0.0572	0.9428
26.12	0.0100	0.9900	0.0080	0.9920	0.0200	0.9800	0.0100	0.9900	0.0800	0.9200	0.1234	0.8766
30.23	0.0200	0.9800	0.0200	0.9800	0.0400	0.9600	0.0300	0.9700	0.1200	0.8800	0.2130	0.7870
33.23	0.0300	0.9700	0.0300	0.9700	0.0600	0.9400	0.0400	0.9600	0.1600	0.8400	0.2868	0.7132



Without Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

Project:	American River Common Features GRR	**Levee Mile:**	5.92	**Crest Elev.:**	33.23	**Analysis By:**	M. Kynett
Study Area:	Sacramento River	**River Mile:**	50.21	**L/S Toe Elev.:**	19.00	**Checked By:**	H. Mulder
River Section:	ARS Reach F Unit 1	**Analysis Case:**	Without Project Cutoff Wall	**W/S Toe Elev.:**	22.00	**Date:**	4/29/2011

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
19.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
22.00	0.0001	0.9999	0.0000	1.0000	0.0000	1.0000	0.0572	0.9428	0.0572	0.9428
26.12	0.0193	0.9807	0.0000	1.0000	0.0000	1.0000	0.1234	0.8766	0.1403	0.8597
30.23	0.1094	0.8906	0.0000	1.0000	0.0000	1.0000	0.2130	0.7870	0.2991	0.7009
33.23	0.2194	0.7806	0.0000	1.0000	0.0191	0.9809	0.2868	0.7132	0.4539	0.5461



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Determination of Random Variables For Underseepage Reliability Analysis

Project: American River Common Features GRR
Channel: Sacramento River
Basin and Reach: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Boring #	Blanket Thickness Variable (z)					Aquifer Thickness Variable (d)					Hydraulic Conductivity Vairables (Kb and Kf)								
	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Layer Thickness (ft)	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation	Blanket Material	Blanket Kb (ft/day)	Aquifer Material Material	Aquifer Material Kf (ft/day)	Kf/Kb	Mean (MLV)	Standard Deviation	Variation	Coefficient of Variation
2F-05-G4-1	32					57.4					ML	0.14	SP/ML	25.13	180				
2F-05-G4-1A	32					63.5					ML	0.14	L/SM/SP/GP-G	24.85	178				
2F-05-G4-2	13.11					94					ML/SM	0.14	SM/SP/GW	20.88	149				
2F-05-G4-2A	16					67.2					ML	0.14	SM/SP/GP-GM	12.47	89				
K-S-4	9.75	19	9	111	47	95.25	83	16	911	19	CL/ML/ML/SM	0.028	SP/GP	29.51	1054	359	393	150273	98
2F-05-G4-3	16					96.8					CL/ML	0.028	SM/SP/GP	22.23	794				
2F-05-G4-3A	8.5					90					CL	0.028	SM/SP/GP-GM	20.99	750				
K-S-2	28					91					SM	0.709	SM/SP-SM/GP	15.12	21				
K-S-3	18.5					93.5					SM	0.709	SM/SP-SM/GM	13.54	19				

Boring #	Blanket Material 1 (lowest permeability)			Blanket Material 2			Transformed Blanket Thickness (z)	Aquifer Material 1			Aquifer Material 2			Aquifer Material 3			Transformed Aquifer Horizontal Permeability (kf)
	Material Type	Thickness (z)	Permeability (Kb)	Material Type	Thickness (z)	Permeability (Kb)		Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	Material Type	Thickness (d)	Permeability (Kf)	
2F-05-G4-1	ML	32	0.14				32	SP	51.4	28	ML	6	0.57				25.13
2F-05-G4-1A	ML	32	0.14				32	ML/SM	9	2.8	SP	50	28	GP-GM	4.5	34	24.85
2F-05-G4-2	ML	10.8	0.14	SM	11.7	0.709	13.11	SM	33	2.8	SP	34	28	GW	27	34	20.88
2F-05-G4-2A	ML	16	0.14				16	SM	43.8	2.8	SP	13.4	28	GP-GM	10	34	12.47
K-S-4	CL/ML	6	0.028	ML/SM	18.75	0.14	9.75	SP	71.25	28	GP	24	34				29.51
2F-05-G4-3	CL	10	0.028	ML	30	0.14	16	SM	33	2.8	SP	18.3	28	GP	45.5	34	22.23
2F-05-G4-3A	CL	8.5	0.028				8.5	SM	31	2.8	SP	34	28	GP-GM	25	34	20.99
K-S-2	SM	28	0.709				28	SM	15	2.8	SP-SM	62.5	14	GP	13.5	34	15.12
K-S-3	SM	18.5	0.709				18.5	SM	19	2.8	SP-SM	66	14	GM	8.5	34	13.54

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Underseepage Reliability Analysis With Blanket Theory Analysis

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

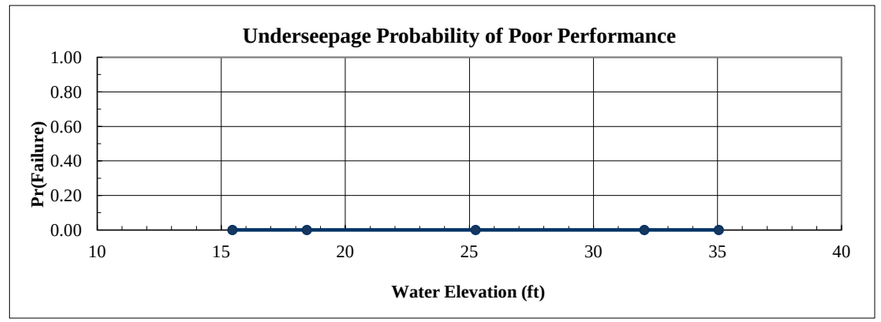
Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Random Variables			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Permaebility Ratio	359	352	98
Blanket Thickness (z)	19	9	47
Aquifer Thickness (d)	83	16	19

Blanket Theory Analysis Inputs					
Pr(f)=0	BTA Case No.	L1	L2	L3	γ Blanket
YES	7A	20	95	∞	112



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	15.45	0.0000
Toe+3ft	3.00	18.45	0.0000
Half Height	9.80	25.25	0.0000
Crest-3ft	16.60	32.05	0.0000
Crest	19.60	35.05	0.0000

Crest		Rh
Head =	19.60	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	17.00			
2	711	19.00	83.00	20.00	1058.76	0.0707	17.68			
3	7	19.00	83.00	19.77	106.41	0.3753	9.43			
4	359	28.00	83.00	20.00	913.41	0.0807	17.41			
5	359	10.00	83.00	19.99	545.87	0.1256	16.19			
6	359	19.00	99.00	20.00	821.75	0.1057	17.19			
7	359	19.00	67.00	19.99	676.02	0.0847	16.75			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

Crest-3ft		Rh
Head =	16.60	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	14.40			
2	711	19.00	83.00	20.00	1058.76	0.0707	14.97			
3	7	19.00	83.00	19.77	106.41	0.3753	7.99			
4	359	28.00	83.00	20.00	913.41	0.0807	14.74			
5	359	10.00	83.00	19.99	545.87	0.1256	13.71			
6	359	19.00	99.00	20.00	821.75	0.1057	14.56			
7	359	19.00	67.00	19.99	676.02	0.0847	14.19			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height		Rh
Head =	9.80	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	8.50			
2	711	19.00	83.00	20.00	1058.76	0.0707	8.84			
3	7	19.00	83.00	19.77	106.41	0.3753	4.71			
4	359	28.00	83.00	20.00	913.41	0.0807	8.70			
5	359	10.00	83.00	19.99	545.87	0.1256	8.09			
6	359	19.00	99.00	20.00	821.75	0.1057	8.60			
7	359	19.00	67.00	19.99	676.02	0.0847	8.38			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft		Rh
Head =	3.00	

Run	Kf/Kb	z	d	x1	x3	$	hx	I	Variance Component	% Variance
1 (Mean)	359	19.00	83.00	20.00	752.42	0.0957	2.60			
2	711	19.00	83.00	20.00	1058.76	0.0707	2.71			
3	7	19.00	83.00	19.77	106.41	0.3753	1.44			
4	359	28.00	83.00	20.00	913.41	0.0807	2.66			
5	359	10.00	83.00	19.99	545.87	0.1256	2.48			
6	359	19.00	99.00	20.00	821.75	0.1057	2.63			
7	359	19.00	67.00	19.99	676.02	0.0847	2.56			
								Total		

E[I] =
Var[I]=
σ[I]=
V(I) =

E[ln I] =
σ [ln I] =

Ic=	0.80

ln(I crit) = -0.223144

β =	
F(z) =	
Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Through-Seepage Reliability Analysis With Khilar's Extended Model

Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

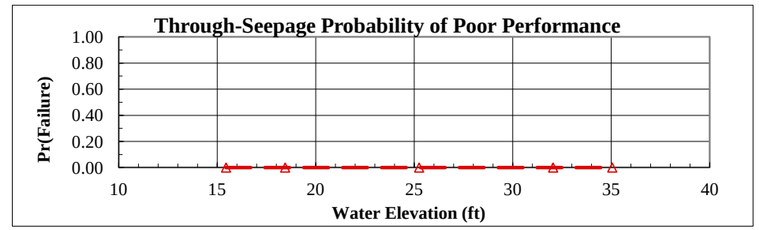
Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Random Variables - Silty Sand (SM) and Sand (SP) Levee			
Parameter	Expected Value	Standard Deviation	Coefficient of Variation, %
Tractive Stress (Tc)	0.8	0.1	10.00
Initial Porosity (n)	0.35	0.04	10.00
Intrinsic Permeability (Ko)	5.00E-07	1.50E-07	30.00

Pr(f)=0
YES



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	15.45	0.0000
Toe+3ft	3.00	18.45	0.000000
Half Height	9.80	25.25	0.000000
Crest-3ft	16.60	32.05	0.000000
Crest	19.60	35.05	0.000000

Crest | **Head =** 19.60 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Crest-3ft | **Head =** 16.60 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Half Height | **Head =** 9.80 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

Toe+3ft | **Head =** 3.00 | **Horizontal Gradient (Ix) =** 0.000

Run	Tractive Stress (Tc)	Initial Porosity (n)	Intrinsic Permeability (Ko)	Critical Gradient (Ic)	FS	Variance Component	% Variance
1 (Mean)	0.80	0.35	5.00E-07	0.24			
2	0.72	0.35	5.00E-07	0.22			
3	0.88	0.35	5.00E-07	0.27			
4	0.80	0.32	5.00E-07	0.23			
5	0.80	0.39	5.00E-07	0.25			
6	0.80	0.35	3.50E-07	0.29			
7	0.80	0.35	6.50E-07	0.21			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =
F(z) =
Pr(f) % = 0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Landside Long-Term Stability Analysis With UTEXAS4

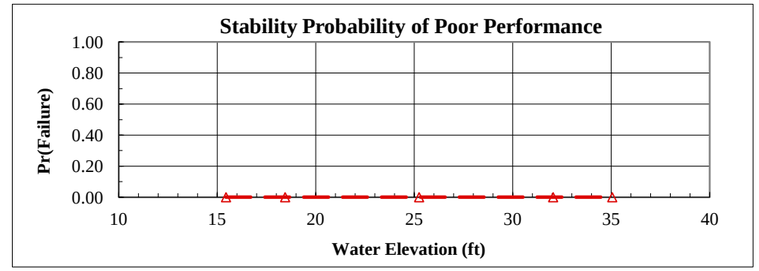
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Random Variables			
Parameter	**Expected Value**	**Standard Deviation**	**Coefficient of Variation, %**
Levee Φ	34	4	13.00
Levee Cohesion	0	0	40.00
Levee γ	125	9	7.00
Foundation Φ	28	4	13.00
Foundation Cohesion	0	0	40.00



Analysis Case	Head	Elevation	Pr(f)
Toe	0.00	15.45	0.0000
Toe+3ft	3.00	18.45	0.000000
Half Height	9.80	25.25	0.000000
Crest-3ft	16.60	32.05	0.000000
Crest	19.60	35.05	0.000001

Crest	Head =	19.60	Pr(f)=0	NO

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0	1.37		
2	30	0	125	28	0	1.28	0.005625	71.62
3	38	0	125	28	0	1.43		
4	34	0	125	28	0	1.37	0.000000	0.00
5	34	0	125	28	0	1.37		
6	34	0	116	28	0	1.39	0.000380	4.84
7	34	0	134	28	0	1.35		
8	34	0	125	24	0	1.43	0.001849	23.54
9	34	0	125	32	0	1.52		
10	34	0	125	28	0	1.37	0.000000	0.00
11	34	0	125	28	0	1.37		

E[FS] = 1.370000 E[ln FS] = 0.312723 Total 0.007854 100.00
Var[FS]= 0.007854
σ[FS]= 0.088624 σ[ln FS]= 0.064622
V(FS) = 0.064689
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	4.839286
F(z) =	0.000001
Pr(f) % =	0.000065

Crest-3ft	Head =	16.60	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0			
2	30	0	125	28	0			
3	38	0	125	28	0			
4	34	0	125	28	0			
5	34	0	125	28	0			
6	34	0	116	28	0			
7	34	0	134	28	0			
8	34	0	125	24	0			
9	34	0	125	32	0			
10	34	0	125	28	0			
11	34	0	125	28	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Half Height	Head =	9.80	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0			
2	30	0	125	28	0			
3	38	0	125	28	0			
4	34	0	125	28	0			
5	34	0	125	28	0			
6	34	0	116	28	0			
7	34	0	134	28	0			
8	34	0	125	24	0			
9	34	0	125	32	0			
10	34	0	125	28	0			
11	34	0	125	28	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

Toe+3ft	Head =	3.00	Pr(f)=0	YES

Run	Levee Φ	Levee Cohesion	Levee γ	Foundation Φ	Foundation Cohesion	FS	Variance Component	% Variance
1 (Mean)	34	0	125	28	0			
2	30	0	125	28	0			
3	38	0	125	28	0			
4	34	0	125	28	0			
5	34	0	125	28	0			
6	34	0	116	28	0			
7	34	0	134	28	0			
8	34	0	125	24	0			
9	34	0	125	32	0			
10	34	0	125	28	0			
11	34	0	125	28	0			

E[FS] = E[ln FS] = Total
Var[FS]=
σ[FS]= σ[ln FS]=
V(FS) =
FS req'd = 1.00 ln(FS req'd) = 0.000000

β =	
F(z) =	
Pr(f) % =	0.000000

With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Judgment Probability of Poor Performance Curve

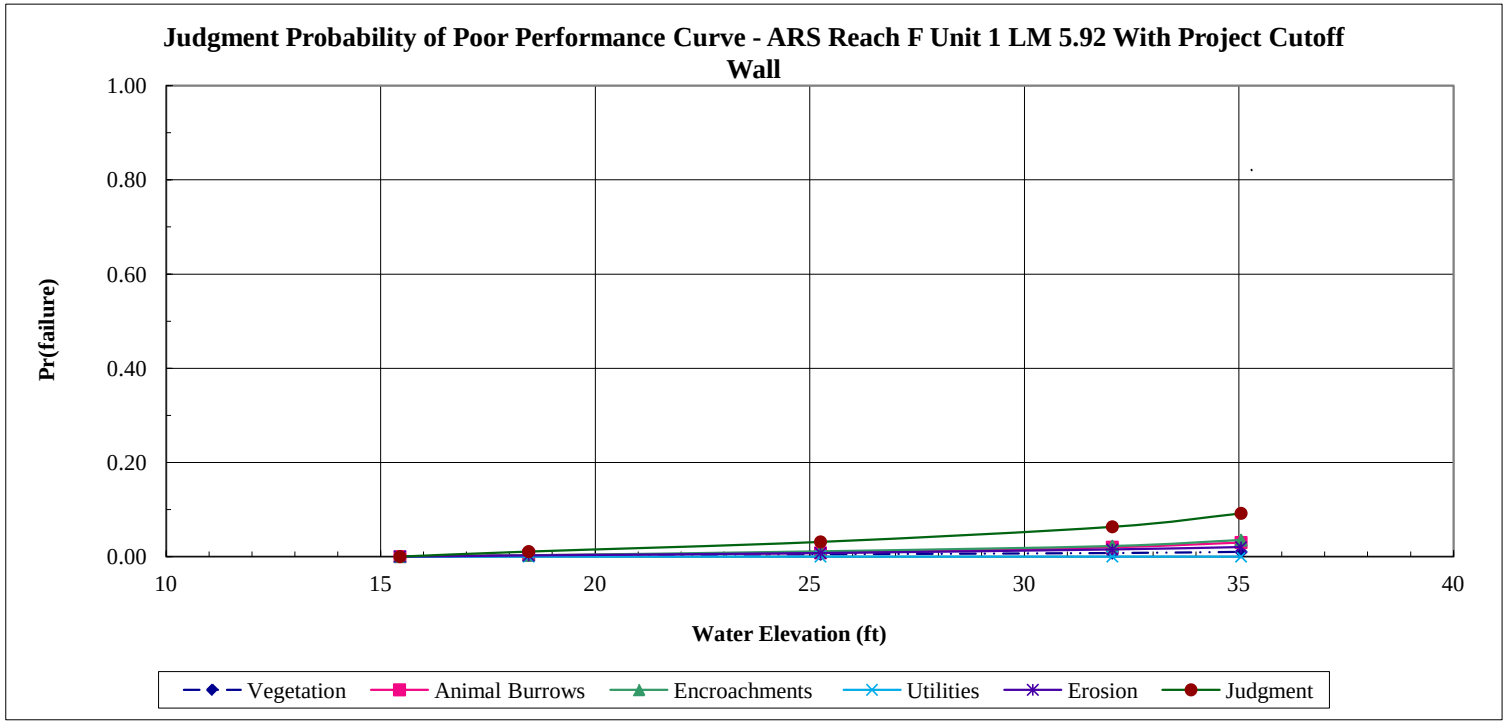
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case: With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Water Surface Elevation	Vegetation		Animal Burrows		Encroachments		Utilities		Erosion		Judgment	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
15.45	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
18.45	0.0025	0.9975	0.0030	0.9970	0.0028	0.9972	0.0000	1.0000	0.0025	0.9975	0.0107	0.9893
25.25	0.0050	0.9950	0.0080	0.9920	0.0112	0.9889	0.0000	1.0000	0.0075	0.9925	0.0313	0.9687
32.05	0.0075	0.9925	0.0200	0.9800	0.0223	0.9777	0.0000	1.0000	0.0150	0.9850	0.0633	0.9367
35.05	0.0100	0.9900	0.0300	0.9700	0.0350	0.9650	0.0000	1.0000	0.0200	0.9800	0.0918	0.9082



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

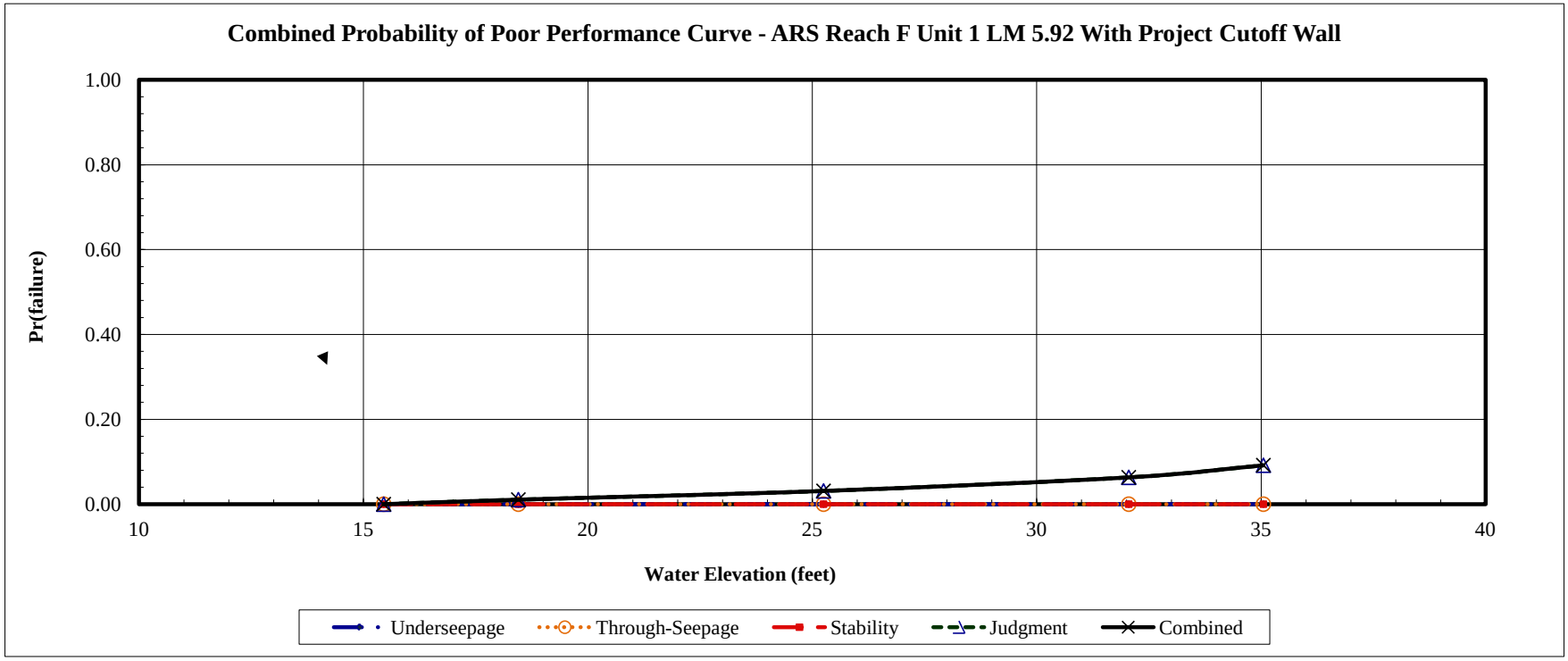
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: ARS Reach F Unit 1

Levee Mile: 5.92
River Mile: 50.21
Analysis Case: With Project Cutoff Wall

Crest Elev.: 35.05
L/S Toe Elev.: 15.45
W/S Toe Elev.: 21.05

Analysis By: A. Deus
Checked By: H. Mulder
Date: 6/28/2012

Water Surface	Underseepage		Through-Seepage		Stability		Judgment		Combined	
Elevation	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
15.45	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
18.45	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0107	0.9893	0.0107	0.9893
25.25	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0313	0.9687	0.0313	0.9687
32.05	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0633	0.9367	0.0633	0.9367
35.05	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0918	0.9082	0.0918	0.9082



With Project Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

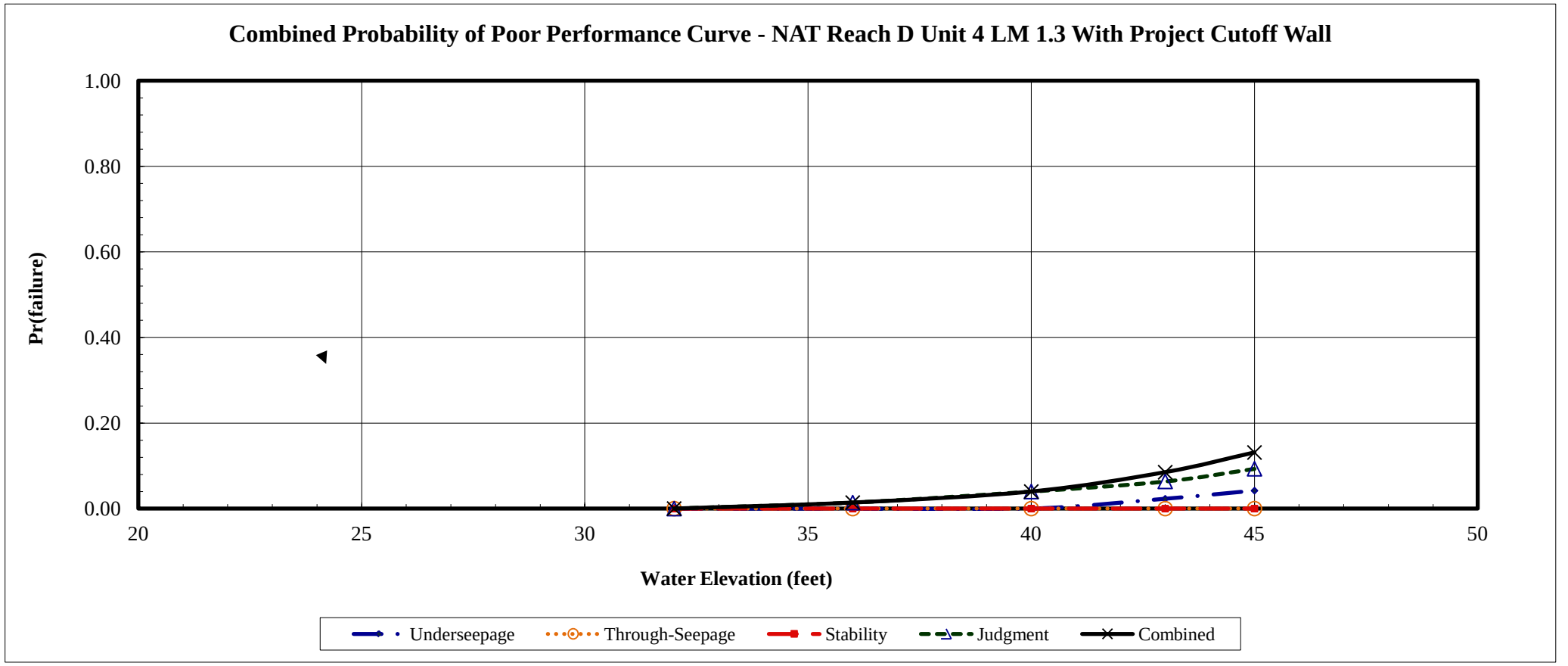
Project: American River Common Features GRR
Study Area: Sacramento River
River Section: NAT Reach D Unit 4

Levee Mile: 1.30
River Mile: 3.10
Analysis Case: With Project Cutoff Wall

Crest Elev.: 45.00
L/S Toe Elev.: 29.00
W/S Toe Elev.:

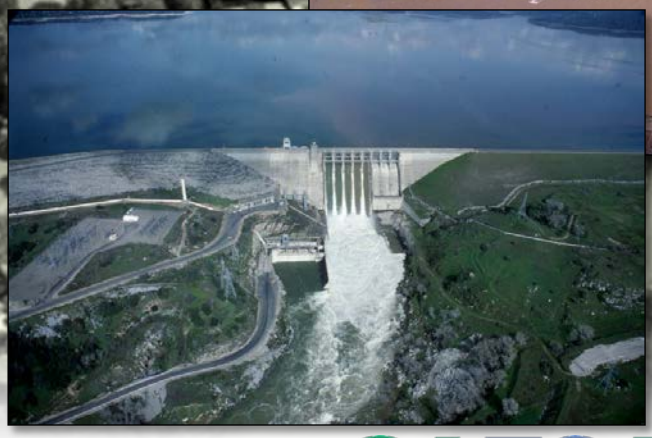
Analysis By: M. Perlea
Checked By: M. Kynett
Date:

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
32.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
36.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0140	0.9860	0.0140	0.9860
40.00	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0398	0.9602	0.0398	0.9602
43.00	0.0230	0.9770	0.0000	1.0000	0.0000	1.0000	0.0635	0.9365	0.0850	0.9150
45.00	0.0420	0.9580	0.0000	1.0000	0.0000	1.0000	0.0931	0.9069	0.1312	0.8688



American River Watershed

Common Features
General Reevaluation Report



Attachment D
Cost Engineering

December 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Attachment D
Cost Engineering

U.S. Army Corps of Engineers
Sacramento District

December 2015

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COST ENGINEERING APPENDIX

1. BASIS OF ESTIMATE

This estimate is based on the Final Feasibility Report:
American River Watershed
Common Features
General Reevaluation Report
Final Report
December 2015

Cost Engineering Data for both an NED plan (Alternative 1) and the locally preferred plan (LPP, Alternative 2) has been developed.

The baseline feasibility cost estimates for the alternatives were developed from quantity take-off calculations provided by the Sacramento District's Civil Design section and Structural Design Section (for the new Sacramento Weir). Levee alignments and stationing were provided to Cost Engineering as Google Earth files (no detailed drawings were developed or printed).

Due to the large scope, the project is broken into construction contracts by reach. Each reach is assumed to be a separate contract. The type of solicitation is expected to be unrestricted IFB.

2. PROJECT SCOPE/DESCRIPTION

Both plans/alternatives typically involve the construction of in-place levee improvement measures to address erosion protection and slope stability, seepage, and overtopping (height) concerns identified for the American and Sacramento River levees, the Natomas East Main Drain Channel (NEMDC), and Arcade, Dry/Robla, and Magpie Creeks. Below are brief descriptions of the design remediation methods. Further detail can be found in the Engineering Appendix.

For both the NED and the LPP, the project area contains two main subareas (basins):

- American River North Basin (ARN) – This area is located north of the American River and east of the Natomas Basin. The basin is bordered by the NEMDC to the west and the American River to the south. This basin is composed of nine reaches, designated A through I for economic evaluation and construction sequencing purposes. The basin consists of two economic areas for economic evaluations (ARNA and ARNB constitute one area; ARNC thru ARNI constitute a second area, the Tributaries). Note that project features for this area are the same for both

the NED and the LPP. Note also that Reach H, while part of the project study area, has no construction associated with it.

- American River South Basin (ARS) – This area is located south of the American River. It is bounded on the north by the American River and on the west by the Sacramento River. This basin includes downtown Sacramento and surrounding neighborhoods. This basin is composed of seven reaches, designated A through G for economic evaluation and construction sequencing purposes. Note that project features for this area are the same for both the NED and the LPP, except that for the LPP, there is much less work associated with raising levees (overtopping concern) for reaches D-G.

In addition, the LPP also includes a third area. The Sacramento Weir and Bypass, North of the city of West Sacramento, will be widened by about 1500 feet and a new (second) weir built just upstream of the existing Sacramento Weir. The Sacramento Weir has both a road and railroad atop it and these will be preserved through the new weir.

Two measures for erosion protection and slope stability are utilized. One is a Bank Protection fix that includes placing revetment on the existing levee waterside and project the revetment to a finished surface slope of 2H:1V or 3H:1V. The second is a Launchable Rock Trench fix that provides protection to the levee by utilizing sacrificial rock berms. For reaches D-G of ARS, it is assumed that rock placement will be from the water side. Other reaches requiring erosion protection are too shallow for barges and placement will be from the land side.

The levee remediation to address seepage is provided through cutoff walls, by degrading the levee and then constructing a cutoff wall either using deep-soil-mixing (DSM) or as a soil-cement-bentonite (SCB) slurry wall, typically through the centerline of the levee, finally rebuilding the levee to pre-project geometry. At some locations, jet grout cutoff walls, seepage berms, or relief wells are used.

Height improvements to address overtopping concerns include levee raising and new floodwalls or height improvements to existing floodwalls.

Along the levees, there are utilities that need to be relocated or removed. Active utilities such as pressure pipes, irrigation pipes, drainage pipes, electrical, sewer, gas, cable and water lines are to be removed and replaced in order to construct the cutoff walls. Temporary utilities service is to be provided during the service outages. Roads on the levee crowns that must be removed in order to demolish or relocate utilities will be replaced.

Reaches D and G of ARS have a railroad atop the levee in some areas. The railroad line in Reach D is currently used for recreational purposes and it is assumed agreements will be made between the local sponsor and the

Recreation Company for shutdown during construction. The railroad in Reach G terminates south of the project (near Hood-Franklin Road) and is currently not in use. It is assumed that it may be reactivated in the future and is thus removed and replaced in the project area.

3. MII COST ESTIMATE - NOTES & ASSUMPTIONS (SEE ATTACHED)

The MII (MCACES, 2nd generation) Cost Estimate is divided by reach and each reach is assumed to be a separate construction contract.

ARS & ARN

Prepared By: Sacramento District, Cost Engineering Section

PROJECT SCOPE/DESCRIPTION
ARS is comprised of seven reaches, designated A through G for economic evaluation and construction sequencing purposes. Costs for both the NED and locally preferred plan (LPP) have been developed. For the LPP, no increase in levee height is to be done in Reaches D-G. The description of each reach, and typical work involved for each, is as follows:

ARS - Reach A: American River, LB - Between Mira Del Rio Drive & Northwest of Carlson Drive (Bank Stabilization, Planting/Fish & Wildlife Facilities)
ARS - Reach B: American River, LB - Between Carlson Drive and State Route 160 (Bank Stabilization, Planting/Fish & Wildlife Facilities)
ARS - Reach C: American and Sacramento Rivers, LB - Between State Route 160 and Richards Blvd (Bank Stabilization, Planting/Fish & Wildlife Facilities)
ARS - Reach D: Sacramento River, LB - Between Richards Blvd and Linden Road (Bank Stabilization, Planting/Fish & Wildlife Facilities, Levee Improvements, Relocations)
ARS - Reach E: Sacramento River, LB - Between Linden Road & Clipper Way (Bank Stabilization, Planting/Fish & Wildlife Facilities, Levee Improvements, Relocations)
ARS - Reach F: Sacramento River, LB - Between Clipper Way and River Garden Ct (Bank Stabilization, Planting/Fish & Wildlife Facilities, Levee Improvements, Relocations)
ARS - Reach G: Sacramento River, LB - Between River Garden Court and Beach Lake Road (Bank Stabilization, Planting/Fish & Wildlife Facilities, Levee Improvements, Relocations)

ARN is comprised of nine reaches, designated A through I for economic evaluation and construction sequencing purposes. Reach G and H require no improvements/work.

ARN - Reach A: American River, RB - Between River Oak Way and North of Northrop Ave (Bank Stabilization, Planting/Fish & Wildlife Facilities)

ARN - Reach B: American River, RB - Between Northrop Ave and State Route 160 (Bank Stabilization, Planting/Fish & Wildlife Facilities)
ARN - Reach C: NEMDC, RB (tributary of American River) - Between State Route 160 and just West of Arcade Blvd (Levee Improvements, Relocations)
ARN - Reach D: Arcade Creek, LB (tributary of NEMDC) Between Arcade Blvd and Marysville Blvd (Levee Improvements, Relocations)
ARN - Reach E: Arcade Creek, RB (tributary of NEMDC) - Between Scoles Ct and High S (Levee Improvements, Relocations)
ARN - Reach F: NEMDC, RB (tributary of American River) - Between Scoles Ct and W Ascot Ave (Levee Improvements, Relocations)
ARN - Reach G: Dry/Robla Creek, LB (tributary of NEMDC) Between Main Ave and in between W Ascot Ave and Neal Rd - (NO WORK in this reach)
ARN - Reach H: Dry/Robla Creek, RB (tributary of NEMDC) - (NO WORK in this reach)
ARN - Reach I: Magpie Creek (tributary of Dry/Robla Creek) - Magpie Creek Diversion Channel from near intersection of Santa Ana Ave & Raley Blvd(NW corner) to Magpie Creek crossing of Dry Creek Road (Levee Improvements)

ACQUISITION PLAN
Reaches of less than about $12M construction costs are assumed to be done by small businesses. For reaches of $12M or more, the type of solicitation is expected to be unrestricted IFB.

CONTRACTING PLAN
For each reach, there is a separate prime contractor expected to be an earthwork contractor responsible for the general site work, borrow site excavation, levee degrading and rebuilding to the restored or new levee height, and bank stabilization.

Service Contractors have been created for planting and plant establishment.

Miscellaneous/General Subcontractors are expected to be utilized for hydroseeding, jet grouting, railroad removal and reconstruction and vibration monitoring.

CONSTRUCTION WINDOWS
This estimate breaks construction for large reaches into seasons based on construction work windows. The construction work window for major Levee Improvement and Relocations construction activities is typically May-Oct, April and November are available for mobilization and demobilization of equipment and non-flood protection items such as hydroseeding that do not change the effectiveness of flood control and drainage system. The construction window for Bank Stabilization is assumed to be April-November, except that placement of materials IN WATER is limited to August thru November.

OVERTIME and PRODUCTIVITY

Overtime is included in this estimate. Assumption is 10 hr days, 6 days/week.

Normal Productivity/Task Durations are based on production for 50 minutes/hr to allow for meetings/breaks, accessing the working area/office trailer to get supplies, etc. Because overtime is expected to go on for months, productivity is reduced to 90% of normal.

CONSTRUCTION SCHEDULE

Design and Construction (sans planting establishment) was to be completed in 10 years if possible. Total Project Schedules including design, pre-construction, construction and post construction were developed using MS Project with construction durations based on those developed in MII. These are used to insure the project reaches could, in general, be completed within the construction windows and with the anticipated crews.

PROJECT CONSTRUCTION

The project consists of 14 reaches where construction will occur, A-G in ARS and A-F+I in ARN, with multiple utility relocations for penetrations through the levees (including several pumping plants for interior drainage).

SITE ACCESS

The project sites are accessible by paved local roads to levee access points and then along the levee. In many areas, the haul route is required to be through residential or highly developed areas. Traffic control will be required at levee access points, many of which are at local parks and hauling delays will undoubtedly occur due to shared use with local residents. Because of this limited access, it is assumed that placement will in general be about 10 loads per hour. This also may require resurfacing the roads following construction.

Locating Contractor Storage areas is problematical. The assumption on haul distances is dependent on the location, but is assumed as long as 10 miles round trip in some residential areas.

BORROW \ DISPOSAL AREAS

The geotechnical designers conducted a Soil Borrow Study to about a 25-30 mile radius of the project area. The larger land areas where there is high confidence in material to meet specs are near the outer edge of this radius and roughly 60 miles round trip from the central reaches. For the purposes of haul distance a general point in the areas of high confidence to both the north and south of Sacramento was chosen as borrow site locations. It is uncertain whether borrow will be obtained from local suppliers or by development of new borrow sites by the Contractor thru land acquisition. Land acquisition, mining, and restoration of borrow sites is not included in the estimate. Instead a royalty cost of $7/TON is assumed, based on a 2014-2015 pricelist from a local supplier.

Disposal Areas are the Yolo and Kiefer landfills. Certain companies in the Sacramento area receive such items as green waste, broken concrete, and

excavation that may not be satisfactory for reuse in levees, etc. A typical haul distance to these areas is assumed as about 30 miles round trip.

CONSTRUCTION METHODOLOGY
The construction methodologies are considered standard for most construction work. One exception is deep soil mixing (DSM) for cutoff walls deeper than 80 ft. Another exception to standard construction is jet grouting around deep utilities.

UNUSUAL CONDITIONS
No unusual conditions.

UNIQUE TECHNIQUES OF CONSTRUCTION
Deep Soil Mixing and Jet Grouting are considered unique in that relatively few contractors perform this work.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
In an urban area such as Sacramento, equipment and labor is readily available within a 100 mile radius of the site. Deep Soil Mixing and Jet Grouting rigs are available, but in limited number. For this reason, it is assumed than no more than three headings for DSM are used within any construction reach. This could change over the 10 year construction period anticipated.

ENVIRONMENTAL CONCERNS
Environment protection requires consideration of air, water, and land, and involves noise, solid-waste management and management of other pollutants. In order to prevent or provide for abatement and control of any environmental pollution arising from the work activities, the Contractor and his subcontractors in the performance of this contract, shall comply with all applicable Federal, State, and local laws, and regulations concerning environmental pollution control and abatement. The Contractor shall use best management practices at all times to minimize the potential for environmental impacts.

STORM WATER POLLUTION PREVENTION (SWPP)
SWPP costs are assumed to utilize BMPs. Quantities are based on those provided by SPK Environmental (ARS_SWPPP_CostEstimate.xlsx and ARN_SWPPP_CostEstimate.xlsx). SWPP development and reporting is considered to be part of JOOH.
The primary sediment control BMP is fiber rolls placed at a maximum interval of 15 ft for slope inclinations between 4:1 and 2:1. Though there are slopes flatter than 4:1 (which would allow for a max spacing of 20 ft), the more conservative interval of 15 ft is used to provide more effective erosion control. Silt fences will be used in conjunction with fiber rolls for further sediment control.

LABOR RATES, EQUIPMENT RATES, MATERIAL & FUEL COSTS & SALES TAX

This estimate meets Davis Bacon wage rates for Davis Bacon wage determinations for the state of California, General Decision Numbers: CA1400003, CA140006, CA140009 and CA1400026 as of December 2014.

Equipment unit costs were obtained from historical Quotes or verbal/telephone conversations with Contractors performing like or similar work and the MII/MCACES Equipment Library.

Note: Gasoline and diesel fuel costs used in the estimate are the average costs in the Sacramento area as of 6/11/15.
Off-road diesel costs are not subject to state and federal excise taxes, so those taxes are removed from off-road diesel prices.

Material prices were obtained from Quotes, supply catalogs, previous similar estimates, and the MII/MCACES Cost Book.

Sales tax is applied at 8.5%.

QUOTES
Specific quotes were obtained for various large volume material items (high total cost.

Quotes obtained are as indicated below, indicating type of material, unit cost, date:
¾" Class II AB $14.71/TON (4/1/2015-9/30/2015)
Riprap (waterside placement) $19/TON (8/27/2015)
Riprap (landside placement) $22.20/TON (4/1/2015-9/30/2015)
Sand $12/TON (4/1/2014-10/31/2014)
Pumps (for Pump Stations, various sizes) $70,000-$430,000/EA (10/17/2014)
Geotextile $1.65/SY (10/24/2014)
Concrete (3000 psi) $90/CY (9/29/2014)
Concrete (4000 psi) $96/CY (9/29/2014)
Cement $95/TON (9/2/2015)
Fiber Rolls $0.69/LF (10/24/2014)
Dump Fees $31/TON average of two local landfills per web search (2015)
Bentonite $98/TON (6/17/2015)

SACRAMENTO BYPASS WIDENING

Prepared By: Walla Walla District, Cost Engineering Section

PROJECT DESCRIPTION
This estimate consists of costs to lengthen the existing Sacramento Bypass Weir and bridge by 1,500 feet. The new Railroad Bridge is the same configuration as the existing bridge. The new roadway bridge is a concrete bridge deck supported

by 5 reinforced concrete piers and 2 abutments. The piers are the same height and length as the existing piers. The existing levee will be relocated 1,500 feet to the North with a seepage berm, relief wells, drainage ditch, and 2 new pump houses.

BASIS OF DESIGN
This estimate is a feasibility level estimate based on a 10% structural conceptual design feasibility report dated August 25, 2014.

ACQUISITION PLAN
The assumption is the project will be acquired by the Bidding process. The project solicitation is for open competition, sealed bid, with award to the low bidder.

This work will not be performed by a Contractor under the Small Business Administration 8a program.

Prices are good for the period October 2014 through October 2015.

SUB-CONTRACTING PLAN
It is assumed that the Prime Contractor will do the excavation, levee, roadwork, and concrete work.
The following are subcontractor on this project:
Subcontractor Tier 1 (Bridge)
Subcontractor Tier 2 (Bridge Painting)

PROJECT CONSTRUCTION

SITE ACCESS
The project site is located 4.5 miles Northwest of Sacramento, CA.

BORROW AREAS
The borrow source is assumed to be within the widened Sacramento Bypass. Because of this, land acquisition of the borrow site is inherent with land acquisition for the widened bypass. Therefore, no royalty or reclamation costs for the borrow area are anticipated.

CONSTRUCTION METHODOLOGY
The construction methodology is standard construction. The site is situated close to the same elevation as the Sacramento River and isolated by a 28 foot elevation levee. The site elevation ranges between 15 to 31 feet in elevation, with a Sacramento River elevation of around 15 feet. Excavation will need to be scheduled for low river stage and ground water level. Minimal dewatering is assumed for the estimate and includes a single pump while constructing the foundation of the weir.

UNIQUE TECHNIQUES OF CONSTRUCTION
The estimate assumes that the existing roadway and railroad will be shutdown during the duration of construction with no accommodations for diversions, detours, or traffic control. Roadways include Old River Road, Levee Road, and E Yolo Levee Road.

CONSTRUCTION WINDOWS
SCHEDULE
The contractor shall commence work under this contract within 14 calendar days of receiving the notice to proceed, and then prosecute said work diligently, and complete the entire work ready for use, with the time frames and not later than the date contracted for. At this stage of the project the schedule is unknown but assumed to be a multi-year contract.

OVERTIME
Due to the risk of flood events, difficulty of extending the duration of the contract, and impacts for shutting down the railroad and roadway, overtime is assumed of 10 hour work days, 6 days a week.

EQUIPMENT AND LABOR AVAILABILITY & DISTANCE TRAVELED
This estimate uses Sacramento Labor rates. Equipment rates used are MII Equipment 2014 Region 07, and the Cost Book is MII English Cost Book 2012-b. Labor and equipment is assumed to be available in Sacramento, CA at a distance of approximately 4 miles.

ENVIRONMENTAL CONCERNS
During site work, the proximity of the water requires additional attention to eliminate all spills and to control / cleanup debris to prevent it from entering the water.

4. CONTRACTOR MARKUPS

As determined by: Sacramento District, Cost Engineering Section

In general, the prime contractor for projects where the construction cost is over $12M-$15M is considered large business. Profit is determined through the use of profit weighted guidelines (PWG) and is based on project cost, duration, amount of subcontracting, etc. and ranges from about 7-9.6% Home Office Overhead (HOOH) is set at 10% and Job/Field Office Overhead (JOOH) is set at 13% for all reaches based on typical values for historic projects with similar type work. Small Tools Markup is set at a running 2% of Labor costs. Bond markup is set at 1.2%.

Prime contractors for projects where construction costs are under $12-15M are considered small business. Profit is based on PWG and varies from about 6.5-9.5%. Home Office Overhead is considered to be 15% (somewhat higher than for large business). Job/Field Office Overhead (JOOH) is set at 13%, the same as

for large business. Small Tool Markup is set at a running 2% of Labor costs. Bond markup is set at 1.2%.

Miscellaneous/General Subcontractors have JOOH set at 15% and HOOH set at 10%. Profit is determined using PWG and ranges from about 8.5-11.25%. Bond is set at 1.2%.

Service Contractors for Plantings & Plant Establishment should have relatively little JOOH and so it is set at 2%. The work is typically by landscape contractors with low HOOH (set at 6%). Profit is determined using PWG and varies from about 9.5-11%. Bond is again assumed to be 1.2%.

5. TOTAL PROJECT SCHEDULE, INCLUDING CONSTRUCTION (SEE ATTACHED)

Total Project Schedules including design, pre-construction, construction and post construction were developed using MS Project with construction durations based on those developed in MII. These were used to insure the project reaches could be completed within the construction windows and with the anticipated crews.

6. COST AND SCHEDULE RISK ANALYSIS (SEE ATTACHED)

The scope of the risk analysis was to calculate and present the cost and schedule 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 study does not include consideration for operation and maintenance or life cycle costs.

7. TOTAL PROJECT COST SUMMARIES (SEE ATTACHED)

First Costs are based on 1 Oct 2014 price levels. Fully funded costs are first costs escalated to the midpoint of design or construction (as per the anticipated construction schedule).

REAL ESTATE (01 Account)
The Real Estate cost estimate (01 Account Lands & Damages and Administrative costs) is performed by the SPK Real Estate Division and provided to the Cost Engineering section. The 01 Account Lands and Damages, Relocation Assistance Payment, and New Utility Easements cost estimates were appraised (please refer to the Real Estate Appendix/Report for more detail). These technical Real Estate increments estimated by the appraiser are independent of the contingency derived though the Cost and Schedule Risk Analysis (CSRA). The contingencies were provided by the Real Estate Division.

RELOCATIONS (02 Account)
Construction costs for relocation of utilities, roads and railroads were developed primarily through the use of MII and the local 'database' of construction methods (labor, equipment, and materials cost data, construction crews and anticipated production rate, anticipated borrow and disposal sites, etc). These are relatively up-to-date (2014 Davis-Bacon rates, 2014 MII equipment rates, and recent quotes for bulk materials and high cost items, such as pumps for interior drainage). Contingency applied to this account is the effective contingency derived from the Cost and Schedule Risk Analysis.

FISH & WILDLIFE FACILITIES - ENVIRONMENTAL MITIGATION (06 Account)
The Environmental Mitigation cost estimate is performed by SPK Environmental Planning and provided to Cost Engineering. Since this is a construction cost the contingency applied to this account is the effective contingency derived from the Cost and Schedule Risk Analysis.

Mitigation costs were estimated based on acreages of habitat types impacted per the requirements of the Biological Opinions. Each habitat type's costs were assessed considering onsite mitigation and offsite mitigation.
On-site mitigation is preferred because it provides higher habitat compensation values than off-site mitigation because the restoration activities occur on the same area as the area of the impact, and was used to the extent practicable. On-site mitigation costs were coordinated with the Corps' landscape architecture department and were based on past experience for implementation of these types of sites in the area. Mitigation occurs at either a 2 to 1 or a 3 to 1 ratio depending on the level of sensitivity of habitat affected, per terms and conditions in the Biological Opinion.

Off-site mitigation costs are estimated based on the acreage of area impacted by construction. Additional consideration went into the feasibility of whether or not on-site mitigation was practicable for the impacted habitat type. The cost for off-site mitigation is based on the acreage required multiplied by a standard rate for buying credits from a local mitigation bank. Mitigation occurs at either a 2 to 1 or a 3 to 1 ratio depending on the level of sensitivity of habitat affected, per terms and conditions in the Biological Opinion.

Other features required to comply with the biological opinion, such as fish monitoring, were directly negotiated with resource agencies in order to address their concerns over adverse impacts to these species and include measures to directly mitigate for the impact. Categories that this direct negotiation occurred on include the following: 1) a physical model study; 2) Pre-construction sampling and monitoring study; 3) construction fish monitoring; 4) post-construction monitoring study; 5) development and certification of the EFM model for use with Green Sturgeon; 6) Mitigation – per acre (for impacts to Green Sturgeon which differs from the off-site mitigation costs item described in the previous paragraph); 7) mitigation – rock removal; and 8) conveyance utilizing the

Sacramento River Deep Water Ship Channel. Details of the scope and budget for these features are included as Appendix B to the Mitigation Monitoring Plan.

Additionally, a cost effectiveness/incremental cost analysis was run on three different alternatives for mitigating for project impacts: maximizing on-site mitigation with no off-site mitigation included, maximizing off-site mitigation with no on-site mitigation included, and the proposed alternative, which includes a combination of on-site and off-site mitigation. This combination alternative was shown to be the best value plan for the project. The incremental cost analysis is included as Appendix A to the project's Mitigation and Monitoring Plan.

FISH & WILDLIFE FACILITIES - CONSTRUCTION (06 Account)
Construction costs for plantings and plant establishment were developed using MII. Contingency applied to this account is the effective contingency derived from the Cost and Schedule Risk Analysis.

LEVEES AND FLOODWALLS, FLOODWAY CONTROL-DIVERSION STRUCTURES, AND BANK STABILIZATION (11, 15 and 16 Accounts)
Construction costs for these accounts were developed using MII. Contingency applied is the effective contingency derived from the Cost and Schedule Risk Analysis.

CULTURAL RESOURCES PRESERVATION (18 Account)
The Cultural Resources Preservation cost is assumed as one Percent of the federal share of the Total Amount. This is the statutory level set by the Archeological and Historic Preservation Act of 1974 (Public Law 93-291) on Corps of Engineers' general authority to make expenditures for data recovery. The Department of the Interior defines "data" as "evidence about historic and prehistoric periods which are buried in the ground" and recovery as "the scientific excavation or removal and preservation of that evidence . . . when construction projects pose threats that would result in their irreparable loss or destruction."

Section 208 of the National Historic Preservation Act Amendments of 1980 authorize data recovery in excess of the one percent level when the Assistant Secretary of the Army (Civil Works) seeks the concurrence of the Secretary of the Interior (through the Departmental Consulting Archeologist) and notification of Congress.

PLANNING, ENGINEERING AND DESIGN (30 Account)
The cost for Planning, Engineering and Design (PED) is assumed as 16% of the Construction Estimate Total, based on historical estimates done by SPK. In addition, $7,778,522 is added to this account for Preconstruction Environmental Activities (physical model study, pre-construction sampling, etc). Contingency applied is the effective contingency derived from the Cost and Schedule Risk Analysis.

For this project, the assumed percentages are as follows:

Project Management	1.6%
Planning & Environmental Compliance	0.6%
Coordination w/ Other Agencies	
Mitigation Analysis Report	
Fish & Wildlife Coordination Act Report	
NPDES Permit	
Preconstruction Environmental Activities	$7,778,522
Engineering and Design	8.2%
Surveying and Mapping	
Civil Design	
Geotechnical Design	
Hydrology & Hydraulic Design	
Structural Design	
Mechanical Design	
Electrical Design	
Physical Closeout Documents	
Audit	
OMRR&R Manual	
Review, ATRs, IEPRs, VE	0.3%
Review Plans & Specs	
BCOE Review and Certification	
Life Cycle Cost Updates (costs, schedule, risks)	0.7%
Cost Estimates – Construction Contracts	
Cost Estimates – Project	
Value Engineering	
Contracting & Reprographics	1.0%
Advertise	
Reproduction	
Award Contract	
Cultural Investigations	1.0%
Engineering During Construction	2.0%
Engineering and Design During Construction	
Amendments to Plans and Specs	
Planning During Construction	0.3%
Project Operations	1.3%

CONSTRUCTION MANAGEMENT (31 Account)

The cost for Construction Management (CM) is assumed as 9% of the Construction Estimate Total, based on historical estimates done by SPK. Contingency applied is the effective contingency derived from the Cost and Schedule Risk Analysis.

For this project, the assumed percentages are as follows:

Project Management	3.1%
Project Mngt Documents	

Funds Control Documents	
Trip Reports	
Upward Reporting Documents	
Budgetary Documents	
Project Authorization Documents	
Annual Notification Letter	
Fact Sheets	
Correspondence (Congress/State)	
Schedule and Cost Changes	
Project Work Directives	
Project Closeout Documents	
Quarterly Cost Report to Local Sponsor	
Other PM Documents	
Mitigation Construction	
Construction Management	4.7%
Project Office Superv and Admin	
Area Office S&A Documents	
District Office S&A Documents	
Contract Mods & Negotiations	
Project Operations	1.2%

The purpose of this project is to improve erosion, seepage and stability concerns with portions of the levee system in the Sacramento area. Specific improvements include construction of one or more of the follow features: Seepage cutoff wall; raised levee; slope flattening; erosion protection (riprap). Additionally improvements at utilities are recommended. Some of these utilities include pipe penetrations (domestic water, interior drainage water, sewer, gas, etc.), power lines, and power poles. The recommended plan includes addressing the various utilities or encroachments so that the seepage and stability problems can be addressed. Project scope also includes: (1) right-of-way acquisition to facilitate long-term operation and maintenance activities; and (2) modifications to existing interior drainage facilities to bring the facilities in compliance with Corps criteria for penetrations through levees (upgrading discharge lines, pumps, etc. to raise the drainage over the top of levee or to provide positive closure for penetrations through levees).

ARS - Fix-in-Place Levees

Level of Estimate: Feasibility

This portion of the project is comprised of seven reaches, three along the south bank of the American River and four along the east bank of the Sacramento River, designated A through G for economic evaluation and construction sequencing purposes.

The primary methods of fixing-in-place are by construction of slurry walls using the DSM method (existing levees and foundation are primarily noncohesive soils) and providing erosion protection (primarily stone/riprap added to the waterside face and toe of the levee).

ARN - Fix-in-Place Levees

Level of Estimate: Feasibility

This portion of the project is comprised of eight reaches, three along the north bank of the American River and five along the east bank Natomas East Main Drain (NEMDC) and it's tributaries, designated A through I for economic evaluation and construction sequencing purposes. NOTE: No work planned in reach H.

The primary methods of fixing-in-place are by construction of SCB slurry walls using the conventional method (existing levees and foundation are primarily cohesive soils) and providing erosion protection along the American River (primarily stone/riprap added to the waterside face and toe of the levee).

Estimated by	CESPK-ED-SC & NWW
Designed by	USACE (Sacramento District)
Prepared by	Robert Vrchoticky (SPK), Phillip Ohnstad (NWW)
Preparation Date	9/21/2015
Effective Date of Pricing	9/21/2015
Estimated Construction Time	Days

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Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
Prime Contractor Cost or Bid Cost w/o Esc			606,769,676	47,953,704	42,715,209	54,757,946	8,201,532	760,398,068
ARS - Reach A	1.00	EA	83,205,815	9,071,044	8,040,123	8,595,205	1,185,001	110,097,188
Fish and Wildlife Facilities (Mitigation)	1.00	LS	9,182,404	0	0	0	0	9,182,404
Bank Stabilization (SP)	1.00	EA	66,655,054	8,630,391	7,501,802	7,889,625	1,088,122	91,764,994
Fish and Wildlife Facilities	1.00	EA	3,544,249	70,885	216,908	368,642	50,408	4,251,092
Relocations	1.00	EA	3,824,108	369,768	321,414	336,938	46,470	4,898,698
ARS - Reach B	1.00	EA	21,900,893	2,251,229	1,999,261	1,897,995	292,427	28,341,806
Fish and Wildlife Facilities (Mitigation)	1.00	LS	3,217,833	0	0	0	0	3,217,833
Bank Stabilization (SP)	1.00	EA	15,894,630	2,055,375	1,786,595	1,648,006	256,615	21,641,222
Fish and Wildlife Facilities	1.00	EA	968,227	19,365	59,255	109,081	13,871	1,169,800
Relocations	1.00	EA	1,820,203	176,490	153,410	140,907	21,941	2,312,951
ARS - Reach C	1.00	EA	13,437,366	1,474,813	1,324,183	1,274,790	195,401	17,706,553
Fish and Wildlife Facilities (Mitigation)	1.00	LS	1,127,833	0	0	0	0	1,127,833
Bank Stabilization (SP)	1.00	EA	10,952,599	1,417,419	1,232,064	1,135,774	176,854	14,914,709
Fish and Wildlife Facilities	1.00	EA	963,804	19,276	58,985	108,583	13,808	1,164,456
Relocations	1.00	EA	393,131	38,119	33,134	30,433	4,739	499,555
ARS - Reach D	1.00	EA	81,680,870	5,090,601	4,501,316	6,480,219	1,033,164	98,786,171
Fish and Wildlife Facilities (Mitigation) (Alt 1)	1.00	LS	6,551,333	0	0	0	0	6,551,333
Levees and Floodwalls (Alt 1)	1.00	EA	36,936,920	1,956,298	1,700,474	3,284,030	526,533	44,404,254
Relocations	1.00	EA	21,572,774	1,175,991	1,022,207	1,510,106	242,117	25,523,196
Bank Stabilization (SP)	1.00	EA	14,875,962	1,923,436	1,671,909	1,494,329	239,588	20,205,223
Fish and Wildlife Facilities	1.00	EA	1,743,882	34,878	106,726	191,754	24,927	2,102,165
ARS - Reach E	1.00	EA	55,812,865	3,006,077	2,687,888	4,324,182	714,457	66,545,470
Fish and Wildlife Facilities (Mitigation) (Alt 1)	1.00	LS	5,464,118	0	0	0	0	5,464,118
Levees and Floodwalls (Alt 1)	1.00	EA	34,286,283	1,220,735	1,061,101	2,834,029	472,826	39,874,974
Relocations	1.00	EA	3,274,791	317,976	276,395	235,626	39,312	4,144,100
Bank Stabilization (SP)	1.00	EA	11,077,910	1,433,170	1,245,756	1,066,155	177,876	15,000,866
Fish and Wildlife Facilities	1.00	EA	1,709,763	34,195	104,637	188,372	24,444	2,061,411
ARS - Reach F	1.00	EA	140,941,059	7,801,585	6,896,378	12,582,161	1,852,963	170,074,146
Fish and Wildlife Facilities (Mitigation) (Alt 1)	1.00	LS	11,523,404	0	0	0	0	11,523,404
Levees and Floodwalls (Alt 1)	1.00	EA	90,710,987	3,375,640	2,934,210	8,586,344	1,267,286	106,874,468
Relocations	1.00	EA	8,960,846	865,449	752,275	734,052	108,341	11,420,965
Bank Stabilization (SP)	1.00	EA	27,121,174	3,508,002	3,049,263	2,980,542	439,908	37,098,889
Fish and Wildlife Facilities (Construction)	1.00	EA	2,624,648	52,493	160,628	281,223	37,428	3,156,421
ARS - Reach G	1.00	EA	66,064,605	5,515,583	4,874,697	5,895,699	868,418	83,219,002
Fish and Wildlife Facilities (Mitigation) (Alt 1)	1.00	LS	4,705,833	0	0	0	0	4,705,833
Levees and Floodwalls (Alt 1)	1.00	EA	23,770,116	2,565,802	2,230,274	2,522,395	373,063	31,461,649
Relocations	1.00	EA	22,257,892	1,167,719	1,015,017	1,692,182	250,274	26,383,085
Bank Stabilization (SP)	1.00	EA	13,496,180	1,745,371	1,517,130	1,479,792	218,862	18,457,334
Fish and Wildlife Facilities	1.00	EA	1,834,584	36,692	112,277	201,331	26,219	2,211,101
ARN - Reach A	1.00	EA	59,254,030	6,794,549	5,997,737	6,220,436	879,243	79,145,994
Fish and Wildlife Facilities (Mitigation)	1.00	LS	4,602,118	0	0	0	0	4,602,118
Bank Stabilization (SP)	1.00	EA	51,016,511	6,603,452	5,739,923	5,860,789	830,648	70,051,324
Fish and Wildlife Facilities	1.00	EA	2,093,020	41,860	128,093	227,655	29,888	2,520,516
Relocations	1.00	EA	1,542,381	149,236	129,721	131,991	18,707	1,972,037
ARN - Reach B	1.00	EA	3,257,125	331,388	441,780	333,139	47,269	4,410,702
Fish and Wildlife Facilities (Mitigation)	1.00	LS	408,000	0	0	0	0	408,000
Bank Stabilization (SP)	1.00	EA	2,470,546	319,134	414,678	291,326	41,948	3,537,633
Fish and Wildlife Facilities	1.00	EA	316,707	6,334	19,382	36,434	4,546	383,404

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
Relocations	1.00	EA	61,872	5,920	7,719	5,379	775	81,665
ARN - Reach C	1.00	EA	5,188,061	282,179	367,918	396,147	70,778	6,305,083
Fish and Wildlife Facilities (Mitigation)	1.00	LS	100,000	0	0	0	0	100,000
Levees and Floodwalls	1.00	EA	4,182,034	195,089	254,366	333,467	59,579	5,024,536
Relocations	1.00	EA	906,027	87,089	113,551	62,680	11,199	1,180,546
ARN - Reach D	1.00	EA	28,380,510	2,530,242	2,199,364	2,554,860	400,036	36,065,012
Fish and Wildlife Facilities (Mitigation)	1.00	LS	660,000	0	0	0	0	660,000
Levees and Floodwalls	1.00	EA	21,152,369	1,893,310	1,645,724	2,049,386	320,889	27,061,679
Relocations	1.00	EA	6,568,141	636,932	553,641	505,474	79,146	8,343,333
ARN - Reach E	1.00	EA	28,782,304	2,536,284	2,204,616	2,565,960	401,774	36,490,937
Fish and Wildlife Facilities (Mitigation)	1.00	LS	495,000	0	0	0	0	495,000
Levees and Floodwalls	1.00	EA	19,970,130	1,729,743	1,503,546	1,925,884	301,552	25,430,854
Relocations	1.00	EA	8,317,174	806,540	701,070	640,077	100,222	10,565,083
ARN - Reach F	1.00	EA	17,194,676	1,089,465	946,997	1,466,342	236,999	20,934,478
Fish and Wildlife Facilities (Mitigation)	1.00	EA	100,000	0	0	0	0	100,000
Levees and Floodwalls	1.00	EA	13,752,037	765,107	665,054	1,217,612	196,798	16,596,608
Relocations	1.00	EA	3,342,639	324,358	281,942	248,730	40,201	4,237,870
ARN - Reach I (Magpie Cr Div Channel)	1.00	EA	1,669,497	178,665	232,952	170,810	23,603	2,275,527
Fish and Wildlife Facilities (Mitigation)	1.00	LS	275,000	0	0	0	0	275,000
Levees and Floodwalls	1.00	EA	1,356,692	175,052	228,241	167,375	23,128	1,950,487
Relocations	1.00	EA	37,805	3,614	4,712	3,435	475	50,040

The purpose of this project is to improve erosion, seepage and stability concerns with portions of the levee system in the Sacramento area. Specific improvements include construction of one or more of the follow features: Seepage cutoff wall; raised levee; slope flattening; erosion protection (riprap). Additionally improvements at utilities are recommended. Some of these utilities include pipe penetrations (domestic water, interior drainage water, sewer, gas, etc.), power lines, and power poles. The recommended plan includes addressing the various utilities or encroachments so that the seepage and stability problems can be addressed. Project scope also includes: (1) right-of-way acquisition to facilitate long-term operation and maintenance activities; and (2) modifications to existing interior drainage facilities to bring the facilities in compliance with Corps criteria for penetrations through levees (upgrading discharge lines, pumps, etc. to raise the drainage over the top of levee or to provide positive closure for penetrations through levees).

ARS - Fix-in-Place Levees

Level of Estimate: Feasibility

This portion of the project is comprised of seven reaches, three along the south bank of the American River and four along the east bank of the Sacramento River, designated A through G for economic evaluation and construction sequencing purposes.

The primary methods of fixing-in-place are by construction of slurry walls using the DSM method (existing levees and foundation are primarily noncohesive soils) and providing erosion protection (primarily stone/riprap added to the waterside face and toe of the levee).

ARN - Fix-in-Place Levees

Level of Estimate: Feasibility

This portion of the project is comprised of eight reaches, three along the north bank of the American River and five along the east bank Natomas East Main Drain (NEMDC) and it's tributaries, designated A through I for economic evaluation and construction sequencing purposes. NOTE: No work planned in reach H.

The primary methods of fixing-in-place are by construction of SCB slurry walls using the conventional method (existing levees and foundation are primarily cohesive soils) and providing erosion protection along the American River (primarily stone/riprap added to the waterside face and toe of the levee).

Estimated by	CESPK-ED-SC & NWW
Designed by	USACE (Sacramento District)
Prepared by	Robert Vrchoticky (SPK), Phillip Ohnstad (NWW)
Preparation Date	9/21/2015
Effective Date of Pricing	9/21/2015
Estimated Construction Time	Days

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Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
Prime Contractor Cost or Bid Cost w/o Esc			728,260,475	58,683,696	52,042,048	66,186,689	9,897,410	915,070,319
ARS - Reach A	1.00	EA	83,205,815	9,071,044	8,040,123	8,595,205	1,185,001	110,097,188
Fish and Wildlife Facilities (Mitigation)	1.00	LS	9,182,404	0	0	0	0	9,182,404
Bank Stabilization (SP)	1.00	EA	66,655,054	8,630,391	7,501,802	7,889,625	1,088,122	91,764,994
Fish and Wildlife Facilities	1.00	EA	3,544,249	70,885	216,908	368,642	50,408	4,251,092
Relocations	1.00	EA	3,824,108	369,768	321,414	336,938	46,470	4,898,698
ARS - Reach B	1.00	EA	21,900,893	2,251,229	1,999,261	1,897,995	292,427	28,341,806
Fish and Wildlife Facilities (Mitigation)	1.00	LS	3,217,833	0	0	0	0	3,217,833
Bank Stabilization (SP)	1.00	EA	15,894,630	2,055,375	1,786,595	1,648,006	256,615	21,641,222
Fish and Wildlife Facilities	1.00	EA	968,227	19,365	59,255	109,081	13,871	1,169,800
Relocations	1.00	EA	1,820,203	176,490	153,410	140,907	21,941	2,312,951
ARS - Reach C	1.00	EA	13,437,366	1,474,813	1,324,183	1,274,790	195,401	17,706,553
Fish and Wildlife Facilities (Mitigation)	1.00	LS	1,127,833	0	0	0	0	1,127,833
Bank Stabilization (SP)	1.00	EA	10,952,599	1,417,419	1,232,064	1,135,774	176,854	14,914,709
Fish and Wildlife Facilities	1.00	EA	963,804	19,276	58,985	108,583	13,808	1,164,456
Relocations	1.00	EA	393,131	38,119	33,134	30,433	4,739	499,555
ARS - Reach D	1.00	EA	78,897,735	4,843,301	4,286,356	6,288,858	1,002,483	95,318,733
Relocations	1.00	EA	21,572,774	1,175,991	1,022,207	1,510,106	242,117	25,523,196
Bank Stabilization (SP)	1.00	EA	14,875,962	1,923,436	1,671,909	1,494,329	239,588	20,205,223
Fish and Wildlife Facilities	1.00	EA	1,743,882	34,878	106,726	191,754	24,927	2,102,165
Fish and Wildlife Facilities (Mitigation) (Alt 2)	1.00	EA	5,671,333	0	0	0	0	5,671,333
Levees and Floodwalls (Alt 2)	1.00	EA	35,033,784	1,708,998	1,485,513	3,092,669	495,852	41,816,816
ARS - Reach E	1.00	EA	54,840,206	2,979,860	2,665,100	4,304,678	711,203	65,501,048
Relocations	1.00	EA	3,274,791	317,976	276,395	235,626	39,312	4,144,100
Bank Stabilization (SP)	1.00	EA	11,077,910	1,433,170	1,245,756	1,066,155	177,876	15,000,866
Fish and Wildlife Facilities	1.00	EA	1,709,763	34,195	104,637	188,372	24,444	2,061,411
Fish and Wildlife Facilities (Mitigation) (Alt 2)	1.00	LS	4,694,118	0	0	0	0	4,694,118
Levees and Floodwalls (Alt 2)	1.00	EA	34,083,624	1,194,519	1,038,313	2,814,525	469,572	39,600,553
ARS - Reach F	1.00	EA	134,344,889	7,133,809	6,315,926	12,015,461	1,769,322	161,579,407
Relocations	1.00	EA	8,960,846	865,449	752,275	734,052	108,341	11,420,965
Bank Stabilization (SP)	1.00	EA	27,121,174	3,508,002	3,049,263	2,980,542	439,908	37,098,889
Fish and Wildlife Facilities (Construction)	1.00	EA	2,624,648	52,493	160,628	281,223	37,428	3,156,421
Fish and Wildlife Facilities (Mitigation) (Alt 2)	1.00	LS	10,082,404	0	0	0	0	10,082,404
Levees and Floodwalls (Alt 2)	1.00	EA	85,555,817	2,707,865	2,353,759	8,019,643	1,183,645	99,820,729
ARS - Reach G	1.00	EA	62,060,278	5,190,751	4,592,344	5,620,599	827,730	78,291,703
Relocations	1.00	EA	22,257,892	1,167,719	1,015,017	1,692,182	250,274	26,383,085
Bank Stabilization (SP)	1.00	EA	13,496,180	1,745,371	1,517,130	1,479,792	218,862	18,457,334
Fish and Wildlife Facilities	1.00	EA	1,834,584	36,692	112,277	201,331	26,219	2,211,101
Fish and Wildlife Facilities (Mitigation) (Alt 2)	1.00	LS	3,209,833	0	0	0	0	3,209,833
Levees and Floodwalls (Alt 2)	1.00	EA	21,261,789	2,240,970	1,947,920	2,247,295	332,376	28,030,350
ARN - Reach A	1.00	EA	59,254,030	6,794,549	5,997,737	6,220,436	879,243	79,145,994
Fish and Wildlife Facilities (Mitigation)	1.00	LS	4,602,118	0	0	0	0	4,602,118
Bank Stabilization (SP)	1.00	EA	51,016,511	6,603,452	5,739,923	5,860,789	830,648	70,051,324
Fish and Wildlife Facilities	1.00	EA	2,093,020	41,860	128,093	227,655	29,888	2,520,516
Relocations	1.00	EA	1,542,381	149,236	129,721	131,991	18,707	1,972,037
ARN - Reach B	1.00	EA	3,257,125	331,388	441,780	333,139	47,269	4,410,702
Fish and Wildlife Facilities (Mitigation)	1.00	LS	408,000	0	0	0	0	408,000
Bank Stabilization (SP)	1.00	EA	2,470,546	319,134	414,678	291,326	41,948	3,537,633
Fish and Wildlife Facilities	1.00	EA	316,707	6,334	19,382	36,434	4,546	383,404

Description	Quantity	UOM	CostToPrime	JOOH_PRM	HOOH_PRM	Profit_PRM	Bond_PRM	ContractCost
Relocations	1.00	EA	61,872	5,920	7,719	5,379	775	81,665
ARN - Reach C	1.00	EA	5,188,061	282,179	367,918	396,147	70,778	6,305,083
Fish and Wildlife Facilities (Mitigation)	1.00	LS	100,000	0	0	0	0	100,000
Levees and Floodwalls	1.00	EA	4,182,034	195,089	254,366	333,467	59,579	5,024,536
Relocations	1.00	EA	906,027	87,089	113,551	62,680	11,199	1,180,546
ARN - Reach D	1.00	EA	28,380,510	2,530,242	2,199,364	2,554,860	400,036	36,065,012
Fish and Wildlife Facilities (Mitigation)	1.00	LS	660,000	0	0	0	0	660,000
Levees and Floodwalls	1.00	EA	21,152,369	1,893,310	1,645,724	2,049,386	320,889	27,061,679
Relocations	1.00	EA	6,568,141	636,932	553,641	505,474	79,146	8,343,333
ARN - Reach E	1.00	EA	28,782,304	2,536,284	2,204,616	2,565,960	401,774	36,490,937
Fish and Wildlife Facilities (Mitigation)	1.00	LS	495,000	0	0	0	0	495,000
Levees and Floodwalls	1.00	EA	19,970,130	1,729,743	1,503,546	1,925,884	301,552	25,430,854
Relocations	1.00	EA	8,317,174	806,540	701,070	640,077	100,222	10,565,083
ARN - Reach F	1.00	EA	17,194,676	1,089,465	946,997	1,466,342	236,999	20,934,478
Fish and Wildlife Facilities (Mitigation)	1.00	EA	100,000	0	0	0	0	100,000
Levees and Floodwalls	1.00	EA	13,752,037	765,107	665,054	1,217,612	196,798	16,596,608
Relocations	1.00	EA	3,342,639	324,358	281,942	248,730	40,201	4,237,870
ARN - Reach I (Magpie Cr Div Channel)	1.00	EA	1,669,497	178,665	232,952	170,810	23,603	2,275,527
Fish and Wildlife Facilities (Mitigation)	1.00	LS	275,000	0	0	0	0	275,000
Levees and Floodwalls	1.00	EA	1,356,692	175,052	228,241	167,375	23,128	1,950,487
Relocations	1.00	EA	37,805	3,614	4,712	3,435	475	50,040
ARCF_GRR_SBW-Extend_Bridge (Alt2) MIIv4.2 141020	1.00	EA	65,462,837	3,798,750	3,301,991	5,227,032	781,217	78,571,827
RELOCATIONS	1.00	EA	3,194,682	0	0	218,727	32,690	3,446,099
ROADS, RAILROADS, AND BRIDGES	1.00	EA	18,242,347	0	0	1,592,557	238,019	20,072,923
LEVEES AND FLOODWALLS	1.00	EA	669,386	0	0	58,437	8,734	736,557
FLOODWAY CONTROL-DIVERSION STRUCTURE	1,500.00	LF	31,356,423	3,798,750	3,301,991	3,357,310	501,774	42,316,248
Fish and Wildlife Facilities (Mitigation)	1.00	LS	12,000,000	0	0	0	0	12,000,000
ARCF_GRR_SBW-Widen_Bypass (Alt 2) MIIv4.2 141020	1.00	EA	70,384,252	8,197,365	7,125,402	7,254,376	1,072,925	94,034,320
RELOCATIONS	1.00	EA	12,187,468	1,180,386	1,026,028	996,581	147,395	15,537,859
ROADS, RAILROADS, AND BRIDGES	1.00	EA	1,739,073	168,434	146,408	142,206	21,032	2,217,153
LEVEES AND FLOODWALLS	1.00	EA	56,457,710	6,848,545	5,952,966	6,115,589	904,498	76,279,308

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
0	**ARCFGRR Alt 1 - Total Project Schedule (including Construction)**	**0**		**3192.5 days**	**Mon 10/2/17**	**Wed 12/26/29**			**Per PM & Civil Des, the project is assumed to begin in FY16. Constr Seq/Priority based on the following start years FY16-ARSF & ARSA, FY17-ARSE, FY19-ARSB, FY20-ARSG & ARNA, FY21-ARSD & SBW, FY22-ARSC, FY23-ARNB, ARND, ARNF & ARNC, FY24-ARNE, ARNG & ARNI**
1	**Design & Construction - ARS, Reach F**	**0**		**1335.06 days**	**Mon 10/2/17**	**Mon 11/14/22**			**Sacramento River - Between Clipper Way and River Garden Ct; From table provided by Civil Design, reach extends from ~Sta 353+85 to 640+20; Reach Length ~ 28,635 LF, Seepage & Stability Concern ~25,500 LF**
2	**Design**	0		**1044 days**	**Mon 10/2/17**	**Thu 9/30/21**		**258SS+783 days,160SS+5**	
8	**Pre-Construction - Season 1**	0		**77 days**	**Tue 10/1/19**	**Wed 1/15/20**		**89SS+262 days**	
17	**Constr - Relocations & Levees (Seepage & Stability) - Season 1 - Sta 354+00 to 438+00 (approx)**	**0**		**250 days**	**Wed 4/1/20**	**Fri 11/20/20**			**assumes ~1/3 of DSM cutoff walls will be constructed during Season 1; ~Sta 355+00 to 479+00; seasonal construction window to reestablish levee is approximately 4/1 - 10/31 (sans ABC, reveg, other non-levee-structure items)**
88	**Pre-Construction - Season 2**	0		**77 days**	**Thu 10/1/20**	**Fri 1/15/21**		**124SS+261 days**	
97	**Constr - Relocations & Levees (Seepage & Stability) - Season 2 - Sta 479+00 to 546+00 (approx)**	**0**		**235 days**	**Thu 4/1/21**	**Sat 11/6/21**			**assumes ~1/3 of DSM cutoff walls will be constructed during Season 2; ~Sta 479+00 to 546+00; seasonal construction window to reestablish levee is approximately 4/1 - 10/31 (sans ABC, reveg, other non-levee-structure items)**
123	**Pre-Construction - Season 3**	0		**77 days**	**Fri 10/1/21**	**Mon 1/17/22**			
132	**Constr - Relocations & Levees (Seepage & Stability) - Season 3 - Sta 546+00 to 640+00 (approx)**	**0**		**242.5 days**	**Fri 4/1/22**	**Mon 11/14/22**			**assumes ~1/3 of DSM cutoff walls will be constructed during Season 2; ~Sta 546+00 to 640+00; seasonal construction window to reestablish levee is approximately 4/1 - 10/31 (sans ABC, reveg, other non-levee-structure items)**
158	**Design & Construction - ARS, Reach F (Erosion Protection)**	**0**		**1137.5 days**	**Tue 10/1/19**	**Thu 2/8/24**			**Sacramento River - Between Clipper Way and River Garden Ct; From table provided by Civil Design, reach extends from ~Sta 353+85 to 640+20; Reach Length ~ 28,635 LF, Erosion Concern ~22,055 LF**
159	**Design**	0		**262 days**	**Tue 10/1/19**	**Wed 9/30/20**			
163	**Pre-Construction - Season 1**	0		**77 days**	**Thu 10/1/20**	**Fri 1/15/21**			
172	**Constr - Levees (Eros Prot), Season 1 - - Sta 354+00 to 438+00 (approx)**	**0**		**113.75 days**	**Sat 7/10/21**	**Sat 10/23/21**			**seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1-11/30**
188	**Pre-Construction - Season 2**	0		**77 days**	**Fri 10/1/21**	**Mon 1/17/22**			

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
197	Constr - Levees (Eros Prot), Season 2 - Sta 479+00 to 546+00 (approx)	0		108.75 days	Tue 7/12/22	Fri 10/21/22			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1-11/30; assumes approximately 1/3 the work can be accomplished during season 2
213	Pre-Construction - Season 3	0		77 days	Mon 10/3/22	Tue 1/17/23			
222	Constr - Levees (Eros Prot), Season 3 - Sta 546+00 to 640+00 (approx)	0		236.25 days	Mon 7/3/23	Thu 2/8/24			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1-11/30; assumes approximately 1/3 the work can be accomplished during season 3; NOTE: Haul/Access RD repair extends duration
243	Plant Maintenance - ARS, Reach F	0		1319.5 days	Mon 10/25/21	Fri 11/13/26			
244	Plant Establishment Watering, ARS, Reach F (Season 1)	0		783 days	Mon 10/25/21	Wed 10/23/24			extends 3 years past finish of initial plant establishment
248	Plant Establishment Watering, ARS, Reach F (Season 2)	0		783 days	Fri 10/21/22	Wed 10/22/25			extends 3 years past finish of initial plant establishment
252	Plant Establishment Watering, ARS, Reach F (Season 3)	0		782 days	Wed 11/15/23	Fri 11/13/26			extends 3 years past finish of initial plant establishment
256	Design & Construction - ARS, Reach E	0		1036.75 days	Thu 10/1/20	Fri 9/20/24			Sacramento River - Between Richards Blvd and Lindent Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 22,825 LF; Levee Work = 10,000 LF (seepage), 10,000 LF (stability)
257	Design	0		543 days	Thu 10/1/20	Mon 10/31/22		427SS	
263	Pre-Construction - Season 1	0		77 days	Tue 11/1/22	Wed 2/15/23		315FS+183 days,361SS	
272	Constr - Relocations & Levees (Seepage & Stability) - Season 1 - Sta 228+00 to 307+00 (approx)	0		183.75 days	Sat 4/1/23	Wed 9/20/23			assumes ~1/2 of DSM cutoff walls will be constructed during Season 1; ~Sta 228+00 to 307+00; seasonal construction window is approximately 4/1 - 10/31
314	Pre-Construction, Season 2	0		77 days	Tue 10/31/23	Wed 2/14/24		365SS	
323	Constr - Relocations & Levees (Seepage & Stability) - Season 2 - Sta 307+00 to 354+00 (approx)	0		185 days	Mon 4/1/24	Fri 9/20/24			assumes ~1/2 of DSM cutoff walls will be constructed during Season 1; ~Sta 307+00 to 354+00; seasonal construction window is approximately 4/1 - 10/31
359	Design & Construction - ARS, Reach E (Erosion Protection)	0		774 days	Tue 11/1/22	Sat 10/18/25			Sacramento River - Between Richards Blvd and Lindent Road (EROSION Deficiencies); Reach Length - 22,825 LF; Levee Work = 11,275 LF (erosion protection)
360	Design	0		260 days	Tue 11/1/22	Mon 10/30/23			
364	Pre-Construction - Season 1	0		77 days	Tue 10/31/23	Wed 2/14/24		374SS+327 days,389SS+26	

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
373	Constr - Levees (Eros Prot) - Season 1 - Sta 228+00 to 307+00 (approx)	0		111.25 days	Fri 8/30/24	Thu 12/12/24			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); rock placement in water is limited to 8/1 - 11/30
388	Pre-Construction - Season 2	0		77 days	Wed 10/30/24	Thu 2/13/25			
397	Constr - Levees (Eros Prot) - Season 2 - Sta 307+00 to 354+00 (approx)	0		96.25 days	Mon 7/21/25	Sat 10/18/25			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); rock placement in water is limited to 8/1 - 11/30
416	Plant Maintenance - ARS, Reach E	0		1002.31 days	Thu 12/12/24	Mon 10/16/28			
417	Plant Establishment Watering, ARS, Reach E, Season 1	0		782 days	Thu 12/12/24	Mon 12/13/27			extends 3 years past finish of initial plant establishment
421	Plant Establishment Watering, ARS, Reach E, Season 2	0		781 days	Mon 10/20/25	Mon 10/16/28			extends 3 years past finish of initial plant establishment
425	Design & Construction - ARS, Reach G	0		1341.5 days	Thu 10/1/20	Fri 11/21/25			Sacramento River - Between River Garden Cour and Beach lake Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 13,105 LF; Levee Work = 8333 LF (seepage), 8333 LF (stability)
426	Design	0		1043 days	Thu 10/1/20	Mon 9/30/24		433SS+1043 days,696SS+78	
432	Pre-Construction	0		77 days	Tue 10/1/24	Wed 1/15/25			
441	Constr - Relocations & Levees (Seepage & Stability)	0		251.25 days	Tue 4/1/25	Fri 11/21/25			seasonal construction window is approximately 4/1 - 10/31 - Schedule fwill be very tight - assumes Reveg can extend into Nov
657	Design & Construction - ARS, Reach G (Erosion Protection)	0		570.25 days	Tue 10/1/24	Tue 12/8/26			Sacramento River - Between River Garden Cour and Beach lake Road (EROSION Deficiencies); Reach Length - 13,120 LF; Levee Work = 11,120 LF (erosion protection)
658	Design	0		261 days	Tue 10/1/24	Tue 9/30/25			
662	Pre-Construction	0		77 days	Wed 10/1/25	Thu 1/15/26		672SS+294 days	
671	Constr - Levees (Eros Prot)	0		170 days	Thu 7/2/26	Tue 12/8/26			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1/ - 11/30
689	Plant Maintenance, ARS, Reach G	0		782 days	Tue 12/8/26	Thu 12/6/29			
690	Plant Establishment Watering	0		782 days	Tue 12/8/26	Thu 12/6/29			extends 3 years past finish of initial plant establishment
694	Design & Construction - ARS, Reach D	0		844.5 days	Mon 10/2/23	Fri 12/25/26			Sacramento River - Between Richards Blvd and Lindent Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 22,825 LF; Lvee Work = 10,000 LF (seepage), 10,000 LF (stability)

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
695	**Design**	0		**545 days**	**Mon 10/2/23**	**Fri 10/31/25**		**702,968SS+261 days**	
701	**Pre-Construction**	0		**77 days**	**Mon 11/3/25**	**Tue 2/17/26**			
710	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**287.5 days**	**Wed 4/1/26**	**Fri 12/25/26**			**seasonal construction window is approximately 4/1 - 10/31 (sans ABC, Reveg, Demob, etc)**
966	**Design & Construction - ARS, Reach D (Erosion Protection)**	**0**		**583.5 days**	**Tue 10/1/24**	**Fri 12/25/26**			**Sacramento River - Between Richards Blvd and Lindent Road (EROSION Deficiencies); Reach Length - 22,825 LF; Levee Work = 11,275 LF (erosion protection)**
967	**Design**	0		**261 days**	**Tue 10/1/24**	**Tue 9/30/25**			
971	**Pre-Construction**	0		**77 days**	**Wed 10/1/25**	**Thu 1/15/26**			
980	**Constr - Levees (Eros Prot)**	**0**		**186.25 days**	**Sat 7/4/26**	**Fri 12/25/26**			**seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 - 11/30**
1001	**Plant Maintenance, ARS, Reach D**	0		782 days	Fri 12/25/26	Tue 12/25/29			
1002	**Plant Establishment Watering**	**0**		**782 days**	**Fri 12/25/26**	**Tue 12/25/29**			**extends 3 years past finish of initial plant establishment**
1006	**Design & Construction - ARN, Reach F**	**0**		**809.5 days**	**Mon 10/2/23**	**Fri 11/6/26**			**Between State Route 160 and just West of Arcade Blvd (SEEPAGE, HEIGHT Deficiencies(; Reach Length - 8330 LF; Levee Work = 2850 LF (Height Improvements) & 2450 LF (Seepage Improvements)**
1007	**Design**	0		**544 days**	**Mon 10/2/23**	**Thu 10/30/25**		**1085SS+261 days,1014**	
1013	**Pre-Construction**	0		**77 days**	**Fri 10/31/25**	**Mon 2/16/26**			
1022	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**235 days**	**Wed 4/1/26**	**Fri 11/6/26**			**seasonal construction window is approximately 4/1 - 10/31 (sans reveg, demob, haul route/access road repairs, etc)**
1083	**Design & Construction - ARN, Reach C**	**0**		**722.31 days**	**Tue 10/1/24**	**Thu 7/8/27**			**Between State Route 160 and just West of Arcade Blvd (SEEPAGE, HEIGHT Deficiencies(; Reach Length - 8330 LF; Levee Work = 2850 LF (Height Improvements) & 2450 LF (Seepage Improvements)**
1084	**Design**	0		**545 days**	**Tue 10/1/24**	**Mon 11/2/26**		**1091**	
1090	**Pre-Construction**	0		**77 days**	**Tue 11/3/26**	**Wed 2/17/27**			
1099	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**105 days**	**Thu 4/1/27**	**Thu 7/8/27**			**seasonal construction window is approximately 4/1 - 10/31**

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1140	**Design & Construction - ARS, Reach A (Erosion Protection)**	0		1139.69 days	Mon 10/2/17	Fri 2/11/22			American River - between Mira Del Rio Drive & Northwest of Carlson Drive (Erosion Deficiency); Reach Length - 36,190 LF; Levee Work = 6850 LF (Bank Protection) 17,750 LF (Rock Trench) (requires 3 seasons)
1141	**Design**	0		261 days	Mon 10/2/17	Mon 10/1/18		1146,1245SS+7 days	
1145	**Pre-Construction, Season 1**	0		77 days	Tue 10/2/18	Wed 1/16/19		1155SS+242 days	
1154	**Constr - Levees (Eros Prot), Season 1**	0		228.75 days	Wed 5/15/19	Sat 12/14/19		1232	seasonal construction window is approximately 4/1 - 11/30 (sans plantings, demob, etc); placement of rock in water is limited to 8/1-11/30; assumes (approximately 1/3 of the work can be accomplished during this period)
1172	**Pre-Construction, Season 2**	0		77 days	Thu 10/3/19	Fri 1/17/20			
1181	**Constr - Levees (Eros Prot), Season 2**	0		227.5 days	Sat 5/16/20	Tue 12/15/20		1236	seasonal construction window is approximately 4/1 - 11/30 (sans plantings, demob, etc); placement of rock in water is limited to 8/1-11/30; assumes (approximately 1/3 of the work can be accomplished during this period)
1199	**Pre-Construction, Season 3**	0		77 days	Mon 10/5/20	Tue 1/19/21			
1208	**Constr - Levees (Eros Prot), Season 3**	0		290.75 days	Mon 5/17/21	Fri 2/11/22			seasonal construction window is approximately 4/1 - 11/30 (sans plantings, demob, etc); placement of rock in water is limited to 8/1-11/30; assumes (approximately 1/3 of the work can be accomplished during this period); NOTE: Haul/Access RD repair extends
1230	**Plant Maintenance, ARS, Reach A**	0		1299 days	Mon 12/16/19	Thu 12/5/24			
1231	**Plant Establishment Watering, ARS, Reach A, Season 1**	1	LS	782 days	Mon 12/16/19	Tue 12/13/22			extends 3 years past finish of initial plant establishment
1235	**Plant Establishment Watering, ARS, Reach A, Season 2**	1	LS	783 days	Tue 12/15/20	Fri 12/15/23			extends 3 years past finish of initial plant establishment
1239	**Plant Establishment Watering, ARS, Reach A, Season 3**	1	LS	784 days	Mon 12/6/21	Thu 12/5/24			extends 3 years past finish of initial plant establishment
1243	**Design & Construction - ARS, Reach B (Erosion Protection)**	0		595 days	Fri 10/2/20	Fri 1/13/23			American River - between Carlson Drive and State Route 160 (Erosion Deficiency); Reach Length - 17,405 LF; Levee Work = 850 LF (Erosion Protection), 6400 LF (Rock Trench)
1244	**Design**	0		261 days	Fri 10/2/20	Fri 10/1/21		1284SS+261 days,1249	
1248	**Pre-Construction**	0		77 days	Mon 10/4/21	Tue 1/18/22			
1257	**Constr - Levees (Eros Prot)**	0		199.25 days	Mon 7/11/22	Fri 1/13/23			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); rock placement in water is limited to 8/1 - 11/30; NOTE: Haul/Access RD repair extends duration

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1277	Plant Maintenance, ARS, Reach B	0		783 days	Wed 12/7/22	Fri 12/5/25			
1278	Plant Establishment Watering, ARS, Reach B	0		783 days	Wed 12/7/22	Fri 12/5/25			extends 3 years past finish of initial plant establishment
1282	Design & Construction - ARN, Reach A (Erosion Protection)	0		845.5 days	Mon 10/4/21	Mon 12/30/24			American River - between River Oak Way and North of Northrop Ave (Erosion Deficiency); Reach Length - 36,400 LF; Levee Work = 18,150 LF (Rock Trench) (requires 2 seasons)
1283	Design	0		260 days	Mon 10/4/21	Fri 9/30/22		1354SS+521 days	
1287	Pre-Construction, Season 1	0		77 days	Mon 10/3/22	Tue 1/17/23			
1296	Constr - Levees (Eros Prot), Season 1	0		238.75 days	Tue 5/9/23	Mon 12/18/23			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 t-11/30; (assumes 50% of the work can be accomplished during this period)
1313	Pre-Construction, Season 2	0		77 days	Tue 10/3/23	Wed 1/17/24			
1322	Constr - Levees (Eros Prot), Season 2	0		251.25 days	Thu 5/9/24	Mon 12/30/24			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 t-11/30; (assumes 50% of the work can be accomplished during this period)
1343	Plant Maintenance, ARN, Reach A	0		1053.25 days	Mon 12/18/23	Thu 12/30/27			
1344	Plant Establishment Watering, ARN, Reach A, Season 1	1	LS	783 days	Mon 12/18/23	Thu 12/17/26			extends 3 years past finish of initial plant establishment
1348	Plant Establishment Watering, ARN, Reach A, Season 2	1	LS	783 days	Mon 12/30/24	Thu 12/30/27			extends 3 years past finish of initial plant establishment
1352	Design & Construction - ARS, Reach C (Erosion Protection)	0		540.5 days	Tue 10/3/23	Tue 10/28/25			American River & Sacramento River - between State Route 160 and Richards Blvd (Erosion Deficiency); Reach Length - 9895 LF; Levee Work = 3800 LF (Erosion Protection), 2150 LF (Rock Trench)
1353	Design	0		261 days	Tue 10/3/23	Tue 10/1/24		1395	
1357	Pre-Construction	0		77 days	Wed 10/2/24	Thu 1/16/25			
1366	Constr - Levees (Eros Prot)	0		158.75 days	Mon 6/2/25	Tue 10/28/25		1390	seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 - 11/30
1388	Plant Maintenance, ARS, Reach C	0		785 days	Tue 10/28/25	Tue 10/31/28			
1389	Plant Establishment Watering	0		785 days	Tue 10/28/25	Tue 10/31/28			extends 3 years past finish of initial plant establishment

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1393	**Design & Construction - ARN, Reach B (Erosion Protection)**	**0**		**537.5 days**	**Wed 10/2/24**	**Fri 10/23/26**			**American River - between Northrop Ave and Stae Route 160 (Erosion Deficiency); Reach Length - 1100 LF; Levee Work = 950 LF (Rock Trench)**
1394	**Design**	0		**261 days**	**Wed 10/2/24**	**Wed 10/1/25**		**1399**	
1398	**Pre-Construction**	0		**77 days**	**Thu 10/2/25**	**Fri 1/16/26**		**1408FS+212 days**	
1407	**Constr - Levees (Eros Prot)**	**0**		**87.5 days**	**Mon 8/3/26**	**Fri 10/23/26**			**seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 - 11/30**
1425	**Plant Maintenance, ARN, Reach B**	0		783 days	Fri 10/23/26	Wed 10/24/29			
1426	**Plant Establishment Watering**	**1**	**LS**	**783 days**	**Fri 10/23/26**	**Wed 10/24/29**			**extends 3 years past finish of initial plant establishment**
1430	**Design & Construction - ARN, Reach D**	**0**		**1346 days**	**Thu 10/1/20**	**Fri 11/28/25**			**Between Arcade Blvd & Marysville Blvd (SEEPAGE, HEIGHT Deficiencies); Reach Length - 10,965 LF**
1431	**Design**	0		**1044 days**	**Thu 10/1/20**	**Tue 10/1/24**		**1641SS+261 days**	
1437	**Pre-Construction**	0		**77 days**	**Wed 10/2/24**	**Thu 1/16/25**		**1447SS+195 days**	
1446	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**257.5 days**	**Wed 4/2/25**	**Fri 11/28/25**			**seasonal construction window is approximately 4/1 - 10/31 - assumes work will proceed from both ends of the reach in order to finish in one construction season**
1639	**Design & Construction - ARN, Reach E**	**0**		**1346 days**	**Fri 10/1/21**	**Mon 11/30/26**			**Between Scoles Ct and High St (SEEPAGE, HEIGHT Deficiencies); Reach Length - 11,155 LF**
1640	**Design**	0		**1044 days**	**Fri 10/1/21**	**Wed 10/1/25**		**1918SS+783 days**	
1646	**Pre-Construction**	0		**77 days**	**Thu 10/2/25**	**Fri 1/16/26**		**1656SS+195 days**	
1655	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**258.75 days**	**Thu 4/2/26**	**Mon 11/30/26**			**seasonal construction window is approximately 4/1 - 10/31 (sans reveg, demob, etc) - assumes work will proceed from both ends of the reach in order to finish in one construction season**
1916	**Design & Construction - ARN, Reach I**	**0**		**730 days**	**Wed 10/2/24**	**Wed 7/21/27**			**Between State Route 160 and just West of Arcade Blvd (SEEPAGE, HEIGHT Deficiencies(; Reach Length - 8330 LF; Levee Work = 2850 LF (Height Improvements) & 2450 LF (Seepage Improvements)**
1917	**Design**	0		**544 days**	**Wed 10/2/24**	**Mon 11/2/26**			
1923	**Pre-Construction**	0		**77 days**	**Tue 11/3/26**	**Wed 2/17/27**			
1932	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**83.75 days**	**Tue 5/4/27**	**Wed 7/21/27**			**seasonal construction window is approximately 4/1 - 10/31; schedule of various sites is uncertain, but assuming work is sequential the duration fits in the construction window**

ID		Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1955		**PROJECT COMPLETION**	*0*		1 day	Tue 12/25/29	Wed 12/26/29	1005,247,251,25		

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
0	**ARCFGRR Alt 2 - Total Project Schedule (including Construction)**	0		3192.5 days	Mon 10/2/17	Wed 12/26/29			Per PM & Civil Des, the project is assumed to begin in FY16. Constr Seq/Priority based on the following start years FY16-ARSF & ARSA, FY17-ARSE, FY19-ARSB, FY20-ARSG & ARNA, FY21-ARSD & SBW, FY22-ARSC, FY23-ARNB, ARND, ARNF & ARNC, FY24-ARNE, ARNG & ARNI
1	**Design & Construction - ARS, Reach F**	0		1335.06 days	Mon 10/2/17	Mon 11/14/22			Sacramento River - Between Clipper Way and River Garden Ct; From table provided by Civil Design, reach extends from ~Sta 353+85 to 640+20; Reach Length ~ 28,635 LF, Seepage & Stability Concern ~25,500 LF
2	**Design**	0		1044 days	Mon 10/2/17	Thu 9/30/21		258SS+783 days,160SS+52	
8	**Pre-Construction - Season 1**	0		77 days	Tue 10/1/19	Wed 1/15/20		89SS+262 days	
17	**Constr - Relocations & Levees (Seepage & Stability) - Season 1 - Sta 354+00 to 438+00 (approx)**	0		250 days	Wed 4/1/20	Fri 11/20/20			assumes ~1/3 of DSM cutoff walls will be constructed during Season 1; ~Sta 355+00 to 479+00; seasonal construction window to reestablish levee is approximately 4/1 - 10/31 (sans ABC, reveg, other non-levee-structure items)
88	**Pre-Construction - Season 2**	0		77 days	Thu 10/1/20	Fri 1/15/21		124SS+261 days	
97	**Constr - Relocations & Levees (Seepage & Stability) - Season 2 - Sta 479+00 to 546+00 (approx)**	0		235 days	Thu 4/1/21	Sat 11/6/21			assumes ~1/3 of DSM cutoff walls will be constructed during Season 2; ~Sta 479+00 to 546+00; seasonal construction window to reestablish levee is approximately 4/1 - 10/31 (sans ABC, reveg, other non-levee-structure items)
123	**Pre-Construction - Season 3**	0		77 days	Fri 10/1/21	Mon 1/17/22			
132	**Constr - Relocations & Levees (Seepage & Stability) - Season 3 - Sta 546+00 to 640+00 (approx)**	0		242.5 days	Fri 4/1/22	Mon 11/14/22			assumes ~1/3 of DSM cutoff walls will be constructed during Season 2; ~Sta 546+00 to 640+00; seasonal construction window to reestablish levee is approximately 4/1 - 10/31 (sans ABC, reveg, other non-levee-structure items)
158	**Design & Construction - ARS, Reach F (Erosion Protection)**	0		1137.5 days	Tue 10/1/19	Thu 2/8/24			Sacramento River - Between Clipper Way and River Garden Ct; From table provided by Civil Design, reach extends from ~Sta 353+85 to 640+20; Reach Length ~ 28,635 LF, Erosion Concern ~22,055 LF
159	**Design**	0		262 days	Tue 10/1/19	Wed 9/30/20			
163	**Pre-Construction - Season 1**	0		77 days	Thu 10/1/20	Fri 1/15/21			
172	**Constr - Levees (Eros Prot), Season 1 - - Sta 354+00 to 438+00 (approx)**	0		113.75 days	Sat 7/10/21	Sat 10/23/21			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1-11/30
188	**Pre-Construction - Season 2**	0		77 days	Fri 10/1/21	Mon 1/17/22			

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
197	Constr - Levees (Eros Prot), Season 2 - Sta 479+00 to 546+00 (approx)	0		108.75 days	Tue 7/12/22	Fri 10/21/22			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1-11/30; assumes approximately 1/3 the work can be accomplished during season 2
213	Pre-Construction - Season 3	0		77 days	Mon 10/3/22	Tue 1/17/23			
222	Constr - Levees (Eros Prot), Season 3 - Sta 546+00 to 640+00 (approx)	0		236.25 days	Mon 7/3/23	Thu 2/8/24			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1-11/30; assumes approximately 1/3 the work can be accomplished during season 3; NOTE: Haul/Access RD repair extends duration
243	Plant Maintenance - ARS, Reach F	0		1319.5 days	Mon 10/25/21	Fri 11/13/26			
244	Plant Establishment Watering, ARS, Reach F (Season 1)	0		783 days	Mon 10/25/21	Wed 10/23/24			extends 3 years past finish of initial plant establishment
248	Plant Establishment Watering, ARS, Reach F (Season 2)	0		783 days	Fri 10/21/22	Wed 10/22/25			extends 3 years past finish of initial plant establishment
252	Plant Establishment Watering, ARS, Reach F (Season 3)	0		782 days	Wed 11/15/23	Fri 11/13/26			extends 3 years past finish of initial plant establishment
256	Design & Construction - ARS, Reach E	0		1036.75 days	Thu 10/1/20	Fri 9/20/24			Sacramento River - Between Richards Blvd and Lindent Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 22,825 LF; Levee Work = 10,000 LF (seepage), 10,000 LF (stability)
257	Design	0		543 days	Thu 10/1/20	Mon 10/31/22		427SS	
263	Pre-Construction - Season 1	0		77 days	Tue 11/1/22	Wed 2/15/23		315FS+183 days,361SS	
272	Constr - Relocations & Levees (Seepage & Stability) - Season 1 - Sta 228+00 to 307+00 (approx)	0		183.75 days	Sat 4/1/23	Wed 9/20/23			assumes ~1/2 of DSM cutoff walls will be constructed during Season 1; ~Sta 228+00 to 307+00; seasonal construction window is approximately 4/1 - 10/31
314	Pre-Construction, Season 2	0		77 days	Tue 10/31/23	Wed 2/14/24		365SS	
323	Constr - Relocations & Levees (Seepage & Stability) - Season 2 - Sta 307+00 to 354+00 (approx)	0		185 days	Mon 4/1/24	Fri 9/20/24			assumes ~1/2 of DSM cutoff walls will be constructed during Season 1; ~Sta 307+00 to 354+00; seasonal construction window is approximately 4/1 - 10/31
359	Design & Construction - ARS, Reach E (Erosion Protection)	0		774 days	Tue 11/1/22	Sat 10/18/25			Sacramento River - Between Richards Blvd and Lindent Road (EROSION Deficiencies); Reach Length - 22,825 LF; Levee Work = 11,275 LF (erosion protection)
360	Design	0		260 days	Tue 11/1/22	Mon 10/30/23			
364	Pre-Construction - Season 1	0		77 days	Tue 10/31/23	Wed 2/14/24		374SS+327 days,389SS+26	

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
373	Constr - Levees (Eros Prot) - Season 1 - Sta 228+00 to 307+00 (approx)	0		111.25 days	Fri 8/30/24	Thu 12/12/24			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); rock placement in water is limited to 8/1 - 11/30
388	Pre-Construction - Season 2	0		77 days	Wed 10/30/24	Thu 2/13/25			
397	Constr - Levees (Eros Prot) - Season 2 - Sta 307+00 to 354+00 (approx)	0		96.25 days	Mon 7/21/25	Sat 10/18/25			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); rock placement in water is limited to 8/1 - 11/30
416	Plant Maintenance - ARS, Reach E	0		1002.31 days	Thu 12/12/24	Mon 10/16/28			
417	Plant Establishment Watering, ARS, Reach E, Season 1	0		782 days	Thu 12/12/24	Mon 12/13/27			extends 3 years past finish of initial plant establishment
421	Plant Establishment Watering, ARS, Reach E, Season 2	0		781 days	Mon 10/20/25	Mon 10/16/28			extends 3 years past finish of initial plant establishment
425	Design & Construction - ARS, Reach G	0		1341.5 days	Thu 10/1/20	Fri 11/21/25			Sacramento River - Between River Garden Cour and Beach lake Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 13,105 LF; Levee Work = 8333 LF (seepage), 8333 LF (stability)
426	Design	0		1043 days	Thu 10/1/20	Mon 9/30/24		433SS+1043 days,696SS+78	
432	Pre-Construction	0		77 days	Tue 10/1/24	Wed 1/15/25			
441	Constr - Relocations & Levees (Seepage & Stability)	0		251.25 days	Tue 4/1/25	Fri 11/21/25			seasonal construction window is approximately 4/1 - 10/31 - Schedule fwill be very tight - assumes Reveg can extend into Nov
657	Design & Construction - ARS, Reach G (Erosion Protection)	0		570.25 days	Tue 10/1/24	Tue 12/8/26			Sacramento River - Between River Garden Cour and Beach lake Road (EROSION Deficiencies); Reach Length - 13,120 LF; Levee Work = 11,120 LF (erosion protection)
658	Design	0		261 days	Tue 10/1/24	Tue 9/30/25			
662	Pre-Construction	0		77 days	Wed 10/1/25	Thu 1/15/26		672SS+294 days	
671	Constr - Levees (Eros Prot)	0		170 days	Thu 7/2/26	Tue 12/8/26			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1/ - 11/30
689	Plant Maintenance, ARS, Reach G	0		782 days	Tue 12/8/26	Thu 12/6/29			
690	Plant Establishment Watering	0		782 days	Tue 12/8/26	Thu 12/6/29			extends 3 years past finish of initial plant establishment
694	Design & Construction - ARS, Reach D	0		844.5 days	Mon 10/2/23	Fri 12/25/26			Sacramento River - Between Richards Blvd and Lindent Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 22,825 LF; Lvee Work = 10,000 LF (seepage), 10,000 LF (stability)

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
695	**Design**	0		**545 days**	**Mon 10/2/23**	**Fri 10/31/25**		**702,968SS+261 days**	
701	**Pre-Construction**	0		**77 days**	**Mon 11/3/25**	**Tue 2/17/26**			
710	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**287.5 days**	**Wed 4/1/26**	**Fri 12/25/26**			**seasonal construction window is approximately 4/1 - 10/31 (sans ABC, Reveg, Demob, etc)**
966	**Design & Construction - ARS, Reach D (Erosion Protection)**	**0**		**583.5 days**	**Tue 10/1/24**	**Fri 12/25/26**			**Sacramento River - Between Richards Blvd and Lindent Road (EROSION Deficiencies); Reach Length - 22,825 LF; Levee Work = 11,275 LF (erosion protection)**
967	**Design**	0		**261 days**	**Tue 10/1/24**	**Tue 9/30/25**			
971	**Pre-Construction**	0		**77 days**	**Wed 10/1/25**	**Thu 1/15/26**			
980	**Constr - Levees (Eros Prot)**	**0**		**186.25 days**	**Sat 7/4/26**	**Fri 12/25/26**			**seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 - 11/30**
1001	**Plant Maintenance, ARS, Reach D**	0		782 days	Fri 12/25/26	Tue 12/25/29			
1002	**Plant Establishment Watering**	**0**		**782 days**	**Fri 12/25/26**	**Tue 12/25/29**			**extends 3 years past finish of initial plant establishment**
1006	**Design & Construction - SBW**	**0**		**1878.5 days**	**Mon 10/2/17**	**Thu 12/12/24**			**Sacramento River - Between River Garden Cour and Beach lake Road (SEEPAGE, STABILITY Deficiencies); Reach Length - 13,105 LF; Levee Work = 8333 LF (seepage), 8333 LF (stability)**
1007	Design	0		653 days	Mon 10/2/17	Wed 4/1/20			
1013	Pre-Construction	0		130 days	Thu 4/2/20	Wed 9/30/20		1168SS+587 days	
1022	Construction - New Weir Structure	0		1337.5 days	Thu 10/1/20	Fri 3/1/24			assumes construction will begin from both ends and that section with 6 bays will be Bays 16 thru 21
1167	Construction - Sac Bypass Widening (new bypass levee west of RR)	0		340 days	Fri 10/1/21	Mon 8/15/22			Note - It will be necessary to leave small gaps in the new levee for placement of the seepage berm during the final season of SBW construction
1224	Construction - Sac Bypass Widening (W of new weir - remove old bypass levee, construct seepage berm to N of new bypass levee, close gap in new bypass lev; N of new Weir - new Sac	0		273.75 days	Mon 4/1/24	Thu 12/12/24			seasonal construction window for levee work adjacent to streams is approximately 4/1 - 10/31 (sans reveg, demob, etc)
1253	**Design & Construction - ARN, Reach F**	**0**		**809.5 days**	**Mon 10/2/23**	**Fri 11/6/26**			**Between State Route 160 and just West of Arcade Blvd (SEEPAGE, HEIGHT Deficiencies(; Reach Length - 8330 LF; Levee Work = 2850 LF (Height Improvements) & 2450 LF (Seepage Improvements)**
1254	**Design**	0		**544 days**	**Mon 10/2/23**	**Thu 10/30/25**		**1332SS+261 days,1261**	
1260	**Pre-Construction**	0		**77 days**	**Fri 10/31/25**	**Mon 2/16/26**			

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1269	Constr - Relocations & Levees (Seepage & Stability)	0		235 days	Wed 4/1/26	Fri 11/6/26			seasonal construction window is approximately 4/1 - 10/31 (sans reveg, demob, haul route/access road repairs, etc)
1330	Design & Construction - ARN, Reach C	0		722.31 days	Tue 10/1/24	Thu 7/8/27			Between State Route 160 and just West of Arcade Blvd (SEEPAGE, HEIGHT Deficiencies(; Reach Length - 8330 LF; Levee Work = 2850 LF (Height Improvements) & 2450 LF (Seepage Improvements)
1331	Design	0		545 days	Tue 10/1/24	Mon 11/2/26		1338	
1337	Pre-Construction	0		77 days	Tue 11/3/26	Wed 2/17/27			
1346	Constr - Relocations & Levees (Seepage & Stability)	0		105 days	Thu 4/1/27	Thu 7/8/27			seasonal construction window is approximately 4/1 - 10/31
1387	Design & Construction - ARS, Reach A (Erosion Protection)	0		1139.69 days	Mon 10/2/17	Fri 2/11/22			American River - between Mira Del Rio Drive & Northwest of Carlson Drive (Erosion Deficiency); Reach Length - 36,190 LF; Levee Work = 6850 LF (Bank Protection) 17,750 LF (Rock Trench) (requires 3 seasons)
1388	Design	0		261 days	Mon 10/2/17	Mon 10/1/18		1393,1492SS+7 days	
1392	Pre-Construction, Season 1	0		77 days	Tue 10/2/18	Wed 1/16/19		1402SS+242 days	
1401	Constr - Levees (Eros Prot), Season 1	0		228.75 days	Wed 5/15/19	Sat 12/14/19		1479	seasonal construction window is approximately 4/1 - 11/30 (sans plantings, demob, etc); placement of rock in water is limited to 8/1-11/30; assumes (approximately 1/3 of the work can be accomplished during this period)
1419	Pre-Construction, Season 2	0		77 days	Thu 10/3/19	Fri 1/17/20			
1428	Constr - Levees (Eros Prot), Season 2	0		227.5 days	Sat 5/16/20	Tue 12/15/20		1483	seasonal construction window is approximately 4/1 - 11/30 (sans plantings, demob, etc); placement of rock in water is limited to 8/1-11/30; assumes (approximately 1/3 of the work can be accomplished during this period)
1446	Pre-Construction, Season 3	0		77 days	Mon 10/5/20	Tue 1/19/21			
1455	Constr - Levees (Eros Prot), Season 3	0		290.75 days	Mon 5/17/21	Fri 2/11/22			seasonal construction window is approximately 4/1 - 11/30 (sans plantings, demob, etc); placement of rock in water is limited to 8/1-11/30; assumes (approximately 1/3 of the work can be accomplished during this period); NOTE: Haul/Access RD repair extends
1477	Plant Maintenance, ARS, Reach A	0		1299 days	Mon 12/16/19	Thu 12/5/24			
1478	Plant Establishment Watering, ARS, Reach A, Season 1	1	LS	782 days	Mon 12/16/19	Tue 12/13/22			extends 3 years past finish of initial plant establishment
1482	Plant Establishment Watering, ARS, Reach A, Season 2	1	LS	783 days	Tue 12/15/20	Fri 12/15/23			extends 3 years past finish of initial plant establishment

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1486	Plant Establishment Watering, ARS, Reach A, Season 3	1	LS	784 days	Mon 12/6/21	Thu 12/5/24			extends 3 years past finish of initial plant establishment
1490	Design & Construction - ARS, Reach B (Erosion Protection)	0		595 days	Fri 10/2/20	Fri 1/13/23			American River - between Carlson Drive and State Route 160 (Erosion Deficiency); Reach Length - 17,405 LF; Levee Work = 850 LF (Erosion Protection), 6400 LF (Rock Trench)
1491	Design	0		261 days	Fri 10/2/20	Fri 10/1/21		1531SS+261 days,1496	
1495	Pre-Construction	0		77 days	Mon 10/4/21	Tue 1/18/22			
1504	Constr - Levees (Eros Prot)	0		199.25 days	Mon 7/11/22	Fri 1/13/23			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); rock placement in water is limited to 8/1 - 11/30; NOTE: Haul/Access RD repair extends duration
1524	Plant Maintenance, ARS, Reach B	0		783 days	Wed 12/7/22	Fri 12/5/25			
1525	Plant Establishment Watering, ARS, Reach B	0		783 days	Wed 12/7/22	Fri 12/5/25			extends 3 years past finish of initial plant establishment
1529	Design & Construction - ARN, Reach A (Erosion Protection)	0		845.5 days	Mon 10/4/21	Mon 12/30/24			American River - between River Oak Way and North of Northrop Ave (Erosion Deficiency); Reach Length - 36,400 LF; Levee Work = 18,150 LF (Rock Trench) (requires 2 seasons)
1530	Design	0		260 days	Mon 10/4/21	Fri 9/30/22		1601SS+521 days	
1534	Pre-Construction, Season 1	0		77 days	Mon 10/3/22	Tue 1/17/23			
1543	Constr - Levees (Eros Prot), Season 1	0		238.75 days	Tue 5/9/23	Mon 12/18/23			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 t-11/30; (assumes 50% of the work can be accomplished during this period)
1560	Pre-Construction, Season 2	0		77 days	Tue 10/3/23	Wed 1/17/24			
1569	Constr - Levees (Eros Prot), Season 2	0		251.25 days	Thu 5/9/24	Mon 12/30/24			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 t-11/30; (assumes 50% of the work can be accomplished during this period)
1590	Plant Maintenance, ARN, Reach A	0		1053.25 days	Mon 12/18/23	Thu 12/30/27			
1591	Plant Establishment Watering, ARN, Reach A, Season 1	1	LS	783 days	Mon 12/18/23	Thu 12/17/26			extends 3 years past finish of initial plant establishment
1595	Plant Establishment Watering, ARN, Reach A, Season 2	1	LS	783 days	Mon 12/30/24	Thu 12/30/27			extends 3 years past finish of initial plant establishment

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1599	**Design & Construction - ARS, Reach C (Erosion Protection)**	0		540.5 days	Tue 10/3/23	Tue 10/28/25			American River & Sacramento River - between State Route 160 and Richards Blvd (Erosion Deficiency); Reach Length - 9895 LF; Levee Work = 3800 LF (Erosion Protection), 2150 LF (Rock Trench)
1600	**Design**	0		261 days	Tue 10/3/23	Tue 10/1/24		1642	
1604	**Pre-Construction**	0		77 days	Wed 10/2/24	Thu 1/16/25			
1613	**Constr - Levees (Eros Prot)**	0		158.75 days	Mon 6/2/25	Tue 10/28/25		1637	seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 - 11/30
1635	**Plant Maintenance, ARS, Reach C**	0		785 days	Tue 10/28/25	Tue 10/31/28			
1636	**Plant Establishment Watering**	0		785 days	Tue 10/28/25	Tue 10/31/28			extends 3 years past finish of initial plant establishment
1640	**Design & Construction - ARN, Reach B (Erosion Protection)**	0		537.5 days	Wed 10/2/24	Fri 10/23/26			American River - between Northrop Ave and Stae Route 160 (Erosion Deficiency); Reach Length - 1100 LF; Levee Work = 950 LF (Rock Trench)
1641	**Design**	0		261 days	Wed 10/2/24	Wed 10/1/25		1646	
1645	**Pre-Construction**	0		77 days	Thu 10/2/25	Fri 1/16/26		1655FS+212 days	
1654	**Constr - Levees (Eros Prot)**	0		87.5 days	Mon 8/3/26	Fri 10/23/26			seasonal construction window is approximately 4/1 - 11/30 (sans plantings); placement of rock in water is limited to 8/1 - 11/30
1672	**Plant Maintenance, ARN, Reach B**	0		783 days	Fri 10/23/26	Wed 10/24/29			
1673	**Plant Establishment Watering**	1	LS	783 days	Fri 10/23/26	Wed 10/24/29			extends 3 years past finish of initial plant establishment
1677	**Design & Construction - ARN, Reach D**	0		1346 days	Thu 10/1/20	Fri 11/28/25			Between Arcade Blvd & Marysville Blvd (SEEPAGE, HEIGHT Deficiencies); Reach Length - 10,965 LF
1678	**Design**	0		1044 days	Thu 10/1/20	Tue 10/1/24		1888SS+261 days	
1684	**Pre-Construction**	0		77 days	Wed 10/2/24	Thu 1/16/25		1694SS+195 days	
1693	**Constr - Relocations & Levees (Seepage & Stability)**	0		257.5 days	Wed 4/2/25	Fri 11/28/25			seasonal construction window is approximately 4/1 - 10/31 - assumes work will proceed from both ends of the reach in order to finish in one construction season
1886	**Design & Construction - ARN, Reach E**	0		1346 days	Fri 10/1/21	Mon 11/30/26			Between Scoles Ct and High St (SEEPAGE, HEIGHT Deficiencies); Reach Length - 11,155 LF
1887	**Design**	0		1044 days	Fri 10/1/21	Wed 10/1/25		2165SS+783 days	
1893	**Pre-Construction**	0		77 days	Thu 10/2/25	Fri 1/16/26		1903SS+195 days	

ID	Task Name	Number1	Unit	Duration	Start	Finish	Predecessors	Successors	Notes
1902	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**258.75 days**	**Thu 4/2/26**	**Mon 11/30/26**			**seasonal construction window is approximately 4/1 - 10/31 (sans reveg, demob, etc) - assumes work will proceed from both ends of the reach in order to finish in one construction season**
2163	**Design & Construction - ARN, Reach I**	**0**		**730 days**	**Wed 10/2/24**	**Wed 7/21/27**			**Between State Route 160 and just West of Arcade Blvd (SEEPAGE, HEIGHT Deficiencies(; Reach Length - 8330 LF; Levee Work = 2850 LF (Height Improvements) & 2450 LF (Seepage Improvements)**
2164	**Design**	0		**544 days**	**Wed 10/2/24**	**Mon 11/2/26**			
2170	**Pre-Construction**	0		**77 days**	**Tue 11/3/26**	**Wed 2/17/27**			
2179	**Constr - Relocations & Levees (Seepage & Stability)**	**0**		**83.75 days**	**Tue 5/4/27**	**Wed 7/21/27**			**seasonal construction window is approximately 4/1 - 10/31; schedule of various sites is uncertain, but assuming work is sequential the duration fits in the construction window**
2202	**PROJECT COMPLETION**	*0*		1 day	Tue 12/25/29	Wed 12/26/29	1005,247,251,25		

US Army Corps
of Engineers®

American River Common Features - General Reevaluation Report 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 Technical Center of Expertise, Walla Walla, WA

December 2, 2015

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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 American River Common Features - GRR. In compliance with Engineer Regulation (ER) 1110-2-1302 CIVIL WORKS COST ENGINEERING, dated September 15, 2008, a *Monte-Carlo* based risk analysis 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.

A post authorization change report has been prepared to document a general reevaluation study of the American River Common Features (ARCF) project for the City of Sacramento and surrounding areas, which is one of the most at risk areas for flooding in the United States due to its location at the confluence and within the floodplain of the American and Sacramento rivers. This General Reevaluation Report (GRR) addresses the flood risk management system for the American and Sacramento Rivers and five other smaller channels.

Specific to the American River Common Features GRR, the current project base cost for the National Economic Development (NED) estimate, approximates $946.0M and for the Locally Preferred Plan (LPP) approximates $1,135.4M, both pre-contingency and expressed in FY 2015 dollars. This CSRA study included all estimated construction costs, Planning, Engineering, Design and Construction Management costs. It excluded Real Estate Costs, where contingencies were provided by the Real Restate office. Based on the results of the analysis, the Cost Engineering Mandatory Center of Expertise for Civil Works (MCX located in Walla Walla District) recommends a contingency value of $255.4M or approximately 27% of base project cost for the NED and $317.9M or approximately 28% of base project cost for the LPP at an 80% confidence level of successful execution.

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 percent values will be reported, cost values rounded.

Table ES-1A. Construction Contingency Results - NED

Base Case Construction Cost Estimate	$946,007,000 *		
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**	**Contingency $**
50%	$1,163,589,000	23%	$217,582,000
80%	**$1,201,429,000**	**27%**	**$255,422,000 ***
90%	$1,229,809,000	30%	$283,802,000

* Excludes 01 – Lands and Damages Costs, Provided by Others

Table ES-1B. Construction Contingency Results - LPP

Base Case Construction Cost Estimate	$1,135,382,000 *		
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**	**Contingency $**
50%	$1,396,520,000	23%	$261,138,000
80%	**$1,453,289,000**	**28%**	**$317,907,000 ***
90%	$1,475,997,000	30%	$340,615,000

* Excludes 01 – Lands and Damages Costs, Provided by Others

KEY FINDINGS/OBSERVATIONS/ASSUMPTIONS & RECOMMENDATIONS

The PDT worked through the risk register in December 2014. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $255.4M for the NED Plan and contingency of $317.9M for the LPP Plan and schedule risks adding a potential 120 months; all at an 80% confidence level.

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

- ET1 – Estimate Quantities – Quantities could vary significantly. No PED level survey is available. No specific designs/quantities based on surveyed cross sections have been developed.
- ET6 – Level of Estimate – Detailed crews and construction methodology have been used in development of the feasibility estimate, but typical cost variations associated with a type 3 estimate should still be anticipated. Crews, assemblies, productivities, and methodologies in the current estimate, while acceptable and reasonable, may not adequately capture ultimate actual contractor technique and

costs. Actual contractor rates are likely to be different than assumed in the estimate. Estimate assumes contractor markups of 13% Job Office Overhead and 10% Home Office Overhead. These Rates could be understated.

Moderate risks, when combined, can also become a cost impact.

- CA1 – Small Business vs Full and Open – 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.
- PR4 – Project Authorization – With submittal of Chief's Report, the project will be awaiting authorization. Chief's Report is scheduled for next year. Next WRDA is scheduled for 2016 but realistically could slip 5 years or more based on current authorization cycle.
- CO6 – Specialized Construction Limiting Competition – Currently some 5 contractors in the area can do slurry wall construction. Deep Soil Mixing has even more limited competition. Multiple contracts between this project and others will be competing for the limited number of construction contractors capable of performing the work.
- CO1 – Modifications and Claims – There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PR4 – Project Authorization – With submittal of Chief's Report, the project will be awaiting authorization. Chief's Report is scheduled for next year. Next WRDA is scheduled for 2016 but realistically could slip 5 years or more based on current authorization cycle.
- PM7 – Competing Project Resources – SPK District has multiple high profile ongoing projects all competing for limited resources both in house and in the vertical chain.

Moderate risks, when combined, can also become a time and resulting cost impact.

- CO10 – Utility Relocations – Utility relocations will require coordination with affected parties. From experience, relocations of KNOWN utilities is not a major issue. Relocations only become problematic when unknown utilities are encountered which has been accounted for in Unknown Utilities Risk.
- PM8 – Internal Red Tape and Timely Review Processes – Project has already experienced delays due to timeliness of leadership decisions and direction. It's anticipated this will continue to be ongoing issue.

Recommendations: The CSRA study serves as a "road map" towards project improvements and reduced risks over time. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

MAIN REPORT

1.0 PURPOSE

Within the authority of the US Army Corps of Engineers (USACE), Sacramento District, this report presents the efforts and results of the cost and schedule risk analysis for the American River Common Features GRR. The report includes risk methodology, discussions, findings and recommendations regarding the identified risks and the necessary contingencies to confidently administer the project, presenting a cost and schedule contingency value with an 80% confidence level of successful execution.

2.0 BACKGROUND

A post authorization change report has been prepared to document a general reevaluation study of the American River Common Features (ARCF) project for the City of Sacramento and surrounding areas, which is one of the most at risk areas for flooding in the United States due to its location at the confluence and within the floodplain of the American and Sacramento rivers. This General Reevaluation Report (GRR) addresses the flood risk management system for the American and Sacramento Rivers and five other smaller channels.

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 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 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 District staff to provide expertise and information gathering. The District PDT

conducted initial risk identification via meetings with the Walla Walla Cost Engineering MCX facilitator in December 2014. The initial risk identification meeting also included qualitative analysis to produce a risk register that served as the draft framework for the risk analysis.

Participants in the risk identification meeting in December 2-3, 2014 included:

Name	Office	Representing
Robert Vrchoticky	Cost Engineer	Sacramento - SPK
Pete Ghelfi	SAFCA	Sponsor
Dan Tibbitts	Project Manager	Sacramento - SPK
Timi Shimabukuo	Economics	Sacramento - SPK
Liz Holland	Environmental Planner	Sacramento - SPK
Melissa Montag	Cultural Resources	Sacramento - SPK
John Hoge	Project Manager	Sacramento - SPK
Mark Boedtker	Civil Engineer	Sacramento – SPK
Jesse Schlunegger	Hydraulic Engineer	Sacramento - SPK
Ajala Ali	DWR	Sponsor
Bob Scarborough	DWR	Sponsor
James Elsberry	Civil Engineer	Sacramento - SPK
Shauna England	Construction	Sacramento - SPK
Andrew Muha	Planner	Sacramento - SPK
Sara Schultz	Planner	Sacramento - SPK
Rachel Rosas	Contracting	Sacramento - SPK
William Bolte	Risk Facilitator	Walla Walla - NWW

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 was held with the District office for the purposes of identifying and assessing risk factors. The meeting included capable and qualified representatives from multiple project team disciplines and functions, including project management, cost engineering, design, environmental compliance, real estate, construction, contracting and representatives of the sponsoring agencies.

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, numerous 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. An update meeting was held for finalization of the risk register, resulting CSRA model, findings and results.

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 section 6 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 quantifying the costs associated with the project.

a. The District provided MII MCACES (Micro-Computer Aided Cost Estimating Software) files electronically. The MII and CWE files transmitted and on September 9, 2015 and resulting independent review, served as the basis for the final cost and schedule risk analyses.

b. The cost comparisons and risk analyses performed and reflected within this report are based on design scope and estimates that are at the feasibility level of design.

c. Schedules are analyzed for impact to the project cost in terms of delayed funding, uncaptured escalation (variance from OMB factors and the local market) and unavoidable fixed contract costs and/or languishing federal administration costs incurred throughout delay.

d. 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.

e. 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 construction cost contingencies for the P5, P50 and P90 confidence levels are also provided for illustrative purposes only.

Table 1A. Construction Cost Contingency Summary – NED

Base Case Construction Cost Estimate	**$946,007,000 ***		
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**	**Contingency $**
50%	$1,163,589,000	23%	$217,582,000
80%	**$1,201,429,000**	**27%**	**$255,422,000 ***
90%	$1,229,809,000	30%	$283,802,000

* Excludes 01 – Lands and Damages Costs, Provided by Others

Table 1B. Construction Cost Contingency Summary – LPP

Base Case Construction Cost Estimate	$1,135,382,000 *		
Confidence Level	**Construction Value ($$) w/ Contingencies**	**Contingency (%)**	**Contingency $**
50%	$1,396,520,000	23%	$261,138,000
80%	**$1,453,289,000**	**28%**	**$317,907,000 ***
90%	$1,475,997,000	30%	$340,615,000

* Excludes 01 – Lands and Damages Costs, Provided by Others

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.

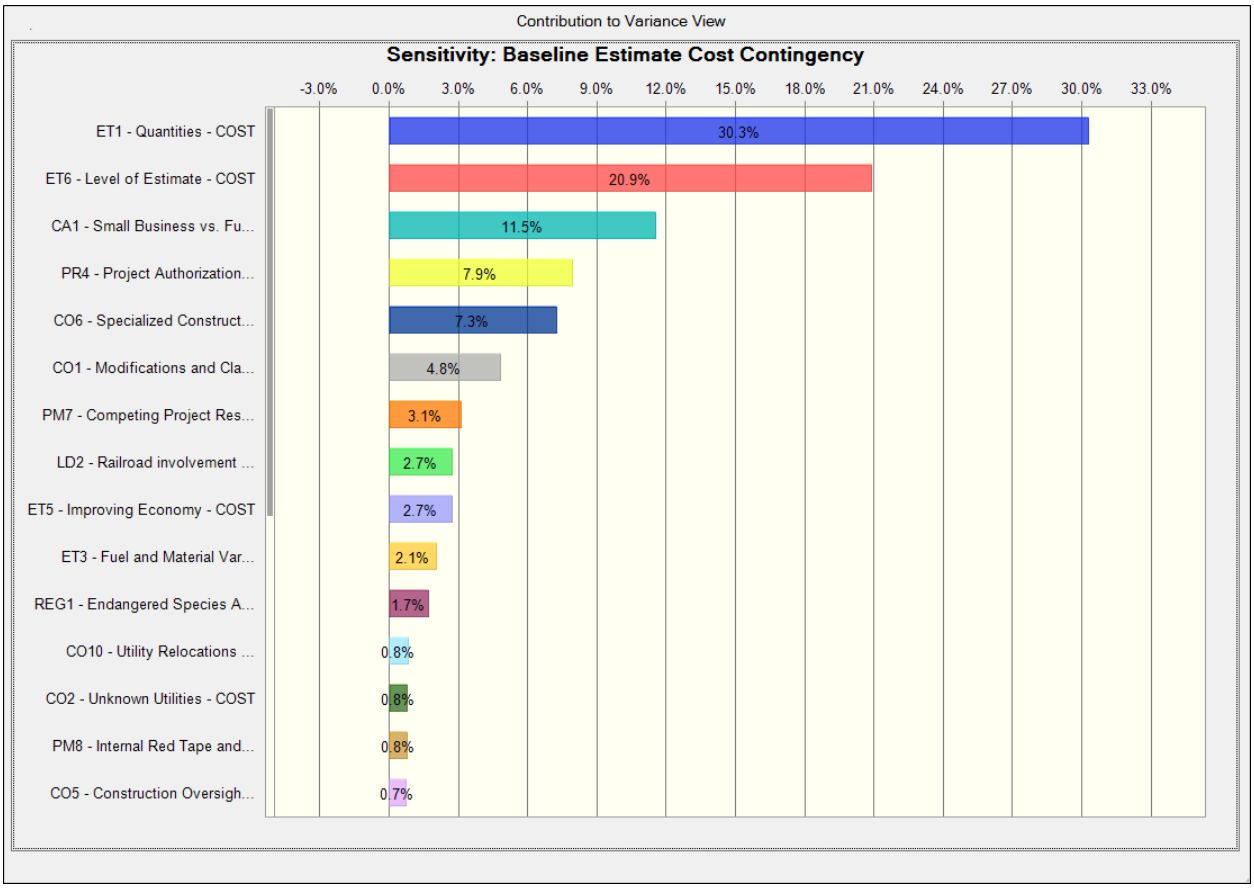
Key cost drivers identified in the sensitivity analysis can be used to support development of a risk management plan that will facilitate control of risk factors and their potential impacts throughout the project lifecycle. Together with the risk register, sensitivity analysis results can also be used 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 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 duration at intervals of confidence (probability).

Table 2 provides the schedule duration contingencies calculated for the P80 confidence level. The schedule duration contingencies for the P50 and P90 confidence levels are also provided for illustrative purposes.

Schedule duration contingency was quantified as 120 months based on the P80 level of confidence. These contingencies were used to calculate the projected residual fixed cost impact of project delays that are included in the Table 1 presentation of total cost contingency. The schedule contingencies were calculated by applying the high level

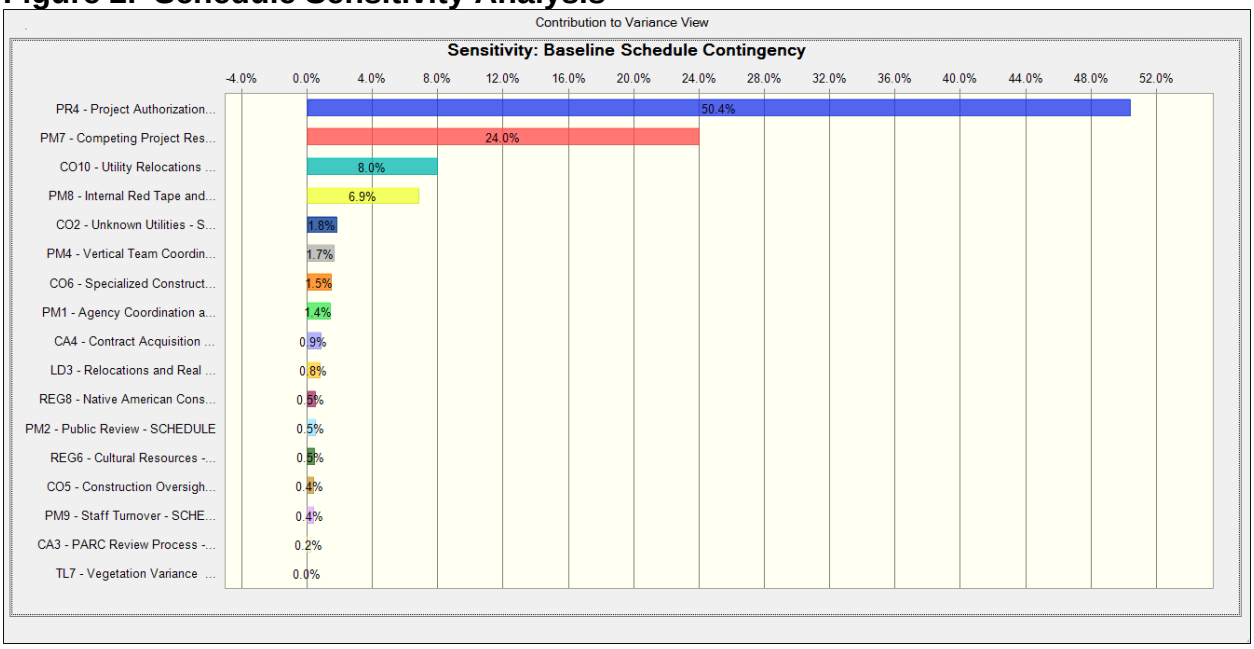
schedule risks identified in the risk register for each option to the durations of critical path and near critical path tasks.

The schedule was not resource loaded and contained open-ended tasks and non-zero lags (gaps in the logic between tasks) that limit the overall utility of the schedule risk analysis. These issues should be considered as limitations in the utility of the schedule contingency data presented. Schedule contingency impacts presented in this analysis are based solely on projected residual fixed costs.

Table 2. Schedule Duration Contingency Summary

Risk Analysis Forecast (base schedule of 174 months)	Duration w/ Contingencies (months)	Contingency[1] (months)
50% Confidence	275	101
80% Confidence	394	120
90% Confidence	305	131

Figure 2. Schedule Sensitivity Analysis



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 and schedule comparison summaries are provided in Table 3 and Table 4 respectively. Additional major findings and observations of the risk analysis are listed below.

The PDT worked through the risk register in December 2014. The key risk drivers identified through sensitivity analysis suggest a cost contingency of $255.4M for the NED Plan and contingency of $317.9M for the LPP Plan and schedule risks adding a potential 120 months; all at an 80% confidence level.

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

- ET1 – Estimate Quantities – Quantities could vary significantly. No PED level survey is available. No specific designs/quantities based on surveyed cross sections have been developed.
- ET6 – Level of Estimate – Detailed crews and construction methodology have been used in development of the feasibility estimate, but typical cost variations associated with a type 3 estimate should still be anticipated. Crews, assemblies, productivities, and methodologies in the current estimate, while acceptable and reasonable, may not adequately capture ultimate actual contractor technique and costs. Actual contractor rates are likely to be different than assumed in the estimate. Estimate assumes contractor markups of 13% Job Office Overhead and 10% Home Office Overhead. These Rates could be understated.

Moderate risks, when combined, can also become a cost impact.

- CA1 – Small Business vs Full and Open – 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.
- PR4 – Project Authorization – With submittal of Chief's Report, the project will be awaiting authorization. Chief's Report is scheduled for next year. Next WRDA is scheduled for 2016 but realistically could slip 5 years or more based on current authorization cycle.
- CO6 – Specialized Construction Limiting Competition – Currently some 5 contractors in the area can do slurry wall construction. Deep Soil Mixing has even more limited competition. Multiple contracts between this project and others will be competing for the limited number of construction contractors capable of performing the work.

- CO1 – Modifications and Claims – There is inherent risk of construction modifications and claims that arise after contract award due to issues such as weather, schedules dictated by O&M cycles, differing site conditions, user directed changes or omissions, inaccurate surveys, and variations in estimated quantities.

Schedule Risks: The high value of schedule risk indicates a significant uncertainty of key risk items, time duration growth that can translate into added costs. Over time, risks increase on those out-year contracts where there is greater potential for change in new scope requirements, uncertain market conditions, and unexpected high inflation. The greatest risk is:

- PR4 – Project Authorization – With submittal of Chief's Report, the project will be awaiting authorization. Chief's Report is scheduled for next year. Next WRDA is scheduled for 2016 but realistically could slip 5 years or more based on current authorization cycle.
- PM7 – Competing Project Resources – SPK District has multiple high profile ongoing projects all competing for limited resources both in house and in the vertical chain.

Moderate risks, when combined, can also become a time and resulting cost impact.

- CO10 – Utility Relocations – Utility relocations will require coordination with affected parties. From experience, relocations of KNOWN utilities is not a major issue. Relocations only become problematic when unknown utilities are encountered which has been accounted for in Unknown Utilities Risk.
- PM8 – Internal Red Tape and Timely Review Processes – Project has already experienced delays due to timeliness of leadership decisions and direction. It’s anticipated this will continue to be ongoing issue.

Table 3A. Construction Cost Comparison Summary (Uncertainty Analysis) – NED

PROJECT FIRST COST BASE ESTIMATE	$946,007,000		
Confidence Level	**Project First Cost**	**Contingency**	**Contingency %**
0%	$974,387,210	$28,380,210	3.00%
5%	$1,078,447,980	$132,440,980	14.00%
10%	$1,097,368,120	$151,361,120	16.00%
15%	$1,106,828,190	$160,821,190	17.00%
20%	$1,116,288,260	$170,281,260	18.00%
25%	$1,125,748,330	$179,741,330	19.00%
30%	$1,135,208,400	$189,201,400	20.00%
35%	$1,144,668,470	$198,661,470	21.00%
40%	$1,144,668,470	$198,661,470	21.00%
45%	$1,154,128,540	$208,121,540	22.00%
50%	$1,163,588,610	$217,581,610	23.00%
55%	$1,163,588,610	$217,581,610	23.00%
60%	$1,173,048,680	$227,041,680	24.00%
65%	$1,182,508,750	$236,501,750	25.00%
70%	$1,191,968,820	$245,961,820	26.00%
75%	$1,191,968,820	$245,961,820	26.00%
80%	**$1,201,428,890**	**$255,421,890**	**27.00%**
85%	$1,220,349,030	$274,342,030	29.00%
90%	$1,229,809,100	$283,802,100	30.00%
95%	$1,248,729,240	$302,722,240	32.00%
100%	$1,371,710,150	$425,703,150	45.00%

Table 3B. Construction Cost Comparison Summary (Uncertainty Analysis) – LPP

PROJECT FIRST COST BASE ESTIMATE	$1,135,382,000		
Confidence Level	**Project First Cost**	**Contingency**	**Contingency %**
0%	$1,169,443,460	$34,061,460	3.00%
5%	$1,305,689,300	$170,307,300	15.00%
10%	$1,317,043,120	$181,661,120	16.00%
15%	$1,339,750,760	$204,368,760	18.00%
20%	$1,351,104,580	$215,722,580	19.00%
25%	$1,351,104,580	$215,722,580	19.00%
30%	$1,362,458,400	$227,076,400	20.00%
35%	$1,373,812,220	$238,430,220	21.00%
40%	$1,385,166,040	$249,784,040	22.00%
45%	$1,385,166,040	$249,784,040	22.00%
50%	$1,396,519,860	$261,137,860	23.00%
55%	$1,407,873,680	$272,491,680	24.00%
60%	$1,407,873,680	$272,491,680	24.00%
65%	$1,419,227,500	$283,845,500	25.00%
70%	$1,430,581,320	$295,199,320	26.00%
75%	$1,441,935,140	$306,553,140	27.00%
80%	**$1,453,288,960**	**$317,906,960**	**28.00%**
85%	$1,464,642,780	$329,260,780	29.00%
90%	$1,475,996,600	$340,614,600	30.00%
95%	$1,498,704,240	$363,322,240	32.00%
100%	$1,646,303,900	$510,921,900	45.00%

Table 4. Construction Schedule Comparison Summary (Uncertainty Analysis)

Base Schedule Duration	174.0 Months		
Confidence Level	**Duration**	**Contingency**	**Contingency %**
0%	217.5 Months	43.5 Months	25.00%
5%	245.3 Months	71.3 Months	41.00%
10%	250.6 Months	76.6 Months	44.00%
15%	255.8 Months	81.8 Months	47.00%
20%	259.3 Months	85.3 Months	49.00%
25%	262.7 Months	88.7 Months	51.00%
30%	264.5 Months	90.5 Months	52.00%
35%	268.0 Months	94.0 Months	54.00%
40%	269.7 Months	95.7 Months	55.00%
45%	273.2 Months	99.2 Months	57.00%
50%	274.9 Months	100.9 Months	58.00%
55%	278.4 Months	104.4 Months	60.00%
60%	280.1 Months	106.1 Months	61.00%
65%	283.6 Months	109.6 Months	63.00%
70%	287.1 Months	113.1 Months	65.00%
75%	290.6 Months	116.6 Months	67.00%
80%	**294.1 Months**	**120.1 Months**	**69.00%**
85%	297.5 Months	123.5 Months	71.00%
90%	302.8 Months	128.8 Months	74.00%
95%	311.5 Months	137.5 Months	79.00%
100%	351.5 Months	177.5 Months	102.00%

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.

The CSRA study serves as a “road map” towards project improvements and reduced risks over time. The PDT must include the recommended cost and schedule contingencies and incorporate risk monitoring and mitigation on those identified risks. Further iterative study and update of the risk analysis throughout the project life-cycle is important in support of remaining within an approved budget and appropriation.

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).

APPENDIX A

American River Common Features - ALT 1 (NED)

Risk Matrix

Likelihood of Occurrence	Impact or Consequence of Occurrence: Negligible	Marginal	Significant	Critical	Crisis
Certain	Moderate	Moderate	High	High	High
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	Moderate

Overall Project Scope

A post authorization change report has been prepared to document a general reevaluation study of the American River Common Features (ARCF) project for the City of Sacramento and surrounding areas, which is one of the most at risk areas for flooding in the United States due to its location at the confluence and within the floodplain of the American and Sacramento rivers. This General Reevaluation Report (GRR) addresses the flood risk management system for the American and Sacramento Rivers and five other smaller channels.

SEE ASSUMPTIONS TAB FOR COST VALUE RANGES DEVELOPMNENT

Negligible--- ***Less than***			**$4,730,035**
Marginal ---*between*	**$4,730,036**	**and**	**$18,920,140**
Significant ---*between*	**$18,920,141**	**and**	**$28,380,210**
Critical--- *between*	**$28,380,211**	**and**	**$47,300,350**
Crisis ---*Over*	**$47,300,351**		

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost: Likelihood*	Project Cost: Impact*	Project Cost: Risk Level*	Project Cost: Rough Order Impact ($)	Project Schedule: Likelihood*	Project Schedule: Impact*	Project Schedule: Risk Level*	Project Schedule: Rough Order Impact (mo)
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)											
	PROJECT & PROGRAM MGMT										
PM1	Agency Coordination and Review	Multiple outside agency reviews remain outstanding and could have significant impacts on project scope.	Multiple SPK USACE projects are going through similar review processes by outside agencies resulting in resource bottlenecks. Typical review timelines may no longer be accurate. It is anticipated schedules could slip 6 to 12 months over the life of the project due to delays in outside agency reviews.	Very Unlikely	Marginal	LOW		Likely	Marginal	MODERATE	
PM2	Public Review	Timeline may not include sufficient time to address public comments and concerns as a result of the public review process.	Major public concerns include acquisition of multiple private properties, loss of wildlife/recreation due to rock placement on the American River. Schedule could slip 3 to 6 months due to public comments. Recirculation or redesign are not anticipated.	Very Unlikely	Negligible	LOW		Likely	Marginal	MODERATE	
PM3	Cost Sharing Agreement	Discussions are ongoing about the cost share for the LPP and the Sacramento Bypass.	Some $100+ Million in cost sharing remain in discussion. A resolution is anticipated within the next 3 to 6 months, which would not impact project schedule. If the sponsor is responsible for the additional $100+ Million cost it is anticipated the sponsor would continue and the LPP design would not change.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PM4	Vertical Team Coordination and Review	System Wide Improvement Framework (SWIF) approval and review by the vertical team.	Vertical team review and approval of the SWIF plan will be required when submitted. It is possible vertical team review could delay schedule 6 to 12 months. Denial of the SWIF would result in sponsors withdrawing from the project and is not modeled in this analysis.	Unlikely	Critical	MODERATE		Unlikely	Critical	MODERATE	
PM5	Project Partnership Agreement Signature	PPA signature will be required.	PPA will be contingent on Cost Sharing Agreement and SWIF approval (captured elsewhere). Once those risks have been resolved, PPA signature will not present an issue.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PM6	Pressure to Compress and Accelerate Schedule	The baseline project assumes an approximate 10 year construction schedule. This deadline came together as a conglomerate of political pressure, anticipated funding levels, staffing levels and managerial judgment.	Schedule is aggressive. All risks of schedule delay have been captured elsewhere in the risk model.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	

PM7	Competing Project Resources	SPK District has multiple high profile ongoing projects all competing for limited resources both in house and in the vertical chain.	ARCF has been a priority project and it is anticipated that it is possible with senior leadership support this project will continue to receive sufficient support, either through internal staffing or through contractual support or with other districts. Work being accomplished by the Sponsor under the 408 process could mitigate staffing requirements. Best case, resource will be sufficiently allocated and no schedule slip; most likely schedule will slip 2 years and worst case schedule could slip 4 years due to staffing shortfalls.	Likely	Marginal	MODERATE		Likely	Significant	HIGH	
PM8	Internal Red Tape and Timely Review Processes	Project has already experienced delays due to timeliness of leadership decisions and direction.	It's anticipated this will continue to be ongoing issue. Schedule could slip another 12 to 24 months over the life of the project. This risk is modeled in correlation with Competing Project Resources.	Very Unlikely	Negligible	LOW		Likely	Significant	HIGH	
PM9	Staff Turnover	Both PDT and Vertical Chain turnover will be an issue resulting in potential project delays as new team members must be brought on board.	Turnover will continue to be an issue. Learning curves will result in inefficiencies and project delays.	Very Unlikely	Negligible	LOW		Likely	Marginal	MODERATE	
	CONTRACT ACQUISITION RISKS										
CA1	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. Assume 30% of the project could be awarded small business with a 20% increase in construction costs.	Likely	Significant	HIGH		Very Unlikely	Negligible	LOW	
CA2	Numerous Contracts	Contracts will attempt to group sites by Fiscal Year wherever practical to minimize the number of individual contracts.	Efforts will be made to minimize number of contracts, but funding constraints, accelerated schedules, limited design resources and site locations could all result in numerous construction contracts. Estimate currently assumes minimal number of contracts. Assume costs could increase marginally due to additional contracts with additional mob/demob, inefficiencies and contract administration costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
CA3	PARC Review Process	Several of these construction contracts may be large enough to require PARC review.	PARC review could delay schedules to allow significant time for review. PARC will review to insure that large contracts contain all the same types of work and are bundled projects and full and open procurement is justified. Contracting Market Research and submittal to the PARC should begin at or before 90% design to insure enough time for sufficient review.	Unlikely	Marginal	LOW		Likely	Marginal	MODERATE	
CA4	Contract Acquisition Strategy	Concerns exist for awarding contracts of this magnitude on LPTA / IFB. Contracting Officer reserves the rights to enter into discussions with Offerors to gain a thorough understanding of the contractors approach.	Trade Off approach opens the contract to subjective judgment and can result in potential higher costs and schedule delays. From experience Best Value / Trade Off can extend the contract award 4 months and could result in protest.	Likely	Marginal	MODERATE		Unlikely	Significant	MODERATE	
	TECHNICAL RISKS										
TL1	HTRW	HTRW could be encountered during site excavation and construction.	Known HTRW Landfill site will be handled by Sponsor. Hazardous Waste Remediation for Real Estate procurement is not a project cost (per CERCLA). Minor HTRW issues may be encountered (asbestos on pipe relocations). Borings will be done in a proactive attempt to locate any HTRW. Estimate currently assumes no HTRW is located. It can be assumed 5 to 8 sites could discovered at a cost of $500K EA. If sites are encountered, individual areas will be skipped, remediated and then completed under existing contract or a follow on contract. This approach has been taken on other sites in ARCF and has worked effectively. No schedule impacts are anticipated.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	

TL2	Exploratory Borings	Limited exploratory borings have been taken on the North Levee of the Bypass. Additional geotechnical investigation will be required.	Depending on exploratory results, site specific design could change. Current North Levee Design is very conservative. If anything, design requirements could be reduced. Design changes are anticipated to be marginal.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL3	Borrow/Fill Sources	Borrow sources have not been located. It is typically the contractors responsibility to procure borrow material.	Estimate assumes 80% excavated material for South Sites and 20% excavated material for North Site will be disposed of offsite and new material will be brought onsite. Based on NRCS data a 20-25 mile radius was evaluated. Sufficient borrow sites were readily available, but will be dependent on willingness of sellers. Availability of borrow material could present an issue and haul distances could increase. As mitigation, some 1.5M cubic yards in excess material may become available from the sewage treatment plant. Sac Bypass expansion could be another source for borrow material.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL4	Rip Rap Supply	Rock quarry availability over time.	Rock placement locations and the volume of rock required is a substantial amount under the current estimates; availability of that magnitude may not be readily available. Estimate currently assumes all Rip Rap will be supplied via barge and placed by either river or land (location dependent). It is believed sufficient quantities will be available over the 20year of the project but may need to be shipped via truck depending on where rock is available from. From similar experience on other local projects with both barge and land placements, cost impacts between differences in truck and barge appear neutral depending on location.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL5	Design Criteria and Assumptions	Given extended project timeline (10yrs or more) revised criteria could result in update designs requirements.	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.	Unlikely	Significant	MODERATE		Very Unlikely	Negligible	LOW	
TL6	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 similar USACE sites have been constructed. If inspections of constructed sites show current design methodology (slurry wall) is not performing as expected designs could change resulting in significant design re-work.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL7	Vegetation Variance	Project will require a Vegetation Variance to allow riverside vegetation.	Without the Vegetation Variance the project would likely be in danger of receiving a Jeopardy Opinion from resource agencies resulting in the project going through a reformulation. This reformulation process could significantly impact both time and budget for the project.	Very Unlikely	Crisis	HIGH		Very Unlikely	Crisis	HIGH	
TL8	Consideration of Upstream Storage alternative and other screening alternatives	Upstream detention has been screened and eliminated with vertical team approval. If upstream detention were to be included project would not proceed.	Schedule impacts are not anticipated.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL9	Design Development	Scope is based on selected plan feasibility designs. Typical cross sections were developed for reaches. Overall the design is conservative. As an example the estimate currently includes some 9 miles of cutoff wall remediation. Existing design refinements by the sponsor have shown cutoff walls may be needed for 7 miles or less. As a whole, the design requirements are much more likely to decrease as opposed to increase.	There is a uncertainty level inherent with feasibility level designs. Expect negligible scope/cost changes as designs are further refined.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL10	As Built Design	Existing Construction was an issue on previous American River construction.	Current design does not rely on existing features and this will not be an issue for this project. In areas where construction projects will overlap, learning from the past, every effort will be made to insure accurate as-builts are created.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
	LANDS AND DAMAGES RISKS										

LD1	Borrow Sites	Potential borrow sites have been located but Real Estate costs do not include procurement costs. It is the responsibility of the contractor to procure borrow material. Borrow material costs in the construction estimate captures all incidental costs to procure real estate.	Multiple potential sites have been located sufficient to supply material for this project. Estimate has conservatively assumed commercial procurement of all material. If the contractor chooses to pursue their own material, it is assumed costs would only decrease.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
LD2	Railroad involvement	Several temporary and permanent easements will be required. Any railroad parcels acquisitions are time consuming and costs vary depending on what railroad charges with no set rates.	Construction schedule has most interactions with the railroad occurring later in the project. Railroad should be engaged early in the project to insure timely resolution. Weir widening will require relocation and integration with Yolo RR. Estimate will require additional costs for temporary closure and disruption of RR service. Estimate includes a $5M lump sum to reflect costs to the RR.	Likely	Significant	HIGH		Very Unlikely	Negligible	LOW	
LD3	Relocations and Real Estate Acquisitions may not happen in time	Relocations can be delayed by unwilling sellers.	Objections to appraisals take more time and funding. If sellers choose to hire attorney and go to court and with judge and jury can delay relocations by over 6 months. With proper management, individual acquisitions may slip schedule but the overall project schedule should not be delayed. Construction would occur in areas where real estate does not hinder project schedule.	Very Unlikely	Negligible	LOW		Likely	Marginal	MODERATE	
LD4	Staging Areas	Staging areas in heavily urban areas will present challenges.	Sponsor has begun actively searching for staging areas. Real Estate has included costs at a ratio of 1 acre staging area for every 1 mile of levee. Estimate currently includes fairly long haul distances (say 4miles) for staging areas. Pumping equipment for some cutoff wall construction may need to occur on riverside of levee. Estimate may need to include additional for re-establishment of parks after construction has completed.	Very Likely	Marginal	MODERATE		Unlikely	Negligible	LOW	
LD5	Vagrancy and Loitering Issues	Several homeless encampments will be encountered.	From experience, it is reasonable to assume loitering issues will be encountered. Law enforcement may need to be called and coordinated. For individual contracts this may present a minimal issue, but for overall project costs and schedules, this will be a non-issue.	Unlikely	Negligible	LOW		Unlikely	Negligible	LOW	
	REGULATORY AND ENVIRONMENTAL RISKS										
REG1	Endangered Species Act	It is possible resource agencies could provide an opinion that proposed mitigation areas are inadequate and additional will be required. In addition, species could be added to ESA.	It is likely resource agencies could require additional mitigation. The addition of species could also result in additional mitigation costs or design adaptations and changes. Review periods and iterative processes could result in minimal impacts to schedule. As a mitigation approach, Alternative 2 (LPP) could potentially use the Sacramento Bypass. Worst Case, mitigation costs could increase by 25% with offsite bank.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
REG2	Offsite Mitigation	Additional offsite mitigation could be required.	The estimate currently includes some 100 acres for elderberry mitigation and some 600 additional acres for Giant Garter Snakes. Some of this area will be mitigated offsite. These numbers are based on conservative assumptions. Additional compensation for SRA habitat may be required. Mitigation costs are very minimal relative to project costs and impacts are considered inconsequential (mitigation costs could increase some 15%). Additional offsite mitigation shouldn't impact schedule.	Likely	Marginal	MODERATE		Unlikely	Negligible	LOW	
REG3	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.	In order to accommodate aggressive schedule, multiple sites could be constructed concurrently. Early coordination with the Air Resource Board and inclusion in State Implementation Plan could mitigate schedule delays. Minimal additional construction cost impacts ($20K/MO) could be encountered.	Very Unlikely	Negligible	LOW		Unlikely	Negligible	LOW	

REG4	Water Quality	Construction could be limited due to water quality impacts.	Water quality for rock placement in the water would only have minimal potential cost impacts. Placement may require some additional costs (i.e. turbidity monitoring and potential decreased production rates) and are captured in our baseline cost estimate.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
REG5	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 occurred but Biologic Opinions have not been received. Until opinions have been received, restoration ratios have not been established. Additional offsite mitigation may be required. This risk has been modeled in REG2	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
REG6	Cultural Resources	Only a limited number of surface surveys have been conducted. It is likely cultural resources could be encountered during levee construction. It is known that cultural sites were buried during initial levee construction.	Extensive additional surveys and historical records searches will be required. It is anticipated additional cultural sites will be encountered. Cultural sites encountered during construction will be much more costly then those mitigated prior to construction. By completing sufficient cultural resource identification during PED and prior to construction schedule impacts should be mitigated. If cultural resources are encountered, construction schedules could be impacted 6-12months.	Very Likely	Marginal	MODERATE		Likely	Significant	HIGH	
REG7	Noise and Vibration Controls	Construction could be impacted by noise and vibration monitoring near occupied areas.	Residents may need to be temporarily relocated, but relative to total project, cost impacts would be minimal. ESTIMATE NEEDS TO INCLUDE VIBRATION MONITORING COSTS.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
REG8	Native American Consultation - Section 106 Compliance and Government to Government	Native American tribes may challenge USACE opinions during either PED or construction.	If sensitive sites are encountered, schedule could be delayed. It is hoped that with due diligence the risk may be mitigated. Construction methodology could also dictate how many sites are found. It is considered likely a challenge will occur, resulting in a potential construction schedule delay of up to 1 month, for up to 10 separate contracts over the life of the project. It is recommended an IDIQ be established for site investigation and documentation services and construction contracts include CLINS for contract relocations when sites are encountered.	Likely	Negligible	LOW		Likely	Marginal	MODERATE	
	CONSTRUCTION RISKS										
CO1	Modifications and Claims	Modifications will be experienced on any construction project. Project Construction is heavily dependent on geotechnical design solutions.	Modifications are to be expected. Inherent with any geotechnical design comes the possibility of differing site conditions such as constructed depth of cutoff wall due to change in key in layer elevation and site geology which would not have previously been noted due to the density of explorations in a given area, groundwater chemistry issues affecting curing of the cutoff wall etc. Current design specifies a design depth plus 10ft for keying into impermeable layer. This can become vastly more expensive if additional depth could require a different construction method (i.e. standard cutoff wall to deep soil mixing). Estimate already assumes DSM, so additional deptl with this approach wouldn't be significantly more expensive.	Very Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	

CO2	Unknown Utilities	A Slurry Wall was previously installed for the Sacramento River. There is a greater chance of unknown utilities on the American River, but those utilities are fewer with most located around bridges. The Bypass area is a relatively rura and few utilities are anticipated.	Marginal impacts for unknown utilities are anticipated.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
CO3	Site Access and Staging Areas	Access for slurry wall and erosion control along the Sacramento River will be difficult. American River erosion control will also be difficult.	In the Pocket Area, construction will be heavily congested in a dense urban environment and residential streets. Estimate is based on average haul times and distances but may not have sufficiently captured all costs.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
CO4	Construction Windows	All in water work must be completed between August 1 to Nov 30. Levee construction is limited between 15 April and 30 October. 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.	Very Unlikely	Negligible	LOW		Unlikely	Negligible	LOW	
CO5	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 experience, mods and claims have been experienced as a result of review delays (either from Construction or Engineering) leading to cost increases. It is being discussed to possibly stand up a Project Office to handle these projects.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
CO6	Specialized Construction Limiting Competition	Currently some 5 contractors in the area can do slurry wall construction. Deep Soil Mixing has even more limited competition. Multiple contracts between this project and others will be competing for the limited number of construction contractors capable of performing the work.	Limited contractor availability and competition could result in higher construction costs and even project delays if no qualified contractors are available.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
CO7	Constrained Site	Multiple locations will have tight site footprints which could constrain construction.	This risk has been captured in Staging Area Risks	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
CO8	Deep Soil Mixing	Deep soil mixing is fairly specialized construction feature many reaches 80ft deep and a few reaches some 130ft deep.	Schedule is highly dependent on availability of Deep Soil Mixing equipment. DSM is a majority of the length of total cutoff wall required and is a fairly slow process. Assumed Estimate Production rates appear reasonable and limited contractor competition has been accounted for elsewhere	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
CO9	Haul Road Resurfacing	Levee access for many locations will be through multiple residential locations.	Street resurfacing costs need to be added into the estimate.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
CO10	Utility Relocations	All impacted utilities will be left constructed in a policy compliant manner (existing deficient utilities will not be left in place). Utility relocations will require temporary supply.	Utility relocations will require coordination with affected parties. From experience, relocations of KNOWN utilities is not a major issue. Relocations only become problematic when unknown utilities are encountered which has been accounted for in Unknown Utilities Risk.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
	ESTIMATE AND SCHEDULE RISKS										
ET1	Quantities	Quantities could vary significantly. Earthwork and cutoff wall quantities are probably conservative and are likely to be reduced during PED.	No PED level survey is available. No specific designs/quantities based on surveyed cross sections has been developed. Quantities were calculated using tables with typical cross sections generated to capture the types of fixes needed along the levee as well as the existing geometry of the levee. These sections were then referenced into a dynamic spreadsheet where the type of fix, hydraulic data, and existing levee geometry were identified. Many fixes with varying levee geometry were developed and quantities did not interpolate between the fixes, but used the next larger fix (taller levee, deeper cutoff wall, etc), The spreadsheet calculated civil quantities using average end area method between stations of varying cross section.	Likely	Significant	HIGH		Very Unlikely	Negligible	LOW	
ET2	Utility Relocations	Large number and variety of requirements for utility relocations.	Variable nature of relocation requirements is difficult to quantify. Potential unknown utilities remain. VERIFY ESTIMATE INCLUDES UTILITY RELOCATION COSTS.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	

ET3	Fuel and Material Variations	Fuel Costs are a major cost driver for any large earthwork project. Bentonite availability for slurry cutoff wall construction could become a critical item.	Assume fuel prices could decrease 5% and increase 10%. Given the slurry wall construction, bentonite cost fluctuations could also have impacts on the project costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
ET4	Project Complexity	This is a relatively simple project consisting of mass earthwork, rock placement, DSM/slurry cutoff walls and floodwall construction. For alternative 2, the Sacramento Bypass is being widened and an adjacent weir added to allow larger bypass flows.	For contractors familiar with this type of construction, minimal cost variation or uncertainty should be anticipated.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
ET5	Improving Economy	Local economy has been improving and Government Work is becoming less attractive.	Much of this work is specialized (DSM) mitigating some of this concern. But there is the issue other construction features could experience higher prices.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
ET6	Level of Estimate	Feasibility level estimates have been developed.	Detailed crews and construction methodology have been used in development of the feasibility estimate, but typcial cost varitions associated with a type 3 estimate should still be anticipated.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)									
PR1	Funding Stream - Sponsor	Sponsor feels confident they can match anticipated Federal funding (say some $30M to $40M / year). For full project implementation a $140M / yr total funding stream would be required.	Sponsor anticipates being able to meet funding requirements in thru credits, LERRDs and cash.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PR2	Funding Stream - Federal	Sponsor feels confident they can match anticipated Federal funding (say some $30M to $40M / year). For full project implementation a $140M / yr total funding stream would be required.	National Civil Works Budget for Flood Risk Reduction is some $250M to $300M per year. Given the political awareness of the potential for major flood losses and the history of this project it may be reasonable to assume $100 Million per year in Federal Funding.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PR3	Weather Delays	Weather events could impact in water construction or delay start of construction windows.	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.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
PR4	Project Authorization	With submittal of Chief's Report, the project will be awaiting authorization.	Chief's Report is scheduled for next year. Next WRDA is scheduled for 2016 but realistically could slip 5 years or more based on current authorization cycle.	Very Unlikely	Negligible	LOW		Likely	Critical	HIGH	

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distributi respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

American River Common Features - ALT 2 (LPP)

Risk Matrix

Likelihood of Occurrence	Impact or Consequence of Occurrence: Negligible	Marginal	Significant	Critical	Crisis
Certain	Moderate	Moderate	High	High	High
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	High	High	High
Unlikely	Low	Low	Moderate	Moderate	High
Very Unlikely	Low	Low	Low	Low	Moderate

Overall Project Scope

A post authorization change report has been prepared to document a general reevaluation study of the American River Common Features (ARCF) project for the City of Sacramento and surrounding areas, which is one of the most at risk areas for flooding in the United States due to its location at the confluence and within the floodplain of the American and Sacramento rivers. This General Reevaluation Report (GRR) addresses the flood risk management system for the American and Sacramento Rivers and five other smaller channels.

SEE ASSUMPTIONS TAB FOR COST VALUE RANGES DEVELOPMNENT

Negligible--- ***Less than***			**$5,676,910**
Marginal ---*between*	**$5,676,911**	**and**	**$22,707,640**
Significant ---*between*	**$22,707,641**	**and**	**$34,061,460**
Critical--- *between*	**$34,061,461**	**and**	**$56,769,100**
Crisis ---*Over*	**$56,769,101**		

Risk No.	Risk/Opportunity Event	Concerns	PDT Discussions	Project Cost: Likelihood*	Project Cost: Impact*	Project Cost: Risk Level*	Project Cost: Rough Order Impact ($)	Project Schedule: Likelihood*	Project Schedule: Impact*	Project Schedule: Risk Level*	Project Schedule: Rough Order Impact (mo)
Contract Risks (Internal Risk Items are those that are generated, caused, or controlled within the PDT's sphere of influence.)											
	PROJECT & PROGRAM MGMT										
PM1	Agency Coordination and Review	Multiple outside agency reviews remain outstanding and could have significant impacts on project scope.	Multiple SPK USACE projects are going through similar review processes by outside agencies resulting in resource bottlenecks. Typical review timelines may no longer be accurate. It is anticipated schedules could slip 6 to 12 months over the life of the project due to delays in outside agency reviews.	Very Unlikely	Marginal	LOW		Likely	Marginal	MODERATE	
PM2	Public Review	Timeline may not include sufficient time to address public comments and concerns as a result of the public review process.	Major public concerns include acquisition of multiple private properties, loss of wildlife/recreation due to rock placement on the American River. Schedule could slip 3 to 6 months due to public comments. Recirculation or redesign are not anticipated.	Very Unlikely	Negligible	LOW		Likely	Marginal	MODERATE	
PM3	Cost Sharing Agreement	Discussions are ongoing about the cost share for the LPP and the Sacramento Bypass.	Some $100+ Million in cost sharing remain in discussion. A resolution is anticipated within the next 3 to 6 months, which woul not impact project schedule. If the sponsor is responsible for the additional $100+ Million cost a is anticipated the sponsor would continue and the LPP design would not change.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PM4	Vertical Team Coordination and Review	System Wide Improvement Framework (SWIF) approval and review by the vertical team.	Vertical team review and approval of the SWIF plan will be required when submitted. It is possible vertical team review could delay schedule 6 to 12 months. Denial of the SWIF would result in sponsors withdrawing from the project and is not modeled in this analysis.	Unlikely	Critical	MODERATE		Unlikely	Critical	MODERATE	
PM5	Project Partnership Agreement Signature	PPA signature will be required.	PPA will be contingent on Cost Sharing Agreement and SWIF approval (captured elsewhere). Once those risks have been resolved, PPA signature will not present an issue.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PM6	Pressure to Compress and Accelerate Schedule	The baseline project assumes an approximate 10 year construction schedule. This deadline came together as a conglomerate of political pressure, anticipated funding levels, staffing levels and managerial judgment.	Schedule is aggressive. All risks of schedule delay have been captured elsewhere in the risk model.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	

PM7	Competing Project Resources	SPK District has multiple high profile ongoing projects all competing for limited resources both in house and in the vertical chain.	ARCF has been a priority project and it is anticipated that it is possible with senior leadership support this project will continue to receive sufficient support, either through internal staffing or through contractual support or with other districts. Work being accomplished by the Sponsor under the 408 process could mitigate staffing requirements. Best case, resource will be sufficiently allocated and no schedule slip; most likely schedule will slip 2 years and worst case schedule could slip 4 years due to staffing shortfalls.	Likely	Marginal	MODERATE		Likely	Significant	HIGH	
PM8	Internal Red Tape and Timely Review Processes	Project has already experienced delays due to timeliness of leadership decisions and direction.	It's anticipated this will continue to be ongoing issue. Schedule could slip another 12 to 24 months over the life of the project. This risk is modeled in correlation with Competing Project Resources.	Very Unlikely	Negligible	LOW		Likely	Significant	HIGH	
PM9	Staff Turnover	Both PDT and Vertical Chain turnover will be an issue resulting in potential project delays as new team members must be brought on board.	Turnover will continue to be an issue. Learning curves will result in inefficiencies and project delays.	Very Unlikely	Negligible	LOW		Likely	Marginal	MODERATE	
	CONTRACT ACQUISITION RISKS										
CA1	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. Assume 30% of the project could be awarded small business with a 20% increase in construction costs.	Likely	Significant	HIGH		Very Unlikely	Negligible	LOW	
CA2	Numerous Contracts	Contracts will attempt to group sites by Fiscal Year wherever practical to minimize the number of individual contracts.	Efforts will be made to minimize number of contracts, but funding constraints, accelerated schedules, limited design resources and site locations could all result in numerous construction contracts. Estimate currently assumes minimal number of contracts. Assume costs could increase marginally due to additional contracts with additional mob/demob, inefficiencies and contract administration costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
CA3	PARC Review Process	Several of these construction contracts may be large enough to require PARC review.	PARC review could delay schedules to allow significant time for review. PARC will review to insure that large contracts contain all the same types of work and are bundled projects and full and open procurement is justified. Contracting Market Research and submittal to the PARC should begin at or before 90% design to insure enough time for sufficient review.	Unlikely	Marginal	LOW		Likely	Marginal	MODERATE	
CA4	Contract Acquisition Strategy	Concerns exist for awarding contracts of this magnitude on LPTA / IFB. Contracting Officer reserves the rights to enter into discussions with Offerors to gain a thorough understanding of the contractors approach.	Trade Off approach opens the contract to subjective judgment and can result in potential higher costs and schedule delays. From experience Best Value / Trade Off can extend the contract award 4 months and could result in protest.	Likely	Marginal	MODERATE		Unlikely	Significant	MODERATE	
	TECHNICAL RISKS										
TL1	HTRW	HTRW could be encountered during site excavation and construction.	Known HTRW Landfill Site will be handled by Sponsor. Hazardous Waste Remediation for Real Estate procurement is not a project cost (per CERCLA). Minor HTRW issues may be encountered (asbestos on pipe relocations). Borings will be done in a proactive attempt to locate any HTRW. Estimate currently assumes no HTRW is located. It can be assumed 5 to 8 sites could discovered at a cost of $500K EA. If sites are encountered, individual areas will be skipped, remediated and then completed under existing contract or a follow on contract. This approach has been taken on other sites in ARCF and has worked effectively. No schedule impacts	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
TL2	Exploratory Borings	Limited exploratory borings have been taken on the North Levee of the Bypass. Additional geotechnical investigation will be required.	Depending on exploratory results, site specific design could change. Current North Levee Design is very conservative. If anything, design requirements could be reduced. Design changes are anticipated to be marginal.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	

TL3	Borrow/Fill Sources	Borrow sources have not been located. It is typically the contractors responsibility to procure borrow material.	Estimate assumes 80% excavated material for South Sites and 20% excavated material for North Site will be disposed of offsite and new material will be brought onsite. Based on NRCS data a 20-25 mile radius was evaluated. Sufficient quantities of material were readily available, but will be dependent on willingness of sellers. Availability of borrow material could present an issue but it is unlikely that haul distances could increase because of quantities identified were orders of magnitude greater. As mitigation, some 1.5M cubic yards in excess material may become available from the sewage treatment plant. Sac Bypass expansion could be another source for borrow material.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL4	Rip Rap Supply	Rock quarry availability over time.	Rock placement locations and the volume of rock required is a substantial amount under the current estimates; availability of tha magnitude may not be readily available. Estimate currently assumes all Rip Rap will be supplied via barge and placed by either river or land (location dependent). It is believed sufficient quantities will be available over the 20years of the project but may need to be shipped via truck depending on where rock is available from. From similar experience on other local projects with both barge and land placements, cost impacts between differences in truck and barge appear neutral depending on location.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL5	Design Criteria and Assumptions	Given extended project timeline (10yrs or more) revised criteria could result in update designs requirements.	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.	Unlikely	Significant	MODERATE		Very Unlikely	Negligible	LOW	
TL6	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 similar USACE sites have been constructed. If inspections of constructed sites show current design methodology (slurry wall is not performing as expected designs could change resulting in significant design re-work.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL7	Vegetation Variance	Project will require a Vegetation Variance to allow riverside vegetation.	Without the Vegetation Variance the project would likely be in danger of receiving a Jeopardy Opinion from resource agencies resulting in the project going through a reformulation. This reformulation process could significantly impact both time and budget for the project.	Very Unlikely	Crisis	HIGH		Very Unlikely	Crisis	HIGH	
TL8	Consideration of Upstream Storage alternative and other screening alternatives	Upstream detention has been screened and eliminated with vertical team approval. If upstream detention were to be included project would not proceed.	Schedule impacts are not anticipated.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL9	Design Development	Scope is based on selected plan feasibility designs. Typical cross sections were developed for reaches. Overall the design is conservative. As an example the estimate currently includes some 9 miles of cutoff wall remediation. Existing design refinements by the sponsor have shown cutoff walls may be needed for 7 miles or less. As a whole, the design requirements are much more likely to decrease as opposed to increase.	There is a uncertainty level inherent with feasibility level designs. Expect negligible scope/cost changes as designs are further refined.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
TL10	As Built Design	Existing Construction was an issue on previous American River construction.	Current design does not rely on existing features and this will not be an issue for this project. In areas where construction projects will overlap, learning from the past, every effort will be made to insure accurate as-builts are created.	Likely	Negligible	LOW		Very Unlikely	Negligible	LOW	
	LANDS AND DAMAGES RISKS										
LD1	Borrow Sites	Potential borrow sites have been located but Real Estate costs do not include procurement costs. It is the responsibility of the contractor to procure borrow material. Borrow material costs in the construction estimate captures all incidental costs to procure real estate.	Multiple potential sites have been located sufficient to supply material for this project. Estimate has conservatively assumed commercial procurement of all material. If the contractor chooses to pursue their own material, it is assumed costs would only decrease.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	

LD2	Railroad involvement	Several temporary and permanent easements will be required. Any railroad parcels acquisitions are time consuming and costs vary depending on what railroad charges with no set rates.	Construction schedule has most interactions with the railroad occurring later in the project. Railroad should be engaged early in the project to insure timely resolution. Weir widening will require relocation and integration with Yolo RR. Estimate will require additional costs for temporary closure and disruption of RR service. Estimate includes a $5M lump sum to reflect costs to the RR.	Likely	Significant	HIGH		Very Unlikely	Negligible	LOW	
LD3	Relocations and Real Estate Acquisitions may not happen in time	Relocations can be delayed by unwilling sellers.	Objections to appraisals take more time and funding. If sellers choose to hire attorney and go to court and with judge and jury can delay relocations by over 6 months. With proper management, individual acquisitions may slip schedule but the overall project schedule should not be delayed. Construction would occur in areas where real estate does not hinder project schedule.	Very Unlikely	Negligible	LOW		Likely	Marginal	MODERATE	
LD4	Staging Areas	Staging areas in heavily urban areas will present challenges	Sponsor has begun actively searching for staging areas. Real Estate has included costs at a ratio of 1 acre staging area for every 1 mile of levee. Estimate currently includes fairly long haul distances (say 4miles) for staging areas. Pumping equipment for some cutoff wall construction may need to occur on riverside of levee. Estimate may need to include additional for re-establishment of parks after construction has completed.	Very Likely	Marginal	MODERATE		Unlikely	Negligible	LOW	
LD5	Vagrancy and Loitering Issues	Several homeless encampments will be encountered.	From experience, it is reasonable to assume loitering issues will be encountered. Law enforcement may need to be called and coordinated. For individual contracts this may present a minimal issue, but for overall project costs and schedules, this will be a non issue.	Unlikely	Negligible	LOW		Unlikely	Negligible	LOW	
	REGULATORY AND ENVIRONMENTAL RISKS										
REG1	Endangered Species Act	It is possible resource agencies could provide an opinion that proposed mitigation areas are inadequate and additional will be required. In addition, species could be added to ESA.	It is likely resource agencies could require additional mitigation. The addition of species could also result in additional mitigation costs or design adaptations and changes. Review periods and iterative processes could result in minimal impacts to schedule. As a mitigation approach, Alternative 2 (LPP) could potentially use the Sacramento Bypass. Worst Case, mitigation costs could increase by 25% with offsite bank.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
REG2	Offsite Mitigation	Additional offsite mitigation could be required.	The estimate currently includes some 100 acres for elderberry mitigation and some 600 additional acres for Giant Garter Snakes. Some of this area will be mitigated offsite. These numbers are based on conservative assumptions. Additional compensation for SRA habitat may be required. Mitigation costs are very minimal relative to project costs and impacts are considered inconsequential (mitigation costs could increase some 15%). Additional offsite mitigation shouldn't impact schedule.	Likely	Marginal	MODERATE		Unlikely	Negligible	LOW	
REG3	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.	In order to accommodate aggressive schedule, multiple sites could be constructed concurrently. Early coordination with the Air Resource Board and inclusion in State Implementation Plan could mitigate schedule delays. Minimal additional construction cost impacts ($20K/MO) could be encountered.	Very Unlikely	Negligible	LOW		Unlikely	Negligible	LOW	
REG4	Water Quality	Construction could be limited due to water quality impacts.	Water quality for rock placement in the water would only have minimal potential cost impacts. Placement may require some additional costs (i.e. turbidity monitoring and potential decreased production rates) and are captured in our baseline cost estimate.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
REG5	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 occurred but Biologic Opinions have not been received. Until opinions have been received, restoration ratios have not been established. Additional offsite mitigation may be required. This risk has been modeled in REG2	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	

REG6	Cultural Resources	Only a limited number of surface surveys have been conducted. It is likely cultural resources could be encountered during levee construction. It is known that cultural sites were buried during initial levee construction.	Extensive additional surveys and historical records searches will be required. It is anticipated additional cultural sites will be encountered. Cultural sites encountered during construction will be much more costly then those mitigated prior to construction. By completing sufficient cultural resource identification during PED and prior to construction schedule impacts should be mitigated. If cultural resources are encountered, construction schedules could be impacted 6-12months.	Very Likely	Marginal	MODERATE		Likely	Significant	HIGH	
REG7	Noise and Vibration Controls	Construction could be impacted by noise and vibration monitoring near occupied areas.	Residents may need to be temporarily relocated, but relative to total project, cost impacts would be minimal. ESTIMATE NEEDS TO INCLUDE VIBRATION MONITORING COSTS.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
REG8	Native American Consultation - Section 106 Compliance and Government to Government	Native American tribes may challenge USACE opinions during either PED or construction.	If sensitive sites are encountered, schedule could be delayed. It is hoped that with due diligence the risk may be mitigated. Construction methodology could also dictate how many sites are found. It is considered likely a challenge will occur, resulting in a potential construction schedule delay of up to 1 month, for up to 10 separate contracts over the life of the project. It is recommended an IDIQ be established for site investigation and documentation services and construction contracts include CLINS for contract relocations when sites are encountered.	Likely	Negligible	LOW		Likely	Marginal	MODERATE	
	CONSTRUCTION RISKS										
CO1	Modifications and Claims	Modifications will be experienced on any construction project. Project Construction is heavily dependent on geotechnical design solutions.	Modifications are to be expected Inherent with any geotechnical design comes the possibility of differing site conditions such as constructed depth of cutoff wall due to change in key in layer elevation and site geology which would not have previously been noted due to the density of explorations in a given area, groundwater chemistry issues affecting curing of the cutoff wall etc. Current design specifies a design depth plus 10ft for keying into impermeable layer. This can become vastly more expensive if additional depth could require a different construction method (i.e standard cutoff wall to deep soil mixing). Estimate already assumes DSM, so additional depth with this approach wouldn't be	Very Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
CO2	Unknown Utilities	A Slurry Wall was previously installed for the Sacramento River. There is a greater chance of unknown utilities on the American River, but those utilities are fewer with most located around bridges. The Bypass area is a relatively rural and few utilities are anticipated.	Marginal impacts for unknown utilities are anticipated.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
CO3	Site Access and Staging Areas	Access for slurry wall and erosion control along the Sacramento River will be difficult. American River erosion control will also be difficult.	In the Pocket Area, construction will be heavily congested in a dense urban environment and residential streets. Estimate is based on average haul times and distances but may not have sufficiently captured all costs.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
CO4	Construction Windows	All in water work must be completed between August 1 to Nov 30. Levee construction is limited between 15 April and 30 October. 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.	Very Unlikely	Negligible	LOW		Unlikely	Negligible	LOW	
CO5	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 experience, mods and claims have been experienced as a result of review delays (either from Construction or Engineering) leading to cost increases. It is being discussed to possibly stand up a Project Office to handle these projects.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
CO6	Specialized Construction Limiting Competition	Currently some 5 contractors in the area can do slurry wall construction. Deep Soil Mixing has even more limited competition. Multiple contracts between this project and others will be competing for the limited number of construction contractors capable of performing the work.	Limited contractor availability and competition could result in higher construction costs and even project delays if no qualified contractors are available.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	

CO7	Constrained Site	Multiple locations will have tight site footprints which could constrain construction.	This risk has been captured in Staging Area Risks	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
CO8	Deep Soil Mixing	Deep soil mixing is fairly specialized construction feature many reaches 80ft deep and a few reaches some 130ft deep.	Schedule is highly dependent on availability of Deep Soil Mixing equipment. DSM is a majority of the length of total cutoff wall required and is a fairly slow process. Assumed Estimate Production rates appear reasonable and limited contractor competition has been accounted for elsewhere	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
CO9	Haul Road Resurfacing	Levee access for many locations will be through multiple residential locations.	Street resurfacing costs need to be added into the estimate.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
CO10	Utility Relocations	All impacted utilities will be left constructed in a policy compliant manner (existing deficient utilities will not be left in place). Utility relocations will require temporary supply.	Utility relocations will require coordination with affected parties. From experience, relocations of KNOWN utilities is not a major issue. Relocations only become problematic when unknown utilities are encountered which has been accounted for in Unknown Utilities Risk.	Likely	Marginal	MODERATE		Likely	Marginal	MODERATE	
	ESTIMATE AND SCHEDULE RISKS										
ET1	Quantities	Quantities could vary significantly. Earthwork and cutoff wall quantities are probably conservative and are likely to be reduced during PED.	No PED level survey is available. No specific designs/quantities based on surveyed cross sections has been developed. Quantities were calculated using tables with typical cross sections generated to capture the types of fixes needed along the levee as well as the existing geometry of the levee. These sections were then referenced into a dynamic spreadsheet where the type of fix, hydraulic data, and existing levee geometry were identified. Many fixes with varying levee geometry were developed and quantities did not interpolate between the fixes, but used the next larger fix (taller levee, higher floodwall, deeper cutoff wall, etc), The spreadsheet calculated civil quantities using average end area method between stations of varying cross section.	Likely	Significant	HIGH		Very Unlikely	Negligible	LOW	
ET2	Utility Relocations	Large number and variety of requirements for utility relocations.	Variable nature of relocation requirements is difficult to quantify. Potential unknown utilities remain. VERIFY ESTIMATE INCLUDES UTILITY RELOCATION COSTS.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
ET3	Fuel and Material Variations	Fuel Costs are a major cost driver for any large earthwork project. Bentonite availability for slurry cutoff wall construction could become a critical item.	Assume fuel prices could decrease 5% and increase 10%. Given the slurry wall construction, bentonite cost fluctuations could also have impacts on the project costs.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
ET4	Project Complexity	[illegible] earthwork, rock placement, DSM/slurry cutoff walls and floodwall construction. For alternative 2, the Sacramento Bypass is being widened and an adjacent weir added to allow larger bypass flows.	For contractors familiar with this type of construction, minimal cost variation or uncertainty should be anticipated.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
ET5	Improving Economy	Local economy has been improving and Government Work is becoming less attractive.	Much of this work is specialized (DSM) mitigating some of this concern. But there is the issue other construction features could experience higher prices.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
ET6	Level of Estimate	Feasibility level estimates have been developed.	Detailed crews and construction methodology have been used in development of the feasibility estimate, but typical cost variations associated with a type 3 estimate should still be anticipated.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
	Programmatic Risks	(External Risk Items are those that are generated, caused, or controlled exclusively outside the PDT's sphere of influence.)									
PR1	Funding Stream - Sponsor	Sponsor feels confident they can match anticipated Federal funding (say some $30M to $40M / year). For full project implementation a $140M / yr total funding stream would be required.	Sponsor anticipates being able to meet funding requirements in thru credits, LERRDs and cash.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PR2	Funding Stream - Federal	Sponsor feels confident they can match anticipated Federal funding (say some $30M to $40M / year). For full project implementation a $140M / yr total funding stream would be required.	National Civil Works Budget for Flood Risk Reduction is some $250M to $300M per year. Given the political awareness of the potential for major flood losses and the history of this project it may be reasonable to assume $100 Million per year in Federal Funding.	Very Unlikely	Negligible	LOW		Very Unlikely	Negligible	LOW	
PR3	Weather Delays	Weather events could impact in water construction or delay start of construction windows.	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.	Likely	Marginal	MODERATE		Very Unlikely	Negligible	LOW	
PR4	Project Authorization	With submittal of Chief's Report, the project will be awaiting authorization.	Chief's Report is scheduled for next year. Next WRDA is scheduled for 2016 but realistically could slip 5 years or more based on current authorization cycle.	Very Unlikely	Negligible	LOW		Likely	Critical	HIGH	

*Likelihood, Impact, and Risk Level to be verified through market research and analysis (conducted by cost engineer).

1. Risk/Opportunity identified with reference to the Risk Identification Checklist and through deliberation and study of the PDT.
2. Discussions and Concerns elaborates on Risk/Opportunity Events and includes any assumptions or findings (should contain information pertinent to eventual study and analysis of event's impact to project).
3. Likelihood is a measure of the probability of the event occurring -- **Very Unlikely**, **Unlikely**, **Moderately Likely**, **Likely**, **Very Likely.** The likelihood of the event will be the same for both Cost and Schedule, regardless of impact.
4. Impact is a measure of the event's effect on project objectives with relation to scope, cost, and/or schedule -- **Negligible**, **Marginal**, **Significant**, **Critical**, or **Crisis.** Impacts on Project Cost may vary in severity from impacts on Project Schedule.
5. Risk Level is the resultant of Likelihood and Impact **Low**, **Moderate**, or **High**. Refer to the matrix located at top of page.
6. Variance Distribution refers to the behavior of the individual risk item with respect to its potential effects on Project Cost and Schedule. For example, an item with clearly defined parameters and a solid most likely scenario would probably follow a triangular or normal distribution. A risk item for which the PDT has little data or probability of modeling with respect to effects on cost or schedule (i.e. "anyone's guess") would probably follow a uniform or discrete uniform distribution.
7. The responsibility or POC is the entity responsible as the Subject Matter Expert (SME) for action, monitoring, or information on the PDT for the identified risk or opportunity.
8. Correlation recognizes those risk events that may be related to one another. Care should be given to ensure the risks are handled correctly without a "double counting."
9. Affected Project Component identifies the specific item of the project to which the risk directly or strongly correlates.
10. Project Implications identifies whether or not the risk item affects project cost, project schedule, or both. The PDT is responsible for conducting studies for both Project Cost and for Project Schedule.
11. Results of the risk identification process are studied and further developed by the Cost Engineer, then analyzed through the Monte Carlo Analysis Method for Cost (Contingency) and Schedule (Escalation) Growth.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

SPK - PN 149827
American River Common Features GRR
Sacramento, CA

The American River Common Features GRR, as presented by the Sacramento District, has undergone a successful Cost Agency Technical Review (Cost ATR) of remaining costs, 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 cost 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 3, 2015, the Cost MCX certifies the estimated total project costs:

Alternative 1 - NED Plan:

Total First Costs:	$1,343,992,000 (Cost ATR Certified) *
Fully Funded Costs:	$1,597,400,000 *

Alternative 2 - LPP Plan:

Total First Costs:	$1,565,750,000 (Cost ATR Certified) *
Fully Funded Costs:	$1,851,993,000 *

* Spent Costs Not Included. "Per direction from HQUSACE, the proposed elements of the American River Common Features GRR should be considered separate from the previously authorized portions including the work constructed using the WRDA 1996 and 1999 authorities as well as the Natomas levee improvements authorized by WRDDA 2014. Both cost sharing and the Section 902 limit would be established individually for the WRDA 96/99 features, for the WRRDA 2014 features, and for the GRR recommended plan."

Note: Cost ATR was devoted to remaining work. It did not review spent costs, which requires an audit process. 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.

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

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

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO: P2 # 149827
LOCATION: Sacramento, CA

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Feasibility Report

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									
											Spent Thru:	TOTAL FIRST				
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
02	RELOCATIONS *		$101,612	$27,435	27%	$129,048	0.8%	$102,411	$27,651	$130,062	$0	$130,062	22.8%	$125,718	$33,944	$159,661
06	FISH & WILDLIFE FACILITIES	Construction	$19,020	$5,135	27%	$24,156	0.4%	$19,103	$5,158	$24,261	$0	$24,261	20.5%	$23,017	$6,215	$29,232
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$48,413	$13,071	27%	$61,484	0.4%	$48,624	$13,128	$61,752	$0	$61,752	15.1%	$55,972	$15,112	$71,084
11	LEVEES & FLOODWALLS	Levees	$298,680	$80,643	27%	$379,323	0.4%	$299,871	$80,965	$380,836	$0	$380,836	17.3%	$351,674	$94,952	$446,626
16	BANK STABILIZATION		$292,672	$79,021	27%	$371,694	1.8%	$297,828	$80,414	$378,242	$0	$378,242	14.7%	$341,678	$92,253	$433,931
	CONSTRUCTION ESTIMATE TOTALS:		$760,397	$205,307		$965,705	1.0%	$767,837	$207,316	$975,153	$0	$975,153	17.0%	$898,059	$242,476	$1,140,535
01	LANDS AND DAMAGES		$88,537	$38,715	44%	$127,253	0.6%	$89,028	$38,930	$127,958	$0	$127,958	12.8%	$100,492	$43,908	$144,399
30	PLANNING, ENGINEERING & DESIGN *		$119,772	$32,338	27%	$152,110	2.3%	$122,529	$33,083	$155,611	$0	$155,611	27.6%	$156,388	$42,225	$198,613
31	CONSTRUCTION MANAGEMENT *		$59,291	$16,009	27%	$75,300	2.3%	$60,656	$16,377	$77,033	$0	$77,033	35.8%	$82,356	$22,236	$104,592
18	CULTURAL RESOURCE PRESERVATION		$6,550	$1,768	27%	$8,318	0.8%	$6,486	$1,751	$8,237	$0	$8,237	12.4%	$7,292	$1,969	$9,260
	PROJECT COST TOTALS:		$1,034,548	$294,138	28%	$1,328,686		$1,046,535	$297,457	**$1,343,992**	$0	**$1,343,992**	18.9%	$1,244,586	$352,813	$1,597,400

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CHIEF, COST ENGINEERING, Jeremiah Frost

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PROJECT MANAGER, Dan Tibbitts

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CHIEF, REAL ESTATE, Diane Simpson

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CHIEF, ENGINEERING, Rick Poeppelman

ESTIMATED FEDERAL COST:	**65%**	**$1,038,310**
ESTIMATED NON-FEDERAL COST:	**35%**	**$559,090**
ESTIMATED TOTAL PROJECT COST:		**$1,597,400**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach A															
02	RELOCATIONS *		$4,899	$1,323	27%	$6,222	0.8%	$4,937	$1,333	$6,271	0	$6,271	9.8%	$5,419	$1,463	$6,882
06	FISH & WILDLIFE FACILITIES	Construction	$4,251	$1,148	27%	$5,399	0.4%	$4,270	$1,153	$5,422	0	$5,422	13.3%	$4,837	$1,306	$6,143
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$9,182	$2,479	27%	$11,662	0.4%	$9,222	$2,490	$11,712	0	$11,712	8.9%	$10,043	$2,712	$12,754
16	BANK STABILIZATION		$91,765	$24,777	27%	$116,542	1.8%	$93,382	$25,213	$118,595	0	$118,595	8.9%	$101,688	$27,456	$129,144
	CONSTRUCTION ESTIMATE TOTALS:		$110,097	$29,726		$139,824	1.6%	$111,811	$30,189	$142,000	0	$142,000	9.1%	$121,987	$32,936	$154,923
01	LANDS AND DAMAGES		$2,002	$832	42%	$2,834	0.6%	$2,013	$836	$2,850	0	$2,850	4.7%	$2,107	$875	$2,982
30	PLANNING, ENGINEERING & DESIGN *		$18,858	$5,092	27%	$23,950	2.3%	$19,292	$5,209	$24,501	0	$24,501	11.1%	$21,431	$5,786	$27,217
31	CONSTRUCTION MANAGEMENT *		$9,468	$2,556	27%	$12,024	2.3%	$9,686	$2,615	$12,301	0	$12,301	19.3%	$11,551	$3,119	$14,669
18	CULTURAL RESOURCE PRESERVATION		$906	$245	27%	$1,151	0.8%	$898	$242	$1,140	0	$1,140	4.7%	$940	$254	$1,194
	PROJECT COST TOTALS:		$141,332	$38,451	27%	$179,783		$143,700	$39,092	**$182,792**	0	**$182,792**	10.0%	$158,015	$42,970	$200,986

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$130,641**
ESTIMATED NON-FEDERAL COST:	35%	**$70,345**
ESTIMATED TOTAL PROJECT COST:		**$200,986**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015; Effective Price Level: 10/1/2014				Program Year (Budget EC): 2016; Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach A, Erosion Protection															
02	RELOCATIONS		$3,919	$1,058	27%	$4,977	0.4%	$3,935	$1,062	$4,997	$0	2020Q3	8.9%	$4,285	$1,157	$5,442
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$9,182	$2,479	27%	$11,662	0.4%	$9,222	$2,490	$11,712	$0	2020Q3	8.9%	$10,043	$2,712	$12,754
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$91,765	$24,777	27%	$116,542	1.8%	$93,382	$25,213	$118,595	$0	2020Q3	8.9%	$101,688	$27,456	$129,144
	CONSTRUCTION ESTIMATE TOTALS:		$104,866	$28,314	27%	**$133,180**		$106,539	$28,765	$135,304	$0			$116,015	$31,324	$147,340
01	LANDS AND DAMAGES	Fed	$95	$5	5%	$100	0.6%	$96	$5	$101	$0	2018Q3	4.7%	$100	$5	$105
01	LANDS AND DAMAGES	Non-Fed	$1,907	$827	43%	$2,734	0.6%	$1,918	$831	$2,749	$0	2018Q3	4.7%	$2,007	$870	$2,877
18	CULTURAL RESOURCE PRESERVATION		$872	$235	27%	$1,107	-1.0%	$863	$233	$1,096	$0	2018Q3	4.7%	$903	$244	$1,147
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,615	$436	27%	$2,051	2.3%	$1,652	$446	$2,098	$0	2018Q3	9.9%	$1,815	$490	$2,306
0.006	Planning & Environmental Compliance		$1,578	$426	27%	$2,004	2.3%	$1,614	$436	$2,050	$0	2018Q3	9.9%	$1,774	$479	$2,253
0.082	Engineering & Design		$8,278	$2,235	27%	$10,513	2.3%	$8,469	$2,286	$10,755	$0	2018Q3	9.9%	$9,306	$2,513	$11,818
0.003	Reviews, ATRs, IEPRs, VE		$303	$82	27%	$385	2.3%	$310	$84	$394	$0	2018Q3	9.9%	$341	$92	$433
0.007	Life Cycle Updates (cost, schedule, risks)		$707	$191	27%	$898	2.3%	$723	$195	$919	$0	2018Q3	9.9%	$795	$215	$1,009
0.01	Contracting & Reprographics		$1,009	$272	27%	$1,281	2.3%	$1,032	$279	$1,311	$0	2018Q3	9.9%	$1,134	$306	$1,441
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$1,009	$272	27%	$1,281	2.3%	$1,032	$279	$1,311	$0	2018Q3	9.9%	$1,134	$306	$1,441
0.02	Engineering During Construction		$2,019	$545	27%	$2,564	2.3%	$2,065	$558	$2,623	$0	2020Q3	18.9%	$2,455	$663	$3,118
0.003	Planning During Construction		$303	$82	27%	$385	2.3%	$310	$84	$394	$0	2020Q3	18.9%	$368	$99	$468
0.013	Project Operations		$1,312	$354	27%	$1,666	2.3%	$1,342	$362	$1,705	$0	2018Q3	9.9%	$1,475	$398	$1,873
0.16	NON-FED Planning, Engineering & Design (Relocations)		$627	$169	27%	$796	2.3%	$641	$173	$815	$0	2018Q3	9.9%	$705	$190	$895
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$4,745	$1,281	27%	$6,026	2.3%	$4,854	$1,311	$6,165	$0	2020Q3	18.9%	$5,769	$1,558	$7,327
0.012	Project Operation:		$1,211	$327	27%	$1,538	2.3%	$1,239	$334	$1,573	$0	2020Q3	18.9%	$1,472	$398	$1,870
0.031	Project Management		$3,129	$845	27%	$3,974	2.3%	$3,201	$864	$4,065	$0	2020Q3	18.9%	$3,804	$1,027	$4,832
0.09	NON-FED Construction Management (Relocations)		$353	$95	27%	$448	2.3%	$361	$98	$459	$0	2020Q3	18.9%	$429	$116	$545
	CONTRACT COST TOTALS:		$135,938	$36,994		**$172,933**		$138,262	$37,624	$175,886	$0			$151,803	$41,293	**$193,096**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach A, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$4,251	$1,148	27%	$5,399	0.4%	$4,270	$1,153	$5,422	$0	2022Q3	13.3%	$4,837	$1,306	$6,143
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$4,251	$1,148	27%	**$5,399**		$4,270	$1,153	$5,422	$0			$4,837	$1,306	$6,143
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$35	$9	27%	$44	-1.0%	$34	$9	$44	$0	2019Q3	6.8%	$37	$10	$47
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$68	$18	27%	$86	2.3%	$70	$19	$88	$0	2018Q3	9.9%	$76	$21	$97
0.006	Planning & Environmental Compliance		$26	$7	27%	$33	2.3%	$27	$7	$34	$0	2018Q3	9.9%	$29	$8	$37
0.082	Engineering & Design		$349	$94	27%	$443	2.3%	$357	$96	$453	$0	2018Q3	9.9%	$392	$106	$498
0.003	Reviews, ATRs, IEPRs, VE		$13	$4	27%	$17	2.3%	$13	$4	$17	$0	2018Q3	9.9%	$15	$4	$19
0.007	Life Cycle Updates (cost, schedule, risks)		$30	$8	27%	$38	2.3%	$31	$8	$39	$0	2018Q3	9.9%	$34	$9	$43
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$43	$12	27%	$55	2.3%	$44	$12	$56	$0	2018Q3	9.9%	$48	$13	$61
0.01	Contracting & Reprographics		$43	$12	27%	$55	2.3%	$44	$12	$56	$0	2018Q3	9.9%	$48	$13	$61
0.02	Engineering During Construction		$85	$23	27%	$108	2.3%	$87	$23	$110	$0	2022Q3	28.7%	$112	$30	$142
0.003	Planning During Construction		$13	$4	27%	$17	2.3%	$13	$4	$17	$0	2022Q3	28.7%	$17	$5	$22
0.013	Project Operations		$55	$15	27%	$70	2.3%	$56	$15	$71	$0	2018Q3	9.9%	$62	$17	$79
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$200	$54	27%	$254	2.3%	$205	$55	$260	$0	2022Q3	28.7%	$263	$71	$334
0.012	Project Operation:		$51	$14	27%	$65	2.3%	$52	$14	$66	$0	2022Q3	28.7%	$67	$18	$85
0.031	Project Management		$132	$36	27%	$168	2.3%	$135	$36	$171	$0	2022Q3	28.7%	$174	$47	$221
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$5,394	$1,456		**$6,850**		$5,438	$1,468	$6,906	$0			$6,212	$1,677	**$7,889**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach B															
02	RELOCATIONS *		$2,313	$625	27%	$2,938	0.8%	$2,332	$630	$2,961	0	$2,961	15.8%	$2,699	$729	$3,428
06	FISH & WILDLIFE FACILITIES	Construction	$1,170	$316	27%	$1,486	0.4%	$1,175	$317	$1,492	0	$1,492	17.9%	$1,385	$374	$1,759
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$3,218	$869	27%	$4,087	0.4%	$3,232	$873	$4,104	0	$4,104	13.3%	$3,661	$989	$4,650
16	BANK STABILIZATION		$21,641	$5,843	27%	$27,484	1.8%	$22,022	$5,946	$27,969	0	$27,969	13.3%	$24,950	$6,737	$31,687
	CONSTRUCTION ESTIMATE TOTALS:		$28,342	$7,652		$35,995	1.5%	$28,761	$7,765	$36,526	0	$36,526	13.7%	$32,696	$8,828	$41,523
01	LANDS AND DAMAGES		$1,011	$208	21%	$1,219	0.6%	$1,017	$209	$1,226	0	$1,226	11.1%	$1,129	$232	$1,361
30	PLANNING, ENGINEERING & DESIGN *		$5,399	$1,458	27%	$6,857	2.3%	$5,523	$1,491	$7,015	0	$7,015	24.3%	$6,863	$1,853	$8,716
31	CONSTRUCTION MANAGEMENT *		$2,342	$632	27%	$2,974	2.3%	$2,396	$647	$3,043	0	$3,043	29.2%	$3,095	$836	$3,931
18	CULTURAL RESOURCE PRESERVATION		$238	$64	27%	$302	0.8%	$236	$64	$299	0	$299	11.2%	$262	$71	$333
	PROJECT COST TOTALS:		$37,332	$10,015	27%	$47,347		$37,932	$10,176	**$48,109**	0	**$48,109**	16.1%	$44,045	$11,820	$55,865

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$36,312**
ESTIMATED NON-FEDERAL COST:	35%	**$19,553**
ESTIMATED TOTAL PROJECT COST:		**$55,865**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.
Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach B, Erosion Protection															
02	RELOCATIONS		$1,850	$500	27%	$2,350	0.4%	$1,858	$502	$2,360	$0	2022Q3	13.3%	$2,105	$568	$2,673
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$3,218	$869	27%	$4,087	0.4%	$3,232	$873	$4,104	$0	2022Q3	13.3%	$3,661	$989	$4,650
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$21,641	$5,843	27%	$27,484	1.8%	$22,022	$5,946	$27,969	$0	2022Q3	13.3%	$24,950	$6,737	$31,687
	CONSTRUCTION ESTIMATE TOTALS:		$26,709	$7,212	27%	**$33,921**		$27,112	$7,320	$34,433	$0			$30,717	$8,293	$39,010
01	LANDS AND DAMAGES	Fed	$166	$9	5%	$175	0.6%	$167	$9	$176	$0	2021Q3	11.1%	$186	$10	$195
01	LANDS AND DAMAGES	Non-Fed	$845	$199	24%	$1,044	0.6%	$849	$200	$1,050	$0	2021Q3	11.1%	$943	$223	$1,166
18	CULTURAL RESOURCE PRESERVATION		$229	$62	27%	$290	-1.0%	$226	$61	$287	$0	2021Q3	11.1%	$251	$68	$319
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$398	$107	27%	$505	2.3%	$407	$110	$517	$0	2021Q3	23.6%	$503	$136	$639
0.006	Planning & Environmental Compliance		$1,121	$303	27%	$1,424	2.3%	$1,147	$310	$1,456	$0	2021Q3	23.6%	$1,418	$383	$1,801
0.082	Engineering & Design		$2,038	$550	27%	$2,588	2.3%	$2,085	$563	$2,648	$0	2021Q3	23.6%	$2,578	$696	$3,274
0.003	Reviews, ATRs, IEPRs, VE		$75	$20	27%	$95	2.3%	$77	$21	$97	$0	2021Q3	23.6%	$95	$26	$120
0.007	Life Cycle Updates (cost, schedule, risks)		$174	$47	27%	$221	2.3%	$178	$48	$226	$0	2021Q3	23.6%	$220	$59	$280
0.01	Contracting & Reprographics		$249	$67	27%	$316	2.3%	$255	$69	$324	$0	2021Q3	23.6%	$315	$85	$400
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$249	$67	27%	$316	2.3%	$255	$69	$324	$0	2021Q3	23.6%	$315	$85	$400
0.02	Engineering During Construction		$497	$134	27%	$631	2.3%	$508	$137	$646	$0	2022Q3	28.7%	$654	$177	$831
0.003	Planning During Construction		$75	$20	27%	$95	2.3%	$77	$21	$97	$0	2022Q3	28.7%	$99	$27	$125
0.013	Project Operations		$323	$87	27%	$410	2.3%	$330	$89	$420	$0	2021Q3	23.6%	$409	$110	$519
0.16	NON-FED Planning, Engineering & Design (Relocations)		$296	$80	27%	$376	2.3%	$303	$82	$385	$0	2021Q3	23.6%	$374	$101	$475
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,168	$315	27%	$1,483	2.3%	$1,195	$323	$1,517	$0	2022Q3	28.7%	$1,538	$415	$1,953
0.012	Project Operation:		$298	$80	27%	$378	2.3%	$305	$82	$387	$0	2022Q3	28.7%	$392	$106	$498
0.031	Project Management		$771	$208	27%	$979	2.3%	$789	$213	$1,002	$0	2022Q3	28.7%	$1,015	$274	$1,289
0.09	NON-FED Construction Management (Relocations)		$167	$45	27%	$212	2.3%	$171	$46	$217	$0	2022Q3	28.7%	$220	$59	$279
	CONTRACT COST TOTALS:		$35,848	$9,614		**$45,462**		$36,436	$9,772	$46,208	$0			$42,242	$11,333	**$53,575**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach B, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$1,170	$316	27%	$1,486	0.4%	$1,175	$317	$1,492	$0	2024Q3	17.9%	$1,385	$374	$1,759
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$1,170	$316	27%	**$1,486**		$1,175	$317	$1,492	$0			$1,385	$374	$1,759
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$10	$3	27%	$12	-1.0%	$9	$3	$12	$0	2022Q3	13.3%	$11	$3	$14
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$19	$5	27%	$24	2.3%	$19	$5	$25	$0	2021Q3	23.6%	$24	$6	$31
0.006	Planning & Environmental Compliance		$7	$2	27%	$9	2.3%	$7	$2	$9	$0	2021Q3	23.6%	$9	$2	$11
0.082	Engineering & Design		$96	$26	27%	$122	2.3%	$98	$27	$125	$0	2021Q3	23.6%	$121	$33	$154
0.003	Reviews, ATRs, IEPRs, VE		$4	$1	27%	$5	2.3%	$4	$1	$5	$0	2021Q3	23.6%	$5	$1	$6
0.007	Life Cycle Updates (cost, schedule, risks)		$8	$2	27%	$10	2.3%	$8	$2	$10	$0	2021Q3	23.6%	$10	$3	$13
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2021Q3	23.6%	$15	$4	$19
0.01	Contracting & Reprographics		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2021Q3	23.6%	$15	$4	$19
0.02	Engineering During Construction		$23	$6	27%	$29	2.3%	$24	$6	$30	$0	2024Q3	39.6%	$33	$9	$42
0.003	Planning During Construction		$4	$1	27%	$5	2.3%	$4	$1	$5	$0	2024Q3	39.6%	$6	$2	$7
0.013	Project Operations		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2021Q3	23.6%	$19	$5	$24
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$55	$15	27%	$70	2.3%	$56	$15	$71	$0	2024Q3	39.6%	$79	$21	$100
0.012	Project Operation:		$14	$4	27%	$18	2.3%	$14	$4	$18	$0	2024Q3	39.6%	$20	$5	$25
0.031	Project Management		$36	$10	27%	$46	2.3%	$37	$10	$47	$0	2024Q3	39.6%	$51	$14	$65
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$1,484	$401		**$1,885**		$1,496	$404	$1,900	$0			$1,803	$487	**$2,290**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:	FIRST				
WBS	Civil Works		COST	CNTG	CNTG	TOTAL	ESC	COST	CNTG	TOTAL	10/1/2014	COST	ESC	COST	CNTG	FULL
NUMBER	Feature & Sub-Feature Description		($K)	($K)	(%)	($K)	(%)	($K)	($K)	($K)	($K)	($K)	(%)	($K)	($K)	($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach C															
02	RELOCATIONS *		$500	$135	27%	$635	0.8%	$504	$136	$640	0	$640	24.6%	$627	$169	$797
06	FISH & WILDLIFE FACILITIES	Construction	$1,164	$314	27%	$1,479	0.4%	$1,170	$316	$1,485	0	$1,485	25.1%	$1,463	$395	$1,858
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$1,128	$305	27%	$1,432	0.4%	$1,133	$306	$1,439	0	$1,439	20.2%	$1,362	$368	$1,730
16	BANK STABILIZATION		$14,915	$4,027	27%	$18,942	1.8%	$15,177	$4,098	$19,275	0	$19,275	20.2%	$18,248	$4,927	$23,175
	CONSTRUCTION ESTIMATE TOTALS:		$17,707	$4,781		$22,487	1.6%	$17,983	$4,855	$22,839	0	$22,839	20.7%	$21,700	$5,859	$27,559
01	LANDS AND DAMAGES		$875	$183	21%	$1,058	0.6%	$880	$184	$1,064	0	$1,064	17.9%	$1,037	$217	$1,254
30	PLANNING, ENGINEERING & DESIGN *		$3,896	$1,052	27%	$4,948	2.3%	$3,986	$1,076	$5,062	0	$5,062	40.3%	$5,593	$1,510	$7,103
31	CONSTRUCTION MANAGEMENT *		$1,549	$418	27%	$1,967	2.3%	$1,585	$428	$2,013	0	$2,013	46.5%	$2,321	$627	$2,948
18	CULTURAL RESOURCE PRESERVATION		$156	$42	27%	$198	0.8%	$154	$42	$196	0	$196	18.0%	$182	$49	$231
	PROJECT COST TOTALS:		$24,182	$6,476	27%	$30,658		$24,588	$6,585	**$31,173**	0	**$31,173**	25.4%	$30,833	$8,262	$39,095

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$25,412**
ESTIMATED NON-FEDERAL COST:	35%	**$13,683**
ESTIMATED TOTAL PROJECT COST:		**$39,095**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach C, Erosion Protection															
02	RELOCATIONS		$400	$108	27%	$508	0.4%	$401	$108	$510	$0	2025Q3	20.2%	$482	$130	$613
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$1,128	$305	27%	$1,432	0.4%	$1,133	$306	$1,439	$0	2025Q3	20.2%	$1,362	$368	$1,730
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$14,915	$4,027	27%	$18,942	1.8%	$15,177	$4,098	$19,275	$0	2025Q3	20.2%	$18,248	$4,927	$23,175
	CONSTRUCTION ESTIMATE TOTALS:		$16,442	$4,439	27%	**$20,882**		$16,711	$4,512	$21,224	$0			$20,092	$5,425	$25,517
01	LANDS AND DAMAGES	Fed	$143	$7	5%	$150	0.6%	$143	$8	$151	$0	2024Q3	17.9%	$169	$9	$178
01	LANDS AND DAMAGES	Non-Fed	$733	$175	24%	$908	0.6%	$737	$176	$913	$0	2024Q3	17.9%	$868	$208	$1,076
18	CULTURAL RESOURCE PRESERVATION		$146	$39	27%	$185	-1.0%	$145	$39	$184	$0	2024Q3	17.9%	$170	$46	$216
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$257	$69	27%	$326	2.3%	$263	$71	$334	$0	2024Q3	39.6%	$367	$99	$466
0.006	Planning & Environmental Compliance		$1,069	$289	27%	$1,358	2.3%	$1,094	$295	$1,389	$0	2024Q3	39.6%	$1,527	$412	$1,939
0.082	Engineering & Design		$1,315	$355	27%	$1,670	2.3%	$1,345	$363	$1,708	$0	2024Q3	39.6%	$1,879	$507	$2,386
0.003	Reviews, ATRs, IEPRs, VE		$48	$13	27%	$61	2.3%	$49	$13	$62	$0	2024Q3	39.6%	$69	$19	$87
0.007	Life Cycle Updates (cost, schedule, risks)		$112	$30	27%	$142	2.3%	$115	$31	$146	$0	2024Q3	39.6%	$160	$43	$203
0.01	Contracting & Reprographics		$160	$43	27%	$203	2.3%	$164	$44	$208	$0	2024Q3	39.6%	$229	$62	$290
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$160	$43	27%	$203	2.3%	$164	$44	$208	$0	2024Q3	39.6%	$229	$62	$290
0.02	Engineering During Construction		$321	$87	27%	$408	2.3%	$328	$89	$417	$0	2025Q3	45.6%	$478	$129	$607
0.003	Planning During Construction		$48	$13	27%	$61	2.3%	$49	$13	$62	$0	2025Q3	45.6%	$71	$19	$91
0.013	Project Operations		$209	$56	27%	$265	2.3%	$214	$58	$272	$0	2024Q3	39.6%	$299	$81	$379
0.16	NON-FED Planning, Engineering & Design (Relocations)		$64	$17	27%	$81	2.3%	$65	$18	$83	$0	2024Q3	39.6%	$91	$25	$116
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$754	$204	27%	$958	2.3%	$771	$208	$980	$0	2025Q3	45.6%	$1,123	$303	$1,426
0.012	Project Operation:		$193	$52	27%	$245	2.3%	$197	$53	$251	$0	2025Q3	45.6%	$287	$78	$365
0.031	Project Management		$497	$134	27%	$631	2.3%	$508	$137	$646	$0	2025Q3	45.6%	$740	$200	$940
0.09	NON-FED Construction Management (Relocations)		$36	$10	27%	$46	2.3%	$37	$10	$47	$0	2025Q3	45.6%	$54	$14	$68
	CONTRACT COST TOTALS:		$22,706	$6,077		**$28,784**		$23,100	$6,183	$29,283	$0			$28,902	$7,740	**$36,642**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach C, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$1,164	$314	27%	$1,479	0.4%	$1,170	$316	$1,485	$0	2027Q3	25.1%	$1,463	$395	$1,858
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$1,164	$314	27%	**$1,479**		$1,170	$316	$1,485	$0			$1,463	$395	$1,858
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$10	$3	27%	$12	-1.0%	$9	$3	$12	$0	2025Q3	20.2%	$11	$3	$14
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$19	$5	27%	$24	2.3%	$19	$5	$25	$0	2024Q3	39.6%	$27	$7	$34
0.006	Planning & Environmental Compliance		$7	$2	27%	$9	2.3%	$7	$2	$9	$0	2024Q3	39.6%	$10	$3	$13
0.082	Engineering & Design		$95	$26	27%	$121	2.3%	$97	$26	$123	$0	2024Q3	39.6%	$136	$37	$172
0.003	Reviews, ATRs, IEPRs, VE		$3	$1	27%	$4	2.3%	$3	$1	$4	$0	2024Q3	39.6%	$4	$1	$5
0.007	Life Cycle Updates (cost, schedule, risks)		$8	$2	27%	$10	2.3%	$8	$2	$10	$0	2024Q3	39.6%	$11	$3	$15
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2024Q3	39.6%	$17	$5	$22
0.01	Contracting & Reprographics		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2024Q3	39.6%	$17	$5	$22
0.02	Engineering During Construction		$23	$6	27%	$29	2.3%	$24	$6	$30	$0	2027Q3	58.7%	$37	$10	$47
0.003	Planning During Construction		$3	$1	27%	$4	2.3%	$3	$1	$4	$0	2027Q3	58.7%	$5	$1	$6
0.013	Project Operations		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2024Q3	39.6%	$21	$6	$27
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$55	$15	27%	$70	2.3%	$56	$15	$71	$0	2027Q3	58.7%	$89	$24	$113
0.012	Project Operation:		$14	$4	27%	$18	2.3%	$14	$4	$18	$0	2027Q3	58.7%	$23	$6	$29
0.031	Project Management		$36	$10	27%	$46	2.3%	$37	$10	$47	$0	2027Q3	58.7%	$58	$16	$74
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$1,476	$399		**$1,875**		$1,488	$402	$1,890	$0			$1,931	$521	**$2,453**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach D															
02	RELOCATIONS *		$25,524	$6,891	27%	$32,415	0.8%	$25,724	$6,946	$32,670	0	$32,670	27.4%	$32,764	$8,846	$41,610
06	FISH & WILDLIFE FACILITIES	Construction	$2,102	$568	27%	$2,670	0.4%	$2,111	$570	$2,681	0	$2,681	27.6%	$2,694	$727	$3,421
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$6,551	$1,769	27%	$8,320	0.4%	$6,580	$1,777	$8,356	0	$8,356	22.6%	$8,069	$2,179	$10,248
11	LEVEES & FLOODWALLS	Levees	$44,404	$11,989	27%	$56,393	0.4%	$44,581	$12,037	$56,618	0	$56,618	22.6%	$54,672	$14,761	$69,433
16	BANK STABILIZATION		$20,205	$5,455	27%	$25,661	1.8%	$20,561	$5,552	$26,113	0	$26,113	22.6%	$25,215	$6,808	$32,023
	CONSTRUCTION ESTIMATE TOTALS:		$98,787	$26,672		$125,459	0.8%	$99,558	$26,881	$126,439	0	$126,439	24.0%	$123,413	$33,322	$156,735
01	LANDS AND DAMAGES		$2,034	$634	31%	$2,668	0.6%	$2,045	$638	$2,683	0	$2,683	19.0%	$2,434	$759	$3,193
30	PLANNING, ENGINEERING & DESIGN *		$13,427	$3,625	27%	$17,052	2.3%	$13,736	$3,709	$17,445	0	$17,445	44.5%	$19,852	$5,360	$25,212
31	CONSTRUCTION MANAGEMENT *		$6,593	$1,780	27%	$8,373	2.3%	$6,745	$1,821	$8,566	0	$8,566	52.4%	$10,278	$2,775	$13,053
18	CULTURAL RESOURCE PRESERVATION		$752	$203	27%	$955	0.8%	$745	$201	$946	0	$946	19.9%	$893	$241	$1,134
	PROJECT COST TOTALS:		$121,593	$32,915	27%	$154,508		$122,829	$33,249	**$156,078**	0	**$156,078**	27.7%	$156,870	$42,457	$199,327

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$129,563**
ESTIMATED NON-FEDERAL COST:	35%	**$69,764**
ESTIMATED TOTAL PROJECT COST:		**$199,327**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016										
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15										
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach D, Levee Improvements															
02	RELOCATIONS		$20,419	$5,513	27%	$25,932	0.4%	$20,502	$5,535	$26,037	$0	2026Q3	22.6%	$25,142	$6,788	$31,930
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$6,551	$1,769	27%	$8,320	0.4%	$6,580	$1,777	$8,356	$0	2026Q3	22.6%	$8,069	$2,179	$10,248
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$44,404	$11,989	27%	$56,393	0.4%	$44,581	$12,037	$56,618	$0	2026Q3	22.6%	$54,672	$14,761	$69,433
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$71,374	$19,271	27%	**$90,645**		$71,663	$19,349	$91,012	$0			$87,882	$23,728	$111,611
01	LANDS AND DAMAGES	Fed	$214	$11	5%	$225	0.6%	$215	$11	$226	$0	2025Q1	19.0%	$256	$13	$269
01	LANDS AND DAMAGES	Non-Fed	$1,820	$623	34%	$2,443	0.6%	$1,830	$626	$2,457	$0	2025Q1	19.0%	$2,178	$746	$2,924
18	CULTURAL RESOURCE PRESERVATION		$570	$154	27%	$723	-1.0%	$564	$152	$716	$0	2025Q1	19.0%	$671	$181	$853
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$815	$220	27%	$1,035	2.3%	$834	$225	$1,059	$0	2025Q1	42.5%	$1,188	$321	$1,509
0.006	Planning & Environmental Compliance		$1,278	$345	27%	$1,623	2.3%	$1,307	$353	$1,660	$0	2025Q1	42.5%	$1,864	$503	$2,367
0.082	Engineering & Design		$4,178	$1,128	27%	$5,306	2.3%	$4,274	$1,154	$5,428	$0	2025Q1	42.5%	$6,093	$1,645	$7,738
0.003	Reviews, ATRs, IEPRs, VE		$153	$41	27%	$194	2.3%	$157	$42	$199	$0	2025Q1	42.5%	$223	$60	$283
0.007	Life Cycle Updates (cost, schedule, risks)		$357	$96	27%	$453	2.3%	$365	$99	$464	$0	2025Q1	42.5%	$521	$141	$661
0.01	Contracting & Reprographics		$510	$138	27%	$648	2.3%	$522	$141	$663	$0	2025Q1	42.5%	$744	$201	$945
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$510	$138	27%	$648	2.3%	$522	$141	$663	$0	2025Q1	42.5%	$744	$201	$945
0.02	Engineering During Construction		$1,019	$275	27%	$1,294	2.3%	$1,042	$281	$1,324	$0	2026Q3	52.0%	$1,584	$428	$2,012
0.003	Planning During Construction		$153	$41	27%	$194	2.3%	$157	$42	$199	$0	2026Q3	52.0%	$238	$64	$302
0.013	Project Operations		$662	$179	27%	$841	2.3%	$677	$183	$860	$0	2025Q1	42.5%	$965	$261	$1,226
0.16	NON-FED Planning, Engineering & Design (Relocations)		$3,267	$882	27%	$4,149	2.3%	$3,342	$902	$4,245	$0	2025Q1	42.5%	$4,764	$1,286	$6,051
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$2,395	$647	27%	$3,042	2.3%	$2,450	$662	$3,112	$0	2026Q3	52.0%	$3,724	$1,005	$4,729
0.012	Project Operation:		$611	$165	27%	$776	2.3%	$625	$169	$794	$0	2026Q3	52.0%	$950	$257	$1,207
0.031	Project Management		$1,580	$427	27%	$2,007	2.3%	$1,616	$436	$2,053	$0	2026Q3	52.0%	$2,457	$663	$3,120
0.09	NON-FED Construction Management (Relocations)		$1,838	$496	27%	$2,334	2.3%	$1,880	$508	$2,388	$0	2026Q3	52.0%	$2,858	$772	$3,629
	CONTRACT COST TOTALS:		$93,304	$25,277		**$118,581**		$94,043	$25,477	$119,520	$0			$119,904	$32,476	**$152,380**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016										
			Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach D, Erosion Protection															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$20,205	$5,455	27%	$25,661	1.8%	$20,561	$5,552	$26,113	$0	2026Q3	22.6%	$25,215	$6,808	$32,023
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$20,205	$5,455	27%	**$25,661**		$20,561	$5,552	$26,113	$0			$25,215	$6,808	$32,023
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$165	$45	27%	$210	-1.0%	$164	$44	$208	$0	2026Q3	22.6%	$201	$54	$255
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$323	$87	27%	$410	2.3%	$330	$89	$420	$0	2025Q3	45.6%	$481	$130	$611
0.006	Planning & Environmental Compliance		$121	$33	27%	$154	2.3%	$124	$33	$157	$0	2025Q3	45.6%	$180	$49	$229
0.082	Engineering & Design		$1,657	$447	27%	$2,104	2.3%	$1,695	$458	$2,153	$0	2025Q3	45.6%	$2,468	$666	$3,134
0.003	Reviews, ATRs, IEPRs, VE		$61	$16	27%	$77	2.3%	$62	$17	$79	$0	2025Q3	45.6%	$91	$25	$115
0.007	Life Cycle Updates (cost, schedule, risks)		$141	$38	27%	$179	2.3%	$144	$39	$183	$0	2025Q3	45.6%	$210	$57	$267
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$202	$55	27%	$257	2.3%	$207	$56	$262	$0	2025Q3	45.6%	$301	$81	$382
0.01	Contracting & Reprographics		$202	$55	27%	$257	2.3%	$207	$56	$262	$0	2025Q3	45.6%	$301	$81	$382
0.02	Engineering During Construction		$404	$109	27%	$513	2.3%	$413	$112	$525	$0	2026Q3	52.0%	$628	$170	$798
0.003	Planning During Construction		$61	$16	27%	$77	2.3%	$62	$17	$79	$0	2026Q3	52.0%	$95	$26	$120
0.013	Project Operations		$263	$71	27%	$334	2.3%	$269	$73	$342	$0	2025Q3	45.6%	$392	$106	$497
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$950	$257	27%	$1,207	2.3%	$972	$262	$1,234	$0	2026Q3	52.0%	$1,477	$399	$1,876
0.012	Project Operation:		$242	$65	27%	$307	2.3%	$248	$67	$314	$0	2026Q3	52.0%	$376	$102	$478
0.031	Project Management		$626	$169	27%	$795	2.3%	$640	$173	$813	$0	2026Q3	52.0%	$973	$263	$1,236
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$25,624	$6,918		**$32,542**		$26,099	$7,047	$33,146	$0			$33,389	$9,015	**$42,404**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach D, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,102	$568	27%	$2,670	0.4%	$2,111	$570	$2,681	$0	2028Q3	27.6%	$2,694	$727	$3,421
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,102	$568	27%	**$2,670**		$2,111	$570	$2,681	$0			$2,694	$727	$3,421
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$17	$5	27%	$22	-1.0%	$17	$5	$22	$0	2026Q3	22.6%	$21	$6	$27
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$34	$9	27%	$43	2.3%	$35	$9	$44	$0	2025Q3	45.6%	$51	$14	$64
0.006	Planning & Environmental Compliance		$13	$4	27%	$17	2.3%	$13	$4	$17	$0	2025Q3	45.6%	$19	$5	$25
0.082	Engineering & Design		$172	$46	27%	$218	2.3%	$176	$48	$223	$0	2025Q3	45.6%	$256	$69	$325
0.003	Reviews, ATRs, IEPRs, VE		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2025Q3	45.6%	$9	$2	$11
0.007	Life Cycle Updates (cost, schedule, risks)		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2025Q3	45.6%	$22	$6	$28
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$21	$6	27%	$27	2.3%	$21	$6	$27	$0	2025Q3	45.6%	$31	$8	$40
0.01	Contracting & Reprographics		$21	$6	27%	$27	2.3%	$21	$6	$27	$0	2025Q3	45.6%	$31	$8	$40
0.02	Engineering During Construction		$42	$11	27%	$53	2.3%	$43	$12	$55	$0	2028Q3	65.9%	$71	$19	$91
0.003	Planning During Construction		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2028Q3	65.9%	$10	$3	$13
0.013	Project Operations		$27	$7	27%	$34	2.3%	$28	$7	$35	$0	2025Q3	45.6%	$40	$11	$51
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$99	$27	27%	$126	2.3%	$101	$27	$129	$0	2028Q3	65.9%	$168	$45	$213
0.012	Project Operation:		$25	$7	27%	$32	2.3%	$26	$7	$32	$0	2028Q3	65.9%	$42	$11	$54
0.031	Project Management		$65	$18	27%	$83	2.3%	$66	$18	$84	$0	2028Q3	65.9%	$110	$30	$140
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$2,665	$720		**$3,385**		$2,687	$725	$3,412	$0			$3,577	$966	**$4,543**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:					
WBS	Civil Works		COST	CNTG	CNTG	TOTAL	ESC	COST	CNTG	TOTAL	10/1/2014	FIRST COST	ESC	COST	CNTG	FULL
NUMBER	Feature & Sub-Feature Description		($K)	($K)	(%)	($K)	(%)	($K)	($K)	($K)	($K)	($K)	(%)	($K)	($K)	($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach E															
02	RELOCATIONS *		$4,143	$1,119	27%	$5,262	0.8%	$4,176	$1,127	$5,303	0	$5,303	19.4%	$4,986	$1,346	$6,332
06	FISH & WILDLIFE FACILITIES	Construction	$2,061	$557	27%	$2,618	0.4%	$2,070	$559	$2,629	0	$2,629	23.8%	$2,564	$692	$3,256
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$5,464	$1,475	27%	$6,939	0.4%	$5,488	$1,482	$6,970	0	$6,970	16.7%	$6,404	$1,729	$8,133
11	LEVEES & FLOODWALLS	Levees	$39,875	$10,766	27%	$50,641	0.4%	$40,034	$10,809	$50,843	0	$50,843	16.7%	$46,718	$12,614	$59,331
16	BANK STABILIZATION		$15,001	$4,050	27%	$19,051	1.8%	$15,265	$4,122	$19,387	0	$19,387	19.0%	$18,170	$4,906	$23,076
	CONSTRUCTION ESTIMATE TOTALS:		$66,545	$17,967		$84,512	0.7%	$67,033	$18,099	$85,132	0	$85,132	17.6%	$78,841	$21,287	$100,128
01	LANDS AND DAMAGES		$6,538	$752	12%	$7,291	0.6%	$6,575	$756	$7,331	0	$7,331	12.2%	$7,374	$848	$8,223
30	PLANNING, ENGINEERING & DESIGN *		$11,578	$3,126	27%	$14,704	2.3%	$11,844	$3,198	$15,042	0	$15,042	29.4%	$15,329	$4,139	$19,468
31	CONSTRUCTION MANAGEMENT *		$5,617	$1,517	27%	$7,134	2.3%	$5,746	$1,551	$7,298	0	$7,298	38.8%	$7,976	$2,153	$10,129
18	CULTURAL RESOURCE PRESERVATION		$581	$157	27%	$738	0.8%	$576	$155	$731	0	$731	12.7%	$649	$175	$824
	PROJECT COST TOTALS:		$90,859	$23,519	26%	$114,378		$91,774	$23,760	**$115,535**	0	**$115,535**	20.1%	$110,169	$28,603	$138,772

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$90,202**
ESTIMATED NON-FEDERAL COST:	35%	**$48,570**
ESTIMATED TOTAL PROJECT COST:		**$138,772**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015; Effective Price Level: 10/1/2014				Program Year (Budget EC): 2016; Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach E, Levee Improvements															
02	RELOCATIONS		$3,315	$895	27%	$4,210	0.4%	$3,329	$899	$4,228	$0	2024Q1	16.7%	$3,884	$1,049	$4,933
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$5,464	$1,475	27%	$6,939	0.4%	$5,488	$1,482	$6,970	$0	2024Q1	16.7%	$6,404	$1,729	$8,133
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$39,875	$10,766	27%	$50,641	0.4%	$40,034	$10,809	$50,843	$0	2024Q1	16.7%	$46,718	$12,614	$59,331
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$48,654	$13,137	27%	**$61,791**		$48,851	$13,190	$62,040	$0			$57,006	$15,392	$72,398
01	LANDS AND DAMAGES	Fed	$1,401	$74	5%	$1,475	0.6%	$1,409	$74	$1,483	$0	2022Q1	12.2%	$1,580	$83	$1,664
01	LANDS AND DAMAGES	Non-Fed	$5,137	$678	13%	$5,816	0.6%	$5,166	$682	$5,848	$0	2022Q1	12.2%	$5,794	$765	$6,559
18	CULTURAL RESOURCE PRESERVATION		$442	$119	27%	$561	-1.0%	$437	$118	$555	$0	2022Q1	12.2%	$491	$132	$623
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$725	$196	27%	$921	2.3%	$742	$200	$942	$0	2022Q1	26.1%	$936	$253	$1,188
0.006	Planning & Environmental Compliance		$1,244	$336	27%	$1,580	2.3%	$1,273	$344	$1,616	$0	2022Q1	26.1%	$1,605	$433	$2,039
0.082	Engineering & Design		$3,718	$1,004	27%	$4,722	2.3%	$3,804	$1,027	$4,831	$0	2022Q1	26.1%	$4,798	$1,295	$6,094
0.003	Reviews, ATRs, IEPRs, VE		$136	$37	27%	$173	2.3%	$139	$38	$177	$0	2022Q1	26.1%	$176	$47	$223
0.007	Life Cycle Updates (cost, schedule, risks)		$317	$86	27%	$403	2.3%	$324	$88	$412	$0	2022Q1	26.1%	$409	$110	$520
0.01	Contracting & Reprographics		$453	$122	27%	$575	2.3%	$463	$125	$589	$0	2022Q1	26.1%	$585	$158	$742
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$453	$122	27%	$575	2.3%	$463	$125	$589	$0	2022Q1	26.1%	$585	$158	$742
0.02	Engineering During Construction		$907	$245	27%	$1,152	2.3%	$928	$251	$1,178	$0	2024Q1	36.8%	$1,269	$343	$1,612
0.003	Planning During Construction		$136	$37	27%	$173	2.3%	$139	$38	$177	$0	2024Q1	36.8%	$190	$51	$242
0.013	Project Operations		$589	$159	27%	$748	2.3%	$603	$163	$765	$0	2022Q1	26.1%	$760	$205	$965
0.16	NON-FED Planning, Engineering & Design (Relocations)		$530	$143	27%	$673	2.3%	$542	$146	$689	$0	2022Q1	26.1%	$684	$185	$869
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$2,131	$575	27%	$2,706	2.3%	$2,180	$589	$2,769	$0	2024Q1	36.8%	$2,982	$805	$3,788
0.012	Project Operation:		$544	$147	27%	$691	2.3%	$557	$150	$707	$0	2024Q1	36.8%	$761	$206	$967
0.031	Project Management		$1,406	$380	27%	$1,786	2.3%	$1,438	$388	$1,827	$0	2024Q1	36.8%	$1,968	$531	$2,499
0.09	NON-FED Construction Management (Relocations)		$298	$80	27%	$378	2.3%	$305	$82	$387	$0	2024Q1	36.8%	$417	$113	$530
	CONTRACT COST TOTALS:		$69,221	$17,677		**$86,898**		$69,762	$17,817	$87,580	$0			$82,996	$21,266	**$104,262**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach E, Erosion Protection															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$15,001	$4,050	27%	$19,051	1.8%	$15,265	$4,122	$19,387	$0	2025Q1	19.0%	$18,170	$4,906	$23,076
	CONSTRUCTION ESTIMATE TOTALS:		$15,001	$4,050	27%	**$19,051**		$15,265	$4,122	$19,387	$0			$18,170	$4,906	$23,076
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$123	$33	27%	$156	-1.0%	$122	$33	$154	$0	2023Q3	15.6%	$141	$38	$179
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$240	$65	27%	$305	2.3%	$246	$66	$312	$0	2023Q3	34.0%	$329	$89	$418
0.006	Planning & Environmental Compliance		$90	$24	27%	$114	2.3%	$92	$25	$117	$0	2023Q3	34.0%	$123	$33	$157
0.082	Engineering & Design		$1,230	$332	27%	$1,562	2.3%	$1,258	$340	$1,598	$0	2023Q3	34.0%	$1,686	$455	$2,142
0.003	Reviews, ATRs, IEPRs, VE		$45	$12	27%	$57	2.3%	$46	$12	$58	$0	2023Q3	34.0%	$62	$17	$78
0.007	Life Cycle Updates (cost, schedule, risks)		$105	$28	27%	$133	2.3%	$107	$29	$136	$0	2023Q3	34.0%	$144	$39	$183
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$150	$41	27%	$191	2.3%	$153	$41	$195	$0	2023Q3	34.0%	$206	$56	$261
0.01	Contracting & Reprographics		$150	$41	27%	$191	2.3%	$153	$41	$195	$0	2023Q3	34.0%	$206	$56	$261
0.02	Engineering During Construction		$300	$81	27%	$381	2.3%	$307	$83	$390	$0	2025Q1	42.5%	$437	$118	$556
0.003	Planning During Construction		$45	$12	27%	$57	2.3%	$46	$12	$58	$0	2025Q1	42.5%	$66	$18	$83
0.013	Project Operations		$195	$53	27%	$248	2.3%	$199	$54	$253	$0	2023Q3	34.0%	$267	$72	$340
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$705	$190	27%	$895	2.3%	$721	$195	$916	$0	2025Q1	42.5%	$1,028	$278	$1,306
0.012	Project Operation:		$180	$49	27%	$229	2.3%	$184	$50	$234	$0	2025Q1	42.5%	$262	$71	$333
0.031	Project Management		$465	$126	27%	$591	2.3%	$476	$128	$604	$0	2025Q1	42.5%	$678	$183	$861
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$19,024	$5,136		**$24,160**		$19,377	$5,232	$24,608	$0			$23,805	$6,427	**$30,233**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach E, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,061	$557	27%	$2,618	0.4%	$2,070	$559	$2,629	$0	2027Q1	23.8%	$2,564	$692	$3,256
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,061	$557	27%	**$2,618**		$2,070	$559	$2,629	$0			$2,564	$692	$3,256
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$17	$5	27%	$21	-1.0%	$17	$5	$21	$0	2018Q4	5.1%	$18	$5	$22
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$33	$9	27%	$42	2.3%	$34	$9	$43	$0	2023Q3	34.0%	$45	$12	$57
0.006	Planning & Environmental Compliance		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2023Q3	34.0%	$16	$4	$21
0.082	Engineering & Design		$169	$46	27%	$215	2.3%	$173	$47	$220	$0	2023Q3	34.0%	$232	$63	$294
0.003	Reviews, ATRs, IEPRs, VE		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2023Q3	34.0%	$8	$2	$10
0.007	Life Cycle Updates (cost, schedule, risks)		$14	$4	27%	$18	2.3%	$14	$4	$18	$0	2023Q3	34.0%	$19	$5	$24
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$21	$6	27%	$27	2.3%	$21	$6	$27	$0	2023Q3	34.0%	$29	$8	$37
0.01	Contracting & Reprographics		$21	$6	27%	$27	2.3%	$21	$6	$27	$0	2023Q3	34.0%	$29	$8	$37
0.02	Engineering During Construction		$41	$11	27%	$52	2.3%	$42	$11	$53	$0	2027Q1	55.3%	$65	$18	$83
0.003	Planning During Construction		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2027Q1	55.3%	$10	$3	$12
0.013	Project Operations		$27	$7	27%	$34	2.3%	$28	$7	$35	$0	2023Q3	34.0%	$37	$10	$47
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$97	$26	27%	$123	2.3%	$99	$27	$126	$0	2027Q1	55.3%	$154	$42	$196
0.012	Project Operation:		$25	$7	27%	$32	2.3%	$26	$7	$32	$0	2027Q1	55.3%	$40	$11	$50
0.031	Project Management		$64	$17	27%	$81	2.3%	$65	$18	$83	$0	2027Q1	55.3%	$102	$27	$129
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$2,614	$706		**$3,320**		$2,635	$712	$3,347	$0			$3,367	$909	**$4,276**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach F															
02	RELOCATIONS *		$11,421	$3,084	27%	$14,504	0.8%	$11,511	$3,108	$14,618	0	$14,618	12.7%	$12,972	$3,503	$16,475
06	FISH & WILDLIFE FACILITIES	Construction	$3,156	$852	27%	$4,009	0.4%	$3,170	$856	$4,026	0	$4,026	17.9%	$3,737	$1,009	$4,746
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$11,523	$3,111	27%	$14,635	0.4%	$11,574	$3,125	$14,698	0	$14,698	11.1%	$12,855	$3,471	$16,326
11	LEVEES & FLOODWALLS	Levees	$106,874	$28,856	27%	$135,731	0.4%	$107,301	$28,971	$136,272	0	$136,272	11.1%	$119,181	$32,179	$151,360
16	BANK STABILIZATION		$37,099	$10,017	27%	$47,116	1.8%	$37,752	$10,193	$47,946	0	$47,946	13.3%	$42,771	$11,548	$54,320
	CONSTRUCTION ESTIMATE TOTALS:		$170,074	$45,920		$215,994	0.7%	$171,308	$46,253	$217,561	0	$217,561	11.8%	$191,517	$51,710	$243,227
01	LANDS AND DAMAGES		$40,436	$21,182	52%	$61,618	0.6%	$40,661	$21,299	$61,960	0	$61,960	7.8%	$43,835	$22,962	$66,798
30	PLANNING, ENGINEERING & DESIGN *		$27,944	$7,545	27%	$35,489	2.3%	$28,587	$7,719	$36,306	0	$36,306	18.2%	$33,777	$9,120	$42,897
31	CONSTRUCTION MANAGEMENT *		$14,279	$3,855	27%	$18,134	2.3%	$14,608	$3,944	$18,552	0	$18,552	25.1%	$18,280	$4,936	$23,216
18	CULTURAL RESOURCE PRESERVATION		$1,628	$440	27%	$2,067	0.8%	$1,612	$435	$2,047	0	$2,047	8.0%	$1,740	$470	$2,210
	PROJECT COST TOTALS:		$254,361	$78,941	31%	$333,303		$256,775	$79,650	**$336,425**	0	**$336,425**	12.5%	$289,150	$89,197	$378,347

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$245,926**
ESTIMATED NON-FEDERAL COST:	35%	**$132,422**
ESTIMATED TOTAL PROJECT COST:		**$378,347**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach F, Levee Improvements															
02	RELOCATIONS		$9,137	$2,467	27%	$11,604	0.4%	$9,174	$2,477	$11,651	$0	2021Q3	11.1%	$10,190	$2,751	$12,941
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$11,523	$3,111	27%	$14,635	0.4%	$11,574	$3,125	$14,698	$0	2021Q3	11.1%	$12,855	$3,471	$16,326
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$106,874	$28,856	27%	$135,731	0.4%	$107,301	$28,971	$136,272	$0	2021Q3	11.1%	$119,181	$32,179	$151,360
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$127,535	$34,434	27%	**$161,969**		$128,048	$34,573	$162,621	$0			$142,226	$38,401	$180,627
01	LANDS AND DAMAGES	Fed	$3,016	$159	5%	$3,175	0.6%	$3,033	$160	$3,193	$0	2020Q1	7.8%	$3,270	$172	$3,442
01	LANDS AND DAMAGES	Non-Fed	$37,420	$21,023	56%	$58,443	0.6%	$37,628	$21,140	$58,767	$0	2020Q1	7.8%	$40,566	$22,790	$63,356
18	CULTURAL RESOURCE PRESERVATION		$1,298	$351	27%	$1,649	-1.0%	$1,285	$347	$1,633	$0	2020Q1	7.8%	$1,386	$374	$1,760
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,894	$511	27%	$2,405	2.3%	$1,938	$523	$2,461	$0	2020Q1	16.5%	$2,258	$610	$2,868
0.006	Planning & Environmental Compliance		$1,683	$454	27%	$2,137	2.3%	$1,722	$465	$2,187	$0	2020Q1	16.5%	$2,007	$542	$2,548
0.082	Engineering & Design		$9,709	$2,621	27%	$12,330	2.3%	$9,932	$2,682	$12,614	$0	2020Q1	16.5%	$11,576	$3,125	$14,701
0.003	Reviews, ATRs, IEPRs, VE		$355	$96	27%	$451	2.3%	$363	$98	$461	$0	2020Q1	16.5%	$423	$114	$538
0.007	Life Cycle Updates (cost, schedule, risks)		$829	$224	27%	$1,053	2.3%	$848	$229	$1,077	$0	2020Q1	16.5%	$988	$267	$1,255
0.01	Contracting & Reprographics		$1,184	$320	27%	$1,504	2.3%	$1,211	$327	$1,538	$0	2020Q1	16.5%	$1,412	$381	$1,793
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$1,184	$320	27%	$1,504	2.3%	$1,211	$327	$1,538	$0	2020Q1	16.5%	$1,412	$381	$1,793
0.02	Engineering During Construction		$2,368	$639	27%	$3,007	2.3%	$2,422	$654	$3,077	$0	2021Q3	23.6%	$2,995	$809	$3,804
0.003	Planning During Construction		$355	$96	27%	$451	2.3%	$363	$98	$461	$0	2021Q3	23.6%	$449	$121	$570
0.013	Project Operations		$1,539	$416	27%	$1,955	2.3%	$1,574	$425	$2,000	$0	2020Q1	16.5%	$1,835	$495	$2,330
0.16	NON-FED Planning, Engineering & Design (Relocations)		$1,462	$395	27%	$1,857	2.3%	$1,496	$404	$1,899	$0	2020Q1	16.5%	$1,743	$471	$2,214
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$5,565	$1,503	27%	$7,068	2.3%	$5,693	$1,537	$7,230	$0	2021Q3	23.6%	$7,039	$1,900	$8,939
0.012	Project Operation:		$1,421	$384	27%	$1,805	2.3%	$1,454	$393	$1,846	$0	2021Q3	23.6%	$1,797	$485	$2,283
0.031	Project Management		$3,670	$991	27%	$4,661	2.3%	$3,754	$1,014	$4,768	$0	2021Q3	23.6%	$4,642	$1,253	$5,895
0.09	NON-FED Construction Management (Relocations)		$822	$222	27%	$1,044	2.3%	$841	$227	$1,068	$0	2021Q3	23.6%	$1,040	$281	$1,320
	CONTRACT COST TOTALS:		$203,309	$65,157		**$268,467**		$204,818	$65,622	$270,440	$0			$229,063	$72,974	**$302,036**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach F, Erosion Protection															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$37,099	$10,017	27%	$47,116	1.8%	$37,752	$10,193	$47,946	$0	2022Q3	13.3%	$42,771	$11,548	$54,320
	CONSTRUCTION ESTIMATE TOTALS:		$37,099	$10,017	27%	**$47,116**		$37,752	$10,193	$47,946	$0			$42,771	$11,548	$54,320
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$304	$82	27%	$386	-1.0%	$301	$81	$382	$0	2020Q3	8.9%	$328	$88	$416
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$594	$160	27%	$754	2.3%	$608	$164	$772	$0	2020Q3	18.9%	$722	$195	$917
0.006	Planning & Environmental Compliance		$223	$60	27%	$283	2.3%	$228	$62	$290	$0	2020Q3	18.9%	$271	$73	$344
0.082	Engineering & Design		$3,042	$821	27%	$3,863	2.3%	$3,112	$840	$3,952	$0	2020Q3	18.9%	$3,699	$999	$4,697
0.003	Reviews, ATRs, IEPRs, VE		$111	$30	27%	$141	2.3%	$114	$31	$144	$0	2020Q3	18.9%	$135	$36	$171
0.007	Life Cycle Updates (cost, schedule, risks)		$260	$70	27%	$330	2.3%	$266	$72	$338	$0	2020Q3	18.9%	$316	$85	$401
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$371	$100	27%	$471	2.3%	$380	$102	$482	$0	2020Q3	18.9%	$451	$122	$573
0.01	Contracting & Reprographics		$371	$100	27%	$471	2.3%	$380	$102	$482	$0	2020Q3	18.9%	$451	$122	$573
0.02	Engineering During Construction		$742	$200	27%	$942	2.3%	$759	$205	$964	$0	2022Q3	28.7%	$977	$264	$1,241
0.003	Planning During Construction		$111	$30	27%	$141	2.3%	$114	$31	$144	$0	2022Q3	28.7%	$146	$39	$186
0.013	Project Operations		$482	$130	27%	$612	2.3%	$493	$133	$626	$0	2020Q3	18.9%	$586	$158	$744
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,744	$471	27%	$2,215	2.3%	$1,784	$482	$2,266	$0	2022Q3	28.7%	$2,296	$620	$2,916
0.012	Project Operation:		$445	$120	27%	$565	2.3%	$455	$123	$578	$0	2022Q3	28.7%	$586	$158	$744
0.031	Project Management		$1,150	$311	27%	$1,461	2.3%	$1,176	$318	$1,494	$0	2022Q3	28.7%	$1,514	$409	$1,923
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$47,049	$12,703		**$59,752**		$47,921	$12,939	$60,860	$0			$55,250	$14,917	**$70,167**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach F, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$3,156	$852	27%	$4,009	0.4%	$3,170	$856	$4,026	$0	2024Q3	17.9%	$3,737	$1,009	$4,746
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$3,156	$852	27%	**$4,009**		$3,170	$856	$4,026	$0			$3,737	$1,009	$4,746
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$26	$7	27%	$33	-1.0%	$26	$7	$33	$0	2018Q4	5.1%	$27	$7	$34
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$51	$14	27%	$65	2.3%	$52	$14	$66	$0	2020Q3	18.9%	$62	$17	$79
0.006	Planning & Environmental Compliance		$19	$5	27%	$24	2.3%	$19	$5	$25	$0	2020Q3	18.9%	$23	$6	$29
0.082	Engineering & Design		$259	$70	27%	$329	2.3%	$265	$72	$337	$0	2020Q3	18.9%	$315	$85	$400
0.003	Reviews, ATRs, IEPRs, VE		$9	$2	27%	$11	2.3%	$9	$2	$12	$0	2020Q3	18.9%	$11	$3	$14
0.007	Life Cycle Updates (cost, schedule, risks)		$22	$6	27%	$28	2.3%	$23	$6	$29	$0	2020Q3	18.9%	$27	$7	$34
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$32	$9	27%	$41	2.3%	$33	$9	$42	$0	2020Q3	18.9%	$39	$11	$49
0.01	Contracting & Reprographics		$32	$9	27%	$41	2.3%	$33	$9	$42	$0	2020Q3	18.9%	$39	$11	$49
0.02	Engineering During Construction		$63	$17	27%	$80	2.3%	$64	$17	$82	$0	2024Q3	39.6%	$90	$24	$114
0.003	Planning During Construction		$9	$2	27%	$11	2.3%	$9	$2	$12	$0	2024Q3	39.6%	$13	$3	$16
0.013	Project Operations		$41	$11	27%	$52	2.3%	$42	$11	$53	$0	2020Q3	18.9%	$50	$13	$63
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$148	$40	27%	$188	2.3%	$151	$41	$192	$0	2024Q3	39.6%	$211	$57	$269
0.012	Project Operation:		$38	$10	27%	$48	2.3%	$39	$10	$49	$0	2024Q3	39.6%	$54	$15	$69
0.031	Project Management		$98	$26	27%	$124	2.3%	$100	$27	$127	$0	2024Q3	39.6%	$140	$38	$178
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$4,003	$1,081		**$5,084**		$4,036	$1,090	$5,125	$0			$4,838	$1,306	**$6,144**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach G															
02	RELOCATIONS *		$26,383	$7,124	27%	$33,507	0.8%	$26,591	$7,180	$33,770	0	$33,770	23.5%	$32,845	$8,868	$41,714
06	FISH & WILDLIFE FACILITIES	Construction	$2,211	$597	27%	$2,808	0.4%	$2,221	$600	$2,820	0	$2,820	27.6%	$2,833	$765	$3,598
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,706	$1,271	27%	$5,976	0.4%	$4,726	$1,276	$6,002	0	$6,002	20.2%	$5,682	$1,534	$7,217
11	LEVEES & FLOODWALLS	Levees	$31,462	$8,495	27%	$39,956	0.4%	$31,587	$8,529	$40,116	0	$40,116	20.2%	$37,977	$10,254	$48,231
16	BANK STABILIZATION		$18,457	$4,983	27%	$23,441	1.8%	$18,782	$5,071	$23,854	0	$23,854	22.6%	$23,034	$6,219	$29,253
	CONSTRUCTION ESTIMATE TOTALS:		$83,219	$22,469		$105,689	0.8%	$83,908	$22,655	$106,563	0	$106,563	22.0%	$102,372	$27,640	$130,012
01	LANDS AND DAMAGES		$5,336	$1,496	28%	$6,832	0.6%	$5,365	$1,505	$6,870	0	$6,870	14.4%	$6,138	$1,721	$7,860
30	PLANNING, ENGINEERING & DESIGN *		$10,635	$2,871	27%	$13,506	2.3%	$10,880	$2,938	$13,817	0	$13,817	37.5%	$14,959	$4,039	$18,999
31	CONSTRUCTION MANAGEMENT *		$5,115	$1,381	27%	$6,496	2.3%	$5,233	$1,413	$6,646	0	$6,646	48.5%	$7,768	$2,097	$9,866
18	CULTURAL RESOURCE PRESERVATION		$644	$174	27%	$817	0.8%	$637	$172	$809	0	$809	15.9%	$739	$200	$938
	PROJECT COST TOTALS:		$104,949	$28,392	27%	$133,341		$106,023	$28,682	**$134,705**	0	**$134,705**	24.5%	$131,977	$35,698	$167,674

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$108,988**
ESTIMATED NON-FEDERAL COST:	35%	**$58,686**
ESTIMATED TOTAL PROJECT COST:		**$167,674**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach G, Levee Improvements															
02	RELOCATIONS		$21,106	$5,699	27%	$26,805	0.4%	$21,192	$5,722	$26,914	$0	2025Q3	20.2%	$25,479	$6,879	$32,358
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,706	$1,271	27%	$5,976	0.4%	$4,726	$1,276	$6,002	$0	2025Q3	20.2%	$5,682	$1,534	$7,217
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$31,462	$8,495	27%	$39,956	0.4%	$31,587	$8,529	$40,116	$0	2025Q3	20.2%	$37,977	$10,254	$48,231
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$57,274	$15,464	27%	**$72,738**		$57,506	$15,527	$73,032	$0			$69,138	$18,667	$87,806
01	LANDS AND DAMAGES	Fed	$570	$30	5%	$600	0.6%	$573	$30	$603	$0	2023Q1	14.4%	$656	$35	$690
01	LANDS AND DAMAGES	Non-Fed	$4,766	$1,466	31%	$6,232	0.6%	$4,792	$1,474	$6,267	$0	2023Q1	14.4%	$5,483	$1,687	$7,169
18	CULTURAL RESOURCE PRESERVATION		$474	$128	27%	$603	-1.0%	$470	$127	$597	$0	2023Q1	14.4%	$537	$145	$683
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$579	$156	27%	$735	2.3%	$592	$160	$752	$0	2023Q1	31.3%	$778	$210	$988
0.006	Planning & Environmental Compliance		$1,189	$321	27%	$1,510	2.3%	$1,216	$328	$1,545	$0	2023Q1	31.3%	$1,597	$431	$2,029
0.082	Engineering & Design		$2,966	$801	27%	$3,767	2.3%	$3,034	$819	$3,854	$0	2023Q1	31.3%	$3,985	$1,076	$5,060
0.003	Reviews, ATRs, IEPRs, VE		$109	$29	27%	$138	2.3%	$112	$30	$142	$0	2023Q1	31.3%	$146	$40	$186
0.007	Life Cycle Updates (cost, schedule, risks)		$253	$68	27%	$321	2.3%	$259	$70	$329	$0	2023Q1	31.3%	$340	$92	$432
0.01	Contracting & Reprographics		$362	$98	27%	$460	2.3%	$370	$100	$470	$0	2023Q1	31.3%	$486	$131	$618
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$362	$98	27%	$460	2.3%	$370	$100	$470	$0	2023Q1	31.3%	$486	$131	$618
0.02	Engineering During Construction		$723	$195	27%	$918	2.3%	$740	$200	$939	$0	2025Q3	45.6%	$1,077	$291	$1,368
0.003	Planning During Construction		$109	$29	27%	$138	2.3%	$112	$30	$142	$0	2025Q3	45.6%	$162	$44	$206
0.013	Project Operations		$470	$127	27%	$597	2.3%	$481	$130	$611	$0	2023Q1	31.3%	$631	$170	$802
0.16	NON-FED Planning, Engineering & Design (Relocations)		$3,377	$912	27%	$4,289	2.3%	$3,455	$933	$4,387	$0	2023Q1	31.3%	$4,537	$1,225	$5,762
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,700	$459	27%	$2,159	2.3%	$1,739	$470	$2,209	$0	2025Q3	45.6%	$2,532	$684	$3,215
0.012	Project Operation:		$434	$117	27%	$551	2.3%	$444	$120	$564	$0	2025Q3	45.6%	$646	$175	$821
0.031	Project Management		$1,121	$303	27%	$1,424	2.3%	$1,147	$310	$1,456	$0	2025Q3	45.6%	$1,670	$451	$2,120
0.09	NON-FED Construction Management (Relocations)		$1,900	$513	27%	$2,413	2.3%	$1,944	$525	$2,469	$0	2025Q3	45.6%	$2,830	$764	$3,594
	CONTRACT COST TOTALS:		$78,738	$21,315		**$100,053**		$79,355	$21,482	$100,837	$0			$97,717	$26,448	**$124,165**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach G, Erosion Protection															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$18,457	$4,983	27%	$23,441	1.8%	$18,782	$5,071	$23,854	$0	2026Q3	22.6%	$23,034	$6,219	$29,253
	CONSTRUCTION ESTIMATE TOTALS:		$18,457	$4,983	27%	**$23,441**		$18,782	$5,071	$23,854	$0			$23,034	$6,219	$29,253
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$151	$41	27%	$192	-1.0%	$150	$40	$190	$0	2025Q3	20.2%	$180	$49	$229
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$295	$80	27%	$375	2.3%	$302	$81	$383	$0	2025Q3	45.6%	$439	$119	$558
0.006	Planning & Environmental Compliance		$111	$30	27%	$141	2.3%	$114	$31	$144	$0	2025Q3	45.6%	$165	$45	$210
0.082	Engineering & Design		$1,514	$409	27%	$1,923	2.3%	$1,549	$418	$1,967	$0	2025Q3	45.6%	$2,255	$609	$2,864
0.003	Reviews, ATRs, IEPRs, VE		$55	$15	27%	$70	2.3%	$56	$15	$71	$0	2025Q3	45.6%	$82	$22	$104
0.007	Life Cycle Updates (cost, schedule, risks)		$129	$35	27%	$164	2.3%	$132	$36	$168	$0	2025Q3	45.6%	$192	$52	$244
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$185	$50	27%	$235	2.3%	$189	$51	$240	$0	2025Q3	45.6%	$276	$74	$350
0.01	Contracting & Reprographics		$185	$50	27%	$235	2.3%	$189	$51	$240	$0	2025Q3	45.6%	$276	$74	$350
0.02	Engineering During Construction		$369	$100	27%	$469	2.3%	$377	$102	$479	$0	2026Q3	52.0%	$574	$155	$729
0.003	Planning During Construction		$55	$15	27%	$70	2.3%	$56	$15	$71	$0	2026Q3	52.0%	$86	$23	$109
0.013	Project Operations		$240	$65	27%	$305	2.3%	$246	$66	$312	$0	2025Q3	45.6%	$357	$97	$454
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$867	$234	27%	$1,101	2.3%	$887	$239	$1,126	$0	2026Q3	52.0%	$1,348	$364	$1,712
0.012	Project Operation:		$221	$60	27%	$281	2.3%	$226	$61	$287	$0	2026Q3	52.0%	$344	$93	$436
0.031	Project Management		$572	$154	27%	$726	2.3%	$585	$158	$743	$0	2026Q3	52.0%	$889	$240	$1,130
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$23,406	$6,320		**$29,726**		$23,841	$6,437	$30,278	$0			$30,496	$8,234	**$38,730**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach G, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,211	$597	27%	$2,808	0.4%	$2,221	$600	$2,820	$0	2028Q3	27.6%	$2,833	$765	$3,598
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,211	$597	27%	**$2,808**		$2,221	$600	$2,820	$0			$2,833	$765	$3,598
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$18	$5	27%	$23	-1.0%	$18	$5	$23	$0	2025Q3	20.2%	$22	$6	$27
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$35	$9	27%	$44	2.3%	$36	$10	$45	$0	2025Q3	45.6%	$52	$14	$66
0.006	Planning & Environmental Compliance		$13	$4	27%	$17	2.3%	$13	$4	$17	$0	2025Q3	45.6%	$19	$5	$25
0.082	Engineering & Design		$181	$49	27%	$230	2.3%	$185	$50	$235	$0	2025Q3	45.6%	$270	$73	$342
0.003	Reviews, ATRs, IEPRs, VE		$7	$2	27%	$9	2.3%	$7	$2	$9	$0	2025Q3	45.6%	$10	$3	$13
0.007	Life Cycle Updates (cost, schedule, risks)		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2025Q3	45.6%	$22	$6	$28
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$22	$6	27%	$28	2.3%	$23	$6	$29	$0	2025Q3	45.6%	$33	$9	$42
0.01	Contracting & Reprographics		$22	$6	27%	$28	2.3%	$23	$6	$29	$0	2025Q3	45.6%	$33	$9	$42
0.02	Engineering During Construction		$44	$12	27%	$56	2.3%	$45	$12	$57	$0	2028Q3	65.9%	$75	$20	$95
0.003	Planning During Construction		$7	$2	27%	$9	2.3%	$7	$2	$9	$0	2028Q3	65.9%	$12	$3	$15
0.013	Project Operations		$29	$8	27%	$37	2.3%	$30	$8	$38	$0	2025Q3	45.6%	$43	$12	$55
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$104	$28	27%	$132	2.3%	$106	$29	$135	$0	2028Q3	65.9%	$177	$48	$224
0.012	Project Operation:		$27	$7	27%	$34	2.3%	$28	$7	$35	$0	2028Q3	65.9%	$46	$12	$58
0.031	Project Management		$69	$19	27%	$88	2.3%	$71	$19	$90	$0	2028Q3	65.9%	$117	$32	$149
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$2,804	$757		**$3,561**		$2,827	$763	$3,590	$0			$3,763	$1,016	**$4,780**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach A															
02	RELOCATIONS *		$1,972	$532	27%	$2,504	0.8%	$1,987	$537	$2,524	0	$2,524	19.7%	$2,379	$642	$3,021
06	FISH & WILDLIFE FACILITIES	Construction	$2,521	$681	27%	$3,201	0.4%	$2,531	$684	$3,215	0	$3,215	19.0%	$3,013	$814	$3,827
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,602	$1,243	27%	$5,845	0.4%	$4,622	$1,248	$5,870	0	$5,870	16.7%	$5,394	$1,456	$6,850
16	BANK STABILIZATION		$70,051	$18,914	27%	$88,965	1.8%	$71,285	$19,247	$90,532	0	$90,532	16.7%	$83,187	$22,461	$105,648
	CONSTRUCTION ESTIMATE TOTALS:		$79,146	$21,369		$100,515	1.6%	$80,426	$21,715	$102,141	0	$102,141	16.8%	$93,974	$25,373	$119,346
01	LANDS AND DAMAGES		$1,646	$518	31%	$2,164	0.6%	$1,656	$520	$2,176	0	$2,176	13.3%	$1,876	$590	$2,465
30	PLANNING, ENGINEERING & DESIGN *		$14,093	$3,805	27%	$17,898	2.3%	$14,417	$3,893	$18,310	0	$18,310	29.7%	$18,706	$5,051	$23,757
31	CONSTRUCTION MANAGEMENT *		$6,945	$1,875	27%	$8,820	2.3%	$7,105	$1,918	$9,023	0	$9,023	37.0%	$9,733	$2,628	$12,361
18	CULTURAL RESOURCE PRESERVATION		$659	$178	27%	$837	0.8%	$653	$176	$829	0	$829	13.4%	$740	$200	$940
	PROJECT COST TOTALS:		$102,489	$27,745	27%	$130,235		$104,257	$28,223	**$132,480**	0	**$132,480**	19.9%	$125,028	$33,841	$158,869

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$103,265**
ESTIMATED NON-FEDERAL COST:	35%	**$55,604**
ESTIMATED TOTAL PROJECT COST:		**$158,869**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST (FULLY FUNDED)			
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach A, Erosion Protection															
02	RELOCATIONS		$1,578	$426	27%	$2,004	0.4%	$1,584	$428	$2,012	$0	2024Q1	16.7%	$1,849	$499	$2,348
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,602	$1,243	27%	$5,845	0.4%	$4,622	$1,248	$5,870	$0	2024Q1	16.7%	$5,394	$1,456	$6,850
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$70,051	$18,914	27%	$88,965	1.8%	$71,285	$19,247	$90,532	$0	2024Q1	16.7%	$83,187	$22,461	$105,648
	CONSTRUCTION ESTIMATE TOTALS:		$76,231	$20,582	27%	**$96,813**		$77,492	$20,923	$98,414	$0			$90,430	$24,416	$114,846
01	LANDS AND DAMAGES	Fed	$190	$10	5%	$200	0.6%	$191	$10	$201	$0	2022Q3	13.3%	$216	$11	$228
01	LANDS AND DAMAGES	Non-Fed	$1,456	$508	35%	$1,964	0.6%	$1,465	$510	$1,975	$0	2022Q3	13.3%	$1,659	$578	$2,237
18	CULTURAL RESOURCE PRESERVATION		$639	$172	27%	$811	-1.0%	$632	$171	$803	$0	2022Q3	13.3%	$717	$193	$910
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,194	$322	27%	$1,516	2.3%	$1,221	$330	$1,551	$0	2022Q3	28.7%	$1,572	$424	$1,997
0.006	Planning & Environmental Compliance		$1,420	$383	27%	$1,803	2.3%	$1,453	$392	$1,845	$0	2022Q3	28.7%	$1,870	$505	$2,375
0.082	Engineering & Design		$6,122	$1,653	27%	$7,775	2.3%	$6,263	$1,691	$7,954	$0	2022Q3	28.7%	$8,061	$2,176	$10,237
0.003	Reviews, ATRs, IEPRs, VE		$224	$60	27%	$284	2.3%	$229	$62	$291	$0	2022Q3	28.7%	$295	$80	$375
0.007	Life Cycle Updates (cost, schedule, risks)		$523	$141	27%	$664	2.3%	$535	$144	$679	$0	2022Q3	28.7%	$689	$186	$875
0.01	Contracting & Reprographics		$747	$202	27%	$949	2.3%	$764	$206	$971	$0	2022Q3	28.7%	$984	$266	$1,249
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$747	$202	27%	$949	2.3%	$764	$206	$971	$0	2022Q3	28.7%	$984	$266	$1,249
0.02	Engineering During Construction		$1,493	$403	27%	$1,896	2.3%	$1,527	$412	$1,940	$0	2024Q1	36.8%	$2,089	$564	$2,654
0.003	Planning During Construction		$224	$60	27%	$284	2.3%	$229	$62	$291	$0	2024Q1	36.8%	$313	$85	$398
0.013	Project Operations		$970	$262	27%	$1,232	2.3%	$992	$268	$1,260	$0	2022Q3	28.7%	$1,277	$345	$1,622
0.16	NON-FED Planning, Engineering & Design (Relocations)		$252	$68	27%	$320	2.3%	$258	$70	$327	$0	2022Q3	28.7%	$332	$90	$421
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$3,509	$947	27%	$4,456	2.3%	$3,590	$969	$4,559	$0	2024Q1	36.8%	$4,911	$1,326	$6,237
0.012	Project Operation:		$896	$242	27%	$1,138	2.3%	$917	$247	$1,164	$0	2024Q1	36.8%	$1,254	$339	$1,593
0.031	Project Management		$2,314	$625	27%	$2,939	2.3%	$2,367	$639	$3,006	$0	2024Q1	36.8%	$3,238	$874	$4,113
0.09	NON-FED Construction Management (Relocations)		$142	$38	27%	$180	2.3%	$145	$39	$184	$0	2024Q1	36.8%	$199	$54	$252
	CONTRACT COST TOTALS:		$99,293	$26,882		**$126,175**		$101,035	$27,353	$128,388	$0			$121,089	$32,777	**$153,866**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARN, Reach A, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,521	$681	27%	$3,201	0.4%	$2,531	$684	$3,215	$0	2025Q1	19.0%	$3,013	$814	$3,827
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,521	$681	27%	**$3,201**		$2,531	$684	$3,215	$0			$3,013	$814	$3,827
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$21	$6	27%	$26	-1.0%	$20	$6	$26	$0	2023Q3	15.6%	$24	$6	$30
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$40	$11	27%	$51	2.3%	$41	$11	$52	$0	2022Q3	28.7%	$53	$14	$67
0.006	Planning & Environmental Compliance		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2022Q3	28.7%	$20	$5	$25
0.082	Engineering & Design		$207	$56	27%	$263	2.3%	$212	$57	$269	$0	2022Q3	28.7%	$273	$74	$346
0.003	Reviews, ATRs, IEPRs, VE		$8	$2	27%	$10	2.3%	$8	$2	$10	$0	2022Q3	28.7%	$11	$3	$13
0.007	Life Cycle Updates (cost, schedule, risks)		$18	$5	27%	$23	2.3%	$18	$5	$23	$0	2022Q3	28.7%	$24	$6	$30
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$25	$7	27%	$32	2.3%	$26	$7	$32	$0	2022Q3	28.7%	$33	$9	$42
0.01	Contracting & Reprographics		$25	$7	27%	$32	2.3%	$26	$7	$32	$0	2022Q3	28.7%	$33	$9	$42
0.02	Engineering During Construction		$50	$14	27%	$64	2.3%	$51	$14	$65	$0	2025Q1	42.5%	$73	$20	$93
0.003	Planning During Construction		$8	$2	27%	$10	2.3%	$8	$2	$10	$0	2025Q1	42.5%	$12	$3	$15
0.013	Project Operations		$33	$9	27%	$42	2.3%	$34	$9	$43	$0	2022Q3	28.7%	$43	$12	$55
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$118	$32	27%	$150	2.3%	$121	$33	$153	$0	2025Q1	42.5%	$172	$46	$219
0.012	Project Operation:		$30	$8	27%	$38	2.3%	$31	$8	$39	$0	2025Q1	42.5%	$44	$12	$56
0.031	Project Management		$78	$21	27%	$99	2.3%	$80	$22	$101	$0	2025Q1	42.5%	$114	$31	$144
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$3,196	$863		**$4,059**		$3,222	$870	$4,092	$0			$3,939	$1,064	**$5,003**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach B															
02	RELOCATIONS *		$81	$22	27%	$103	0.8%	$82	$22	$104	0	$104	27.7%	$105	$28	$133
06	FISH & WILDLIFE FACILITIES	Construction	$383	$104	27%	$487	0.4%	$385	$104	$489	0	$489	27.6%	$491	$133	$624
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$408	$110	27%	$518	0.4%	$410	$111	$520	0	$520	22.6%	$503	$136	$638
16	BANK STABILIZATION		$3,538	$955	27%	$4,493	1.8%	$3,600	$972	$4,572	0	$4,572	22.6%	$4,415	$1,192	$5,607
	CONSTRUCTION ESTIMATE TOTALS:		$4,410	$1,191		$5,601	1.5%	$4,477	$1,209	$5,685	0	$5,685	23.2%	$5,513	$1,489	$7,002
01	LANDS AND DAMAGES		$235	$41	18%	$276	0.6%	$236	$41	$278	0	$278	20.2%	$284	$50	$334
30	PLANNING, ENGINEERING & DESIGN *		$736	$199	27%	$935	2.3%	$753	$203	$956	0	$956	46.6%	$1,104	$298	$1,402
31	CONSTRUCTION MANAGEMENT *		$389	$105	27%	$494	2.3%	$398	$107	$505	0	$505	53.2%	$610	$165	$774
18	CULTURAL RESOURCE PRESERVATION		$37	$10	27%	$48	0.8%	$37	$10	$47	0	$47	20.4%	$45	$12	$57
	PROJECT COST TOTALS:		$5,808	$1,546	27%	$7,353		$5,901	$1,571	**$7,472**	0	**$7,472**	28.1%	$7,556	$2,013	$9,569

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$6,220**
ESTIMATED NON-FEDERAL COST:	35%	**$3,349**
ESTIMATED TOTAL PROJECT COST:		**$9,569**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach B, Erosion Protection															
02	RELOCATIONS		$65	$18	27%	$83	0.4%	$66	$18	$83	$0	2026Q3	22.6%	$80	$22	$102
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$408	$110	27%	$518	0.4%	$410	$111	$520	$0	2026Q3	22.6%	$503	$136	$638
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$3,538	$955	27%	$4,493	1.8%	$3,600	$972	$4,572	$0	2026Q3	22.6%	$4,415	$1,192	$5,607
	CONSTRUCTION ESTIMATE TOTALS:		$4,011	$1,083	27%	**$5,094**		$4,075	$1,100	$5,176	$0			$4,998	$1,349	$6,347
01	LANDS AND DAMAGES	Fed	$48	$2	5%	$50	0.6%	$48	$3	$50	$0	2025Q3	20.2%	$57	$3	$60
01	LANDS AND DAMAGES	Non-Fed	$187	$39	21%	$226	0.6%	$188	$39	$227	$0	2025Q3	20.2%	$227	$47	$273
18	CULTURAL RESOURCE PRESERVATION		$34	$9	27%	$44	-1.0%	$34	$9	$43	$0	2025Q3	20.2%	$41	$11	$52
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$63	$17	27%	$80	2.3%	$64	$17	$82	$0	2025Q3	45.6%	$94	$25	$119
0.006	Planning & Environmental Compliance		$24	$6	27%	$30	2.3%	$25	$7	$31	$0	2025Q3	45.6%	$36	$10	$45
0.082	Engineering & Design		$324	$87	27%	$411	2.3%	$331	$89	$421	$0	2025Q3	45.6%	$483	$130	$613
0.003	Reviews, ATRs, IEPRs, VE		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2025Q3	45.6%	$18	$5	$23
0.007	Life Cycle Updates (cost, schedule, risks)		$28	$8	27%	$36	2.3%	$29	$8	$36	$0	2025Q3	45.6%	$42	$11	$53
0.01	Contracting & Reprographics		$39	$11	27%	$50	2.3%	$40	$11	$51	$0	2025Q3	45.6%	$58	$16	$74
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$39	$11	27%	$50	2.3%	$40	$11	$51	$0	2025Q3	45.6%	$58	$16	$74
0.02	Engineering During Construction		$79	$21	27%	$100	2.3%	$81	$22	$103	$0	2026Q3	52.0%	$123	$33	$156
0.003	Planning During Construction		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2026Q3	52.0%	$19	$5	$24
0.013	Project Operations		$51	$14	27%	$65	2.3%	$52	$14	$66	$0	2025Q3	45.6%	$76	$21	$96
0.16	NON-FED Planning, Engineering & Design (Relocations)		$10	$3	27%	$13	2.3%	$10	$3	$13	$0	2025Q3	45.6%	$15	$4	$19
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$185	$50	27%	$235	2.3%	$189	$51	$240	$0	2026Q3	52.0%	$288	$78	$365
0.012	Project Operation:		$47	$13	27%	$60	2.3%	$48	$13	$61	$0	2026Q3	52.0%	$73	$20	$93
0.031	Project Management		$122	$33	27%	$155	2.3%	$125	$34	$159	$0	2026Q3	52.0%	$190	$51	$241
0.09	NON-FED Construction Management (Relocations)		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2026Q3	52.0%	$9	$3	$12
	CONTRACT COST TOTALS:		$5,321	$1,414		**$6,736**		$5,410	$1,438	$6,849	$0			$6,902	$1,837	**$8,739**

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARN, Reach B, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$383	$104	27%	$487	0.4%	$385	$104	$489	$0	2028Q3	27.6%	$491	$133	$624
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$383	$104	27%	**$487**		$385	$104	$489	$0			$491	$133	$624
01	LANDS AND DAMAGES	Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$3	$1	27%	$4	-1.0%	$3	$1	$4	$0	2026Q3	22.6%	$4	$1	$5
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2025Q3	45.6%	$9	$2	$11
0.006	Planning & Environmental Compliance		$2	$1	27%	$3	2.3%	$2	$1	$3	$0	2025Q3	45.6%	$3	$1	$4
0.082	Engineering & Design		$31	$8	27%	$39	2.3%	$32	$9	$40	$0	2025Q3	45.6%	$46	$12	$59
0.003	Reviews, ATRs, IEPRs, VE		$1	$0	27%	$1	2.3%	$1	$0	$1	$0	2025Q3	45.6%	$1	$0	$2
0.007	Life Cycle Updates (cost, schedule, risks)		$3	$1	27%	$4	2.3%	$3	$1	$4	$0	2025Q3	45.6%	$4	$1	$6
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$4	$1	27%	$5	2.3%	$4	$1	$5	$0	2025Q3	45.6%	$6	$2	$8
0.01	Contracting & Reprographics		$4	$1	27%	$5	2.3%	$4	$1	$5	$0	2025Q3	45.6%	$6	$2	$8
0.02	Engineering During Construction		$8	$2	27%	$10	2.3%	$8	$2	$10	$0	2028Q3	65.9%	$14	$4	$17
0.003	Planning During Construction		$1	$0	27%	$1	2.3%	$1	$0	$1	$0	2028Q3	65.9%	$2	$0	$2
0.013	Project Operations		$5	$1	27%	$6	2.3%	$5	$1	$6	$0	2025Q3	45.6%	$7	$2	$9
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$18	$5	27%	$23	2.3%	$18	$5	$23	$0	2028Q3	65.9%	$31	$8	$39
0.012	Project Operation:		$5	$1	27%	$6	2.3%	$5	$1	$6	$0	2028Q3	65.9%	$8	$2	$11
0.031	Project Management		$12	$3	27%	$15	2.3%	$12	$3	$16	$0	2028Q3	65.9%	$20	$5	$26
0.09	NON-FED Construction Management (Relocations)		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$487	$131		**$618**		$490	$132	$623	$0			$653	$176	**$830**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach C															
02	RELOCATIONS *		$1,180	$319	27%	$1,499	0.8%	$1,190	$321	$1,511	0	$1,511	30.0%	$1,546	$418	$1,964
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$27	27%	$127	0.4%	$100	$27	$128	0	$128	24.5%	$125	$34	$159
11	LEVEES & FLOODWALLS	Levees	$5,025	$1,357	27%	$6,381	0.4%	$5,045	$1,362	$6,407	0	$6,407	24.5%	$6,279	$1,695	$7,974
	CONSTRUCTION ESTIMATE TOTALS:		$6,305	$1,702		$8,007	0.5%	$6,335	$1,710	$8,045	0	$8,045	25.5%	$7,950	$2,147	$10,097
01	LANDS AND DAMAGES		$191	$15	8%	$206	0.6%	$192	$15	$207	0	$207	21.4%	$233	$18	$251
30	PLANNING, ENGINEERING & DESIGN *		$870	$235	27%	$1,105	2.3%	$890	$240	$1,130	0	$1,130	49.9%	$1,334	$360	$1,694
31	CONSTRUCTION MANAGEMENT *		$461	$124	27%	$585	2.3%	$472	$127	$599	0	$599	56.9%	$740	$200	$940
18	CULTURAL RESOURCE PRESERVATION		$49	$13	27%	$63	0.8%	$49	$13	$62	0	$62	21.4%	$59	$16	$75
	PROJECT COST TOTALS:		$7,876	$2,090	27%	$9,966		$7,937	$2,106	**$10,043**	0	**$10,043**	30.0%	$10,316	$2,741	$13,057

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$8,487**
ESTIMATED NON-FEDERAL COST:	35%	**$4,570**
ESTIMATED TOTAL PROJECT COST:		**$13,057**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST (FULLY FUNDED)			
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach C, Levee Improvements															
02	RELOCATIONS		$944	$255	27%	$1,199	0.4%	$948	$256	$1,204	$0	2027Q2	24.5%	$1,180	$319	$1,499
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$27	27%	$127	0.4%	$100	$27	$128	$0	2027Q2	24.5%	$125	$34	$159
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$5,025	$1,357	27%	$6,381	0.4%	$5,045	$1,362	$6,407	$0	2027Q2	24.5%	$6,279	$1,695	$7,974
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$6,069	$1,639	27%	**$7,708**		$6,093	$1,645	$7,738	$0			$7,584	$2,048	$9,631
01	LANDS AND DAMAGES	Fed	$48	$2	5%	$50	0.6%	$48	$3	$50	$0	2026Q1	21.4%	$58	$3	$61
01	LANDS AND DAMAGES	Non-Fed	$143	$13	9%	$156	0.6%	$144	$13	$157	$0	2026Q1	21.4%	$175	$15	$190
18	CULTURAL RESOURCE PRESERVATION		$49	$13	27%	$63	-1.0%	$49	$13	$62	$0	2026Q1	21.4%	$59	$16	$75
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$82	$22	27%	$104	2.3%	$84	$23	$107	$0	2026Q1	48.7%	$125	$34	$158
0.006	Planning & Environmental Compliance		$31	$8	27%	$39	2.3%	$32	$9	$40	$0	2026Q1	48.7%	$47	$13	$60
0.082	Engineering & Design		$420	$113	27%	$533	2.3%	$430	$116	$546	$0	2026Q1	48.7%	$639	$173	$812
0.003	Reviews, ATRs, IEPRs, VE		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2026Q1	48.7%	$23	$6	$29
0.007	Life Cycle Updates (cost, schedule, risks)		$36	$10	27%	$46	2.3%	$37	$10	$47	$0	2026Q1	48.7%	$55	$15	$70
0.01	Contracting & Reprographics		$51	$14	27%	$65	2.3%	$52	$14	$66	$0	2026Q1	48.7%	$78	$21	$99
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$51	$14	27%	$65	2.3%	$52	$14	$66	$0	2026Q1	48.7%	$78	$21	$99
0.02	Engineering During Construction		$102	$28	27%	$130	2.3%	$104	$28	$133	$0	2027Q2	56.9%	$164	$44	$208
0.003	Planning During Construction		$15	$4	27%	$19	2.3%	$15	$4	$19	$0	2027Q2	56.9%	$24	$7	$31
0.013	Project Operations		$67	$18	27%	$85	2.3%	$69	$19	$87	$0	2026Q1	48.7%	$102	$28	$129
0.16	NON-FED Planning, Engineering & Design (Relocations)		$151	$41	27%	$192	2.3%	$154	$42	$196	$0	2026Q1	48.7%	$230	$62	$292
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$241	$65	27%	$306	2.3%	$247	$67	$313	$0	2027Q2	56.9%	$387	$104	$491
0.012	Project Operation:		$61	$16	27%	$77	2.3%	$62	$17	$79	$0	2027Q2	56.9%	$98	$26	$124
0.031	Project Management		$159	$43	27%	$202	2.3%	$163	$44	$207	$0	2027Q2	56.9%	$255	$69	$324
0.09	NON-FED Construction Management (Relocations)		$85	$23	27%	$108	2.3%	$87	$23	$110	$0	2027Q2	56.9%	$136	$37	$173
	CONTRACT COST TOTALS:		$7,876	$2,090		**$9,966**		$7,937	$2,106	$10,043	$0			$10,316	$2,741	**$13,057**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach D															
02	RELOCATIONS *		$8,344	$2,253	27%	$10,596	0.8%	$8,409	$2,271	$10,680	0	$10,680	23.5%	$10,387	$2,805	$13,192
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$660	$178	27%	$838	0.4%	$663	$179	$842	0	$842	20.2%	$797	$215	$1,012
11	LEVEES & FLOODWALLS	Levees	$27,062	$7,307	27%	$34,368	0.4%	$27,170	$7,336	$34,505	0	$34,505	20.2%	$32,666	$8,820	$41,485
	CONSTRUCTION ESTIMATE TOTALS:		$36,065	$9,738		$45,803	0.5%	$36,242	$9,785	$46,027	0	$46,027	21.0%	$43,850	$11,839	$55,689
01	LANDS AND DAMAGES		$2,950	$405	14%	$3,355	0.6%	$2,967	$407	$3,374	0	$3,374	14.4%	$3,394	$465	$3,860
30	PLANNING, ENGINEERING & DESIGN *		$4,711	$1,272	27%	$5,983	2.3%	$4,819	$1,301	$6,121	0	$6,121	33.2%	$6,422	$1,734	$8,156
31	CONSTRUCTION MANAGEMENT *		$2,495	$674	27%	$3,169	2.3%	$2,552	$689	$3,242	0	$3,242	45.6%	$3,716	$1,003	$4,719
18	CULTURAL RESOURCE PRESERVATION		$290	$78	27%	$368	0.8%	$287	$77	$364	0	$364	14.4%	$328	$89	$417
	PROJECT COST TOTALS:		$46,511	$12,166	26%	$58,677		$46,867	$12,260	**$59,127**	0	**$59,127**	23.2%	$57,710	$15,131	$72,840

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

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CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$47,346**
ESTIMATED NON-FEDERAL COST:	35%	**$25,494**
ESTIMATED TOTAL PROJECT COST:		**$72,840**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach D, Levee Improvements															
02	RELOCATIONS		$6,675	$1,802	27%	$8,477	0.4%	$6,702	$1,809	$8,511	$0	2025Q3	20.2%	$8,057	$2,176	$10,233
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$660	$178	27%	$838	0.4%	$663	$179	$842	$0	2025Q3	20.2%	$797	$215	$1,012
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$27,062	$7,307	27%	$34,368	0.4%	$27,170	$7,336	$34,505	$0	2025Q3	20.2%	$32,666	$8,820	$41,485
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$34,396	$9,287	27%	**$43,683**		$34,534	$9,324	$43,859	$0			$41,520	$11,210	$52,731
01	LANDS AND DAMAGES	Fed	$665	$35	5%	$700	0.6%	$669	$35	$704	$0	2023Q1	14.4%	$765	$40	$805
01	LANDS AND DAMAGES	Non-Fed	$2,285	$370	16%	$2,655	0.6%	$2,298	$372	$2,670	$0	2023Q1	14.4%	$2,629	$425	$3,054
18	CULTURAL RESOURCE PRESERVATION		$290	$78	27%	$368	-1.0%	$287	$77	$364	$0	2023Q1	14.4%	$328	$89	$417
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$444	$120	27%	$564	2.3%	$454	$123	$577	$0	2023Q1	31.3%	$596	$161	$758
0.006	Planning & Environmental Compliance		$166	$45	27%	$211	2.3%	$170	$46	$216	$0	2023Q1	31.3%	$223	$60	$283
0.082	Engineering & Design		$2,273	$614	27%	$2,887	2.3%	$2,325	$628	$2,953	$0	2023Q1	31.3%	$3,054	$824	$3,878
0.003	Reviews, ATRs, IEPRs, VE		$83	$22	27%	$105	2.3%	$85	$23	$108	$0	2023Q1	31.3%	$112	$30	$142
0.007	Life Cycle Updates (cost, schedule, risks)		$194	$52	27%	$246	2.3%	$198	$54	$252	$0	2023Q1	31.3%	$261	$70	$331
0.01	Contracting & Reprographics		$277	$75	27%	$352	2.3%	$283	$77	$360	$0	2023Q1	31.3%	$372	$100	$473
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$277	$75	27%	$352	2.3%	$283	$77	$360	$0	2023Q1	31.3%	$372	$100	$473
0.02	Engineering During Construction		$554	$150	27%	$704	2.3%	$567	$153	$720	$0	2025Q3	45.6%	$825	$223	$1,048
0.003	Planning During Construction		$83	$22	27%	$105	2.3%	$85	$23	$108	$0	2025Q3	45.6%	$124	$33	$157
0.013	Project Operations		$360	$97	27%	$457	2.3%	$368	$99	$468	$0	2023Q1	31.3%	$484	$131	$614
0.16	NON-FED Planning, Engineering & Design (Relocations)		$1,068	$288	27%	$1,356	2.3%	$1,093	$295	$1,388	$0	2023Q1	31.3%	$1,435	$387	$1,822
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,303	$352	27%	$1,655	2.3%	$1,333	$360	$1,693	$0	2025Q3	45.6%	$1,941	$524	$2,465
0.012	Project Operation:		$333	$90	27%	$423	2.3%	$341	$92	$433	$0	2025Q3	45.6%	$496	$134	$630
0.031	Project Management		$859	$232	27%	$1,091	2.3%	$879	$237	$1,116	$0	2025Q3	45.6%	$1,279	$345	$1,625
0.09	NON-FED Construction Management (Relocations)		$601	$162	27%	$763	2.3%	$615	$166	$781	$0	2025Q3	45.6%	$895	$242	$1,137
	CONTRACT COST TOTALS:		$46,511	$12,166		**$58,677**		$46,867	$12,260	$59,127	$0			$57,710	$15,131	**$72,840**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach E															
02	RELOCATIONS *		$10,565	$2,853	27%	$13,418	0.8%	$10,648	$2,875	$13,523	0	$13,523	26.6%	$13,483	$3,640	$17,123
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$495	$134	27%	$629	0.4%	$497	$134	$631	0	$631	22.6%	$610	$165	$774
11	LEVEES & FLOODWALLS	Levees	$25,431	$6,866	27%	$32,297	0.4%	$25,532	$6,894	$32,426	0	$32,426	22.6%	$31,311	$8,454	$39,765
	CONSTRUCTION ESTIMATE TOTALS:		$36,491	$9,853		$46,343	0.5%	$36,678	$9,903	$46,581	0	$46,581	23.8%	$45,403	$12,259	$57,662
01	LANDS AND DAMAGES		$4,325	$594	14%	$4,919	0.6%	$4,348	$597	$4,946	0	$4,946	16.7%	$5,074	$697	$5,771
30	PLANNING, ENGINEERING & DESIGN *		$4,408	$1,190	27%	$5,598	2.3%	$4,509	$1,218	$5,727	0	$5,727	38.9%	$6,262	$1,691	$7,952
31	CONSTRUCTION MANAGEMENT *		$2,334	$630	27%	$2,964	2.3%	$2,388	$645	$3,032	0	$3,032	52.0%	$3,629	$980	$4,609
18	CULTURAL RESOURCE PRESERVATION		$295	$80	27%	$375	0.8%	$292	$79	$371	0	$371	16.7%	$341	$92	$433
	PROJECT COST TOTALS:		$47,853	$12,347	26%	$60,199		$48,216	$12,441	**$60,657**	0	**$60,657**	26.0%	$60,710	$15,719	$76,428

ESTIMATED FEDERAL COST:	65%	**$49,678**
ESTIMATED NON-FEDERAL COST:	35%	**$26,750**
ESTIMATED TOTAL PROJECT COST:		**$76,428**

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST (FULLY FUNDED)			
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach E, Levee Improvements															
02	RELOCATIONS		$8,452	$2,282	27%	$10,734	0.4%	$8,486	$2,291	$10,778	$0	2026Q3	22.6%	$10,407	$2,810	$13,217
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$495	$134	27%	$629	0.4%	$497	$134	$631	$0	2026Q3	22.6%	$610	$165	$774
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$25,431	$6,866	27%	$32,297	0.4%	$25,532	$6,894	$32,426	$0	2026Q3	22.6%	$31,311	$8,454	$39,765
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$34,378	$9,282	27%	**$43,660**		$34,516	$9,319	$43,835	$0			$42,328	$11,429	$53,757
01	LANDS AND DAMAGES	Fed	$974	$51	5%	$1,025	0.6%	$979	$52	$1,031	$0	2024Q1	16.7%	$1,143	$60	$1,203
01	LANDS AND DAMAGES	Non-Fed	$3,351	$543	16%	$3,894	0.6%	$3,369	$546	$3,915	$0	2024Q1	16.7%	$3,932	$637	$4,569
18	CULTURAL RESOURCE PRESERVATION		$295	$80	27%	$375	-1.0%	$292	$79	$371	$0	2024Q1	16.7%	$341	$92	$433
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$415	$112	27%	$527	2.3%	$425	$115	$539	$0	2024Q1	36.8%	$581	$157	$738
0.006	Planning & Environmental Compliance		$156	$42	27%	$198	2.3%	$160	$43	$203	$0	2024Q1	36.8%	$218	$59	$277
0.082	Engineering & Design		$2,126	$574	27%	$2,700	2.3%	$2,175	$587	$2,762	$0	2024Q1	36.8%	$2,975	$803	$3,779
0.003	Reviews, ATRs, IEPRs, VE		$78	$21	27%	$99	2.3%	$80	$22	$101	$0	2024Q1	36.8%	$109	$29	$139
0.007	Life Cycle Updates (cost, schedule, risks)		$181	$49	27%	$230	2.3%	$185	$50	$235	$0	2024Q1	36.8%	$253	$68	$322
0.01	Contracting & Reprographics		$259	$70	27%	$329	2.3%	$265	$72	$337	$0	2024Q1	36.8%	$362	$98	$460
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$259	$70	27%	$329	2.3%	$265	$72	$337	$0	2024Q1	36.8%	$362	$98	$460
0.02	Engineering During Construction		$519	$140	27%	$659	2.3%	$531	$143	$674	$0	2026Q3	52.0%	$807	$218	$1,025
0.003	Planning During Construction		$78	$21	27%	$99	2.3%	$80	$22	$101	$0	2026Q3	52.0%	$121	$33	$154
0.013	Project Operations		$337	$91	27%	$428	2.3%	$345	$93	$438	$0	2024Q1	36.8%	$472	$127	$599
0.16	NON-FED Planning, Engineering & Design (Relocations)		$1,352	$365	27%	$1,717	2.3%	$1,383	$373	$1,757	$0	2024Q1	36.8%	$1,892	$511	$2,403
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,219	$329	27%	$1,548	2.3%	$1,247	$337	$1,584	$0	2026Q3	52.0%	$1,895	$512	$2,407
0.012	Project Operation:		$311	$84	27%	$395	2.3%	$318	$86	$404	$0	2026Q3	52.0%	$484	$131	$614
0.031	Project Management		$804	$217	27%	$1,021	2.3%	$823	$222	$1,045	$0	2026Q3	52.0%	$1,250	$338	$1,588
0.09	NON-FED Construction Management (Relocations)		$761	$205	27%	$966	2.3%	$779	$210	$989	$0	2026Q3	52.0%	$1,183	$319	$1,503
	CONTRACT COST TOTALS:		$47,853	$12,347		**$60,199**		$48,216	$12,441	$60,657	$0			$60,710	$15,719	**$76,428**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach F															
02	RELOCATIONS *		$4,237	$1,144	27%	$5,381	0.8%	$4,271	$1,153	$5,424	0	$5,424	27.4%	$5,439	$1,469	$6,908
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$27	27%	$127	0.4%	$100	$27	$128	0	$128	22.6%	$123	$33	$156
11	LEVEES & FLOODWALLS	Levees	$16,597	$4,481	27%	$21,078	0.4%	$16,663	$4,499	$21,162	0	$21,162	22.6%	$20,434	$5,517	$25,951
	CONSTRUCTION ESTIMATE TOTALS:		$20,934	$5,652		$26,586	0.5%	$21,034	$5,679	$26,713	0	$26,713	23.6%	$25,996	$7,019	$33,016
01	LANDS AND DAMAGES		$466	$68	15%	$534	0.6%	$468	$68	$536	0	$536	19.0%	$557	$81	$639
30	PLANNING, ENGINEERING & DESIGN *		$2,838	$766	27%	$3,604	2.3%	$2,903	$784	$3,687	0	$3,687	43.8%	$4,176	$1,127	$5,303
31	CONSTRUCTION MANAGEMENT *		$1,503	$406	27%	$1,909	2.3%	$1,538	$415	$1,953	0	$1,953	52.0%	$2,337	$631	$2,968
18	CULTURAL RESOURCE PRESERVATION		$162	$44	27%	$205	0.8%	$160	$43	$203	0	$203	19.0%	$191	$51	$242
	PROJECT COST TOTALS:		$25,902	$6,936	27%	$32,838		$26,103	$6,990	**$33,093**	0	**$33,093**	27.4%	$33,257	$8,910	$42,167

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$27,409**
ESTIMATED NON-FEDERAL COST:	35%	**$14,759**
ESTIMATED TOTAL PROJECT COST:		**$42,167**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach F, Levee Improvements															
02	RELOCATIONS		$3,390	$915	27%	$4,306	0.4%	$3,404	$919	$4,323	$0	2026Q3	22.6%	$4,175	$1,127	$5,302
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$27	27%	$127	0.4%	$100	$27	$128	$0	2026Q3	22.6%	$123	$33	$156
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$16,597	$4,481	27%	$21,078	0.4%	$16,663	$4,499	$21,162	$0	2026Q3	22.6%	$20,434	$5,517	$25,951
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$20,087	$5,423	27%	**$25,510**		$20,167	$5,445	$25,613	$0			$24,732	$6,678	$31,409
01	LANDS AND DAMAGES	Fed	$71	$4	5%	$75	0.6%	$72	$4	$75	$0	2025Q1	19.0%	$85	$4	$90
01	LANDS AND DAMAGES	Non-Fed	$395	$64	16%	$459	0.6%	$397	$64	$461	$0	2025Q1	19.0%	$472	$77	$549
18	CULTURAL RESOURCE PRESERVATION		$162	$44	27%	$205	-1.0%	$160	$43	$203	$0	2025Q1	19.0%	$191	$51	$242
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$267	$72	27%	$339	2.3%	$273	$74	$347	$0	2025Q1	42.5%	$389	$105	$494
0.006	Planning & Environmental Compliance		$100	$27	27%	$127	2.3%	$102	$28	$130	$0	2025Q1	42.5%	$146	$39	$185
0.082	Engineering & Design		$1,369	$370	27%	$1,739	2.3%	$1,401	$378	$1,779	$0	2025Q1	42.5%	$1,996	$539	$2,535
0.003	Reviews, ATRs, IEPRs, VE		$50	$14	27%	$64	2.3%	$51	$14	$65	$0	2025Q1	42.5%	$73	$20	$93
0.007	Life Cycle Updates (cost, schedule, risks)		$117	$32	27%	$149	2.3%	$120	$32	$152	$0	2025Q1	42.5%	$171	$46	$217
0.01	Contracting & Reprographics		$167	$45	27%	$212	2.3%	$171	$46	$217	$0	2025Q1	42.5%	$244	$66	$309
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$167	$45	27%	$212	2.3%	$171	$46	$217	$0	2025Q1	42.5%	$244	$66	$309
0.02	Engineering During Construction		$334	$90	27%	$424	2.3%	$342	$92	$434	$0	2026Q3	52.0%	$519	$140	$660
0.003	Planning During Construction		$50	$14	27%	$64	2.3%	$51	$14	$65	$0	2026Q3	52.0%	$78	$21	$99
0.013	Project Operations		$217	$59	27%	$276	2.3%	$222	$60	$282	$0	2025Q1	42.5%	$316	$85	$402
0.16	NON-FED Planning, Engineering & Design (Relocations)		$542	$146	27%	$688	2.3%	$554	$150	$704	$0	2025Q1	42.5%	$790	$213	$1,004
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$785	$212	27%	$997	2.3%	$803	$217	$1,020	$0	2026Q3	52.0%	$1,221	$330	$1,550
0.012	Project Operation:		$200	$54	27%	$254	2.3%	$205	$55	$260	$0	2026Q3	52.0%	$311	$84	$395
0.031	Project Management		$518	$140	27%	$658	2.3%	$530	$143	$673	$0	2026Q3	52.0%	$805	$217	$1,023
0.09	NON-FED Construction Management (Relocations)		$305	$82	27%	$387	2.3%	$312	$84	$396	$0	2026Q3	52.0%	$474	$128	$602
	CONTRACT COST TOTALS:		$25,902	$6,936		**$32,838**		$26,103	$6,990	$33,093	$0			$33,257	$8,910	**$42,167**

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

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: 10/1/2014 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach I															
02	RELOCATIONS *		$50	$14	27%	$64	0.8%	$50	$14	$64	0	$64	30.1%	$66	$18	$83
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$275	$74	27%	$349	0.4%	$276	$75	$351	0	$351	24.5%	$344	$93	$437
11	LEVEES & FLOODWALLS	Levees	$1,950	$527	27%	$2,477	0.4%	$1,958	$529	$2,487	0	$2,487	24.5%	$2,437	$658	$3,095
	CONSTRUCTION ESTIMATE TOTALS:		$2,276	$614		$2,890	0.4%	$2,285	$617	$2,902	0	$2,902	24.6%	$2,847	$769	$3,615
01	LANDS AND DAMAGES		$20,492	$11,788	58%	$32,280	0.6%	$20,606	$11,853	$32,459	0	$32,459	21.4%	$25,017	$14,391	$39,408
30	PLANNING, ENGINEERING & DESIGN *		$379	$102	27%	$481	2.3%	$388	$105	$492	0	$492	49.9%	$581	$157	$738
31	CONSTRUCTION MANAGEMENT *		$201	$54	27%	$255	2.3%	$206	$56	$261	0	$261	56.9%	$323	$87	$410
18	CULTURAL RESOURCE PRESERVATION		$152	$41	27%	$193	0.8%	$150	$41	$191	0	$191	21.4%	$182	$49	$232
	PROJECT COST TOTALS:		$23,499	$12,600	54%	$36,099		$23,634	$12,671	**$36,305**	0	**$36,305**	22.3%	$28,950	$15,453	$44,403

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	65%	**$28,862**
ESTIMATED NON-FEDERAL COST:	35%	**$15,541**
ESTIMATED TOTAL PROJECT COST:		**$44,403**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 1 - NED
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach I, Levee Improvements															
02	RELOCATIONS		$40	$11	27%	$51	0.4%	$40	$11	$51	$0	2027Q2	24.5%	$50	$14	$64
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$275	$74	27%	$349	0.4%	$276	$75	$351	$0	2027Q2	24.5%	$344	$93	$437
09	CHANNELS & CANALS		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$1,950	$527	27%	$2,477	0.4%	$1,958	$529	$2,487	$0	2027Q2	24.5%	$2,437	$658	$3,095
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	27%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,266	$612	27%	**$2,877**		$2,275	$614	$2,889	$0			$2,831	$764	$3,595
01	LANDS AND DAMAGES	Fed	$713	$38	5%	$750	0.6%	$716	$38	$754	$0	2026Q1	21.4%	$870	$46	$916
01	LANDS AND DAMAGES	Non-Fed	$19,780	$11,750	59%	$31,530	0.6%	$19,889	$11,816	$31,705	$0	2026Q1	21.4%	$24,147	$14,345	$38,493
18	CULTURAL RESOURCE PRESERVATION		$152	$41	27%	$193	-1.0%	$150	$41	$191	$0	2026Q1	21.4%	$182	$49	$232
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$36	$10	27%	$46	2.3%	$37	$10	$47	$0	2026Q1	48.7%	$55	$15	$70
0.006	Planning & Environmental Compliance		$13	$4	27%	$17	2.3%	$13	$4	$17	$0	2026Q1	48.7%	$20	$5	$25
0.082	Engineering & Design		$182	$49	27%	$231	2.3%	$186	$50	$236	$0	2026Q1	48.7%	$277	$75	$352
0.003	Reviews, ATRs, IEPRs, VE		$7	$2	27%	$9	2.3%	$7	$2	$9	$0	2026Q1	48.7%	$11	$3	$14
0.007	Life Cycle Updates (cost, schedule, risks)		$16	$4	27%	$20	2.3%	$16	$4	$21	$0	2026Q1	48.7%	$24	$7	$31
0.01	Contracting & Reprographics		$22	$6	27%	$28	2.3%	$23	$6	$29	$0	2026Q1	48.7%	$33	$9	$43
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$22	$6	27%	$28	2.3%	$23	$6	$29	$0	2026Q1	48.7%	$33	$9	$43
0.02	Engineering During Construction		$45	$12	27%	$57	2.3%	$46	$12	$58	$0	2027Q2	56.9%	$72	$20	$92
0.003	Planning During Construction		$7	$2	27%	$9	2.3%	$7	$2	$9	$0	2027Q2	56.9%	$11	$3	$14
0.013	Project Operations		$29	$8	27%	$37	2.3%	$30	$8	$38	$0	2026Q1	48.7%	$44	$12	$56
0.16	NON-FED Planning, Engineering & Design (Relocations)		$6	$2	27%	$8	2.3%	$6	$2	$8	$0	2026Q1	48.7%	$9	$2	$12
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$105	$28	27%	$133	2.3%	$107	$29	$136	$0	2027Q2	56.9%	$169	$46	$214
0.012	Project Operation:		$27	$7	27%	$34	2.3%	$28	$7	$35	$0	2027Q2	56.9%	$43	$12	$55
0.031	Project Management		$69	$19	27%	$88	2.3%	$71	$19	$90	$0	2027Q2	56.9%	$111	$30	$141
0.09	NON-FED Construction Management (Relocations)		$4	$1	27%	$5	2.3%	$4	$1	$5	$0	2027Q2	56.9%	$6	$2	$8
	CONTRACT COST TOTALS:		$23,499	$12,600		**$36,099**		$23,634	$12,671	$36,305	$0			$28,950	$15,453	**$44,403**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO: P2 # 149827
LOCATION: Sacramento, CA

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Feasibility Report

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									
											Spent Thru:	TOTAL FIRST				
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
02	RELOCATIONS *		$122,813	$34,388	28%	$157,201	0.8%	$123,779	$34,658	$158,437	$0	$158,437	21.4%	$150,279	$42,078	$192,357
06	FISH & WILDLIFE FACILITIES	Construction	$19,020	$5,326	28%	$24,346	0.4%	$19,103	$5,349	$24,452	$0	$24,452	20.5%	$23,017	$6,445	$29,462
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$55,826	$15,631	28%	$71,457	0.4%	$56,069	$15,699	$71,768	$0	$71,768	14.7%	$64,294	$18,002	$82,297
08	ROADS, RAILROADS & BRIDGES		$20,073	$5,620	28%	$25,693	0.4%	$20,155	$5,643	$25,798	$0	$25,798	5.1%	$21,192	$5,934	$27,126
11	LEVEES & FLOODWALLS	Levees	$362,348	$101,458	28%	$463,806	0.4%	$363,794	$101,862	$465,656	$0	$465,656	16.6%	$424,199	$118,776	$542,975
16	BANK STABILIZATION		$292,672	$81,948	28%	$374,620	1.8%	$297,828	$83,392	$381,220	$0	$381,220	14.7%	$341,678	$95,670	$437,347
15	FLOODWAY CONTROL & DIVERSION STRUCTURE		$42,316	$11,849	28%	$54,165	0.4%	$42,501	$11,900	$54,401	$0	$54,401	13.9%	$48,391	$13,549	$61,941
	CONSTRUCTION ESTIMATE TOTALS:		$915,069	$256,219		$1,171,289	0.9%	$923,228	$258,504	$1,181,732	$0	$1,181,732	16.2%	$1,073,050	$300,454	$1,373,504
01	LANDS AND DAMAGES		$71,078	$24,255	34%	$95,333	0.6%	$71,472	$24,389	$95,862	$0	$95,862	14.2%	$81,345	$28,148	$109,494
30	PLANNING, ENGINEERING & DESIGN *		$142,464	$39,890	28%	$182,354	2.3%	$145,743	$40,808	$186,551	$0	$186,551	25.4%	$182,808	$51,186	$233,994
31	CONSTRUCTION MANAGEMENT *		$71,303	$19,965	28%	$91,268	2.3%	$72,944	$20,424	$93,368	$0	$93,368	34.7%	$98,235	$27,506	$125,741
18	CULTURAL RESOURCE PRESERVATION		$6,550	$1,768	27%	$8,318	0.8%	$6,486	$1,751	$8,237	$0	$8,237	12.4%	$7,292	$1,969	$9,260
	PROJECT COST TOTALS:		$1,206,465	$342,097	28%	$1,548,562		$1,219,873	$345,877	**$1,565,750**	$0	**$1,565,750**	18.3%	$1,442,730	$409,263	$1,851,993

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CHIEF, COST ENGINEERING, Jeremiah Frost

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PROJECT MANAGER, Dan Tibbitts

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CHIEF, REAL ESTATE, Diane Simpson

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CHIEF, ENGINEERING, Rick Poeppelman

ESTIMATED FEDERAL COST:	56%	$1,038,310
ESTIMATED NON-FEDERAL COST:	44%	$813,683
ESTIMATED TOTAL PROJECT COST:		**$1,851,993**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
								Program Year (Budget EC):			2016					
								Effective Price Level Date:			1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach A															
02	RELOCATIONS *		$4,899	$1,372	28%	$6,271	0.8%	$4,937	$1,382	$6,320	0	$6,320	9.8%	$5,419	$1,517	$6,936
06	FISH & WILDLIFE FACILITIES	Construction	$4,251	$1,190	28%	$5,441	0.4%	$4,270	$1,195	$5,465	0	$5,465	13.3%	$4,837	$1,354	$6,192
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$9,182	$2,571	28%	$11,753	0.4%	$9,222	$2,582	$11,805	0	$11,805	8.9%	$10,043	$2,812	$12,855
16	BANK STABILIZATION		$91,765	$25,694	28%	$117,459	1.8%	$93,382	$26,147	$119,528	0	$119,528	8.9%	$101,688	$28,473	$130,160
	CONSTRUCTION ESTIMATE TOTALS:		$110,097	$30,827		$140,925	1.6%	$111,811	$31,307	$143,118	0	$143,118	9.1%	$121,987	$34,156	$156,143
01	LANDS AND DAMAGES		$2,002	$832	42%	$2,834	0.6%	$2,013	$836	$2,850	0	$2,850	4.7%	$2,107	$875	$2,982
30	PLANNING, ENGINEERING & DESIGN *		$18,858	$5,280	28%	$24,138	2.3%	$19,292	$5,402	$24,694	0	$24,694	11.1%	$21,431	$6,001	$27,432
31	CONSTRUCTION MANAGEMENT *		$9,468	$2,651	28%	$12,119	2.3%	$9,686	$2,712	$12,398	0	$12,398	19.3%	$11,551	$3,234	$14,785
18	CULTURAL RESOURCE PRESERVATION		$906	$245	27%	$1,151	0.8%	$898	$242	$1,140	0	$1,140	4.7%	$940	$254	$1,194
	PROJECT COST TOTALS:		$141,332	$39,835	28%	$181,167		$143,700	$40,500	**$184,199**	0	**$184,199**	10.0%	$158,015	$44,520	$202,535

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED TOTAL PROJECT COST: **$202,535**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.
Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach A, Erosion Protection															
02	RELOCATIONS		$3,919	$1,097	28%	$5,016	0.4%	$3,935	$1,102	$5,037	$0	2020Q3	8.9%	$4,285	$1,200	$5,485
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$9,182	$2,571	28%	$11,753	0.4%	$9,222	$2,582	$11,805	$0	2020Q3	8.9%	$10,043	$2,812	$12,855
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$91,765	$25,694	28%	$117,459	1.8%	$93,382	$26,147	$119,528	$0	2020Q3	8.9%	$101,688	$28,473	$130,160
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$104,866	$29,363	28%	**$134,229**		$106,539	$29,831	$136,370	$0			$116,015	$32,484	$148,500
01	LANDS AND DAMAGES	Fed	$95	$5	5%	$100	0.6%	$96	$5	$101	$0	2018Q3	4.7%	$100	$5	$105
01	LANDS AND DAMAGES	Non-Fed	$1,907	$827	43%	$2,734	0.6%	$1,918	$831	$2,749	$0	2018Q3	4.7%	$2,007	$870	$2,877
18	CULTURAL RESOURCE PRESERVATION		$872	$235	27%	$1,107	-1.0%	$863	$233	$1,096	$0	2018Q3	4.7%	$903	$244	$1,147
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,615	$452	28%	$2,067	2.3%	$1,652	$463	$2,115	$0	2018Q3	9.9%	$1,815	$508	$2,324
0.006	Planning & Environmental Compliance		$1,578	$442	28%	$2,020	2.3%	$1,614	$452	$2,066	$0	2018Q3	9.9%	$1,774	$497	$2,271
0.082	Engineering & Design		$8,278	$2,318	28%	$10,596	2.3%	$8,469	$2,371	$10,840	$0	2018Q3	9.9%	$9,306	$2,606	$11,911
0.003	Reviews, ATRs, IEPRs, VE		$303	$85	28%	$388	2.3%	$310	$87	$397	$0	2018Q3	9.9%	$341	$95	$436
0.007	Life Cycle Updates (cost, schedule, risks)		$707	$198	28%	$905	2.3%	$723	$203	$926	$0	2018Q3	9.9%	$795	$223	$1,017
0.01	Contracting & Reprographics		$1,009	$283	28%	$1,292	2.3%	$1,032	$289	$1,321	$0	2018Q3	9.9%	$1,134	$318	$1,452
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$1,009	$283	28%	$1,292	2.3%	$1,032	$289	$1,321	$0	2018Q3	9.9%	$1,134	$318	$1,452
0.02	Engineering During Construction		$2,019	$565	28%	$2,584	2.3%	$2,065	$578	$2,644	$0	2020Q3	18.9%	$2,455	$687	$3,142
0.003	Planning During Construction		$303	$85	28%	$388	2.3%	$310	$87	$397	$0	2020Q3	18.9%	$368	$103	$472
0.013	Project Operations		$1,312	$367	28%	$1,679	2.3%	$1,342	$376	$1,718	$0	2018Q3	9.9%	$1,475	$413	$1,888
0.16	NON-FED Planning, Engineering & Design (Relocations)		$627	$176	28%	$803	2.3%	$641	$180	$821	$0	2018Q3	9.9%	$705	$197	$902
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$4,745	$1,329	28%	$6,074	2.3%	$4,854	$1,359	$6,213	$0	2020Q3	18.9%	$5,769	$1,615	$7,385
0.012	Project Operation:		$1,211	$339	28%	$1,550	2.3%	$1,239	$347	$1,586	$0	2020Q3	18.9%	$1,472	$412	$1,885
0.031	Project Management		$3,129	$876	28%	$4,005	2.3%	$3,201	$896	$4,097	$0	2020Q3	18.9%	$3,804	$1,065	$4,870
0.09	NON-FED Construction Management (Relocations)		$353	$99	28%	$452	2.3%	$361	$101	$462	$0	2020Q3	18.9%	$429	$120	$549
	CONTRACT COST TOTALS:		$135,938	$38,325		**$174,263**		$138,262	$38,977	$177,240	$0			$151,803	$42,781	**$194,584**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	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: 10/1/2014	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*
	ARS, Reach A, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$4,251	$1,190	28%	$5,441	0.4%	$4,270	$1,195	$5,465	$0	2022Q3	13.3%	$4,837	$1,354	$6,192
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$4,251	$1,190	28%	**$5,441**		$4,270	$1,195	$5,465	$0			$4,837	$1,354	$6,192
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$35	$9	27%	$44	-1.0%	$34	$9	$44	$0	2019Q3	6.8%	$37	$10	$47
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$68	$19	28%	$87	2.3%	$70	$19	$89	$0	2018Q3	9.9%	$76	$21	$98
0.006	Planning & Environmental Compliance		$26	$7	28%	$33	2.3%	$27	$7	$34	$0	2018Q3	9.9%	$29	$8	$37
0.082	Engineering & Design		$349	$98	28%	$447	2.3%	$357	$100	$457	$0	2018Q3	9.9%	$392	$110	$502
0.003	Reviews, ATRs, IEPRs, VE		$13	$4	28%	$17	2.3%	$13	$4	$17	$0	2018Q3	9.9%	$15	$4	$19
0.007	Life Cycle Updates (cost, schedule, risks)		$30	$8	28%	$38	2.3%	$31	$9	$39	$0	2018Q3	9.9%	$34	$9	$43
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$43	$12	28%	$55	2.3%	$44	$12	$56	$0	2018Q3	9.9%	$48	$14	$62
0.01	Contracting & Reprographics		$43	$12	28%	$55	2.3%	$44	$12	$56	$0	2018Q3	9.9%	$48	$14	$62
0.02	Engineering During Construction		$85	$24	28%	$109	2.3%	$87	$24	$111	$0	2022Q3	28.7%	$112	$31	$143
0.003	Planning During Construction		$13	$4	28%	$17	2.3%	$13	$4	$17	$0	2022Q3	28.7%	$17	$5	$22
0.013	Project Operations		$55	$15	28%	$70	2.3%	$56	$16	$72	$0	2018Q3	9.9%	$62	$17	$79
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$200	$56	28%	$256	2.3%	$205	$57	$262	$0	2022Q3	28.7%	$263	$74	$337
0.012	Project Operation:		$51	$14	28%	$65	2.3%	$52	$15	$67	$0	2022Q3	28.7%	$67	$19	$86
0.031	Project Management		$132	$37	28%	$169	2.3%	$135	$38	$173	$0	2022Q3	28.7%	$174	$49	$222
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$5,394	$1,510		**$6,904**		$5,438	$1,522	$6,960	$0			$6,212	$1,739	**$7,951**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
								Program Year (Budget EC):			2016					
								Effective Price Level Date:			1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach B															
02	RELOCATIONS *		$2,313	$648	28%	$2,961	0.8%	$2,332	$653	$2,984	0	$2,984	15.8%	$2,699	$756	$3,455
06	FISH & WILDLIFE FACILITIES	Construction	$1,170	$328	28%	$1,497	0.4%	$1,175	$329	$1,504	0	$1,504	17.9%	$1,385	$388	$1,773
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$3,218	$901	28%	$4,119	0.4%	$3,232	$905	$4,137	0	$4,137	13.3%	$3,661	$1,025	$4,687
16	BANK STABILIZATION		$21,641	$6,060	28%	$27,701	1.8%	$22,022	$6,166	$28,189	0	$28,189	13.3%	$24,950	$6,986	$31,936
	CONSTRUCTION ESTIMATE TOTALS:		$28,342	$7,936		$36,278	1.5%	$28,761	$8,053	$36,814	0	$36,814	13.7%	$32,696	$9,155	$41,850
01	LANDS AND DAMAGES		$1,011	$208	21%	$1,219	0.6%	$1,017	$209	$1,226	0	$1,226	11.1%	$1,129	$232	$1,361
30	PLANNING, ENGINEERING & DESIGN *		$5,399	$1,512	28%	$6,911	2.3%	$5,523	$1,547	$7,070	0	$7,070	24.3%	$6,863	$1,922	$8,784
31	CONSTRUCTION MANAGEMENT *		$2,342	$656	28%	$2,998	2.3%	$2,396	$671	$3,067	0	$3,067	29.2%	$3,095	$867	$3,962
18	CULTURAL RESOURCE PRESERVATION		$238	$64	27%	$302	0.8%	$236	$64	$299	0	$299	11.2%	$262	$71	$333
	PROJECT COST TOTALS:		$37,332	$10,376	28%	$47,708		$37,932	$10,543	**$48,475**	0	**$48,475**	16.1%	$44,045	$12,246	$56,291

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$56,291**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.
Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach B, Erosion Protection															
02	RELOCATIONS		$1,850	$518	28%	$2,368	0.4%	$1,858	$520	$2,378	$0	2022Q3	13.3%	$2,105	$589	$2,694
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$3,218	$901	28%	$4,119	0.4%	$3,232	$905	$4,137	$0	2022Q3	13.3%	$3,661	$1,025	$4,687
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$21,641	$6,060	28%	$27,701	1.8%	$22,022	$6,166	$28,189	$0	2022Q3	13.3%	$24,950	$6,986	$31,936
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$26,709	$7,479	28%	**$34,188**		$27,112	$7,591	$34,704	$0			$30,717	$8,601	$39,317
01	LANDS AND DAMAGES	Fed	$166	$9	5%	$175	0.6%	$167	$9	$176	$0	2021Q3	11.1%	$186	$10	$195
01	LANDS AND DAMAGES	Non-Fed	$845	$199	24%	$1,044	0.6%	$849	$200	$1,050	$0	2021Q3	11.1%	$943	$223	$1,166
18	CULTURAL RESOURCE PRESERVATION		$229	$62	27%	$290	-1.0%	$226	$61	$287	$0	2021Q3	11.1%	$251	$68	$319
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$398	$111	28%	$509	2.3%	$407	$114	$521	$0	2021Q3	23.6%	$503	$141	$644
0.006	Planning & Environmental Compliance		$1,121	$314	28%	$1,435	2.3%	$1,147	$321	$1,468	$0	2021Q3	23.6%	$1,418	$397	$1,815
0.082	Engineering & Design		$2,038	$571	28%	$2,609	2.3%	$2,085	$584	$2,669	$0	2021Q3	23.6%	$2,578	$722	$3,299
0.003	Reviews, ATRs, IEPRs, VE		$75	$21	28%	$96	2.3%	$77	$21	$98	$0	2021Q3	23.6%	$95	$27	$121
0.007	Life Cycle Updates (cost, schedule, risks)		$174	$49	28%	$223	2.3%	$178	$50	$228	$0	2021Q3	23.6%	$220	$62	$282
0.01	Contracting & Reprographics		$249	$70	28%	$319	2.3%	$255	$71	$326	$0	2021Q3	23.6%	$315	$88	$403
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$249	$70	28%	$319	2.3%	$255	$71	$326	$0	2021Q3	23.6%	$315	$88	$403
0.02	Engineering During Construction		$497	$139	28%	$636	2.3%	$508	$142	$651	$0	2022Q3	28.7%	$654	$183	$838
0.003	Planning During Construction		$75	$21	28%	$96	2.3%	$77	$21	$98	$0	2022Q3	28.7%	$99	$28	$126
0.013	Project Operations		$323	$90	28%	$413	2.3%	$330	$93	$423	$0	2021Q3	23.6%	$409	$114	$523
0.16	NON-FED Planning, Engineering & Design (Relocations)		$296	$83	28%	$379	2.3%	$303	$85	$388	$0	2021Q3	23.6%	$374	$105	$479
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,168	$327	28%	$1,495	2.3%	$1,195	$335	$1,529	$0	2022Q3	28.7%	$1,538	$431	$1,968
0.012	Project Operation:		$298	$83	28%	$381	2.3%	$305	$85	$390	$0	2022Q3	28.7%	$392	$110	$502
0.031	Project Management		$771	$216	28%	$987	2.3%	$789	$221	$1,010	$0	2022Q3	28.7%	$1,015	$284	$1,299
0.09	NON-FED Construction Management (Relocations)		$167	$47	28%	$214	2.3%	$171	$48	$219	$0	2022Q3	28.7%	$220	$62	$281
	CONTRACT COST TOTALS:		$35,848	$9,960		**$45,808**		$36,436	$10,124	$46,560	$0			$42,242	$11,742	**$53,984**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	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: 10/1/2014	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*
	ARS, Reach B, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$1,170	$328	28%	$1,497	0.4%	$1,175	$329	$1,504	$0	2024Q3	17.9%	$1,385	$388	$1,773
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$1,170	$328	28%	**$1,497**		$1,175	$329	$1,504	$0			$1,385	$388	$1,773
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$10	$3	27%	$12	-1.0%	$9	$3	$12	$0	2022Q3	13.3%	$11	$3	$14
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$19	$5	28%	$24	2.3%	$19	$5	$25	$0	2021Q3	23.6%	$24	$7	$31
0.006	Planning & Environmental Compliance		$7	$2	28%	$9	2.3%	$7	$2	$9	$0	2021Q3	23.6%	$9	$2	$11
0.082	Engineering & Design		$96	$27	28%	$123	2.3%	$98	$27	$126	$0	2021Q3	23.6%	$121	$34	$155
0.003	Reviews, ATRs, IEPRs, VE		$4	$1	28%	$5	2.3%	$4	$1	$5	$0	2021Q3	23.6%	$5	$1	$6
0.007	Life Cycle Updates (cost, schedule, risks)		$8	$2	28%	$10	2.3%	$8	$2	$10	$0	2021Q3	23.6%	$10	$3	$13
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2021Q3	23.6%	$15	$4	$19
0.01	Contracting & Reprographics		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2021Q3	23.6%	$15	$4	$19
0.02	Engineering During Construction		$23	$6	28%	$29	2.3%	$24	$7	$30	$0	2024Q3	39.6%	$33	$9	$42
0.003	Planning During Construction		$4	$1	28%	$5	2.3%	$4	$1	$5	$0	2024Q3	39.6%	$6	$2	$7
0.013	Project Operations		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2021Q3	23.6%	$19	$5	$24
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$55	$15	28%	$70	2.3%	$56	$16	$72	$0	2024Q3	39.6%	$79	$22	$101
0.012	Project Operation:		$14	$4	28%	$18	2.3%	$14	$4	$18	$0	2024Q3	39.6%	$20	$6	$26
0.031	Project Management		$36	$10	28%	$46	2.3%	$37	$10	$47	$0	2024Q3	39.6%	$51	$14	$66
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$1,484	$416		**$1,900**		$1,496	$419	$1,915	$0			$1,803	$505	**$2,308**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach C															
02	RELOCATIONS *		$500	$140	28%	$640	0.8%	$504	$141	$645	0	$645	24.6%	$627	$176	$803
06	FISH & WILDLIFE FACILITIES	Construction	$1,164	$326	28%	$1,491	0.4%	$1,170	$327	$1,497	0	$1,497	25.1%	$1,463	$410	$1,873
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$1,128	$316	28%	$1,444	0.4%	$1,133	$317	$1,450	0	$1,450	20.2%	$1,362	$381	$1,743
16	BANK STABILIZATION		$14,915	$4,176	28%	$19,091	1.8%	$15,177	$4,250	$19,427	0	$19,427	20.2%	$18,248	$5,109	$23,357
	CONSTRUCTION ESTIMATE TOTALS:		$17,707	$4,958		$22,665	1.6%	$17,983	$5,035	$23,019	0	$23,019	20.7%	$21,700	$6,076	$27,776
01	LANDS AND DAMAGES		$875	$183	21%	$1,058	0.6%	$880	$184	$1,064	0	$1,064	17.9%	$1,037	$217	$1,254
30	PLANNING, ENGINEERING & DESIGN *		$3,896	$1,091	28%	$4,987	2.3%	$3,986	$1,116	$5,102	0	$5,102	40.3%	$5,593	$1,566	$7,159
31	CONSTRUCTION MANAGEMENT *		$1,549	$434	28%	$1,983	2.3%	$1,585	$444	$2,028	0	$2,028	46.5%	$2,321	$650	$2,971
18	CULTURAL RESOURCE PRESERVATION		$156	$42	27%	$198	0.8%	$154	$42	$196	0	$196	18.0%	$182	$49	$231
	PROJECT COST TOTALS:		$24,182	$6,707	28%	$30,890		$24,588	$6,820	**$31,408**	0	**$31,408**	25.4%	$30,833	$8,558	$39,391

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED TOTAL PROJECT COST: **$39,391**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.
Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach C, Erosion Protection															
02	RELOCATIONS		$400	$112	28%	$512	0.4%	$401	$112	$514	$0	2025Q3	20.2%	$482	$135	$618
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$1,128	$316	28%	$1,444	0.4%	$1,133	$317	$1,450	$0	2025Q3	20.2%	$1,362	$381	$1,743
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$14,915	$4,176	28%	$19,091	1.8%	$15,177	$4,250	$19,427	$0	2025Q3	20.2%	$18,248	$5,109	$23,357
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$16,442	$4,604	28%	**$21,046**		$16,711	$4,679	$21,391	$0			$20,092	$5,626	$25,718
01	LANDS AND DAMAGES	Fed	$143	$7	5%	$150	0.6%	$143	$8	$151	$0	2024Q3	17.9%	$169	$9	$178
01	LANDS AND DAMAGES	Non-Fed	$733	$175	24%	$908	0.6%	$737	$176	$913	$0	2024Q3	17.9%	$868	$208	$1,076
18	CULTURAL RESOURCE PRESERVATION		$146	$39	27%	$185	-1.0%	$145	$39	$184	$0	2024Q3	17.9%	$170	$46	$216
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$257	$72	28%	$329	2.3%	$263	$74	$337	$0	2024Q3	39.6%	$367	$103	$470
0.006	Planning & Environmental Compliance		$1,069	$299	28%	$1,368	2.3%	$1,094	$306	$1,400	$0	2024Q3	39.6%	$1,527	$428	$1,955
0.082	Engineering & Design		$1,315	$368	28%	$1,683	2.3%	$1,345	$377	$1,722	$0	2024Q3	39.6%	$1,879	$526	$2,405
0.003	Reviews, ATRs, IEPRs, VE		$48	$13	28%	$61	2.3%	$49	$14	$63	$0	2024Q3	39.6%	$69	$19	$88
0.007	Life Cycle Updates (cost, schedule, risks)		$112	$31	28%	$143	2.3%	$115	$32	$147	$0	2024Q3	39.6%	$160	$45	$205
0.01	Contracting & Reprographics		$160	$45	28%	$205	2.3%	$164	$46	$210	$0	2024Q3	39.6%	$229	$64	$293
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$160	$45	28%	$205	2.3%	$164	$46	$210	$0	2024Q3	39.6%	$229	$64	$293
0.02	Engineering During Construction		$321	$90	28%	$411	2.3%	$328	$92	$420	$0	2025Q3	45.6%	$478	$134	$612
0.003	Planning During Construction		$48	$13	28%	$61	2.3%	$49	$14	$63	$0	2025Q3	45.6%	$71	$20	$92
0.013	Project Operations		$209	$59	28%	$268	2.3%	$214	$60	$274	$0	2024Q3	39.6%	$299	$84	$382
0.16	NON-FED Planning, Engineering & Design (Relocations)		$64	$18	28%	$82	2.3%	$65	$18	$84	$0	2024Q3	39.6%	$91	$26	$117
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$754	$211	28%	$965	2.3%	$771	$216	$987	$0	2025Q3	45.6%	$1,123	$314	$1,437
0.012	Project Operation:		$193	$54	28%	$247	2.3%	$197	$55	$253	$0	2025Q3	45.6%	$287	$80	$368
0.031	Project Management		$497	$139	28%	$636	2.3%	$508	$142	$651	$0	2025Q3	45.6%	$740	$207	$947
0.09	NON-FED Construction Management (Relocations)		$36	$10	28%	$46	2.3%	$37	$10	$47	$0	2025Q3	45.6%	$54	$15	$69
	CONTRACT COST TOTALS:		$22,706	$6,294		**$29,000**		$23,100	$6,404	$29,504	$0			$28,902	$8,017	**$36,919**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach C, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$1,164	$326	28%	$1,491	0.4%	$1,170	$327	$1,497	$0	2027Q3	25.1%	$1,463	$410	$1,873
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$1,164	$326	28%	**$1,491**		$1,170	$327	$1,497	$0			$1,463	$410	$1,873
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$10	$3	27%	$12	-1.0%	$9	$3	$12	$0	2025Q3	20.2%	$11	$3	$14
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$19	$5	28%	$24	2.3%	$19	$5	$25	$0	2024Q3	39.6%	$27	$8	$35
0.006	Planning & Environmental Compliance		$7	$2	28%	$9	2.3%	$7	$2	$9	$0	2024Q3	39.6%	$10	$3	$13
0.082	Engineering & Design		$95	$27	28%	$122	2.3%	$97	$27	$124	$0	2024Q3	39.6%	$136	$38	$174
0.003	Reviews, ATRs, IEPRs, VE		$3	$1	28%	$4	2.3%	$3	$1	$4	$0	2024Q3	39.6%	$4	$1	$5
0.007	Life Cycle Updates (cost, schedule, risks)		$8	$2	28%	$10	2.3%	$8	$2	$10	$0	2024Q3	39.6%	$11	$3	$15
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2024Q3	39.6%	$17	$5	$22
0.01	Contracting & Reprographics		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2024Q3	39.6%	$17	$5	$22
0.02	Engineering During Construction		$23	$6	28%	$29	2.3%	$24	$7	$30	$0	2027Q3	58.7%	$37	$10	$48
0.003	Planning During Construction		$3	$1	28%	$4	2.3%	$3	$1	$4	$0	2027Q3	58.7%	$5	$1	$6
0.013	Project Operations		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2024Q3	39.6%	$21	$6	$27
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$55	$15	28%	$70	2.3%	$56	$16	$72	$0	2027Q3	58.7%	$89	$25	$114
0.012	Project Operation:		$14	$4	28%	$18	2.3%	$14	$4	$18	$0	2027Q3	58.7%	$23	$6	$29
0.031	Project Management		$36	$10	28%	$46	2.3%	$37	$10	$47	$0	2027Q3	58.7%	$58	$16	$75
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$1,476	$413		**$1,889**		$1,488	$417	$1,904	$0			$1,931	$541	**$2,472**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):				2016					
							Effective Price Level Date:				1 OCT 15					
											Spent Thru:					
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach D															
02	RELOCATIONS *		$25,524	$7,147	28%	$32,670	0.8%	$25,724	$7,203	$32,927	0	$32,927	27.4%	$32,764	$9,174	$41,938
06	FISH & WILDLIFE FACILITIES	Construction	$2,102	$589	28%	$2,691	0.4%	$2,111	$591	$2,702	0	$2,702	27.6%	$2,694	$754	$3,448
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$5,671	$1,588	28%	$7,259	0.4%	$5,696	$1,595	$7,291	0	$7,291	22.6%	$6,985	$1,956	$8,941
11	LEVEES & FLOODWALLS	Levees	$41,817	$11,709	28%	$53,526	0.4%	$41,984	$11,755	$53,739	0	$53,739	22.6%	$51,486	$14,416	$65,902
16	BANK STABILIZATION		$20,205	$5,657	28%	$25,863	1.8%	$20,561	$5,757	$26,318	0	$26,318	22.6%	$25,215	$7,060	$32,275
	CONSTRUCTION ESTIMATE TOTALS:		$95,319	$26,689		$122,008	0.8%	$96,076	$26,901	$122,978	0	$122,978	24.0%	$119,144	$33,360	$152,504
01	LANDS AND DAMAGES		$1,405	$375	27%	$1,780	0.6%	$1,413	$377	$1,790	0	$1,790	19.0%	$1,682	$449	$2,130
30	PLANNING, ENGINEERING & DESIGN *		$12,836	$3,594	28%	$16,430	2.3%	$13,131	$3,677	$16,808	0	$16,808	44.6%	$18,982	$5,315	$24,297
31	CONSTRUCTION MANAGEMENT *		$6,281	$1,759	28%	$8,040	2.3%	$6,426	$1,799	$8,225	0	$8,225	52.4%	$9,793	$2,742	$12,535
18	CULTURAL RESOURCE PRESERVATION		$752	$203	27%	$955	0.8%	$745	$201	$946	0	$946	19.9%	$893	$241	$1,134
	PROJECT COST TOTALS:		$116,593	$32,620	28%	$149,214		$117,791	$32,956	**$150,747**	0	**$150,747**	27.8%	$150,493	$42,107	$192,600

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: $192,600

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

NOTE - Estimated Federal Cost based on NED Plan so appears greater than 65%

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach D, Levee Improvements															
02	RELOCATIONS		$20,419	$5,717	28%	$26,136	0.4%	$20,502	$5,740	$26,242	$0	2026Q3	22.6%	$25,142	$7,040	$32,182
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$5,671	$1,588	28%	$7,259	0.4%	$5,696	$1,595	$7,291	$0	2026Q3	22.6%	$6,985	$1,956	$8,941
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$41,817	$11,709	28%	$53,526	0.4%	$41,984	$11,755	$53,739	$0	2026Q3	22.6%	$51,486	$14,416	$65,902
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$67,907	$19,014	28%	**$86,921**		$68,181	$19,091	$87,272	$0			$83,613	$23,412	$107,025
01	LANDS AND DAMAGES	Fed	$214	$11	5%	$225	0.6%	$215	$11	$226	$0	2025Q1	19.0%	$256	$13	$269
01	LANDS AND DAMAGES	Non-Fed	$1,191	$364	31%	$1,555	0.6%	$1,198	$366	$1,564	$0	2025Q1	19.0%	$1,426	$435	$1,861
18	CULTURAL RESOURCE PRESERVATION		$570	$154	27%	$723	-1.0%	$564	$152	$716	$0	2025Q1	19.0%	$671	$181	$853
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$760	$213	28%	$973	2.3%	$777	$218	$995	$0	2025Q1	42.5%	$1,108	$310	$1,419
0.006	Planning & Environmental Compliance		$1,257	$352	28%	$1,609	2.3%	$1,286	$360	$1,646	$0	2025Q1	42.5%	$1,833	$513	$2,346
0.082	Engineering & Design		$3,894	$1,090	28%	$4,984	2.3%	$3,984	$1,115	$5,099	$0	2025Q1	42.5%	$5,679	$1,590	$7,269
0.003	Reviews, ATRs, IEPRs, VE		$142	$40	28%	$182	2.3%	$145	$41	$186	$0	2025Q1	42.5%	$207	$58	$265
0.007	Life Cycle Updates (cost, schedule, risks)		$332	$93	28%	$425	2.3%	$340	$95	$435	$0	2025Q1	42.5%	$484	$136	$620
0.01	Contracting & Reprographics		$475	$133	28%	$608	2.3%	$486	$136	$622	$0	2025Q1	42.5%	$693	$194	$887
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$475	$133	28%	$608	2.3%	$486	$136	$622	$0	2025Q1	42.5%	$693	$194	$887
0.02	Engineering During Construction		$950	$266	28%	$1,216	2.3%	$972	$272	$1,244	$0	2026Q3	52.0%	$1,477	$414	$1,891
0.003	Planning During Construction		$142	$40	28%	$182	2.3%	$145	$41	$186	$0	2026Q3	52.0%	$221	$62	$283
0.013	Project Operations		$617	$173	28%	$790	2.3%	$631	$177	$808	$0	2025Q1	42.5%	$900	$252	$1,152
0.16	NON-FED Planning, Engineering & Design (Relocations)		$3,267	$915	28%	$4,182	2.3%	$3,342	$936	$4,278	$0	2025Q1	42.5%	$4,764	$1,334	$6,098
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$2,232	$625	28%	$2,857	2.3%	$2,283	$639	$2,923	$0	2026Q3	52.0%	$3,470	$972	$4,442
0.012	Project Operation:		$570	$160	28%	$730	2.3%	$583	$163	$746	$0	2026Q3	52.0%	$886	$248	$1,134
0.031	Project Management		$1,472	$412	28%	$1,884	2.3%	$1,506	$422	$1,928	$0	2026Q3	52.0%	$2,289	$641	$2,930
0.09	NON-FED Construction Management (Relocations)		$1,838	$515	28%	$2,353	2.3%	$1,880	$526	$2,407	$0	2026Q3	52.0%	$2,858	$800	$3,658
	CONTRACT COST TOTALS:		$88,304	$24,701		**$113,005**		$89,005	$24,897	$113,902	$0			$113,527	$31,759	**$145,286**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach D, Erosion Protection															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$20,205	$5,657	28%	$25,863	1.8%	$20,561	$5,757	$26,318	$0	2026Q3	22.6%	$25,215	$7,060	$32,275
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$20,205	$5,657	28%	**$25,863**		$20,561	$5,757	$26,318	$0			$25,215	$7,060	$32,275
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$165	$45	27%	$210	-1.0%	$164	$44	$208	$0	2026Q3	22.6%	$201	$54	$255
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$323	$90	28%	$413	2.3%	$330	$93	$423	$0	2025Q3	45.6%	$481	$135	$616
0.006	Planning & Environmental Compliance		$121	$34	28%	$155	2.3%	$124	$35	$158	$0	2025Q3	45.6%	$180	$50	$231
0.082	Engineering & Design		$1,657	$464	28%	$2,121	2.3%	$1,695	$475	$2,170	$0	2025Q3	45.6%	$2,468	$691	$3,159
0.003	Reviews, ATRs, IEPRs, VE		$61	$17	28%	$78	2.3%	$62	$17	$80	$0	2025Q3	45.6%	$91	$25	$116
0.007	Life Cycle Updates (cost, schedule, risks)		$141	$39	28%	$180	2.3%	$144	$40	$185	$0	2025Q3	45.6%	$210	$59	$269
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$202	$57	28%	$259	2.3%	$207	$58	$265	$0	2025Q3	45.6%	$301	$84	$385
0.01	Contracting & Reprographics		$202	$57	28%	$259	2.3%	$207	$58	$265	$0	2025Q3	45.6%	$301	$84	$385
0.02	Engineering During Construction		$404	$113	28%	$517	2.3%	$413	$116	$529	$0	2026Q3	52.0%	$628	$176	$804
0.003	Planning During Construction		$61	$17	28%	$78	2.3%	$62	$17	$80	$0	2026Q3	52.0%	$95	$27	$121
0.013	Project Operations		$263	$74	28%	$337	2.3%	$269	$75	$344	$0	2025Q3	45.6%	$392	$110	$501
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$950	$266	28%	$1,216	2.3%	$972	$272	$1,244	$0	2026Q3	52.0%	$1,477	$414	$1,891
0.012	Project Operation:		$242	$68	28%	$310	2.3%	$248	$69	$317	$0	2026Q3	52.0%	$376	$105	$482
0.031	Project Management		$626	$175	28%	$801	2.3%	$640	$179	$820	$0	2026Q3	52.0%	$973	$273	$1,246
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$25,624	$7,173		**$32,797**		$26,099	$7,306	$33,405	$0			$33,389	$9,347	**$42,736**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach D, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,102	$589	28%	$2,691	0.4%	$2,111	$591	$2,702	$0	2028Q3	27.6%	$2,694	$754	$3,448
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,102	$589	28%	**$2,691**		$2,111	$591	$2,702	$0			$2,694	$754	$3,448
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$17	$5	27%	$22	-1.0%	$17	$5	$22	$0	2026Q3	22.6%	$21	$6	$27
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$34	$10	28%	$44	2.3%	$35	$10	$45	$0	2025Q3	45.6%	$51	$14	$65
0.006	Planning & Environmental Compliance		$13	$4	28%	$17	2.3%	$13	$4	$17	$0	2025Q3	45.6%	$19	$5	$25
0.082	Engineering & Design		$172	$48	28%	$220	2.3%	$176	$49	$225	$0	2025Q3	45.6%	$256	$72	$328
0.003	Reviews, ATRs, IEPRs, VE		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2025Q3	45.6%	$9	$3	$11
0.007	Life Cycle Updates (cost, schedule, risks)		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2025Q3	45.6%	$22	$6	$29
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$21	$6	28%	$27	2.3%	$21	$6	$27	$0	2025Q3	45.6%	$31	$9	$40
0.01	Contracting & Reprographics		$21	$6	28%	$27	2.3%	$21	$6	$27	$0	2025Q3	45.6%	$31	$9	$40
0.02	Engineering During Construction		$42	$12	28%	$54	2.3%	$43	$12	$55	$0	2028Q3	65.9%	$71	$20	$91
0.003	Planning During Construction		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2028Q3	65.9%	$10	$3	$13
0.013	Project Operations		$27	$8	28%	$35	2.3%	$28	$8	$35	$0	2025Q3	45.6%	$40	$11	$51
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$99	$28	28%	$127	2.3%	$101	$28	$130	$0	2028Q3	65.9%	$168	$47	$215
0.012	Project Operation:		$25	$7	28%	$32	2.3%	$26	$7	$33	$0	2028Q3	65.9%	$42	$12	$54
0.031	Project Management		$65	$18	28%	$83	2.3%	$66	$19	$85	$0	2028Q3	65.9%	$110	$31	$141
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$2,665	$746		**$3,412**		$2,687	$752	$3,439	$0			$3,577	$1,001	**$4,578**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach E															
02	RELOCATIONS *		$4,143	$1,160	28%	$5,303	0.8%	$4,176	$1,169	$5,345	0	$5,345	19.4%	$4,986	$1,396	$6,381
06	FISH & WILDLIFE FACILITIES	Construction	$2,061	$577	28%	$2,639	0.4%	$2,070	$580	$2,650	0	$2,650	23.8%	$2,564	$718	$3,282
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,694	$1,314	28%	$6,008	0.4%	$4,715	$1,320	$6,035	0	$6,035	16.7%	$5,502	$1,540	$7,042
11	LEVEES & FLOODWALLS	Levees	$39,601	$11,088	28%	$50,689	0.4%	$39,759	$11,132	$50,891	0	$50,891	16.7%	$46,396	$12,991	$59,387
16	BANK STABILIZATION		$15,001	$4,200	28%	$19,201	1.8%	$15,265	$4,274	$19,539	0	$19,539	19.0%	$18,170	$5,088	$23,258
	CONSTRUCTION ESTIMATE TOTALS:		$65,500	$18,340		$83,840	0.7%	$65,984	$18,476	$84,460	0	$84,460	17.6%	$77,617	$21,733	$99,350
01	LANDS AND DAMAGES		$6,431	$700	11%	$7,131	0.6%	$6,466	$704	$7,170	0	$7,170	12.2%	$7,253	$790	$8,042
30	PLANNING, ENGINEERING & DESIGN *		$11,403	$3,193	28%	$14,596	2.3%	$11,665	$3,266	$14,932	0	$14,932	29.4%	$15,100	$4,228	$19,328
31	CONSTRUCTION MANAGEMENT *		$5,523	$1,546	28%	$7,069	2.3%	$5,650	$1,582	$7,232	0	$7,232	38.8%	$7,844	$2,196	$10,040
18	CULTURAL RESOURCE PRESERVATION		$581	$157	27%	$738	0.8%	$576	$155	$731	0	$731	12.7%	$649	$175	$824
	PROJECT COST TOTALS:		$89,438	$23,936	27%	$113,375		$90,342	$24,183	**$114,525**	0	**$114,525**	20.1%	$108,463	$29,122	$137,585

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: $137,585

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

NOTE - Estimated Federal Cost based on NED Plan so appears greater than 65%

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach E, Levee Improvements															
02	RELOCATIONS		$3,315	$928	28%	$4,244	0.4%	$3,329	$932	$4,261	$0	2024Q1	16.7%	$3,884	$1,088	$4,972
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,694	$1,314	28%	$6,008	0.4%	$4,715	$1,320	$6,035	$0	2024Q1	16.7%	$5,502	$1,540	$7,042
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$39,601	$11,088	28%	$50,689	0.4%	$39,759	$11,132	$50,891	$0	2024Q1	16.7%	$46,396	$12,991	$59,387
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$47,610	$13,331	28%	**$60,941**		$47,802	$13,385	$61,186	$0			$55,782	$15,619	$71,401
01	LANDS AND DAMAGES	Fed	$1,401	$74	5%	$1,475	0.6%	$1,409	$74	$1,483	$0	2022Q1	12.2%	$1,580	$83	$1,664
01	LANDS AND DAMAGES	Non-Fed	$5,029	$626	12%	$5,656	0.6%	$5,057	$630	$5,687	$0	2022Q1	12.2%	$5,672	$706	$6,379
18	CULTURAL RESOURCE PRESERVATION		$442	$119	27%	$561	-1.0%	$437	$118	$555	$0	2022Q1	12.2%	$491	$132	$623
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$709	$199	28%	$908	2.3%	$725	$203	$928	$0	2022Q1	26.1%	$915	$256	$1,171
0.006	Planning & Environmental Compliance		$1,238	$347	28%	$1,585	2.3%	$1,266	$355	$1,621	$0	2022Q1	26.1%	$1,598	$447	$2,045
0.082	Engineering & Design		$3,632	$1,017	28%	$4,649	2.3%	$3,716	$1,040	$4,756	$0	2022Q1	26.1%	$4,687	$1,312	$5,999
0.003	Reviews, ATRs, IEPRs, VE		$133	$37	28%	$170	2.3%	$136	$38	$174	$0	2022Q1	26.1%	$172	$48	$220
0.007	Life Cycle Updates (cost, schedule, risks)		$310	$87	28%	$397	2.3%	$317	$89	$406	$0	2022Q1	26.1%	$400	$112	$512
0.01	Contracting & Reprographics		$443	$124	28%	$567	2.3%	$453	$127	$580	$0	2022Q1	26.1%	$572	$160	$732
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$443	$124	28%	$567	2.3%	$453	$127	$580	$0	2022Q1	26.1%	$572	$160	$732
0.02	Engineering During Construction		$886	$248	28%	$1,134	2.3%	$906	$254	$1,160	$0	2024Q1	36.8%	$1,240	$347	$1,587
0.003	Planning During Construction		$133	$37	28%	$170	2.3%	$136	$38	$174	$0	2024Q1	36.8%	$186	$52	$238
0.013	Project Operations		$576	$161	28%	$737	2.3%	$589	$165	$754	$0	2022Q1	26.1%	$743	$208	$951
0.16	NON-FED Planning, Engineering & Design (Relocations)		$530	$148	28%	$678	2.3%	$542	$152	$694	$0	2022Q1	26.1%	$684	$192	$875
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$2,082	$583	28%	$2,665	2.3%	$2,130	$596	$2,726	$0	2024Q1	36.8%	$2,914	$816	$3,730
0.012	Project Operation:		$532	$149	28%	$681	2.3%	$544	$152	$697	$0	2024Q1	36.8%	$745	$208	$953
0.031	Project Management		$1,373	$384	28%	$1,757	2.3%	$1,405	$393	$1,798	$0	2024Q1	36.8%	$1,922	$538	$2,460
0.09	NON-FED Construction Management (Relocations)		$298	$83	28%	$381	2.3%	$305	$85	$390	$0	2024Q1	36.8%	$417	$117	$534
	CONTRACT COST TOTALS:		$67,800	$17,879		**$85,679**		$68,330	$18,021	$86,351	$0			$81,291	$21,515	**$102,806**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach E, Erosion Protection															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$15,001	$4,200	28%	$19,201	1.8%	$15,265	$4,274	$19,539	$0	2025Q1	19.0%	$18,170	$5,088	$23,258
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$15,001	$4,200	28%	**$19,201**		$15,265	$4,274	$19,539	$0			$18,170	$5,088	$23,258
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$123	$33	27%	$156	-1.0%	$122	$33	$154	$0	2023Q3	15.6%	$141	$38	$179
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$240	$67	28%	$307	2.3%	$246	$69	$314	$0	2023Q3	34.0%	$329	$92	$421
0.006	Planning & Environmental Compliance		$90	$25	28%	$115	2.3%	$92	$26	$118	$0	2023Q3	34.0%	$123	$35	$158
0.082	Engineering & Design		$1,230	$344	28%	$1,574	2.3%	$1,258	$352	$1,611	$0	2023Q3	34.0%	$1,686	$472	$2,159
0.003	Reviews, ATRs, IEPRs, VE		$45	$13	28%	$58	2.3%	$46	$13	$59	$0	2023Q3	34.0%	$62	$17	$79
0.007	Life Cycle Updates (cost, schedule, risks)		$105	$29	28%	$134	2.3%	$107	$30	$137	$0	2023Q3	34.0%	$144	$40	$184
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$150	$42	28%	$192	2.3%	$153	$43	$196	$0	2023Q3	34.0%	$206	$58	$263
0.01	Contracting & Reprographics		$150	$42	28%	$192	2.3%	$153	$43	$196	$0	2023Q3	34.0%	$206	$58	$263
0.02	Engineering During Construction		$300	$84	28%	$384	2.3%	$307	$86	$393	$0	2025Q1	42.5%	$437	$122	$560
0.003	Planning During Construction		$45	$13	28%	$58	2.3%	$46	$13	$59	$0	2025Q1	42.5%	$66	$18	$84
0.013	Project Operations		$195	$55	28%	$250	2.3%	$199	$56	$255	$0	2023Q3	34.0%	$267	$75	$342
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$705	$197	28%	$902	2.3%	$721	$202	$923	$0	2025Q1	42.5%	$1,028	$288	$1,316
0.012	Project Operation:		$180	$50	28%	$230	2.3%	$184	$52	$236	$0	2025Q1	42.5%	$262	$73	$336
0.031	Project Management		$465	$130	28%	$595	2.3%	$476	$133	$609	$0	2025Q1	42.5%	$678	$190	$868
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$19,024	$5,325		**$24,349**		$19,377	$5,424	$24,801	$0			$23,805	$6,664	**$30,470**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach E, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,061	$577	28%	$2,639	0.4%	$2,070	$580	$2,650	$0	2027Q1	23.8%	$2,564	$718	$3,282
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,061	$577	28%	**$2,639**		$2,070	$580	$2,650	$0			$2,564	$718	$3,282
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$17	$5	27%	$21	-1.0%	$17	$5	$21	$0	2018Q4	5.1%	$18	$5	$22
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$33	$9	28%	$42	2.3%	$34	$9	$43	$0	2023Q3	34.0%	$45	$13	$58
0.006	Planning & Environmental Compliance		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2023Q3	34.0%	$16	$5	$21
0.082	Engineering & Design		$169	$47	28%	$216	2.3%	$173	$48	$221	$0	2023Q3	34.0%	$232	$65	$297
0.003	Reviews, ATRs, IEPRs, VE		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2023Q3	34.0%	$8	$2	$11
0.007	Life Cycle Updates (cost, schedule, risks)		$14	$4	28%	$18	2.3%	$14	$4	$18	$0	2023Q3	34.0%	$19	$5	$25
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$21	$6	28%	$27	2.3%	$21	$6	$27	$0	2023Q3	34.0%	$29	$8	$37
0.01	Contracting & Reprographics		$21	$6	28%	$27	2.3%	$21	$6	$27	$0	2023Q3	34.0%	$29	$8	$37
0.02	Engineering During Construction		$41	$11	28%	$52	2.3%	$42	$12	$54	$0	2027Q1	55.3%	$65	$18	$83
0.003	Planning During Construction		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2027Q1	55.3%	$10	$3	$12
0.013	Project Operations		$27	$8	28%	$35	2.3%	$28	$8	$35	$0	2023Q3	34.0%	$37	$10	$47
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$97	$27	28%	$124	2.3%	$99	$28	$127	$0	2027Q1	55.3%	$154	$43	$197
0.012	Project Operation:		$25	$7	28%	$32	2.3%	$26	$7	$33	$0	2027Q1	55.3%	$40	$11	$51
0.031	Project Management		$64	$18	28%	$82	2.3%	$65	$18	$84	$0	2027Q1	55.3%	$102	$28	$130
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$2,614	$732		**$3,346**		$2,635	$738	$3,373	$0			$3,367	$943	**$4,310**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

NOTE - Estimated Federal Cost based on NED Plan so appears greater than 65%

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach F															
02	RELOCATIONS *		$11,421	$3,198	28%	$14,619	0.8%	$11,511	$3,223	$14,733	0	$14,733	12.7%	$12,972	$3,632	$16,605
06	FISH & WILDLIFE FACILITIES	Construction	$3,156	$884	28%	$4,040	0.4%	$3,170	$888	$4,058	0	$4,058	17.9%	$3,737	$1,046	$4,783
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$10,082	$2,823	28%	$12,905	0.4%	$10,126	$2,835	$12,962	0	$12,962	11.1%	$11,248	$3,149	$14,397
11	LEVEES & FLOODWALLS	Levees	$99,821	$27,950	28%	$127,771	0.4%	$100,219	$28,061	$128,280	0	$128,280	11.1%	$111,315	$31,168	$142,484
16	BANK STABILIZATION		$37,099	$10,388	28%	$47,487	1.8%	$37,752	$10,571	$48,323	0	$48,323	13.3%	$42,771	$11,976	$54,747
	CONSTRUCTION ESTIMATE TOTALS:		$161,579	$45,242		$206,821	0.7%	$162,778	$45,578	$208,356	0	$208,356	11.8%	$182,044	$50,972	$233,016
01	LANDS AND DAMAGES		$21,396	$6,099	29%	$27,495	0.6%	$21,514	$6,133	$27,647	0	$27,647	7.8%	$23,194	$6,612	$29,806
30	PLANNING, ENGINEERING & DESIGN *		$26,500	$7,420	28%	$33,920	2.3%	$27,110	$7,591	$34,701	0	$34,701	18.2%	$32,041	$8,972	$41,013
31	CONSTRUCTION MANAGEMENT *		$13,514	$3,784	28%	$17,298	2.3%	$13,825	$3,871	$17,696	0	$17,696	25.2%	$17,312	$4,847	$22,160
18	CULTURAL RESOURCE PRESERVATION		$1,628	$440	27%	$2,067	0.8%	$1,612	$435	$2,047	0	$2,047	8.0%	$1,740	$470	$2,210
	PROJECT COST TOTALS:		$224,617	$62,985	28%	$287,602		$226,840	$63,608	**$290,448**	0	**$290,448**	13.0%	$256,332	$71,873	$328,205

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED FEDERAL COST:	75%	**$244,697**
ESTIMATED NON-FEDERAL COST:	25%	**$83,508**
ESTIMATED TOTAL PROJECT COST:		**$328,205**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST							TOTAL PROJECT COST (FULLY FUNDED)		
			Estimate Prepared: 9/21/2015				Program Year (Budget EC): 2016									
			Effective Price Level: 10/1/2014				Effective Price Level Date: 1 OCT 15									
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach F, Levee Improvements															
02	RELOCATIONS		$9,137	$2,558	28%	$11,695	0.4%	$9,174	$2,569	$11,743	$0	2021Q3	11.1%	$10,190	$2,853	$13,043
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$10,082	$2,823	28%	$12,905	0.4%	$10,126	$2,835	$12,962	$0	2021Q3	11.1%	$11,248	$3,149	$14,397
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$99,821	$27,950	28%	$127,771	0.4%	$100,219	$28,061	$128,280	$0	2021Q3	11.1%	$111,315	$31,168	$142,484
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$119,040	$33,331	28%	**$152,371**		$119,519	$33,465	$152,985	$0			$132,753	$37,171	$169,924
01	LANDS AND DAMAGES	Fed	$3,040	$160	5%	$3,200	0.6%	$3,057	$161	$3,218	$0	2020Q1	7.8%	$3,296	$173	$3,469
01	LANDS AND DAMAGES	Non-Fed	$18,356	$5,939	32%	$24,295	0.6%	$18,458	$5,972	$24,430	$0	2020Q1	7.8%	$19,899	$6,439	$26,337
18	CULTURAL RESOURCE PRESERVATION		$1,298	$351	27%	$1,649	-1.0%	$1,285	$347	$1,633	$0	2020Q1	7.8%	$1,386	$374	$1,760
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,758	$492	28%	$2,250	2.3%	$1,798	$504	$2,302	$0	2020Q1	16.5%	$2,096	$587	$2,683
0.006	Planning & Environmental Compliance		$1,632	$457	28%	$2,089	2.3%	$1,670	$467	$2,137	$0	2020Q1	16.5%	$1,946	$545	$2,491
0.082	Engineering & Design		$9,012	$2,523	28%	$11,535	2.3%	$9,219	$2,581	$11,801	$0	2020Q1	16.5%	$10,745	$3,009	$13,753
0.003	Reviews, ATRs, IEPRs, VE		$330	$92	28%	$422	2.3%	$338	$95	$432	$0	2020Q1	16.5%	$393	$110	$504
0.007	Life Cycle Updates (cost, schedule, risks)		$769	$215	28%	$984	2.3%	$787	$220	$1,007	$0	2020Q1	16.5%	$917	$257	$1,174
0.01	Contracting & Reprographics		$1,099	$308	28%	$1,407	2.3%	$1,124	$315	$1,439	$0	2020Q1	16.5%	$1,310	$367	$1,677
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$1,099	$308	28%	$1,407	2.3%	$1,124	$315	$1,439	$0	2020Q1	16.5%	$1,310	$367	$1,677
0.02	Engineering During Construction		$2,198	$615	28%	$2,813	2.3%	$2,249	$630	$2,878	$0	2021Q3	23.6%	$2,780	$778	$3,559
0.003	Planning During Construction		$330	$92	28%	$422	2.3%	$338	$95	$432	$0	2021Q3	23.6%	$417	$117	$534
0.013	Project Operations		$1,429	$400	28%	$1,829	2.3%	$1,462	$409	$1,871	$0	2020Q1	16.5%	$1,704	$477	$2,181
0.16	NON-FED Planning, Engineering & Design (Relocations)		$1,462	$409	28%	$1,871	2.3%	$1,496	$419	$1,914	$0	2020Q1	16.5%	$1,743	$488	$2,231
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$5,165	$1,446	28%	$6,611	2.3%	$5,284	$1,479	$6,763	$0	2021Q3	23.6%	$6,533	$1,829	$8,362
0.012	Project Operation:		$1,319	$369	28%	$1,688	2.3%	$1,349	$378	$1,727	$0	2021Q3	23.6%	$1,668	$467	$2,135
0.031	Project Management		$3,407	$954	28%	$4,361	2.3%	$3,485	$976	$4,461	$0	2021Q3	23.6%	$4,309	$1,207	$5,516
0.09	NON-FED Construction Management (Relocations)		$822	$230	28%	$1,052	2.3%	$841	$235	$1,076	$0	2021Q3	23.6%	$1,040	$291	$1,331
	CONTRACT COST TOTALS:		$173,565	$48,694		**$222,258**		$174,883	$49,063	$223,946	$0			$196,245	$55,052	**$251,297**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach F, Erosion Protection															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$37,099	$10,388	28%	$47,487	1.8%	$37,752	$10,571	$48,323	$0	2022Q3	13.3%	$42,771	$11,976	$54,747
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$37,099	$10,388	28%	**$47,487**		$37,752	$10,571	$48,323	$0			$42,771	$11,976	$54,747
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$304	$82	27%	$386	-1.0%	$301	$81	$382	$0	2020Q3	8.9%	$328	$88	$416
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$594	$166	28%	$760	2.3%	$608	$170	$778	$0	2020Q3	18.9%	$722	$202	$924
0.006	Planning & Environmental Compliance		$223	$62	28%	$285	2.3%	$228	$64	$292	$0	2020Q3	18.9%	$271	$76	$347
0.082	Engineering & Design		$3,042	$852	28%	$3,894	2.3%	$3,112	$871	$3,983	$0	2020Q3	18.9%	$3,699	$1,036	$4,734
0.003	Reviews, ATRs, IEPRs, VE		$111	$31	28%	$142	2.3%	$114	$32	$145	$0	2020Q3	18.9%	$135	$38	$173
0.007	Life Cycle Updates (cost, schedule, risks)		$260	$73	28%	$333	2.3%	$266	$74	$340	$0	2020Q3	18.9%	$316	$89	$405
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$371	$104	28%	$475	2.3%	$380	$106	$486	$0	2020Q3	18.9%	$451	$126	$577
0.01	Contracting & Reprographics		$371	$104	28%	$475	2.3%	$380	$106	$486	$0	2020Q3	18.9%	$451	$126	$577
0.02	Engineering During Construction		$742	$208	28%	$950	2.3%	$759	$213	$972	$0	2022Q3	28.7%	$977	$274	$1,251
0.003	Planning During Construction		$111	$31	28%	$142	2.3%	$114	$32	$145	$0	2022Q3	28.7%	$146	$41	$187
0.013	Project Operations		$482	$135	28%	$617	2.3%	$493	$138	$631	$0	2020Q3	18.9%	$586	$164	$750
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,744	$488	28%	$2,232	2.3%	$1,784	$500	$2,284	$0	2022Q3	28.7%	$2,296	$643	$2,939
0.012	Project Operation:		$445	$125	28%	$570	2.3%	$455	$127	$583	$0	2022Q3	28.7%	$586	$164	$750
0.031	Project Management		$1,150	$322	28%	$1,472	2.3%	$1,176	$329	$1,506	$0	2022Q3	28.7%	$1,514	$424	$1,938
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$47,049	$13,171		**$60,219**		$47,921	$13,415	$61,336	$0			$55,250	$15,467	**$70,716**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach F, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$3,156	$884	28%	$4,040	0.4%	$3,170	$888	$4,058	$0	2024Q3	17.9%	$3,737	$1,046	$4,783
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$3,156	$884	28%	**$4,040**		$3,170	$888	$4,058	$0			$3,737	$1,046	$4,783
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$26	$7	27%	$33	-1.0%	$26	$7	$33	$0	2018Q4	5.1%	$27	$7	$34
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$51	$14	28%	$65	2.3%	$52	$15	$67	$0	2020Q3	18.9%	$62	$17	$79
0.006	Planning & Environmental Compliance		$19	$5	28%	$24	2.3%	$19	$5	$25	$0	2020Q3	18.9%	$23	$6	$30
0.082	Engineering & Design		$259	$73	28%	$332	2.3%	$265	$74	$339	$0	2020Q3	18.9%	$315	$88	$403
0.003	Reviews, ATRs, IEPRs, VE		$9	$3	28%	$12	2.3%	$9	$3	$12	$0	2020Q3	18.9%	$11	$3	$14
0.007	Life Cycle Updates (cost, schedule, risks)		$22	$6	28%	$28	2.3%	$23	$6	$29	$0	2020Q3	18.9%	$27	$7	$34
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$32	$9	28%	$41	2.3%	$33	$9	$42	$0	2020Q3	18.9%	$39	$11	$50
0.01	Contracting & Reprographics		$32	$9	28%	$41	2.3%	$33	$9	$42	$0	2020Q3	18.9%	$39	$11	$50
0.02	Engineering During Construction		$63	$18	28%	$81	2.3%	$64	$18	$82	$0	2024Q3	39.6%	$90	$25	$115
0.003	Planning During Construction		$9	$3	28%	$12	2.3%	$9	$3	$12	$0	2024Q3	39.6%	$13	$4	$16
0.013	Project Operations		$41	$11	28%	$52	2.3%	$42	$12	$54	$0	2020Q3	18.9%	$50	$14	$64
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$148	$41	28%	$189	2.3%	$151	$42	$194	$0	2024Q3	39.6%	$211	$59	$271
0.012	Project Operation:		$38	$11	28%	$49	2.3%	$39	$11	$50	$0	2024Q3	39.6%	$54	$15	$69
0.031	Project Management		$98	$27	28%	$125	2.3%	$100	$28	$128	$0	2024Q3	39.6%	$140	$39	$179
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$4,003	$1,121		**$5,124**		$4,036	$1,130	$5,165	$0			$4,838	$1,354	**$6,192**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							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: 10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARS, Reach G															
02	RELOCATIONS *		$26,383	$7,387	28%	$33,771	0.8%	$26,591	$7,445	$34,036	0	$34,036	23.5%	$32,845	$9,197	$42,042
06	FISH & WILDLIFE FACILITIES	Construction	$2,211	$619	28%	$2,830	0.4%	$2,221	$622	$2,843	0	$2,843	27.6%	$2,833	$793	$3,627
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$3,210	$899	28%	$4,109	0.4%	$3,224	$903	$4,126	0	$4,126	20.2%	$3,876	$1,085	$4,961
11	LEVEES & FLOODWALLS	Levees	$28,030	$7,848	28%	$35,879	0.4%	$28,142	$7,880	$36,022	0	$36,022	20.2%	$33,835	$9,474	$43,309
16	BANK STABILIZATION		$18,457	$5,168	28%	$23,625	1.8%	$18,782	$5,259	$24,042	0	$24,042	22.6%	$23,034	$6,449	$29,483
	CONSTRUCTION ESTIMATE TOTALS:		$78,292	$21,922		$100,214	0.9%	$78,960	$22,109	$101,069	0	$101,069	22.1%	$96,423	$26,999	$123,422
01	LANDS AND DAMAGES		$4,037	$1,046	26%	$5,083	0.6%	$4,059	$1,052	$5,111	0	$5,111	14.4%	$4,644	$1,204	$5,848
30	PLANNING, ENGINEERING & DESIGN *		$9,797	$2,743	28%	$12,540	2.3%	$10,022	$2,806	$12,829	0	$12,829	37.9%	$13,817	$3,869	$17,686
31	CONSTRUCTION MANAGEMENT *		$4,671	$1,308	28%	$5,979	2.3%	$4,779	$1,338	$6,116	0	$6,116	48.7%	$7,107	$1,990	$9,097
18	CULTURAL RESOURCE PRESERVATION		$644	$174	27%	$817	0.8%	$637	$172	$809	0	$809	15.9%	$739	$200	$938
	PROJECT COST TOTALS:		$97,441	$27,193	28%	$124,633		$98,458	$27,477	**$125,935**	0	**$125,935**	24.7%	$122,730	$34,260	$156,991

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED TOTAL PROJECT COST: **$156,991**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

NOTE - Estimated Federal Cost based on NED Plan so appears greater than 65%

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST							TOTAL PROJECT COST (FULLY FUNDED)		
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARS, Reach G, Levee Improvements															
02	RELOCATIONS		$21,106	$5,910	28%	$27,016	0.4%	$21,192	$5,934	$27,126	$0	2025Q3	20.2%	$25,479	$7,134	$32,613
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$3,210	$899	28%	$4,109	0.4%	$3,224	$903	$4,126	$0	2025Q3	20.2%	$3,876	$1,085	$4,961
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$28,030	$7,848	28%	$35,879	0.4%	$28,142	$7,880	$36,022	$0	2025Q3	20.2%	$33,835	$9,474	$43,309
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$52,347	$14,657	28%	**$67,004**		$52,558	$14,716	$67,275	$0			$63,190	$17,693	$80,883
01	LANDS AND DAMAGES	Fed	$475	$25	5%	$500	0.6%	$478	$25	$503	$0	2023Q1	14.4%	$546	$29	$575
01	LANDS AND DAMAGES	Non-Fed	$3,562	$1,021	29%	$4,583	0.6%	$3,582	$1,027	$4,608	$0	2023Q1	14.4%	$4,098	$1,175	$5,272
18	CULTURAL RESOURCE PRESERVATION		$474	$128	27%	$603	-1.0%	$470	$127	$597	$0	2023Q1	14.4%	$537	$145	$683
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$500	$140	28%	$640	2.3%	$512	$143	$655	$0	2023Q1	31.3%	$672	$188	$860
0.006	Planning & Environmental Compliance		$1,160	$325	28%	$1,485	2.3%	$1,187	$332	$1,519	$0	2023Q1	31.3%	$1,558	$436	$1,995
0.082	Engineering & Design		$2,562	$717	28%	$3,279	2.3%	$2,621	$734	$3,355	$0	2023Q1	31.3%	$3,442	$964	$4,405
0.003	Reviews, ATRs, IEPRs, VE		$94	$26	28%	$120	2.3%	$96	$27	$123	$0	2023Q1	31.3%	$126	$35	$162
0.007	Life Cycle Updates (cost, schedule, risks)		$219	$61	28%	$280	2.3%	$224	$63	$287	$0	2023Q1	31.3%	$294	$82	$377
0.01	Contracting & Reprographics		$312	$87	28%	$399	2.3%	$319	$89	$409	$0	2023Q1	31.3%	$419	$117	$536
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$312	$87	28%	$399	2.3%	$319	$89	$409	$0	2023Q1	31.3%	$419	$117	$536
0.02	Engineering During Construction		$625	$175	28%	$800	2.3%	$639	$179	$818	$0	2025Q3	45.6%	$931	$261	$1,191
0.003	Planning During Construction		$94	$26	28%	$120	2.3%	$96	$27	$123	$0	2025Q3	45.6%	$140	$39	$179
0.013	Project Operations		$406	$114	28%	$520	2.3%	$415	$116	$532	$0	2023Q1	31.3%	$545	$153	$698
0.16	NON-FED Planning, Engineering & Design (Relocations)		$3,377	$946	28%	$4,323	2.3%	$3,455	$967	$4,422	$0	2023Q1	31.3%	$4,537	$1,270	$5,807
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,468	$411	28%	$1,879	2.3%	$1,502	$420	$1,922	$0	2025Q3	45.6%	$2,186	$612	$2,798
0.012	Project Operation:		$375	$105	28%	$480	2.3%	$384	$107	$491	$0	2025Q3	45.6%	$558	$156	$715
0.031	Project Management		$968	$271	28%	$1,239	2.3%	$990	$277	$1,268	$0	2025Q3	45.6%	$1,442	$404	$1,845
0.09	NON-FED Construction Management (Relocations)		$1,900	$532	28%	$2,432	2.3%	$1,944	$544	$2,488	$0	2025Q3	45.6%	$2,830	$792	$3,622
	CONTRACT COST TOTALS:		$71,230	$19,856		**$91,085**		$71,790	$20,012	$91,802	$0			$88,471	$24,670	**$113,141**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST							TOTAL PROJECT COST (FULLY FUNDED)			
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach G, Erosion Protection															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$18,457	$5,168	28%	$23,625	1.8%	$18,782	$5,259	$24,042	$0	2026Q3	22.6%	$23,034	$6,449	$29,483
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$18,457	$5,168	28%	**$23,625**		$18,782	$5,259	$24,042	$0			$23,034	$6,449	$29,483
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$151	$41	27%	$192	-1.0%	$150	$40	$190	$0	2025Q3	20.2%	$180	$49	$229
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$295	$83	28%	$378	2.3%	$302	$85	$386	$0	2025Q3	45.6%	$439	$123	$562
0.006	Planning & Environmental Compliance		$111	$31	28%	$142	2.3%	$114	$32	$145	$0	2025Q3	45.6%	$165	$46	$212
0.082	Engineering & Design		$1,514	$424	28%	$1,938	2.3%	$1,549	$434	$1,983	$0	2025Q3	45.6%	$2,255	$631	$2,886
0.003	Reviews, ATRs, IEPRs, VE		$55	$15	28%	$70	2.3%	$56	$16	$72	$0	2025Q3	45.6%	$82	$23	$105
0.007	Life Cycle Updates (cost, schedule, risks)		$129	$36	28%	$165	2.3%	$132	$37	$169	$0	2025Q3	45.6%	$192	$54	$246
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$185	$52	28%	$237	2.3%	$189	$53	$242	$0	2025Q3	45.6%	$276	$77	$353
0.01	Contracting & Reprographics		$185	$52	28%	$237	2.3%	$189	$53	$242	$0	2025Q3	45.6%	$276	$77	$353
0.02	Engineering During Construction		$369	$103	28%	$472	2.3%	$377	$106	$483	$0	2026Q3	52.0%	$574	$161	$734
0.003	Planning During Construction		$55	$15	28%	$70	2.3%	$56	$16	$72	$0	2026Q3	52.0%	$86	$24	$109
0.013	Project Operations		$240	$67	28%	$307	2.3%	$246	$69	$314	$0	2025Q3	45.6%	$357	$100	$458
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$867	$243	28%	$1,110	2.3%	$887	$248	$1,135	$0	2026Q3	52.0%	$1,348	$377	$1,726
0.012	Project Operation:		$221	$62	28%	$283	2.3%	$226	$63	$289	$0	2026Q3	52.0%	$344	$96	$440
0.031	Project Management		$572	$160	28%	$732	2.3%	$585	$164	$749	$0	2026Q3	52.0%	$889	$249	$1,138
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$23,406	$6,552		**$29,959**		$23,841	$6,674	$30,514	$0			$30,496	$8,537	**$39,033**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARS, Reach G, Erosion Protection, Planting & Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,211	$619	28%	$2,830	0.4%	$2,221	$622	$2,843	$0	2028Q3	27.6%	$2,833	$793	$3,627
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,211	$619	28%	**$2,830**		$2,221	$622	$2,843	$0			$2,833	$793	$3,627
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$18	$5	27%	$23	-1.0%	$18	$5	$23	$0	2025Q3	20.2%	$22	$6	$27
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$35	$10	28%	$45	2.3%	$36	$10	$46	$0	2025Q3	45.6%	$52	$15	$67
0.006	Planning & Environmental Compliance		$13	$4	28%	$17	2.3%	$13	$4	$17	$0	2025Q3	45.6%	$19	$5	$25
0.082	Engineering & Design		$181	$51	28%	$232	2.3%	$185	$52	$237	$0	2025Q3	45.6%	$270	$75	$345
0.003	Reviews, ATRs, IEPRs, VE		$7	$2	28%	$9	2.3%	$7	$2	$9	$0	2025Q3	45.6%	$10	$3	$13
0.007	Life Cycle Updates (cost, schedule, risks)		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2025Q3	45.6%	$22	$6	$29
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$22	$6	28%	$28	2.3%	$23	$6	$29	$0	2025Q3	45.6%	$33	$9	$42
0.01	Contracting & Reprographics		$22	$6	28%	$28	2.3%	$23	$6	$29	$0	2025Q3	45.6%	$33	$9	$42
0.02	Engineering During Construction		$44	$12	28%	$56	2.3%	$45	$13	$58	$0	2028Q3	65.9%	$75	$21	$96
0.003	Planning During Construction		$7	$2	28%	$9	2.3%	$7	$2	$9	$0	2028Q3	65.9%	$12	$3	$15
0.013	Project Operations		$29	$8	28%	$37	2.3%	$30	$8	$38	$0	2025Q3	45.6%	$43	$12	$55
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$104	$29	28%	$133	2.3%	$106	$30	$136	$0	2028Q3	65.9%	$177	$49	$226
0.012	Project Operation:		$27	$8	28%	$35	2.3%	$28	$8	$35	$0	2028Q3	65.9%	$46	$13	$59
0.031	Project Management		$69	$19	28%	$88	2.3%	$71	$20	$90	$0	2028Q3	65.9%	$117	$33	$150
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$2,804	$785		**$3,589**		$2,827	$791	$3,618	$0			$3,763	$1,054	**$4,817**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach A															
02	RELOCATIONS *		$1,972	$552	28%	$2,524	0.8%	$1,987	$556	$2,544	0	$2,544	19.7%	$2,379	$666	$3,045
06	FISH & WILDLIFE FACILITIES	Construction	$2,521	$706	28%	$3,226	0.4%	$2,531	$709	$3,240	0	$3,240	19.0%	$3,013	$844	$3,857
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,602	$1,289	28%	$5,891	0.4%	$4,622	$1,294	$5,916	0	$5,916	16.7%	$5,394	$1,510	$6,904
16	BANK STABILIZATION		$70,051	$19,614	28%	$89,666	1.8%	$71,285	$19,960	$91,245	0	$91,245	16.7%	$83,187	$23,292	$106,480
	CONSTRUCTION ESTIMATE TOTALS:		$79,146	$22,161		$101,306	1.6%	$80,426	$22,519	$102,945	0	$102,945	16.8%	$93,974	$26,313	$120,286
01	LANDS AND DAMAGES		$1,646	$518	31%	$2,164	0.6%	$1,656	$520	$2,176	0	$2,176	13.3%	$1,876	$590	$2,465
30	PLANNING, ENGINEERING & DESIGN *		$14,093	$3,946	28%	$18,039	2.3%	$14,417	$4,037	$18,454	0	$18,454	29.7%	$18,706	$5,238	$23,944
31	CONSTRUCTION MANAGEMENT *		$6,945	$1,945	28%	$8,890	2.3%	$7,105	$1,989	$9,094	0	$9,094	37.0%	$9,733	$2,725	$12,458
18	CULTURAL RESOURCE PRESERVATION		$659	$178	27%	$837	0.8%	$653	$176	$829	0	$829	13.4%	$740	$200	$940
	PROJECT COST TOTALS:		$102,489	$28,747	28%	$131,236		$104,257	$29,242	**$133,499**	0	**$133,499**	19.9%	$125,028	$35,065	$160,093

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$160,093**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach A, Erosion Protection															
02	RELOCATIONS		$1,578	$442	28%	$2,019	0.4%	$1,584	$444	$2,028	$0	2024Q1	16.7%	$1,849	$518	$2,366
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$4,602	$1,289	28%	$5,891	0.4%	$4,622	$1,294	$5,916	$0	2024Q1	16.7%	$5,394	$1,510	$6,904
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$70,051	$19,614	28%	$89,666	1.8%	$71,285	$19,960	$91,245	$0	2024Q1	16.7%	$83,187	$23,292	$106,480
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$76,231	$21,345	28%	**$97,576**		$77,492	$21,698	$99,189	$0			$90,430	$25,320	$115,750
01	LANDS AND DAMAGES	Fed	$190	$10	5%	$200	0.6%	$191	$10	$201	$0	2022Q3	13.3%	$216	$11	$228
01	LANDS AND DAMAGES	Non-Fed	$1,456	$508	35%	$1,964	0.6%	$1,465	$510	$1,975	$0	2022Q3	13.3%	$1,659	$578	$2,237
18	CULTURAL RESOURCE PRESERVATION		$639	$172	27%	$811	-1.0%	$632	$171	$803	$0	2022Q3	13.3%	$717	$193	$910
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,194	$334	28%	$1,528	2.3%	$1,221	$342	$1,563	$0	2022Q3	28.7%	$1,572	$440	$2,012
0.006	Planning & Environmental Compliance		$1,420	$398	28%	$1,818	2.3%	$1,453	$407	$1,859	$0	2022Q3	28.7%	$1,870	$524	$2,393
0.082	Engineering & Design		$6,122	$1,714	28%	$7,836	2.3%	$6,263	$1,754	$8,017	$0	2022Q3	28.7%	$8,061	$2,257	$10,318
0.003	Reviews, ATRs, IEPRs, VE		$224	$63	28%	$287	2.3%	$229	$64	$293	$0	2022Q3	28.7%	$295	$83	$378
0.007	Life Cycle Updates (cost, schedule, risks)		$523	$146	28%	$669	2.3%	$535	$150	$685	$0	2022Q3	28.7%	$689	$193	$881
0.01	Contracting & Reprographics		$747	$209	28%	$956	2.3%	$764	$214	$978	$0	2022Q3	28.7%	$984	$275	$1,259
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$747	$209	28%	$956	2.3%	$764	$214	$978	$0	2022Q3	28.7%	$984	$275	$1,259
0.02	Engineering During Construction		$1,493	$418	28%	$1,911	2.3%	$1,527	$428	$1,955	$0	2024Q1	36.8%	$2,089	$585	$2,674
0.003	Planning During Construction		$224	$63	28%	$287	2.3%	$229	$64	$293	$0	2024Q1	36.8%	$313	$88	$401
0.013	Project Operations		$970	$272	28%	$1,242	2.3%	$992	$278	$1,270	$0	2022Q3	28.7%	$1,277	$358	$1,635
0.16	NON-FED Planning, Engineering & Design (Relocations)		$252	$71	28%	$323	2.3%	$258	$72	$330	$0	2022Q3	28.7%	$332	$93	$425
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$3,509	$983	28%	$4,492	2.3%	$3,590	$1,005	$4,595	$0	2024Q1	36.8%	$4,911	$1,375	$6,286
0.012	Project Operation:		$896	$251	28%	$1,147	2.3%	$917	$257	$1,173	$0	2024Q1	36.8%	$1,254	$351	$1,605
0.031	Project Management		$2,314	$648	28%	$2,962	2.3%	$2,367	$663	$3,030	$0	2024Q1	36.8%	$3,238	$907	$4,145
0.09	NON-FED Construction Management (Relocations)		$142	$40	28%	$182	2.3%	$145	$41	$186	$0	2024Q1	36.8%	$199	$56	$254
	CONTRACT COST TOTALS:		$99,293	$27,852		**$127,145**		$101,035	$28,340	$129,375	$0			$121,089	$33,962	**$155,051**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	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: 10/1/2014	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*
	ARN, Reach A, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$2,521	$706	28%	$3,226	0.4%	$2,531	$709	$3,240	$0	2025Q1	19.0%	$3,013	$844	$3,857
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,521	$706	28%	**$3,226**		$2,531	$709	$3,240	$0			$3,013	$844	$3,857
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$21	$6	27%	$26	-1.0%	$20	$6	$26	$0	2023Q3	15.6%	$24	$6	$30
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$40	$11	28%	$51	2.3%	$41	$11	$52	$0	2022Q3	28.7%	$53	$15	$67
0.006	Planning & Environmental Compliance		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2022Q3	28.7%	$20	$6	$25
0.082	Engineering & Design		$207	$58	28%	$265	2.3%	$212	$59	$271	$0	2022Q3	28.7%	$273	$76	$349
0.003	Reviews, ATRs, IEPRs, VE		$8	$2	28%	$10	2.3%	$8	$2	$10	$0	2022Q3	28.7%	$11	$3	$13
0.007	Life Cycle Updates (cost, schedule, risks)		$18	$5	28%	$23	2.3%	$18	$5	$24	$0	2022Q3	28.7%	$24	$7	$30
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$25	$7	28%	$32	2.3%	$26	$7	$33	$0	2022Q3	28.7%	$33	$9	$42
0.01	Contracting & Reprographics		$25	$7	28%	$32	2.3%	$26	$7	$33	$0	2022Q3	28.7%	$33	$9	$42
0.02	Engineering During Construction		$50	$14	28%	$64	2.3%	$51	$14	$65	$0	2025Q1	42.5%	$73	$20	$93
0.003	Planning During Construction		$8	$2	28%	$10	2.3%	$8	$2	$10	$0	2025Q1	42.5%	$12	$3	$15
0.013	Project Operations		$33	$9	28%	$42	2.3%	$34	$9	$43	$0	2022Q3	28.7%	$43	$12	$56
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$118	$33	28%	$151	2.3%	$121	$34	$155	$0	2025Q1	42.5%	$172	$48	$220
0.012	Project Operation:		$30	$8	28%	$38	2.3%	$31	$9	$39	$0	2025Q1	42.5%	$44	$12	$56
0.031	Project Management		$78	$22	28%	$100	2.3%	$80	$22	$102	$0	2025Q1	42.5%	$114	$32	$146
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$3,196	$895		**$4,091**		$3,222	$902	$4,124	$0			$3,939	$1,103	**$5,042**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach B															
02	RELOCATIONS *		$81	$23	28%	$104	0.8%	$82	$23	$105	0	$105	27.7%	$105	$29	$134
06	FISH & WILDLIFE FACILITIES	Construction	$383	$107	28%	$491	0.4%	$385	$108	$493	0	$493	27.6%	$491	$138	$629
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$408	$114	28%	$522	0.4%	$410	$115	$525	0	$525	22.6%	$503	$141	$643
16	BANK STABILIZATION		$3,538	$991	28%	$4,528	1.8%	$3,600	$1,008	$4,608	0	$4,608	22.6%	$4,415	$1,236	$5,651
	CONSTRUCTION ESTIMATE TOTALS:		$4,410	$1,235		$5,645	1.5%	$4,477	$1,253	$5,730	0	$5,730	23.2%	$5,513	$1,544	$7,057
01	LANDS AND DAMAGES		$235	$41	18%	$276	0.6%	$236	$41	$278	0	$278	20.2%	$284	$50	$334
30	PLANNING, ENGINEERING & DESIGN *		$736	$206	28%	$942	2.3%	$753	$211	$964	0	$964	46.6%	$1,104	$309	$1,413
31	CONSTRUCTION MANAGEMENT *		$389	$109	28%	$498	2.3%	$398	$111	$509	0	$509	53.2%	$610	$171	$781
18	CULTURAL RESOURCE PRESERVATION		$37	$10	27%	$48	0.8%	$37	$10	$47	0	$47	20.4%	$45	$12	$57
	PROJECT COST TOTALS:		$5,808	$1,601	28%	$7,409		$5,901	$1,627	**$7,528**	0	**$7,528**	28.1%	$7,556	$2,085	$9,641

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

ESTIMATED TOTAL PROJECT COST: **$9,641**

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.
Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach B, Erosion Protection															
02	RELOCATIONS		$65	$18	28%	$84	0.4%	$66	$18	$84	$0	2026Q3	22.6%	$80	$23	$103
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$408	$114	28%	$522	0.4%	$410	$115	$525	$0	2026Q3	22.6%	$503	$141	$643
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$3,538	$991	28%	$4,528	1.8%	$3,600	$1,008	$4,608	$0	2026Q3	22.6%	$4,415	$1,236	$5,651
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$4,011	$1,123	28%	**$5,134**		$4,075	$1,141	$5,216	$0			$4,998	$1,399	$6,397
01	LANDS AND DAMAGES	Fed	$48	$2	5%	$50	0.6%	$48	$3	$50	$0	2025Q3	20.2%	$57	$3	$60
01	LANDS AND DAMAGES	Non-Fed	$187	$39	21%	$226	0.6%	$188	$39	$227	$0	2025Q3	20.2%	$227	$47	$273
18	CULTURAL RESOURCE PRESERVATION		$34	$9	27%	$44	-1.0%	$34	$9	$43	$0	2025Q3	20.2%	$41	$11	$52
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$63	$18	28%	$81	2.3%	$64	$18	$82	$0	2025Q3	45.6%	$94	$26	$120
0.006	Planning & Environmental Compliance		$24	$7	28%	$31	2.3%	$25	$7	$31	$0	2025Q3	45.6%	$36	$10	$46
0.082	Engineering & Design		$324	$91	28%	$415	2.3%	$331	$93	$424	$0	2025Q3	45.6%	$483	$135	$618
0.003	Reviews, ATRs, IEPRs, VE		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2025Q3	45.6%	$18	$5	$23
0.007	Life Cycle Updates (cost, schedule, risks)		$28	$8	28%	$36	2.3%	$29	$8	$37	$0	2025Q3	45.6%	$42	$12	$53
0.01	Contracting & Reprographics		$39	$11	28%	$50	2.3%	$40	$11	$51	$0	2025Q3	45.6%	$58	$16	$74
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$39	$11	28%	$50	2.3%	$40	$11	$51	$0	2025Q3	45.6%	$58	$16	$74
0.02	Engineering During Construction		$79	$22	28%	$101	2.3%	$81	$23	$103	$0	2026Q3	52.0%	$123	$34	$157
0.003	Planning During Construction		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2026Q3	52.0%	$19	$5	$24
0.013	Project Operations		$51	$14	28%	$65	2.3%	$52	$15	$67	$0	2025Q3	45.6%	$76	$21	$97
0.16	NON-FED Planning, Engineering & Design (Relocations)		$10	$3	28%	$13	2.3%	$10	$3	$13	$0	2025Q3	45.6%	$15	$4	$19
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$185	$52	28%	$237	2.3%	$189	$53	$242	$0	2026Q3	52.0%	$288	$81	$368
0.012	Project Operation:		$47	$13	28%	$60	2.3%	$48	$13	$62	$0	2026Q3	52.0%	$73	$20	$94
0.031	Project Management		$122	$34	28%	$156	2.3%	$125	$35	$160	$0	2026Q3	52.0%	$190	$53	$243
0.09	NON-FED Construction Management (Relocations)		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2026Q3	52.0%	$9	$3	$12
	CONTRACT COST TOTALS:		$5,321	$1,465		**$6,786**		$5,410	$1,490	$6,900	$0			$6,902	$1,902	**$8,805**

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				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: 10/1/2014	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*
	ARN, Reach B, Erosion Protection, Plant Establishment															
02	RELOCATIONS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Construction	$383	$107	28%	$491	0.4%	$385	$108	$493	$0	2028Q3	27.6%	$491	$138	$629
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$383	$107	28%	**$491**		$385	$108	$493	$0			$491	$138	$629
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$3	$1	27%	$4	-1.0%	$3	$1	$4	$0	2026Q3	22.6%	$4	$1	$5
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2025Q3	45.6%	$9	$3	$11
0.006	Planning & Environmental Compliance		$2	$1	28%	$3	2.3%	$2	$1	$3	$0	2025Q3	45.6%	$3	$1	$4
0.082	Engineering & Design		$31	$9	28%	$40	2.3%	$32	$9	$41	$0	2025Q3	45.6%	$46	$13	$59
0.003	Reviews, ATRs, IEPRs, VE		$1	$0	28%	$1	2.3%	$1	$0	$1	$0	2025Q3	45.6%	$1	$0	$2
0.007	Life Cycle Updates (cost, schedule, risks)		$3	$1	28%	$4	2.3%	$3	$1	$4	$0	2025Q3	45.6%	$4	$1	$6
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$4	$1	28%	$5	2.3%	$4	$1	$5	$0	2025Q3	45.6%	$6	$2	$8
0.01	Contracting & Reprographics		$4	$1	28%	$5	2.3%	$4	$1	$5	$0	2025Q3	45.6%	$6	$2	$8
0.02	Engineering During Construction		$8	$2	28%	$10	2.3%	$8	$2	$10	$0	2028Q3	65.9%	$14	$4	$17
0.003	Planning During Construction		$1	$0	28%	$1	2.3%	$1	$0	$1	$0	2028Q3	65.9%	$2	$0	$2
0.013	Project Operations		$5	$1	28%	$6	2.3%	$5	$1	$7	$0	2025Q3	45.6%	$7	$2	$10
0.16	NON-FED Planning, Engineering & Design (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$18	$5	28%	$23	2.3%	$18	$5	$24	$0	2028Q3	65.9%	$31	$9	$39
0.012	Project Operation:		$5	$1	28%	$6	2.3%	$5	$1	$7	$0	2028Q3	65.9%	$8	$2	$11
0.031	Project Management		$12	$3	28%	$15	2.3%	$12	$3	$16	$0	2028Q3	65.9%	$20	$6	$26
0.09	NON-FED Construction Management (Relocations)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:		$487	$136		**$623**		$490	$137	$628	$0			$653	$183	**$836**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach C															
02	RELOCATIONS *		$1,180	$331	28%	$1,511	0.8%	$1,190	$333	$1,523	0	$1,523	30.0%	$1,546	$433	$1,980
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$28	28%	$128	0.4%	$100	$28	$129	0	$129	24.5%	$125	$35	$160
11	LEVEES & FLOODWALLS	Levees	$5,025	$1,407	28%	$6,431	0.4%	$5,045	$1,412	$6,457	0	$6,457	24.5%	$6,279	$1,758	$8,037
	CONSTRUCTION ESTIMATE TOTALS:		$6,305	$1,765		$8,070	0.5%	$6,335	$1,774	$8,108	0	$8,108	25.5%	$7,950	$2,226	$10,176
01	LANDS AND DAMAGES		$191	$15	8%	$206	0.6%	$192	$15	$207	0	$207	21.4%	$233	$18	$251
30	PLANNING, ENGINEERING & DESIGN *		$870	$244	28%	$1,114	2.3%	$890	$249	$1,139	0	$1,139	49.9%	$1,334	$373	$1,707
31	CONSTRUCTION MANAGEMENT *		$461	$129	28%	$590	2.3%	$472	$132	$604	0	$604	56.9%	$740	$207	$947
18	CULTURAL RESOURCE PRESERVATION		$49	$13	27%	$63	0.8%	$49	$13	$62	0	$62	21.4%	$59	$16	$75
	PROJECT COST TOTALS:		$7,876	$2,166	28%	$10,043		$7,937	$2,183	**$10,120**	0	**$10,120**	30.0%	$10,316	$2,841	$13,157

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$13,157**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared: 9/21/2015 Effective Price Level: 10/1/2014				Program Year (Budget EC): 2016 Effective Price Level Date: 1 OCT 15									
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach C, Levee Improvements															
02	RELOCATIONS		$944	$264	28%	$1,209	0.4%	$948	$266	$1,214	$0	2027Q2	24.5%	$1,180	$330	$1,511
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$28	28%	$128	0.4%	$100	$28	$129	$0	2027Q2	24.5%	$125	$35	$160
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$5,025	$1,407	28%	$6,431	0.4%	$5,045	$1,412	$6,457	$0	2027Q2	24.5%	$6,279	$1,758	$8,037
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$6,069	$1,699	28%	**$7,768**		$6,093	$1,706	$7,799	$0			$7,584	$2,123	$9,707
01	LANDS AND DAMAGES	Fed	$48	$2	5%	$50	0.6%	$48	$3	$50	$0	2026Q1	21.4%	$58	$3	$61
01	LANDS AND DAMAGES	Non-Fed	$143	$13	9%	$156	0.6%	$144	$13	$157	$0	2026Q1	21.4%	$175	$15	$190
18	CULTURAL RESOURCE PRESERVATION		$49	$13	27%	$63	-1.0%	$49	$13	$62	$0	2026Q1	21.4%	$59	$16	$75
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$82	$23	28%	$105	2.3%	$84	$23	$107	$0	2026Q1	48.7%	$125	$35	$160
0.006	Planning & Environmental Compliance		$31	$9	28%	$40	2.3%	$32	$9	$41	$0	2026Q1	48.7%	$47	$13	$60
0.082	Engineering & Design		$420	$118	28%	$538	2.3%	$430	$120	$550	$0	2026Q1	48.7%	$639	$179	$818
0.003	Reviews, ATRs, IEPRs, VE		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2026Q1	48.7%	$23	$6	$29
0.007	Life Cycle Updates (cost, schedule, risks)		$36	$10	28%	$46	2.3%	$37	$10	$47	$0	2026Q1	48.7%	$55	$15	$70
0.01	Contracting & Reprographics		$51	$14	28%	$65	2.3%	$52	$15	$67	$0	2026Q1	48.7%	$78	$22	$99
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$51	$14	28%	$65	2.3%	$52	$15	$67	$0	2026Q1	48.7%	$78	$22	$99
0.02	Engineering During Construction		$102	$29	28%	$131	2.3%	$104	$29	$134	$0	2027Q2	56.9%	$164	$46	$210
0.003	Planning During Construction		$15	$4	28%	$19	2.3%	$15	$4	$20	$0	2027Q2	56.9%	$24	$7	$31
0.013	Project Operations		$67	$19	28%	$86	2.3%	$69	$19	$88	$0	2026Q1	48.7%	$102	$29	$131
0.16	NON-FED Planning, Engineering & Design (Relocations)		$151	$42	28%	$193	2.3%	$154	$43	$198	$0	2026Q1	48.7%	$230	$64	$294
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$241	$67	28%	$308	2.3%	$247	$69	$316	$0	2027Q2	56.9%	$387	$108	$495
0.012	Project Operation:		$61	$17	28%	$78	2.3%	$62	$17	$80	$0	2027Q2	56.9%	$98	$27	$125
0.031	Project Management		$159	$45	28%	$204	2.3%	$163	$46	$208	$0	2027Q2	56.9%	$255	$71	$327
0.09	NON-FED Construction Management (Relocations)		$85	$24	28%	$109	2.3%	$87	$24	$111	$0	2027Q2	56.9%	$136	$38	$175
	CONTRACT COST TOTALS:		$7,876	$2,166		**$10,043**		$7,937	$2,183	$10,120	$0			$10,316	$2,841	**$13,157**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
								Program Year (Budget EC):		2016						
								Effective Price Level Date:		1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach D															
02	RELOCATIONS *		$8,344	$2,336	28%	$10,680	0.8%	$8,409	$2,355	$10,764	0	$10,764	23.5%	$10,387	$2,908	$13,296
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$660	$185	28%	$845	0.4%	$663	$186	$848	0	$848	20.2%	$797	$223	$1,020
11	LEVEES & FLOODWALLS	Levees	$27,062	$7,577	28%	$34,639	0.4%	$27,170	$7,607	$34,777	0	$34,777	20.2%	$32,666	$9,146	$41,812
	CONSTRUCTION ESTIMATE TOTALS:		$36,065	$10,098		$46,164	0.5%	$36,242	$10,148	$46,389	0	$46,389	21.0%	$43,850	$12,278	$56,128
01	LANDS AND DAMAGES		$2,950	$405	14%	$3,355	0.6%	$2,967	$407	$3,374	0	$3,374	14.4%	$3,394	$465	$3,860
30	PLANNING, ENGINEERING & DESIGN *		$4,711	$1,319	28%	$6,030	2.3%	$4,819	$1,349	$6,169	0	$6,169	33.2%	$6,422	$1,798	$8,220
31	CONSTRUCTION MANAGEMENT *		$2,495	$699	28%	$3,194	2.3%	$2,552	$715	$3,267	0	$3,267	45.6%	$3,716	$1,040	$4,756
18	CULTURAL RESOURCE PRESERVATION		$290	$78	27%	$368	0.8%	$287	$77	$364	0	$364	14.4%	$328	$89	$417
	PROJECT COST TOTALS:		$46,511	$12,599	27%	$59,110		$46,867	$12,696	**$59,563**	0	**$59,563**	23.2%	$57,710	$15,671	$73,380

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$73,380**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach D, Levee Improvements															
02	RELOCATIONS		$6,675	$1,869	28%	$8,544	0.4%	$6,702	$1,877	$8,578	$0	2025Q3	20.2%	$8,057	$2,256	$10,314
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$660	$185	28%	$845	0.4%	$663	$186	$848	$0	2025Q3	20.2%	$797	$223	$1,020
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$27,062	$7,577	28%	$34,639	0.4%	$27,170	$7,607	$34,777	$0	2025Q3	20.2%	$32,666	$9,146	$41,812
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$34,396	$9,631	28%	**$44,027**		$34,534	$9,670	$44,204	$0			$41,520	$11,626	$53,146
01	LANDS AND DAMAGES	Fed	$665	$35	5%	$700	0.6%	$669	$35	$704	$0	2023Q1	14.4%	$765	$40	$805
01	LANDS AND DAMAGES	Non-Fed	$2,285	$370	16%	$2,655	0.6%	$2,298	$372	$2,670	$0	2023Q1	14.4%	$2,629	$425	$3,054
18	CULTURAL RESOURCE PRESERVATION		$290	$78	27%	$368	-1.0%	$287	$77	$364	$0	2023Q1	14.4%	$328	$89	$417
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$444	$124	28%	$568	2.3%	$454	$127	$581	$0	2023Q1	31.3%	$596	$167	$763
0.006	Planning & Environmental Compliance		$166	$46	28%	$212	2.3%	$170	$48	$217	$0	2023Q1	31.3%	$223	$62	$285
0.082	Engineering & Design		$2,273	$636	28%	$2,909	2.3%	$2,325	$651	$2,976	$0	2023Q1	31.3%	$3,054	$855	$3,909
0.003	Reviews, ATRs, IEPRs, VE		$83	$23	28%	$106	2.3%	$85	$24	$109	$0	2023Q1	31.3%	$112	$31	$143
0.007	Life Cycle Updates (cost, schedule, risks)		$194	$54	28%	$248	2.3%	$198	$56	$254	$0	2023Q1	31.3%	$261	$73	$334
0.01	Contracting & Reprographics		$277	$78	28%	$355	2.3%	$283	$79	$363	$0	2023Q1	31.3%	$372	$104	$476
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$277	$78	28%	$355	2.3%	$283	$79	$363	$0	2023Q1	31.3%	$372	$104	$476
0.02	Engineering During Construction		$554	$155	28%	$709	2.3%	$567	$159	$725	$0	2025Q3	45.6%	$825	$231	$1,056
0.003	Planning During Construction		$83	$23	28%	$106	2.3%	$85	$24	$109	$0	2025Q3	45.6%	$124	$35	$158
0.013	Project Operations		$360	$101	28%	$461	2.3%	$368	$103	$471	$0	2023Q1	31.3%	$484	$135	$619
0.16	NON-FED Planning, Engineering & Design (Relocations)		$1,068	$299	28%	$1,367	2.3%	$1,093	$306	$1,399	$0	2023Q1	31.3%	$1,435	$402	$1,836
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,303	$365	28%	$1,668	2.3%	$1,333	$373	$1,706	$0	2025Q3	45.6%	$1,941	$543	$2,484
0.012	Project Operation:		$333	$93	28%	$426	2.3%	$341	$95	$436	$0	2025Q3	45.6%	$496	$139	$635
0.031	Project Management		$859	$241	28%	$1,100	2.3%	$879	$246	$1,125	$0	2025Q3	45.6%	$1,279	$358	$1,638
0.09	NON-FED Construction Management (Relocations)		$601	$168	28%	$769	2.3%	$615	$172	$787	$0	2025Q3	45.6%	$895	$251	$1,146
	CONTRACT COST TOTALS:		$46,511	$12,599		**$59,110**		$46,867	$12,696	$59,563	$0			$57,710	$15,671	**$73,380**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach E															
02	RELOCATIONS *		$10,565	$2,958	28%	$13,523	0.8%	$10,648	$2,981	$13,630	0	$13,630	26.6%	$13,483	$3,775	$17,258
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$495	$139	28%	$634	0.4%	$497	$139	$636	0	$636	22.6%	$610	$171	$780
11	LEVEES & FLOODWALLS	Levees	$25,431	$7,121	28%	$32,551	0.4%	$25,532	$7,149	$32,681	0	$32,681	22.6%	$31,311	$8,767	$40,078
	CONSTRUCTION ESTIMATE TOTALS:		$36,491	$10,217		$46,708	0.5%	$36,678	$10,270	$46,947	0	$46,947	23.8%	$45,403	$12,713	$58,116
01	LANDS AND DAMAGES		$4,325	$594	14%	$4,919	0.6%	$4,348	$597	$4,946	0	$4,946	16.7%	$5,074	$697	$5,771
30	PLANNING, ENGINEERING & DESIGN *		$4,408	$1,234	28%	$5,642	2.3%	$4,509	$1,263	$5,772	0	$5,772	38.9%	$6,262	$1,753	$8,015
31	CONSTRUCTION MANAGEMENT *		$2,334	$654	28%	$2,988	2.3%	$2,388	$669	$3,056	0	$3,056	52.0%	$3,629	$1,016	$4,645
18	CULTURAL RESOURCE PRESERVATION		$295	$80	27%	$375	0.8%	$292	$79	$371	0	$371	16.7%	$341	$92	$433
	PROJECT COST TOTALS:		$47,853	$12,779	27%	$60,632		$48,216	$12,877	**$61,093**	0	**$61,093**	26.0%	$60,710	$16,272	$76,981

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$76,981**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach E, Levee Improvements															
02	RELOCATIONS		$8,452	$2,367	28%	$10,819	0.4%	$8,486	$2,376	$10,863	$0	2026Q3	22.6%	$10,407	$2,914	$13,321
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$495	$139	28%	$634	0.4%	$497	$139	$636	$0	2026Q3	22.6%	$610	$171	$780
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$25,431	$7,121	28%	$32,551	0.4%	$25,532	$7,149	$32,681	$0	2026Q3	22.6%	$31,311	$8,767	$40,078
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$34,378	$9,626	28%	**$44,004**		$34,516	$9,664	$44,180	$0			$42,328	$11,852	$54,180
01	LANDS AND DAMAGES	Fed	$974	$51	5%	$1,025	0.6%	$979	$52	$1,031	$0	2024Q1	16.7%	$1,143	$60	$1,203
01	LANDS AND DAMAGES	Non-Fed	$3,351	$543	16%	$3,894	0.6%	$3,369	$546	$3,915	$0	2024Q1	16.7%	$3,932	$637	$4,569
18	CULTURAL RESOURCE PRESERVATION		$295	$80	27%	$375	-1.0%	$292	$79	$371	$0	2024Q1	16.7%	$341	$92	$433
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$415	$116	28%	$531	2.3%	$425	$119	$543	$0	2024Q1	36.8%	$581	$163	$743
0.006	Planning & Environmental Compliance		$156	$44	28%	$200	2.3%	$160	$45	$204	$0	2024Q1	36.8%	$218	$61	$279
0.082	Engineering & Design		$2,126	$595	28%	$2,721	2.3%	$2,175	$609	$2,784	$0	2024Q1	36.8%	$2,975	$833	$3,808
0.003	Reviews, ATRs, IEPRs, VE		$78	$22	28%	$100	2.3%	$80	$22	$102	$0	2024Q1	36.8%	$109	$31	$140
0.007	Life Cycle Updates (cost, schedule, risks)		$181	$51	28%	$232	2.3%	$185	$52	$237	$0	2024Q1	36.8%	$253	$71	$324
0.01	Contracting & Reprographics		$259	$73	28%	$332	2.3%	$265	$74	$339	$0	2024Q1	36.8%	$362	$101	$464
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$259	$73	28%	$332	2.3%	$265	$74	$339	$0	2024Q1	36.8%	$362	$101	$464
0.02	Engineering During Construction		$519	$145	28%	$664	2.3%	$531	$149	$680	$0	2026Q3	52.0%	$807	$226	$1,033
0.003	Planning During Construction		$78	$22	28%	$100	2.3%	$80	$22	$102	$0	2026Q3	52.0%	$121	$34	$155
0.013	Project Operations		$337	$94	28%	$431	2.3%	$345	$97	$441	$0	2024Q1	36.8%	$472	$132	$604
0.16	NON-FED Planning, Engineering & Design		$1,352	$379	28%	$1,731	2.3%	$1,383	$387	$1,770	$0	2024Q1	36.8%	$1,892	$530	$2,422
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$1,219	$341	28%	$1,560	2.3%	$1,247	$349	$1,596	$0	2026Q3	52.0%	$1,895	$531	$2,426
0.012	Project Operation:		$311	$87	28%	$398	2.3%	$318	$89	$407	$0	2026Q3	52.0%	$484	$135	$619
0.031	Project Management		$804	$225	28%	$1,029	2.3%	$823	$230	$1,053	$0	2026Q3	52.0%	$1,250	$350	$1,600
0.09	NON-FED Construction Management		$761	$213	28%	$974	2.3%	$779	$218	$996	$0	2026Q3	52.0%	$1,183	$331	$1,515
	CONTRACT COST TOTALS:		$47,853	$12,779		**$60,632**		$48,216	$12,877	$61,093	$0			$60,710	$16,272	**$76,981**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach F															
02	RELOCATIONS *		$4,237	$1,186	28%	$5,424	0.8%	$4,271	$1,196	$5,466	0	$5,466	27.4%	$5,439	$1,523	$6,962
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$28	28%	$128	0.4%	$100	$28	$129	0	$129	22.6%	$123	$34	$158
11	LEVEES & FLOODWALLS	Levees	$16,597	$4,647	28%	$21,244	0.4%	$16,663	$4,666	$21,328	0	$21,328	22.6%	$20,434	$5,722	$26,156
	CONSTRUCTION ESTIMATE TOTALS:		$20,934	$5,861		$26,795	0.5%	$21,034	$5,889	$26,923	0	$26,923	23.6%	$25,996	$7,279	$33,275
01	LANDS AND DAMAGES		$466	$68	15%	$534	0.6%	$468	$68	$536	0	$536	19.0%	$557	$81	$639
30	PLANNING, ENGINEERING & DESIGN *		$2,838	$795	28%	$3,633	2.3%	$2,903	$813	$3,716	0	$3,716	43.8%	$4,176	$1,169	$5,345
31	CONSTRUCTION MANAGEMENT *		$1,503	$421	28%	$1,924	2.3%	$1,538	$431	$1,968	0	$1,968	52.0%	$2,337	$654	$2,991
18	CULTURAL RESOURCE PRESERVATION		$162	$44	27%	$205	0.8%	$160	$43	$203	0	$203	19.0%	$191	$51	$242
	PROJECT COST TOTALS:		$25,902	$7,188	28%	$33,091		$26,103	$7,244	**$33,348**	0	**$33,348**	27.4%	$33,257	$9,235	$42,492

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$42,492**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach F, Levee Improvements															
02	RELOCATIONS		$3,390	$949	28%	$4,340	0.4%	$3,404	$953	$4,357	$0	2026Q3	22.6%	$4,175	$1,169	$5,343
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$100	$28	28%	$128	0.4%	$100	$28	$129	$0	2026Q3	22.6%	$123	$34	$158
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$16,597	$4,647	28%	$21,244	0.4%	$16,663	$4,666	$21,328	$0	2026Q3	22.6%	$20,434	$5,722	$26,156
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$20,087	$5,624	28%	**$25,711**		$20,167	$5,647	$25,814	$0			$24,732	$6,925	$31,657
01	LANDS AND DAMAGES	Fed	$71	$4	5%	$75	0.6%	$72	$4	$75	$0	2025Q1	19.0%	$85	$4	$90
01	LANDS AND DAMAGES	Non-Fed	$395	$64	16%	$459	0.6%	$397	$64	$461	$0	2025Q1	19.0%	$472	$77	$549
18	CULTURAL RESOURCE PRESERVATION		$162	$44	27%	$205	-1.0%	$160	$43	$203	$0	2025Q1	19.0%	$191	$51	$242
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$267	$75	28%	$342	2.3%	$273	$76	$350	$0	2025Q1	42.5%	$389	$109	$498
0.006	Planning & Environmental Compliance		$100	$28	28%	$128	2.3%	$102	$29	$131	$0	2025Q1	42.5%	$146	$41	$187
0.082	Engineering & Design		$1,369	$383	28%	$1,752	2.3%	$1,401	$392	$1,793	$0	2025Q1	42.5%	$1,996	$559	$2,555
0.003	Reviews, ATRs, IEPRs, VE		$50	$14	28%	$64	2.3%	$51	$14	$65	$0	2025Q1	42.5%	$73	$20	$93
0.007	Life Cycle Updates (cost, schedule, risks)		$117	$33	28%	$150	2.3%	$120	$34	$153	$0	2025Q1	42.5%	$171	$48	$218
0.01	Contracting & Reprographics		$167	$47	28%	$214	2.3%	$171	$48	$219	$0	2025Q1	42.5%	$244	$68	$312
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$167	$47	28%	$214	2.3%	$171	$48	$219	$0	2025Q1	42.5%	$244	$68	$312
0.02	Engineering During Construction		$334	$94	28%	$428	2.3%	$342	$96	$437	$0	2026Q3	52.0%	$519	$145	$665
0.003	Planning During Construction		$50	$14	28%	$64	2.3%	$51	$14	$65	$0	2026Q3	52.0%	$78	$22	$100
0.013	Project Operations		$217	$61	28%	$278	2.3%	$222	$62	$284	$0	2025Q1	42.5%	$316	$89	$405
0.16	NON-FED Planning, Engineering & Design (Relocations)		$542	$152	28%	$694	2.3%	$554	$155	$710	$0	2025Q1	42.5%	$790	$221	$1,012
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$785	$220	28%	$1,005	2.3%	$803	$225	$1,028	$0	2026Q3	52.0%	$1,221	$342	$1,562
0.012	Project Operation:		$200	$56	28%	$256	2.3%	$205	$57	$262	$0	2026Q3	52.0%	$311	$87	$398
0.031	Project Management		$518	$145	28%	$663	2.3%	$530	$148	$678	$0	2026Q3	52.0%	$805	$226	$1,031
0.09	NON-FED Construction Management (Relocations)		$305	$85	28%	$390	2.3%	$312	$87	$399	$0	2026Q3	52.0%	$474	$133	$607
	CONTRACT COST TOTALS:		$25,902	$7,188		**$33,091**		$26,103	$7,244	$33,348	$0			$33,257	$9,235	**$42,492**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT N(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

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: 10/1/2014 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	ARN, Reach I															
02	RELOCATIONS *		$50	$14	28%	$64	0.8%	$50	$14	$65	0	$65	30.1%	$66	$18	$84
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$275	$77	28%	$352	0.4%	$276	$77	$354	0	$354	24.5%	$344	$96	$440
11	LEVEES & FLOODWALLS	Levees	$1,950	$546	28%	$2,497	0.4%	$1,958	$548	$2,507	0	$2,507	24.5%	$2,437	$682	$3,120
	CONSTRUCTION ESTIMATE TOTALS:		$2,276	$637		$2,913	0.4%	$2,285	$640	$2,925	0	$2,925	24.6%	$2,847	$797	$3,644
01	LANDS AND DAMAGES		$20,492	$11,788	58%	$32,280	0.6%	$20,606	$11,853	$32,459	0	$32,459	21.4%	$25,017	$14,391	$39,408
30	PLANNING, ENGINEERING & DESIGN *		$379	$106	28%	$485	2.3%	$388	$109	$496	0	$496	49.9%	$581	$163	$744
31	CONSTRUCTION MANAGEMENT *		$201	$56	28%	$257	2.3%	$206	$58	$263	0	$263	56.9%	$323	$90	$413
18	CULTURAL RESOURCE PRESERVATION		$152	$41	27%	$193	0.8%	$150	$41	$191	0	$191	21.4%	$182	$49	$232
	PROJECT COST TOTALS:		$23,499	$12,628	54%	$36,128		$23,634	$12,700	**$36,334**	0	**$36,334**	22.3%	$28,950	$15,490	$44,440

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$44,440**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account. Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	ARN, Reach I, Levee Improvements															
02	RELOCATIONS		$40	$11	28%	$51	0.4%	$40	$11	$51	$0	2027Q2	24.5%	$50	$14	$64
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$275	$77	28%	$352	0.4%	$276	$77	$354	$0	2027Q2	24.5%	$344	$96	$440
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$1,950	$546	28%	$2,497	0.4%	$1,958	$548	$2,507	$0	2027Q2	24.5%	$2,437	$682	$3,120
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$2,266	$634	28%	**$2,900**		$2,275	$637	$2,912	$0			$2,831	$793	$3,624
01	LANDS AND DAMAGES	Fed	$713	$38	5%	$750	0.6%	$716	$38	$754	$0	2026Q1	21.4%	$870	$46	$916
01	LANDS AND DAMAGES	Non-Fed	$19,780	$11,750	59%	$31,530	0.6%	$19,889	$11,816	$31,705	$0	2026Q1	21.4%	$24,147	$14,345	$38,493
18	CULTURAL RESOURCE PRESERVATION		$152	$41	27%	$193	-1.0%	$150	$41	$191	$0	2026Q1	21.4%	$182	$49	$232
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$36	$10	28%	$46	2.3%	$37	$10	$47	$0	2026Q1	48.7%	$55	$15	$70
0.006	Planning & Environmental Compliance		$13	$4	28%	$17	2.3%	$13	$4	$17	$0	2026Q1	48.7%	$20	$6	$25
0.082	Engineering & Design		$182	$51	28%	$233	2.3%	$186	$52	$238	$0	2026Q1	48.7%	$277	$78	$355
0.003	Reviews, ATRs, IEPRs, VE		$7	$2	28%	$9	2.3%	$7	$2	$9	$0	2026Q1	48.7%	$11	$3	$14
0.007	Life Cycle Updates (cost, schedule, risks)		$16	$4	28%	$20	2.3%	$16	$5	$21	$0	2026Q1	48.7%	$24	$7	$31
0.01	Contracting & Reprographics		$22	$6	28%	$28	2.3%	$23	$6	$29	$0	2026Q1	48.7%	$33	$9	$43
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$22	$6	28%	$28	2.3%	$23	$6	$29	$0	2026Q1	48.7%	$33	$9	$43
0.02	Engineering During Construction		$45	$13	28%	$58	2.3%	$46	$13	$59	$0	2027Q2	56.9%	$72	$20	$92
0.003	Planning During Construction		$7	$2	28%	$9	2.3%	$7	$2	$9	$0	2027Q2	56.9%	$11	$3	$14
0.013	Project Operations		$29	$8	28%	$37	2.3%	$30	$8	$38	$0	2026Q1	48.7%	$44	$12	$56
0.16	NON-FED Planning, Engineering & Design (Relocations)		$6	$2	28%	$8	2.3%	$6	$2	$8	$0	2026Q1	48.7%	$9	$3	$12
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$105	$29	28%	$134	2.3%	$107	$30	$137	$0	2027Q2	56.9%	$169	$47	$216
0.012	Project Operation:		$27	$8	28%	$35	2.3%	$28	$8	$35	$0	2027Q2	56.9%	$43	$12	$55
0.031	Project Management		$69	$19	28%	$88	2.3%	$71	$20	$90	$0	2027Q2	56.9%	$111	$31	$142
0.09	NON-FED Construction Management (Relocations)		$4	$1	28%	$5	2.3%	$4	$1	$5	$0	2027Q2	56.9%	$6	$2	$8
	CONTRACT COST TOTALS:		$23,499	$12,628		**$36,128**		$23,634	$12,700	$36,334	$0			$28,950	$15,490	**$44,440**

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO(P2 # 149827
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

NOTE - Sacramento Bypass Widening is an LPP feature, so the Cultural Resources Preservation cost is set to $0

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST						TOTAL PROJECT COST			
							Program Year (Budget EC):			2016						
							Effective Price Level Date:			1 OCT 15						
										Spent Thru:						
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
	Sacramento Bypass Widening															
02	RELOCATIONS *		$21,201	$5,936	28%	$27,137	0.8%	$21,368	$5,983	$27,350	0	$27,350	14.9%	$24,561	$6,877	$31,438
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$12,000	$3,360	28%	$15,360	0.4%	$12,052	$3,375	$15,427	0	$15,427	13.9%	$13,723	$3,842	$17,565
08	ROADS, RAILROADS & BRIDGES		$20,073	$5,620	28%	$25,693	0.4%	$20,155	$5,643	$25,798	0	$25,798	5.1%	$21,192	$5,934	$27,126
11	LEVEES & FLOODWALLS	Levees	$77,016	$21,564	28%	$98,580	0.4%	$77,323	$21,650	$98,974	0	$98,974	13.9%	$88,040	$24,651	$112,691
15	FLOODWAY CONTROL & DIVERSION STRUCTURE		$42,316	$11,849	28%	$54,165	0.4%	$42,501	$11,900	$54,401	0	$54,401	13.9%	$48,391	$13,549	$61,941
	CONSTRUCTION ESTIMATE TOTALS:		$172,606	$48,330		$220,936	0.5%	$173,398	$48,551	$221,950	0	$221,950	13.0%	$195,907	$54,854	$250,761
01	LANDS AND DAMAGES		$3,617	$1,383	38%	$5,000	0.6%	$3,637	$1,391	$5,028	0	$5,028	6.2%	$3,864	$1,478	$5,341
30	PLANNING, ENGINEERING & DESIGN *		$25,740	$7,207	28%	$32,947	2.3%	$26,332	$7,373	$33,705	0	$33,705	15.4%	$30,396	$8,511	$38,907
31	CONSTRUCTION MANAGEMENT *		$13,627	$3,816	28%	$17,443	2.3%	$13,941	$3,903	$17,844	0	$17,844	30.0%	$18,124	$5,075	$23,199
18	CULTURAL RESOURCE PRESERVATION		$0	$0	-	$0	0.8%	$0	$0	$0	0	$0	-	$0	$0	$0
	PROJECT COST TOTALS:		$215,590	$60,736	28%	$276,326		$217,308	$61,219	**$278,527**	0	**$278,527**	14.2%	$248,291	$69,917	$318,208

CHIEF, COST ENGINEERING, Jeremiah Frost

PROJECT MANAGER, Dan Tibbitts

CHIEF, REAL ESTATE, Diane Simpson

ESTIMATED TOTAL PROJECT COST: **$318,208**

CHIEF, PLANNING, Alicia Kirchner

CHIEF, ENGINEERING, Rick Poeppelman

CHIEF, OPERATIONS, Randy Olsen

CHIEF, CONSTRUCTION, Norbert Suter

CHIEF, CONTRACTING, Kim Ford

CHIEF, PM-PB, Mary Evans

CHIEF, DPM, Tambour Eller

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.
Associated 30 and 31 Account costs are itemized below.

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	Effective Price Level Date:			1 OCT 15						
					RISK BASED											
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Spent Thru: 10/1/2014	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*
	Sacramento Bypass Widening, New Weir															
02	RELOCATIONS		$2,757	$772	28%	$3,529	0.4%	$2,768	$775	$3,543	$0	2022Q4	13.9%	$3,152	$882	$4,034
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$12,000	$3,360	28%	$15,360	0.4%	$12,052	$3,375	$15,427	$0	2022Q4	13.9%	$13,723	$3,842	$17,565
08	ROADS, RAILROADS & BRIDGES		$20,073	$5,620	28%	$25,693	0.4%	$20,155	$5,643	$25,798	$0	2018Q4	5.1%	$21,192	$5,934	$27,126
11	LEVEES & FLOODWALLS	Levees	$737	$206	28%	$943	0.4%	$739	$207	$947	$0	2022Q4	13.9%	$842	$236	$1,078
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
15	FLOODWAY CONTROL & DIVERSION STRUCTURE		$42,316	$11,849	28%	$54,165	0.4%	$42,501	$11,900	$54,401	$0	2022Q4	13.9%	$48,391	$13,549	$61,941
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$77,883	$21,807	28%	**$99,690**		$78,215	$21,900	$100,115	$0			$87,300	$24,444	$111,744
01	LANDS AND DAMAGES	Fed	$238	$13	5%	$251	0.6%	$239	$13	$252	$0	2019Q2	6.2%	$254	$13	$268
01	LANDS AND DAMAGES	Non-Fed	$3,379	$1,371	41%	$4,750	0.6%	$3,398	$1,379	$4,776	$0	2019Q2	6.2%	$3,609	$1,464	$5,074
18	CULTURAL RESOURCE PRESERVATION		$0	$0	0%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,202	$337	28%	$1,539	2.3%	$1,230	$344	$1,574	$0	2019Q2	13.1%	$1,391	$390	$1,781
0.006	Planning & Environmental Compliance		$451	$126	28%	$577	2.3%	$461	$129	$591	$0	2019Q2	13.1%	$522	$146	$668
0.082	Engineering & Design		$6,160	$1,725	28%	$7,885	2.3%	$6,302	$1,764	$8,066	$0	2019Q2	13.1%	$7,130	$1,997	$9,127
0.003	Reviews, ATRs, IEPRs, VE		$225	$63	28%	$288	2.3%	$230	$64	$295	$0	2019Q2	13.1%	$260	$73	$333
0.007	Life Cycle Updates (cost, schedule, risks)		$526	$147	28%	$673	2.3%	$538	$151	$689	$0	2019Q2	13.1%	$609	$170	$779
0.01	Contracting & Reprographics		$751	$210	28%	$961	2.3%	$768	$215	$983	$0	2019Q2	13.1%	$869	$243	$1,113
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$751	$210	28%	$961	2.3%	$768	$215	$983	$0	2019Q2	13.1%	$869	$243	$1,113
0.02	Engineering During Construction		$1,503	$421	28%	$1,924	2.3%	$1,538	$431	$1,968	$0	2022Q4	30.0%	$1,999	$560	$2,559
0.003	Planning During Construction		$225	$63	28%	$288	2.3%	$230	$64	$295	$0	2022Q4	30.0%	$299	$84	$383
0.013	Project Operations		$977	$274	28%	$1,251	2.3%	$999	$280	$1,279	$0	2019Q2	13.1%	$1,131	$317	$1,448
0.16	NON-FED Planning, Engineering & Design (Relocations)		$441	$123	28%	$564	2.3%	$451	$126	$577	$0	2019Q2	13.1%	$510	$143	$653
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$3,531	$989	28%	$4,520	2.3%	$3,612	$1,011	$4,624	$0	2022Q4	30.0%	$4,696	$1,315	$6,011
0.012	Project Operation:		$902	$253	28%	$1,155	2.3%	$923	$258	$1,181	$0	2022Q4	30.0%	$1,200	$336	$1,536
0.031	Project Management		$2,329	$652	28%	$2,981	2.3%	$2,383	$667	$3,050	$0	2022Q4	30.0%	$3,098	$867	$3,965
0.09	NON-FED Construction Management (Relocations)		$248	$69	28%	$317	2.3%	$254	$71	$325	$0	2022Q4	30.0%	$330	$92	$422
	CONTRACT COST TOTALS:		$101,722	$28,853		**$130,574**		$102,540	$29,084	$131,623	$0			$116,078	$32,898	**$148,976**

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

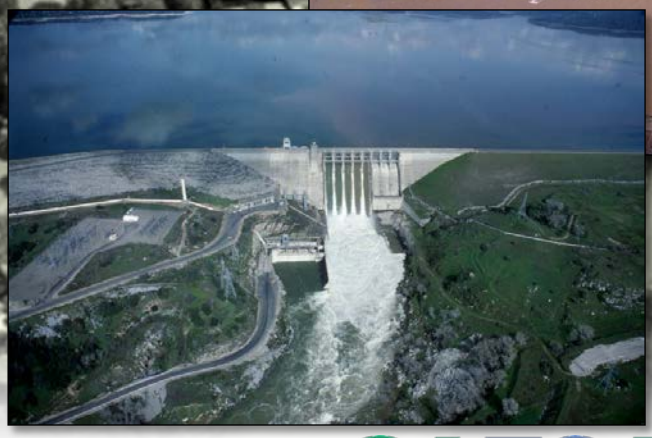
PROJECT: American River Common Features GRR - Alt 2 - LPP
LOCATION: Sacramento, CA
This Estimate reflects the scope and schedule in report; Feasibility Report

DISTRICT: SPK - Sacramento District
POC: CHIEF, COST ENGINEERING, Jeremiah Frost
PREPARED: 11/20/2015

Civil Works Work Breakdown Structure			ESTIMATED COST				PROJECT FIRST COST					TOTAL PROJECT COST (FULLY FUNDED)				
			Estimate Prepared:			9/21/2015	Program Year (Budget EC):			2016						
			Effective Price Level:			10/1/2014	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: 10/1/2014	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*
	Sacramento Bypass Widening															
02	RELOCATIONS		$14,204	$3,977	28%	$18,181	0.4%	$14,262	$3,993	$18,255	$0	2022Q4	13.9%	$16,238	$4,547	$20,785
06	FISH & WILDLIFE FACILITIES	Construction	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
09	CHANNELS & CANALS		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
11	LEVEES & FLOODWALLS	Levees	$76,279	$21,358	28%	$97,638	0.4%	$76,584	$21,443	$98,027	$0	2022Q4	13.9%	$87,198	$24,415	$111,613
11	LEVEES & FLOODWALLS	Floodwalls	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
16	BANK STABILIZATION		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
ALL	COMPOSITE INDEX (WEIGHTED AVERAGE)		$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
	CONSTRUCTION ESTIMATE TOTALS:		$90,483	$25,335	28%	**$115,819**		$90,845	$25,437	$116,282	$0			$103,436	$28,962	$132,398
01	LANDS AND DAMAGES	Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
01	LANDS AND DAMAGES	Non-Fed	$0	$0	28%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
18	CULTURAL RESOURCE PRESERVATION		$0	$0	0%	$0	0.0%	$0	$0	$0	$0	0	0.0%	$0	$0	$0
30	PLANNING, ENGINEERING & DESIGN															
0.016	Project Management		$1,220	$342	28%	$1,562	2.3%	$1,248	$349	$1,598	$0	2019Q2	13.1%	$1,412	$395	$1,808
0.006	Planning & Environmental Compliance		$458	$128	28%	$586	2.3%	$469	$131	$600	$0	2019Q2	13.1%	$530	$148	$679
0.082	Engineering & Design		$6,255	$1,751	28%	$8,006	2.3%	$6,399	$1,792	$8,191	$0	2019Q2	13.1%	$7,240	$2,027	$9,268
0.003	Reviews, ATRs, IEPRs, VE		$229	$64	28%	$293	2.3%	$234	$66	$300	$0	2019Q2	13.1%	$265	$74	$339
0.007	Life Cycle Updates (cost, schedule, risks)		$534	$150	28%	$684	2.3%	$546	$153	$699	$0	2019Q2	13.1%	$618	$173	$791
0.01	Cultural Investigations (Survey, test,& Evaluate archeological resources)		$763	$214	28%	$977	2.3%	$781	$219	$999	$0	2019Q2	13.1%	$883	$247	$1,130
0.01	Contracting & Reprographics		$763	$214	28%	$977	2.3%	$781	$219	$999	$0	2019Q2	13.1%	$883	$247	$1,130
0.02	Engineering During Construction		$1,526	$427	28%	$1,953	2.3%	$1,561	$437	$1,998	$0	2022Q4	30.0%	$2,030	$568	$2,598
0.003	Planning During Construction		$229	$64	28%	$293	2.3%	$234	$66	$300	$0	2022Q4	30.0%	$305	$85	$390
0.013	Project Operations		$992	$278	28%	$1,270	2.3%	$1,015	$284	$1,299	$0	2019Q2	13.1%	$1,148	$322	$1,470
0.16	NON-FED Planning, Engineering & Design (Relocations)		$2,273	$636	28%	$2,909	2.3%	$2,325	$651	$2,976	$0	2019Q2	13.1%	$2,631	$737	$3,368
31	CONSTRUCTION MANAGEMENT															
0.047	Construction Management		$3,585	$1,004	28%	$4,589	2.3%	$3,668	$1,027	$4,694	$0	2022Q4	30.0%	$4,768	$1,335	$6,103
0.012	Project Operation:		$915	$256	28%	$1,171	2.3%	$936	$262	$1,198	$0	2022Q4	30.0%	$1,217	$341	$1,558
0.031	Project Management		$2,365	$662	28%	$3,027	2.3%	$2,419	$677	$3,097	$0	2022Q4	30.0%	$3,146	$881	$4,026
0.09	NON-FED Construction Management (Relocations)		$1,278	$358	28%	$1,636	2.3%	$1,307	$366	$1,673	$0	2022Q4	30.0%	$1,700	$476	$2,176
	CONTRACT COST TOTALS:		$113,868	$31,883		**$145,751**		$114,769	$32,135	$146,904	$0			$132,212	$37,019	**$169,232**

American River Watershed

Common Features
General Reevaluation Report



Attachment E
Erosion Protection Report

December 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Attachment E
Erosion Protection Report

U.S. Army Corps of Engineers
Sacramento District

December 2015

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American River Watershed Common Features General Re-Evaluation Report

Erosion Protection Report

Post-ATR Version Dated 8 April 2014

April 2014

On the cover:
Erosion of the left bank and levee of the Lower American River between river miles 4 and 5 resulting from the February 1986 flood.

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ACRONYNMS and ABBREVIATIONS

ACN ..... Arcade Creek North
ACS ..... Arcade Creek South
ARCF ..... American River Common Features
ARCH ..... Air Rotary Casing Hammer
ARFCD ..... American River Flood Control District
ARFCP ..... American River Flood Control Project
ARN ..... American River North Basin
ARS ..... American River South Basin
ASTM ..... American Society of Testing and Materials
ARWI ..... American River Watershed Investigation
BGS ..... Below Ground Surface
BTA ..... Blanket Theory Analysis
CB ..... Cement-Bentonite
CFS ..... Cubic Feet Per Second
CHP ..... California Highway Patrol
COS ..... City of Sacramento
CPT ..... Cone Penetrometer Test
CW ..... Cutoff Wall
CVFPB ..... Central Valley Flood Protection Board
CVFPP ..... Central Valley Flood Protection Plan
CY ..... Cubic Yard(s)
DBH ..... Diameter at Breast Height
DCN ..... Dry Creek North
DCS ..... Dry Creek South
DMM ..... Deep Mix Method
DSM ..... Deep Soil Mixing
DWR ..... Department of Water Resources
DWSC ..... Deep Water Ship Channel
EFA ..... Erosion Function Apparatus
EIP ..... Early Implementation Project
EM ..... Engineering Manual
ERU ..... Erosionally Resistant Unit
ESP ..... Erosion Screening Process
ETL ..... Engineering Technical Letter
EVS ..... Environmental Visualization System
FEMA ..... Federal Emergency Management Agency
FOS ..... Factor(s) Of Safety
FOSM ..... First Order Second Moment
FT ..... Foot/Feet
FT/S ..... Feet Per Second
GER ..... Geotechnical Engineering Report
GIS ..... Geographical Information System
GMS ..... Groundwater Modeling Software
GRR ..... General Reevaluation Report
H:V ..... Horizontal To Vertical Ratio
HTRW ..... Hazardous, Toxic, and Radioactive Waste
HQUSACE ..... Headquarters U.S. Army Corps Of Engineers
IBC ..... International Building Code
IWM ..... In-Stream Woody Material
JET ..... Jet Erosion Test

K ..... Coefficient Of Permeability
KH ..... Horizontal Hydraulic Conductivity Under Fully Saturated Conditions
KH/KV ..... Ratio Between The Vertical And Horizontal Conductivities; Anisotropic Ratio
KV ..... Vertical Hydraulic Conductivity Under Fully Saturated Conditions
Ky ..... Yield Acceleration
LAR ..... Lower American River
LiDAR ..... Light Detection and Ranging
LM ..... Levee Mile
MA ..... Maintenance Area
MCDC ..... Magpie Creek Diversion Canal
MCY ..... Million Cubic Yards
MSWL ..... Mean Summer Water Level
MUSYM ..... Map Unit Symbol
Mw ..... Moment Magnitude
NAD83 ..... North American Datum of 1983
NAFCI ..... Natomas Area Flood Control Improvement
NALP ..... North Area Levee Project
NAT ..... Natomas Basin
NAVD88 ..... North American Vertical Datum of 1988
NCC ..... Natomas Cross Canal
NCEER ..... National Center for Earthquake Engineering Research
NCMWC ..... Natomas Central Mutual Water Company
NCSS ..... National Cooperative Soil Survey
NGA ..... Next Generation Attenuation
NGVD29 ..... National Geodetic Vertical Datum of 1929
NEMDC ..... Natomas East Main Drainage Canal
NLD ..... National Levee Database
NLIP ..... Natomas Levee Improvement Project
NPACR ..... Natomas Post Authorization Change Report
NRCS ..... National Resources Conservation Service
NSF ..... National Science Foundation
NULE ..... Nonurban Levee Evaluations
OCR ..... Over-Consolidation Ratio
PACR ..... Post Authorization Change Report
PDT ..... Project Delivery Team
PED ..... Pre-Construction Engineering and Design
PGA ..... Peak Ground Acceleration
PGCC ..... Pleasant Grove Creek Canal
PGL ..... Policy Guidance Letter
Pr(f) ..... Probability of Failure
PSHA ..... Probabilistic Seismic Hazard Analysis
P1GDR ..... Phase 1 Geotechnical Data Report
P1GER ..... Phase 1 Geotechnical Engineering Report
QA ..... Quality Assurance
QC ..... Quality Control
RD ..... Reclamation District
RM ..... River Mile
SAFCA ..... Sacramento Area Flood Control Agency
SB ..... Soil-Bentonite
SCB ..... Soil-Cement-Bentonite
SGDR ..... Supplemental Geotechnical Data Report
SOP ..... Standard Operating Procedure
SPT ..... Standard Penetration Test

SRBPP ..... Sacramento River Bank Protection Project
SRFCP ..... Sacramento River Flood Control Project
SRN ..... Sacramento River North
SRS ..... Sacramento River South
SSURGO ..... Soil Survey Geographic Database
SUALRP ..... Sacramento Urban Area Levee Reconstruction Project
SWIF ..... System-Wide Improvement Framework Policy
TEC ..... Topographic Engineering Center
TM ..... Technical Memorandum
TRM ..... Technical Review Memorandum
ULE ..... Urban Levee Evaluations
USACE ..... U.S. Army Corps Of Engineers
USDA ..... United States Department of Agriculture
USGS ..... United States Geological Society
V:H ..... Vertical To Horizontal Ratio
¯VS30 ..... Velocity Of The Upper 30 Meters
VVR ..... Vegetation Variance Request
WRDA ..... Water Resources Development Act
WSAFCA ..... West Sacramento Area Flood Control Agency
WSE ..... water surface elevation

1 INTRODUCTION AND BACKGROUND

1.1 Introduction

The purpose of this attachment is to provide a concise summary of the work performed to date regarding understanding and predicting the stability of the Lower American and Sacramento Rivers with regards to erosion and the capability of the leveed reaches of the mainstem river channels to convey flood releases from Folsom Dam. Additionally, this attachment provides the rationale for the proposed erosion protection features presented in the Engineering Appendix of the American River Common Features GRR Study (ARCF).

This attachment provides further rationale for why the erosion protection features are needed. This is in addition to the American River Common Features General Re-Evaluation Report (ARCF GRR) study efforts to quantify the risk of erosion using levee performance curves (probability of failure) and floodplain delineation (consequence) from a levee break. The levee performance curves are summarized in section 5.4 and are fully described in the ARCF GRR Geotechnical Report (Attachment C). The floodplain delineation is described in the ARCF GRR Hydraulic Report (Attachment B).

1.2 Location

The overall study area for the ARCF GRR Study is illustrated on Figure 1-1 and includes the Sacramento River between Verona and the Freeport Bridge and the American River between Nimbus Dam and the Sacramento River confluence.

In the study area there are additional reaches depicted but not highlighted in Figure 1-1 where erosion concerns have been addressed in one of two ways:

1) The following reaches were analyzed for erosion protection as part of the Natomas Post Authorization Chief's Report of December 2010:

- Sacramento River: Left Bank, From the American Confluence up to the Confluence with the Natomas Cross Canal
- Natomas Cross Canal: Left Bank, Entire reach
- Pleasant Grove Creek Canal: Left Bank, Entire reach
- Natomas East Main Drain Canal: Right Bank, Entire reach,

2) The proposed design in the chief's report and subsequent site specific design refinements are assumed to adequately address erosion concerns on these reaches.

The remaining project reaches in the ARCF Study include:

- Natomas East Main Drain Canal: Left Bank, Entire reach
- Arcade Creek, Left and Right Banks, Entire reach
- Dry Creek, Right Bank, Entire reach
- Robla Creek, Left Bank, Entire reach
- Magpie Creek, Left Bank, Entire reach.

These tributary project reaches are significantly influenced by backwater and, therefore, the erosion concerns in these reaches are not considered as critical to address with a separate analysis given the

reduced velocities and erosive forces. In addition, the tributaries on the eastside of Natomas including Dry Creek, Arcade and others do not share the same high risk of erosion in terms of consequence, duration and velocity as on the American and Sacramento Rivers. As discussed in the ARCF Hydraulic Appendix, any features required to address erosion will be part of the site specific design. The cost of these features is likely minimal and will not affect selection of the tentatively selected plan (TSP) nor significantly impact the overall project costs.

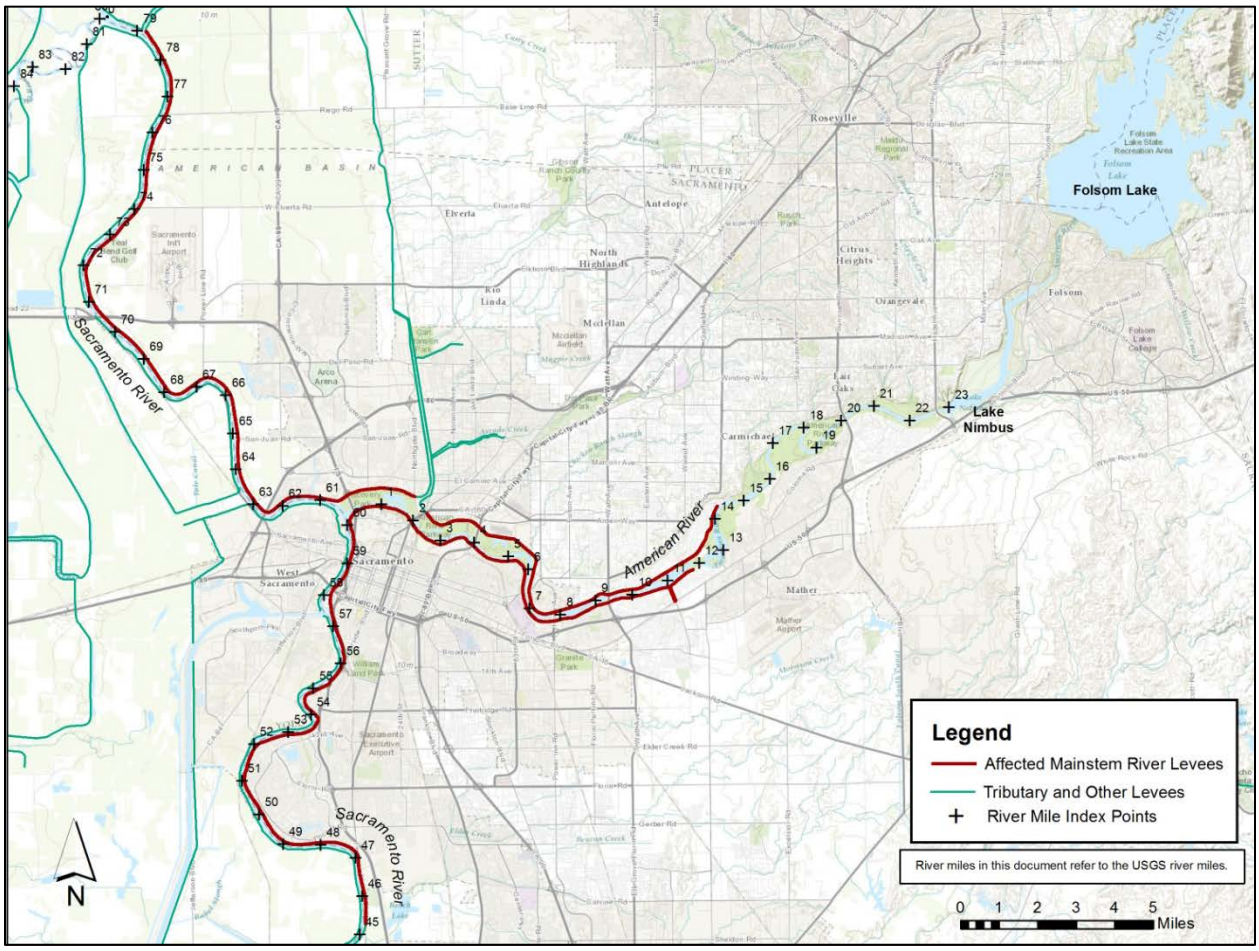

Figure 1-1. ARCF study area and affected mainstem channel levees

The focus areas for this attachment are the leveed reaches of mainstem channels shown in red on Figure 1-1 and specifically include the left levee (i.e. looking downstream) of the Sacramento River and both levees of the American River. The detailed focus area for many of the in depth investigations and analyses is the American River between RM 5 (Paradise Beach) and RM 11 (located above Watt Avenue). The focus areas for the with-project conditions and erosion mitigation features are the American River between RM 0 and 14 and the Sacramento River between the Freeport Bridge (RM 46) and the American River confluence (RM 60.5).

1.3 Background – Lower American River (LAR) Overview

The American River levees were originally intended to convey a release from Folsom Dam of 115,000 cubic feet per second (cfs). During several events since the construction of Folsom Dam, flows have equaled or exceeded the design capacity and caused significant erosion distress. All four significant

flood events since the completion of the Federal flood control system in the mid 1950s (1955, 1966, 1986, and 1997) caused considerable damage to the American River levee system due to erosion. The 1986 event had an imminent threat of levee failure. In addition, all four events required extensive repair after the event so the American River levee system could perform for the next major event. The objective release from Folsom Dam is currently under review as part of the Folsom Dam Reoperations Study and the Joint Federal Project is currently constructing improvements to the dam for a release of 160,000 cfs. Based on past performance and recent investigations, erosion is a serious threat to the American River levees that must be addressed.

Figure 1-2 is a typical view of the leveed reach of the Lower American River. This photo is looking upstream in the vicinity of the Guy West pedestrian bridge (RM 7). Figure 1-3 shows a view of an erosion site on the left bank near the lower end of the American River at RM 0.3 in 2008. This site is located just upstream from the Interstate 5 crossing (bridge seen in the background) and is affected by backwater from the Sacramento River.

A recent study (2010) was completed by Ayres Associates for the USACE that further assessed channel stability of the American River. The report included recommendations of short term and long term measures needed to safely convey a discharge (river flow) of 160,000 cfs from Folsom Dam through the Lower American River (LAR), including revetment and grade control.

Following the 2010 report a panel of experts in engineering fields associated with erosion was convened by West Consultants for the USACE due to questions and uncertainties regarding previous design recommendations and the environmental sensitivity of doing extensive erosion work on the American River including grade control. The panel was tasked to consider the adequacy of studies conducted to date, provide recommendations of additional study as appropriate, or recommend moving forward to basis of design and construction. Conclusions and recommendations from this panel led the USACE to pursue additional studies to address if the channel had reached equilibrium in terms of aggradation/degradation, additional refinements to the sediment transport model, further characterization of the geotechnical and geologic characteristics of the watershed, and refinement to the procedure for prioritization of repair sites and the development of erosion protection alternatives. There are a number of past studies that help with understanding erosion issues on the American River. These are summarized below in Section 1.7.

As part of the expanded erosion study, the USACE Project Delivery Team (PDT) found that insufficient geotechnical data were available to adequately support existing and proposed channel stability analysis and potential design recommendations. Specifically, the geotechnical and geologic study focused on characterization of soil properties through exploration and testing, geologic mapping, and 3-dimensional modeling of the subsurface stratigraphy. Additional geotechnical data were generated to characterize the material comprising the existing channel bed between the right and left bank levees of the LAR between River Miles (RM) 5.0 and 11.0. Emphasis was placed on the study reach between RM 5.0 and 11.0 due to substantial increases in velocities and applied shear stresses caused by changes in river geometry, including a narrowing of the channel and two sharp bends (downstream of Watt Avenue and near Paradise Beach, see Figure 1-1).

Figure 1-2. View of Lower American River (looking upstream) at Guy West pedestrian bridge

Figure 1-3. Erosion site on left bank near LAR RM 0.3 (2008)

1.4 Background - Sacramento River Overview

The portion of the Sacramento River in this study has two distinct reaches. The Sacramento River was split at the confluence with the American River for the purposes of this discussion because the conditions of the river change at this location.

Sacramento River – Verona to American River Confluence (RM 79 to RM 61). This reach of the Sacramento River has the levees close to the river and contains the Sacramento Weir which diverts flow into the bypass system. This reach was intentionally designed with the levees close to the banks to help move some of the bed load and debris that remained from the days of hydraulic mining. In addition, USACE was responsible for keeping the river navigable up to the city of Colusa. As a result of this design, much of the reach is protected with rock, especially the outsides of bends. The majority of the rock in this reach consists of cobbles placed prior to the 1960s and some areas with more recent quarry stone. The cobble sites are reaching the end of their design life. Many of the levees are constructed of dredged soils from the bottom of the channel. This reach is also notable because it contains numerous private residences and commercial structures including boat docks on the waterside of the levee. Figure 1-4 shows a section of this reach of the Sacramento River.

Figure 1-4. Typical View of the Sacramento River - Verona to American River Confluence (RM 79 to RM 61)

Sacramento River – Sacramento River South, American River Confluence to Freeport (RM 61 to RM 45). This section of the Sacramento River has tight levees and is tidally influenced. The location of the channel has been relatively stable for the past 150 years (although local scour and erosion can still be an issue). A large percentage of this reach has already been armored with riprap. This area has heavy wave action from recreational boats and wind, and the banks are heavily used by the general public in contrast to the reach discussed above where the banks are heavily occupied by private residences and commercial structures that limits public access along the levees. The general public use in this reach often creates local erosion by walking directly on the levee and banks. Many of the levees are constructed of dredged soils from the bottom of the channel. This reach does not have significant waterside structures such as private and commercial buildings, but has some sections of heavy vegetation and boat docks. Figure 1-5 shows a section of the Sacramento River South study area. The causes of erosion in this reach are boat wake, wind-wave, mass failure, fluvial processes, and public use.

Figure 1-5. Typical View of the Sacramento River Sacramento River South, American River Confluence to Freeport (RM 61 to RM 45)

1.5 Historical Performance

1.5.1 American River

The history of the American River has been significantly impacted by human activity. During the California Gold Rush of 1849 to 1864, the foothills upstream of the river were mined hydraulically, resulting in millions of cubic yards of mining debris being sent down the American River. The hydraulic mining caused approximately 15 to 20 ft of aggradation in the project reach. Dredge mining for gold caused alignment changes to the floodplain and in-channel bars, and significantly altered the

topography. Subsequent sand and gravel mining in the river and floodplain resulted in the development of split flow reaches. In 1864, a rechanneling project moved the downstream end of the American River to its present location from an alignment which ran roughly through the Union Pacific rail yard. In the 1950's, the construction of Folsom Dam (RM 30) and Nimbus Dam (RM 23) essentially eliminated the sediment supply from the upper watershed, resulting in the lower reaches of the LAR to become sediment starved causing a lowering of the river channel invert.

Construction of the south levee of the American River started around 1850 and was completed in the 1910's. Construction of the north levee of the American River, located between the Sacramento River and about RM 5 (near Cal Expo), occurred in the 1910's. Construction of the remainder of the north levee, upstream of Cal Expo extending to RM 14, occurred between 1955 and 1957.

In 1955, the American River experienced the flood of record. This is an important flood event in that of the 1 million acre-feet reservoir at Folsom Dam(only 400,000 acre feet is allocated to flood control) was filled in a single event. The peak release from this flood event was 115,000 cfs. Soon after this flood event, the flood magnitude was factored into the hydrology for Folsom Dam operations, which led to the level of protection provided by Folsom Dam being considerably lowered.

Sacramento experienced significant flood events again in 1964, 1986, and 1997. The 1964 flood event was the first time the complete American River levee system was tested with a flow of 115,000 cfs. The 1964 flood event showed considerable stress on the levee system for a flow of 115,000 cfs. An emergency flood-fight along the left bank of the American River near H Street was required to pass the flood event.

The 1986 flood event is significant in that it required a peak release from Folsom Dam of 130,000 cfs in order to avoid a dam failure. The peak flow was passed without a levee failure, but two locations were in the process of failing as flows were receding. Figure 1-6 shows one of the erosion sites located just upstream of the Capital City Freeway. Had the discharge been sustained longer, the levee would have likely failed from erosion.

In 1997, the Sacramento and San Joaquin River systems experienced record flooding and a number of levee breaks. However, in the American River watershed, Folsom Lake experienced a peak inflow of 255,000 cfs and was able to control it to the objective release of 115,000 cfs down the American River, with 28 percent of the flood management storage available at the peak of the storm. Nonetheless, significant erosion occurred at five sites along the American River which required immediate repair following the flood event. These repairs were accomplished under the SRBPP.

All four significant flood events since completion of the federal flood control system in the mid 1950's (1955, 1964, 1986, and 1997) caused considerable damage to the levee system because of erosion. And, all four events required extensive repair after the event so the system was ready for the next major flood event. In addition, erosion also occurred during a flood event in 2006.

Outflow hydrographs (from Folsom Dam) for these flood events are depicted in Figure 1-7 and the approximate durations at various peak flows are listed in Table 1-1.

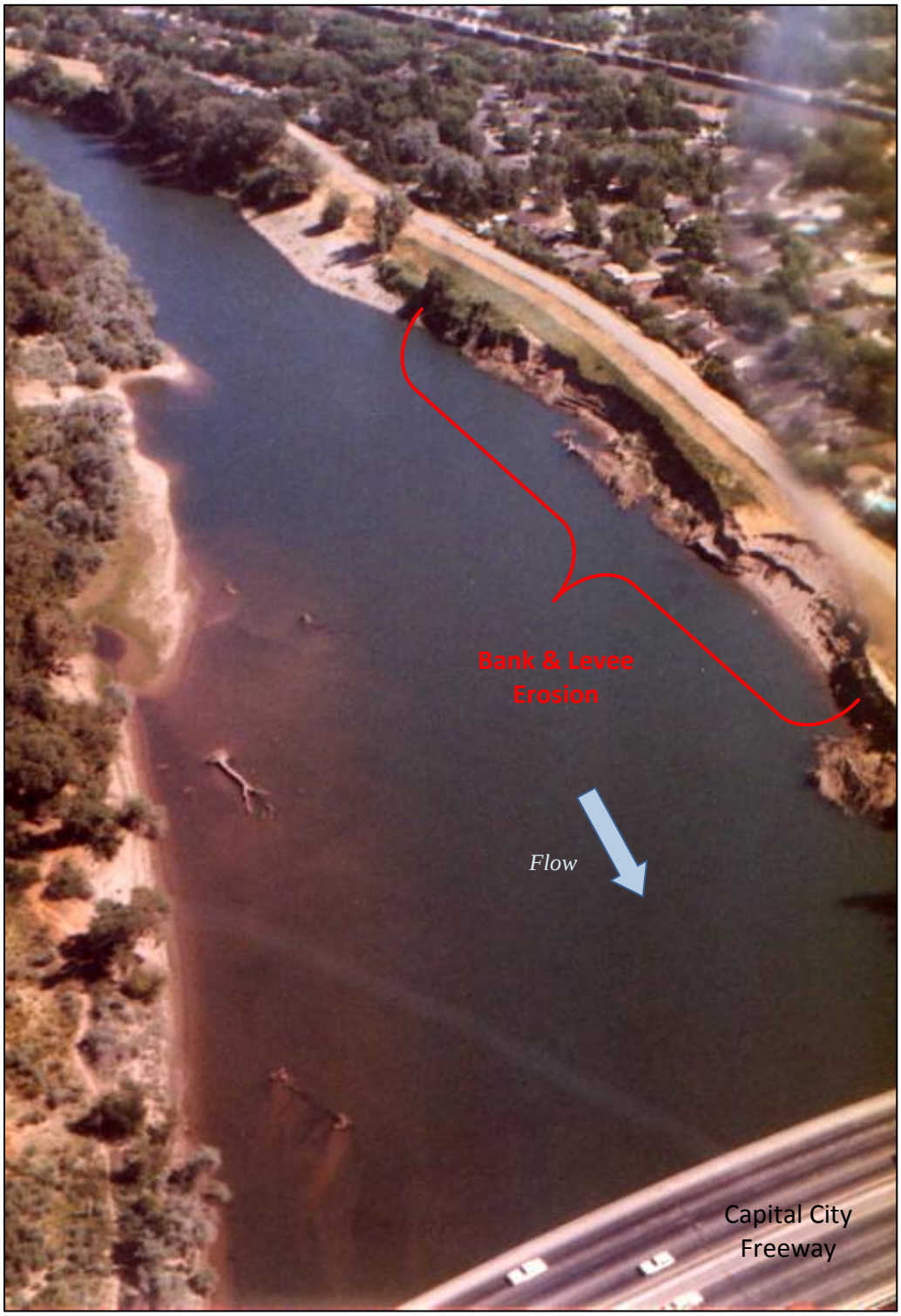

Figure 1-6. Levee erosion from the 1986 flood event (130,000 cfs) on the American River left bank just upstream of the Capital City Freeway (Business 80)

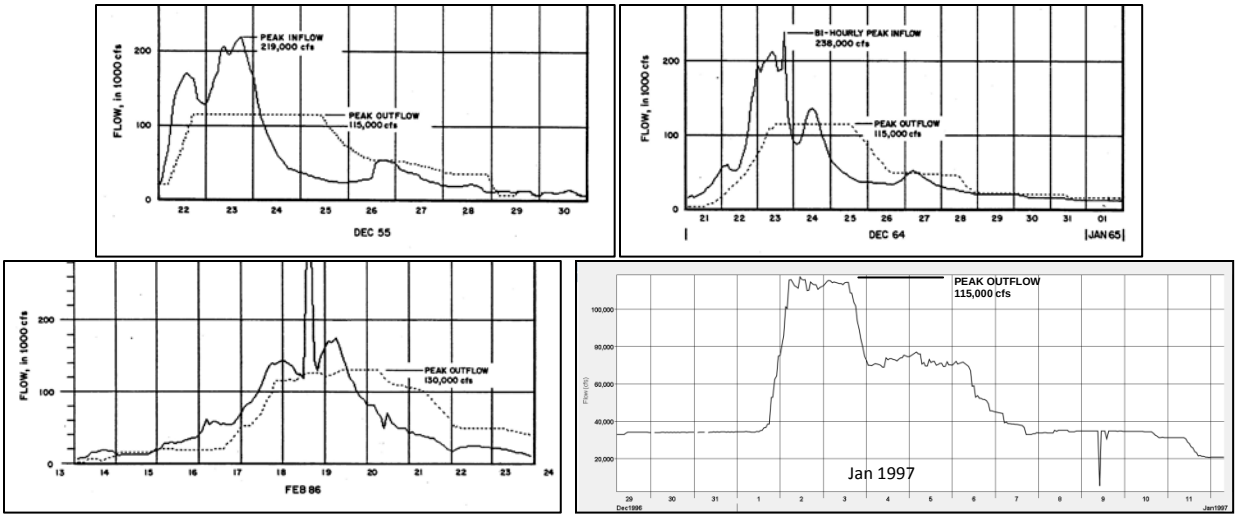

Figure 1-7. Historic outflow hydrographs from Folsom Dam[1]

Table 1-1. Duration of significant historic peak flood events

Flood Event	Approximate Duration (hrs)		
	90,000 cfs	115,000 cfs	> 115,000 cfs
1955	74	64	---
1964	68	48	---
1986	94	64	52
1997	42	33	---

1.5.2 Sacramento River

The history of the Sacramento River has been greatly impacted by the influx of people into the Central Valley. Prior to 1800's the Sacramento River had insufficient capacity to carry the large winter and spring flows, resulting in floodplains that extended for miles beyond the channel banks. The overbank velocities were low and much of the sediment eroded from the mountain and foothill areas would drop out, resulting in floodplain deposition (vertical accretion) and the development of natural levees through the rapid deposition of coarse particles as flow velocities decreased. Hydraulic mining, particularly in the Yuba and Bear Rivers resulted in an excess of sediment load being washed into the Sacramento River and resulted in reduced channel flow and increased flooding in the low elevation areas.

In addition to the hydraulic mining, increased agriculture in the area resulted in land owners building low levees along the river to protect their cultivated fields. The levees were a piecemeal fashion, without coordination between landowners, and led to competition between landowners to continually raise and strengthen their section of the levee to induce flooding on someone else's land.

[1] 1955, 1964, & 1986 events from USACE 1987; the hydrograph for the 1997 event is from CDEC (FOL - Reservoir Outflow)

During the time of hydraulic mining and agricultural development (1850 to 1900), the Sacramento River saw 13 large flood events. The flood of 1862 flooded the city of Sacramento and resulted in loss of life and destruction of property. The levees protecting the city of Sacramento were subsequently raised following this flood. The floods of 1881 resulted in numerous levee breaks on both sides of the Sacramento River, downstream of the city of Sacramento. After the 1800's, significant floods occurred in 1904, 1907, 1909, and 1928 on the Sacramento River.

Following the floods of the 1800's and early 1900's, early planning for the modern Sacramento River flood protection system started and consisted of dams, bypasses, channel widening and deepening, and levee enlargement. Construction of the Sacramento River Flood Control Project began in 1918 and was completed in 1953. The major features that were constructed included levees along the Sacramento River channel, leveed bypasses, and weirs.

The levees along the Sacramento River south of the confluence with the American River were constructed by a private mining and dredging company with the purpose of reclaiming and selling thousands of acres of farmland. The levees were constructed using large "clam shell" dredging machines. The work began in 1912 and was completed by the end of 1915. Based on typical construction schematics shown on basin-wide maps and historical literature, the levees along the Sacramento River were constructed in the following manner:

- A dragline was used to excavate a trench about 6 to 12 feet deep along the centerline of the levee alignment. The trench bottom width ranged from about 12 to 28 feet. The excavated material was deposited along both sides of the trench forming two small containment dikes.

- Hydraulic dredging operations placed material from the adjacent Sacramento River bottom into the excavation area between the dikes. This material consisted predominately of sands.

- The final levee configuration was achieved by covering the dredged sand with the adjacent dike materials. These materials consisted predominately of silt, clay, and fine sand.

It should be noted that because of the construction history outlined above, the upper portion of the semi-pervious blanket beneath the center of the levee has been removed and commonly replaced with sand. Typically, the sand core extends to a greater depth beneath the center of the levee than beneath either of the flanks or the surrounding ground. Most of the levee material was hydraulically dredged from the Sacramento River and piled or pushed into place with no mechanical compaction. Some mechanical shaping of the upper and outer portions of the sand core likely occurred during establishment of the general levee geometry.

The levees along the Sacramento River south of the confluence with the American River were constructed by local interests using clamshell dredges excavating material from the Sacramento River in the early 1900's. This method of construction usually resulted in a levee constructed on the channel banks with loose, sandy fill material that is deepest below the center of the levee. The materials within the levee embankment are predominantly sands, silty sands, and cohesionless materials. Since the construction of the original levee embankment in the early 1900's the levee has been remediated and improved several times. Levee remediation and improvements have consisted of embankment reconstruction and or enlargement, floodwalls, waterside rock slope protection, shallow through seepage cutoff wall, deep underseepage cutoff walls, seepage berms, and relief wells.

The 1955 flood was the first test of the new Sacramento River Flood Protection system. At the Sacramento Weir, 30 gates were opened with the peak flow reaching 48,000 cfs sent into the bypass. The peak flow in the Sacramento River at I Street was about 95,000 cfs. During the 1964 flood, the peak flow on the Sacramento River at I Street was about 100,000 cfs, just below the channel capacity of the reach. The flood of 1969 was largely controlled by the reservoirs, flood channels, and bypasses. The flood of 1974 saw a peak of 95,000 cfs at the I Street gage; the Sacramento Weir gates were not opened.

In 1960, Congress authorized the Sacramento River Bank Protection Project for the construction of bank erosion control works and setback levees within the limits of the existing levee system. This project is intended to maintain the integrity of the levee system to continue the degree of protection for which it was designed.

The flood of 1986 had a peak flow of 117,000 cfs at the Freeport gage, just south of the city of Sacramento. The levees on the Sacramento River were severely stressed from high water and seepage. The levees near the Garden Highway required extensive repairs during the flood and nearly failed. The north bank along Arcade Creek was overtopped and 500 homes were inundated.

Since the completion of the Sacramento River Flood Control Project, significant floods have caused considerable erosion related damage to the levee system. Erosion in the Sacramento River has even occurred during lower flow events, as documented by the Sacramento River Bank Protection Project. Numerous emergency bank repairs and repairs done by SRBPP (over 800,000 linear feet) have been constructed in the last 50 years. Erosion continues along the Sacramento River banks and levees and there are currently numerous sites that are in need of repair.

1.6 Monitoring by Corps and CVFPB

USACE and the Central Valley Flood Protection Board (CVFPB) have an ongoing program that identifies critical erosion sites and monitors erosion sites that may become critical. No critical erosion sites were identified during the 2012 reconnaissance by USACE; however, multiple erosion sites were identified on the left bank of the Sacramento River between RM 50.3 to 58.5 (corresponding to approximately MA9 LM 6.0 to COS LM 1.4). Based on the report, some of these sites currently have scattered rock, cobbles or quarry stone at the levee toe and have exhibited no change relative to previous erosion surveys, other than minor new slumping. The erosion mechanisms identified at these sites include wavewash, eddy scour, tree pop-outs, fluvial and whole bank failure.

Two erosion sites were also identified at RM 56.6 and RM 58.5 (corresponding to approximately COS LM 3.5 to LM 1.4), with the erosion mechanisms including fluvial and whole bank failure. These sites reportedly have concrete rubble (does not meet USCAC standards) on the bank and at the toe that is in poor condition; no significant changes in condition have been observed between annual inspections. One erosion site at RM 46.7 (corresponding to MA9 LM 10.0) was recently repaired by the State.

1.7 Stability Investigations

There are a number of studies, investigations, research efforts, and assemblages of expert panels which were focused on quantifying erosion on the Lower American River. These efforts are summarized below. Additional in-depth documentation of these studies is presented in Section 2.3 of the report titled "American River Common Features Project, American River Erosion Advisory Panel Workshop, November 29, 2011 – December 2, 2011, DRAFT Summary of Presentation and Conclusions" by the Sacramento District, U.S. Army Corps of Engineers, dated September 2012.

1.7.1 Prior Studies, Investigations, & Research Efforts

1.7.1.1 Geomorphic Analysis and Bank Protection Alternatives (Water Engineering and Technology, Inc., June 1991)

This study looked at the Sacramento and American Rivers as well as a number of other reaches. The report presents the results of a geomorphic study that was conducted "to determine the dynamics of the studied rivers and sloughs with the objective of developing a geomorphically-based framework upon which bank protection methods could be evaluated and overall protection strategies formulated." The study discussed Lower American River channel aggradation that occurred as a result of hydraulic mining, then degradation that occurred after mining ceased and then much more degradation that has occurred since completion of Folsom Dam in the mid 1950s. The channel incision has slowed down and even stopped in some locations as it reached Pleistocene-age rock outcrops. The study states the river is "sediment hungry" as flow leaves Folsom Dam. The channel degradation creates concerns for both levees and bridges. The levees are at a higher risk of toe scour and the several bridge footings have been exposed as a result of the channel incision.

It is important to note that at the time this report was written, many of the seepage and stability mitigation features had not been constructed along the LAR. In addition, the thinking at that time was that an Auburn Dam would eventually be constructed and that Folsom Dam would limit outflows to 115,000 cfs for events up to the 0.25% (1/400) ACE event.

1.7.1.2 American and Sacramento River, California Project- Geomorphic, Sediment Engineering, and Channel Stability Analyses (Ayres Associates, December 1997)

The purpose of this study was to examine the effects of a potential dry dam (Auburn Dam) including potential modifications to the existing flood control levees along the Lower American River. This included HEC-2 (hydraulic model) and HEC-6 (sediment model) modeling. Output from the HEC-2 model was used to evaluate channel capacity, bed shear stress, work done on the channel banks, and local scour at bridge crossings. Sediment routing was performed for five different scenarios, all using the 100-year flood event. Predicted bed elevation changes within the lower 13 miles of the LAR were all less than 1 foot (either aggradation or degradation). The report concluded that vertical stability along the LAR is not a significant issue. An incipient motion analysis indicated that the bed material is generally immobile at discharges less than 50,000 cfs. A quantitative analysis of the relative effects of the various design scenarios on lateral stability of the channel was conducted using the results from the HEC-2 model and a "weighted average work index" (velocity * bank shear stress * time for various frequency events multiplied by the probability of that event in a year and summed over all events). Rock-based revetments and dikes were recommended as the only forms of bank protection that will insure the integrity of the levees at the majority of the erosion locations.

1.7.1.3 Two-Dimensional Modeling and Analysis of Spawning Bed Mobilization Lower American River (Ayres Associates, October 2001)

The purpose of this report was to examine the possibility of spawning bed mobilization at different flow values on the LAR. A two dimensional model was developed to examine the velocities of different potential flow scenarios. The largest tested flow for the study was 115,000 cfs. The study confirmed the 50,000 cfs as the break point for incipient motion as determined in the previous report. The results indicate that there will be some movement of the spawning material especially above Goethe Park in the upper part of the study reach. The movement of the material largely depends on how long the high flows last. The model is a good indicator of whether movement will occur, but it does not show how far the motion will carry the material or where it is likely to end up.

1.7.1.4 Lower American River, Erosion Susceptibility Analysis For infrequent Flood Events (Ayres Associates, July 2004)

The purpose of this report was to determine the potential for erosion of grass-lined levees and overbanks when flows reached the design flow of 145,000 cfs. This study concluded that the river is degradational under present operating conditions as confirmed by geomorphic principles, by the thalweg profile, and by the field review.

It also concluded that since the channel bed is comprised of erosion resistant material in many locations, the river will tend to erode laterally to satisfy the need for sediment. A field review verified riverbank erosion is occurring even at flows of only 7,000 cfs. The bare soil on these eroded channel banks is increasingly susceptible to future erosion even at lower velocities. The report states a levee failure is possible for at least one location for 145,000 cfs. Additionally, other discharges ranging from 115,000 to 160,000 cfs were investigated and documented in this report.

1.7.1.5 Channel Stability Analysis of the Lower American River, Folsom Dam to the Confluence Sacramento, California (Ayres Associates, January 2010)

The purpose of this study was to assess the long term stability of the LAR for flows up to 160,000 cfs and to identify short and long term measures required to ensure safe and reliable conveyance of these flood flows. This study included a bathymetric survey of the LAR from Nimbus Dam to the confluence with the Sacramento River. The data collection for this survey was completed in August 2006. Ayres performed a field review of the reach (RM 0 to RM 23) of the LAR below Nimbus Dam. Riverbed and riverbank sampling was done for the entire reach and erosion and armored sites were inventoried through the project levee reach (RM 0 to RM 14). The current methods of bank protection include revetments, river cobble revetments, concrete walls, gabions, stone dikes, and concrete rubble. The four primary modes of channel response to the current conditions are channel degradation, increased sinuosity, channel widening, and bed material coarsening. Potential solutions include: revetment, vegetation, grade control, and introducing sediment supply. The only place the HEC-6T model (MBH, 2002) predicted degradation was at Guy West Bridge. In the other reaches, the lateral movement or widening of the channel is expected to occur as the river looks to fill its sediment capacity.

Although each expert provided recommendations that were summarized in the previous chapter of this report, several of the common or related recommendations have been summarized in this section. The consensus was that the current levee system most likely requires repairs to pass the 160,000 cfs release.

The majority of the experts agreed that the location and prioritization of the repairs have not been adequately defined, leading to some of the following observations and recommendations. The status of actions taken or not taken on the recommendations are noted in parentheses below each recommendation:

- Field observations show the bed material is coarsening in the upstream reaches. The coarsening of bed material is not obvious downstream of RM 10, but the pattern of propagation downstream is a logical conclusion.

- The right overbank area between RM 8 and RM 9.5 is also composed of mostly sand and will erode in areas were no armor is available and also where armor is in poor condition. The levee is much closer to the existing riverbank and could be threatened in a single high flow event.

- The river bottom at Guy West Bridge is scoured clean of alluvium. The exposed material in the riverbed consists of clay and has been found to be erodible.

- Based on a discharge of 160,000 cfs and corresponding erosion rates, there is approximately 10 feet of vertical erosion potential into the clay material at Guy West Bridge. The degradation is likely to propagate upstream through the abandoned sewer line and past the Fairbairn water intake structure.

- The river invert immediately upstream of Watt Avenue is also composed of clay. However, river thalweg plots show no change in elevation at that location since 1955.

- The two highest priorities for preventative maintenance at this point in time are to armor the bed at Guy West Bridge and provide bank protection at select locations on the right bank between Howe and Watt.

1.7.2 Expert Panel Consultations and Recent Activities

A series of expert panels were convened on three occasions: 1) October 6-8 & November 16, 2010, 2) November 29 – December 2, 2011, and 3) October 16-17, 2012. Key recommendations and concerns from these panels led to additional investigations and analyses which complimented the studies which were already in progress.

1.7.2.1 Lower American River, Panel of Experts Findings Report (West Consultants, December 2010). [Panel meeting from October 6-8 & November 16, 2010]

A panel of experts was convened to consider the adequacy of what has been done to date and to provide recommendations of additional study as appropriate or to recommend studies completed to date are adequate and can be used as a basis for design and construction. The main conclusions and recommendations include:

- With relatively little effort the existing HEC-6T sediment transport model can be modified to better reflect bed sediment conditions. Results of the model may shed light on vertical stability of the system and could also be used to examine “what-if” scenarios (e.g., stable points such as the gravel plug or clay outcrops are removed). (Status: HEC-6T was modified to reflect improved

information on bed sediment conditions. However, what-if scenarios have not been conducted to date.)

- The horizontal and vertical location of the scour resistant clay should be clearly identified and mapped as these materials can impact both vertical and lateral erosion potential of the river. Existing geophysical studies may help with this task and should be identified (see recommendation on consolidating data below). (Status: An initial phase of geologic mapping and 3-dimensional stratigraphic modeling has been completed using existing data as well as data generated for the ARCF GRR study. The level of detail included in the current mapping and modeling is sufficient to support planning level recommendations and conclusions but further refinement could be of benefit depending on the level of certainty required in understanding the locations of this geologic unit).

- Many of the experts viewed the results of the EFA erosion testing program with some doubt or skepticism which points to the need for better characterization of the erodibility of the resistant materials. (Status: Additional EFA as well as JET testing was completed on many samples collected on the channel banks and riverbed. There is a need to study those results, place them in a geologic context, calibrate them based on judgment and any potential scaling effects, and provide guidance on incorporating them into the hydraulic models. This has not been completed).

- Levee slopes previously treated with mixtures of soil and rock be assessed to determine if they meet USACE levee criteria for erosion. Non-standard designs need to be backed up with research or defendable scientific analysis. (Status: The tentatively selected plan assumes that recently constructed bank protection (e.g. “modern” bank protection) is adequately designed for 160,000 cfs. However, this will need to be confirmed in the future, such as during selecting and prioritizing sites).

- Many of the experts agreed that existing data is scattered may not be readily available to professionals studying this reach of river. A centralized database should be created to make past studies accessible. (Status: Much of the data has been centralized on the network).

- Monitoring should continue and possibly be enhanced or extended by various methods. (This has not been completed for this project during the feasibility phase of the study, but should be a component of future efforts).

- Systematic and justifiable criteria for site stabilization will be useful not only for prioritizing work but also to rationalize projects to the public and decision makers. (Status: Criteria for site stabilization and prioritization will need to be completed in the future).

- Written opinions and discussion touched upon the confusing nature and different methodologies employed in gathering bed profiles. Past profiles should be verified and future profiles collected in a consistent and systematic manner. (Status: No plan in place for collecting regular profiles in a consistent manner. This should be addressed as part of future systematic monitoring plan).

1.7.2.2 American River Common Features Project, American River Erosion Advisory Panel Workshop (report dated September 2012). [Panel meeting from November 29 – December 2, 2011]

A new panel of advisors was compiled to evaluate the then current course of study. Some of the recommendations from this panel include:

- The upstream extent of the study area currently is about one mile above Watt Avenue. This boundary should be extended upstream. The purpose of this is that from a sediment transport standpoint, there is still significant quantities of material above the leveed reach of the American River that can be transported through the leveed reach, and this needs to be understand because it will influence how rapidly erosion will occur in the leveed reach. (Status: The study was extended upstream but with lower level of detail. Further investigation would be needed to bring this section of the study up to the same level of detail.)

- The downstream extent of the study area currently is just downstream of H Street/Fair Oaks Boulevard. This boundary should be extended downstream. The purpose of this is that significant erosion has not only occurred in the current study reach but also downstream of here, most notably near the Capital City Freeway. (Status: The study was extended downstream but with lower level of detail. Further investigation would be needed to bring this section of the study up to the same level of detail.)

- There is a considerable amount of data available with regards to historic borings and characterizations of materials. A few examples of this include drilling logs for water wells and groundwater models. Research should occur to identify this data and it should be incorporated into the modeling efforts. (Status: This comment was in regard to including the regional geologic model into a more detailed site specific study and to make sure the study is not isolated from the larger regional context. This was addressed through an expansion to the high and low resolution study areas.)

- The extent of the geophysical investigation should be expanded. This expansion should include extending the overall study area in the upstream and downstream direction but also should include collecting cross sections at various locations; all of the geophysical lines collected at the time of the panel have been profiles (running parallel with the river) as opposed to cross sections (running perpendicular to the river). Additionally, geophysics should be validated by comparison to bore hole data. (Status: This has not been completed to date. However, it is not needed for a feasibility decision at this time. However, additional geophysics to refine the estimate of where highly erodible materials are located in profile and cross-section could be helpful information in the future if more refined modeling is desired such as to inform phasing construction using relative risk.)

- Modeling, most specifically the HEC-6T model is not calibrated. To the extent that any modeling can be calibrated, it should be. (Status: Model was verified using available gage data.)

- Soil filled rock mixtures used for bank protection should be closely monitored during and after flood events to assure that their performance meets USACE standards. (Status: At this time, the

use of soil filled rock is not specified as part of the tentatively selected plan. Monitored should be considered moving forward.)

- Existing modern bank protection sites need to be analyzed to assure they can withstand a flow of 160,000 cfs. (Note: This recommendation has not been followed to date. The feasibility study assumes that recent erosion protection was designed and constructed adequately to withstand this discharge without the need for additional analysis beyond what was conducted for the design. It has not been verified that each site was designed for 160,000 cfs.)

- Based on input presented to the panel, there is a high degree of variability in the bed materials. Interpretations made of connecting the dots between borings could be erroneous. More borings should be collected to assure continuity of various layers. Additionally, this refinement in detail needs to be accounted for in the stratigraphic model. (Status: This is true of any such geotechnical model. Additional investigation is deferred to future analysis and design efforts).

- Characterization of materials is primarily being completed by the EFA and JET testing. Other methods to characterize engineering properties of geologic materials should be utilized. An example of one would be the NRCS soil/rock erosion model. Additionally, lab test results needs to be correlated to behavior in the field. (Status: The method was not considered practical for use in the feasibility study and therefore was not conducted).

- Because of the large extent of bankline/levee requiring armoring, a site prioritization method needs to be developed so that the sites being the most urgent will be addressed first when construction begins. (Note: This recommendation to develop this site prioritization method has not been completed at this time and will need to be developed in the future.)

1.7.2.3 American River Common Features Project, American River Erosion Analysis, Technical Working Group Meeting (Final Meeting Minutes dated December 2012). [Panel meeting from October 16-17, 2012]

The previous advisory panel reconvened as a follow-on working group meeting to the November-December 2011 workshop. The following recommendations were given as a summary of the findings of the expert panel:

- Need to combine the results of the geophysical data into the stratigraphic mapping to develop a more complete picture. (Status: This was performed to the extent possible given the restrictions of the data and various software programs currently available.)

- Collect additional borings downstream of Paradise Beach down to the Business 80 crossing. Additionally, there is concern regarding erosion and scour in the downstream end of the river for releases made at Folsom for times when the Sacramento River is at a low stage. (This is anticipated to occur during the design and construction phase of the project).

- Conduct an analysis of how the dredge tailings located near RM's 16 – 19.2 act as a sediment supply to the river. (Status: This has been completed and is discussed later in this report).

- Results of the geophysical data need to be combined into the stratigraphic mapping to develop a more complete picture. (Status: This was performed to the extent possible given the restrictions of the data and various software programs currently available.)

- Collect additional borings downstream of Paradise Beach down to the Business 80 crossing. Additionally, there is concern regarding erosion and scour in the downstream end of the river for releases made at Folsom for times when the Sacramento River is at a low stage. (Status: Additional borings are deferred to future analysis and design efforts. No specific action taken to address erosion and scour in the Lower American River when the Sacramento is at a relatively low stage).

- Conduct an analysis of how the dredge tailings located near RM's 16 – 19.2 act as a sediment supply to the river. (Status: This is complete).

Many of the expert and/or advisory panel recommendations were addressed by work performed by the Sacramento District and/or by the District's contractors, or anticipated to be performed as part of the design and construction phases of the project. Most of these recommendations related to geotechnical, geologic, and/or geophysical investigations (refer to Section 1.8). Some of the recommendations were not addressed due to budget and schedule considerations. Some of these recommendations that were not completed are noted above in parentheses. The District envisions that, as appropriate, the remaining work efforts will be addressed in future studies. For example, there is currently an ongoing channel widening threshold analysis to support changing operations at Folsom Dam.

1.8 Geologic and Geotechnical Investigations and Analyses – Lower American River

1.8.1 Soil Boring and Cone Penetration Test Investigations

Subsurface exploration, soil borings and Cone Penetration Tests (CPT), and subsequent laboratory testing were performed in support of the various geologic, geophysical, and geotechnical investigations, mapping, modeling, and analyses associated with studying erosion on the LAR. The subsurface exploration was led by two teams, one using Sacramento District In-House resources and one led by URS Corporation (URS).

The Sacramento District In-House subsurface investigation included drilling a total of 11 vertical soil borings within the American River channel, 29 vertical soil borings on the levee crest and waterside channel bench, and 15 cone penetrometer tests (CPTs) on the waterside channel bench. The URS subsurface investigation included a total of 44 borings, with 24 primary sonic borings and 20 companion air rotary casing hammer (ARCH) borings along the levee crest and waterside bench.

1.8.2 Erosion Rate Testing

The Engineer Research and Development Center (ERDC), Geotechnical Structures Lab (GSL) and Texas A&M University (TAMU) Department of Civil Engineering further assed the erosion resistance of the LAR by performing Jet Erosion Tests (JET) and Erosion Function Apparatus (EFA) testing on undisturbed samples of cohesive materials located near the bed elevation of the LAR (URS, January 2012; USACE-ERDC, May 2013; USACE, February 2012; USACE, June 2013). The tests resulted in determining values of Erodibility Coefficient, K_d, and Critical Stress, τ_C, of the samples. A total of 81 JET tests were performed on 38 samples and 46 EFA tests on 46 samples.

1.8.3 Geophysical Investigations

To characterize the extent and thickness of lithologic units that may have differing scour potential, the United States Geological Survey (USGS) has performed several geoelectrical surveys of the LAR channel and floodplain between RM 5.5 and RM 11.0. Preceding reports document the methods and results of each survey (Asch et al, 2007; Ball and Teeple, 2012; Powers and Burton, 2012). The combined results of these surveys are released in the subject report as digital data in a three-dimensional (3-D) framework that allows geospatial comparison between the geophysical results and available geotechnical and lithologic data. The data resulting from these surveys have been compiled into similar database formats and converted to uniform geospatial datums and projections. These data have been visualized in a digital three-dimensional framework project that can be viewed using freely available software, allowing a comprehensive analysis of the resistivity structure underlying the LAR corridor and assisting in levee system management.

Traditionally, exploration of lithologic and geotechnical properties is accomplished through borehole drilling, where subsurface materials can be directly observed, described, and tested. Extensive drilling has been conducted on the LAR corridor, resulting in high vertical resolution datasets describing the lithology and stiffness of the sediments. While these types of data are invaluable, their inherently one-dimensional nature makes upscaling to a more manageable regional interpretation difficult. Surface geophysical data can provide supporting information about the variability of subsurface physical properties that may be correlated to changes in lithology or scour potential. While borings provide high-resolution data about the vertical distribution of properties, surface geophysical data can provide high-resolution supplemental data about the lateral variations in physical earth properties. Geoelectrical data, in particular, measure the electrical resistivity of the subsurface. The electrical resistivity of a given material is controlled primarily by the water content and quality, and also by the presence of clays or other conductive minerals. Changes in resistivity structure therefore reflect changes in porosity/compaction, lithologic texture, degree of saturation, and groundwater salinity. Geoelectrical methods also facilitate wide-spread data collection while minimizing potential noise presented by the urban environment, something that typically more strongly affects seismic and electromagnetic methods.

1.8.4 Stratigraphic and Geomorphic Mapping

Fugro Consultants developed reconnaissance and detailed surficial geologic maps of the LAR study area and developed conceptual geomorphic and stratigraphic model with the primary purpose of better understanding the stratigraphy exposed in the channel banks and bed of the LAR. The stratigraphic and geomorphic mapping effort was undertaken in direct response to concerns raised in the Lower American River, Panel of Experts Findings Report (West Consultants, December 2010) in regards to location and extents of the erosion resistant unit and better organizing existing geotechnical and geologic data.

Two levels of investigation were performed: (1) detailed mapping (1:2,400 scale [1 inch = 200 feet]) and analysis of the geologic deposits between the levees from RM 5.0 to 11.0, and (2) development of 1:12,000 [1 inch = 1,000 feet] reconnaissance mapping along the channel corridor between RM 0.0 to 5.5 and RM 11.0 to 22.4. The mapping synthesized existing surface and subsurface data including geomorphic/geologic maps, geophysical data, aerial photographs (both historic and recent), and boring logs, to augment the new field mapping and to aid in the interpretation of deposits and the development of the map.

Fieldwork included reconnaissance of the levees, banks, and river channel to map the riverbed and bank materials, surveying the elevation of relevant stratigraphic contacts, and documenting relevant exposures. Stratigraphic analysis of the apparently hard/dense unit specimens included section description, specimen petrography and microscopy, and pedogenic evaluation of the units. Geomorphic analysis included development of three-dimensional surface contour maps of erosion resistant units, and geologic cross sections and longitudinal profiles. The results of this study were used to identify locations requiring further study and investigation, validate the results of the laboratory testing, and were incorporated into the 3-dimensional stratigraphic model of the LAR.

1.8.5 Upstream Sediment Source Reconnaissance

Fugro Consultants conducted geologic field reconnaissance in areas of gold dredge tailings and aggregate quarries along the LAR in the approximate area between Nimbus Dam (RM ~22.4) and the Watt Avenue Bridge (RM ~9.1). This study was designed to directly address the recommendations of an LAR advisory panel convened by the USACE in October 2012. The primary goal of this reconnaissance level study was to estimate, at order-of-magnitude levels, the potential volume of sediment that could be available for river transport to the LAR from gold dredge tailings and former aggregate quarries along the river's floodplain, principally at flood discharge levels (115,000 cfs and above). A secondary goal was to characterize dredge tailings stratigraphy and visually estimate distributions of tailings' grain size distributions. The results of this study provided the initial field-based context for evaluating the significance of gold dredge tailings and former aggregate quarries as input sources to river sediment transport models. It is anticipated that the results of this reconnaissance effort will be incorporated into future hydraulic models and analyses.

1.8.6 3-Dimensional Stratigraphic Model

URS developed a three-dimensional (3D) stratigraphic model of the LAR to describe the stratigraphy and subsurface conditions of the study reach and help evaluate the stratigraphic susceptibility of this reach to erosion. The model encompassed the levees, banks, and channel of the LAR from RM 5.25 to RM 10.2. In late 2011, an initial model was created and served as a precursor and guide for producing the revised and final 3D model. The initial model included stratigraphic interpretation from numerous borings drilled through the levees along the north and south banks of the river. Except at the bridges, the initial model did not include information from borings drilled within the channel or along the inner banks. The final version of the 3D stratigraphic model represented an increase in detail and complexity over the initial version, presented data included from additional borings that were drilled between the levees and incorporated more geologic, geotechnical, and geophysical data than the earlier models. These data were constrained using an understanding of depositional and erosional processes to fit the model to its geologic environment. As a result, the final 3D model contains enhanced information, especially within the area between the levees where young alluvial sediments related to hydraulic mining have been deposited. In addition to showing subsurface alluvial stratigraphy, the final model shows the top of erosionally resistant sediments that are exposed and identified in the channel at several locations.

1.9 Geologic and Geotechnical Investigations and Analyses – Sacramento River

1.9.1 DWR Urban Levee Evaluations

The California Department of Water Resources' (DWR) Department of Flood Management is managing a levee evaluation program to assess the existing conditions of urban levees in California's Central Valley. The Urban Levee Geotechnical Evaluations (ULE) Program evaluates levee systems that are expected to protect communities of more than 10,000 people and includes a study area referred to as the Sacramento River South Study Area. This study area comprises the levees on the east (left) bank of the Sacramento River from the American River to Freeport, and is comparable to the ARCF GRR Sacramento River study area outside of Natomas. The DWR ULE Project consists of a multiphase investigation and evaluation of levee study area. This multiphase approach consists of a Technical Review Memorandum (TRM), Phase I Geotechnical Data Report (GDR), Phase I Geotechnical Evaluation Report (GER), Supplemental GDR, and GER. These phases of the ULE Project collect existing data, generate new geotechnical data, evaluate the levees based on these data, and form recommendations for improvement measures. While the DWR ULE program and ARCF GRR are independent and separate studies, both studies share relatively common approaches and desired outcomes. The data, results, and recommendations generated by each study are reviewed by both DWR and USACE for consistency and share much of the same supporting information without relying on each other as a basis of conclusions or recommendations. In that form, the Erosion Screening Process (ESP) developed by DWR and discussed in summary in this Section was used by the USACE ARCF GRR PDT not as a basis of decision making but as an independent check.

Part of the ULE Project is a three-tiered ESP that was developed to qualitatively analyze the potential for erosion-induced levee breach during a 200-year flood event. Tier 1 analyses included the following tests: historical performance, levee prism geometry, wind fetch length, and soil erodibility. Tier 2 analyses involved evaluating: flow velocity and testing erosion surface adequacy, wind-wave shear and testing erosion surface adequacy, and field reconnaissance. During Tier 3 analysis, a representative cross section was selected for each levee segment based on existing levee geometry and soil erodibility conditions, given that the other properties (i.e., velocity and wind) were generally constant within a segment. Levee segments are assigned one of three erosion risk levels (low erosion risk, medium erosion risk, or high erosion risk) based on Tier 3 erosion analyses results.

During the Tier 1 evaluation the Sacramento River Study Area was subdivided into 22 levee segments, all of which did not meet one or more of the four Tier 1 test criteria and were advanced to Tier 2 for analysis. Of those 22 segments, 20 did not meet Tier 2 analysis criteria and were advanced to Tier 3 for analysis. The 2 segments not advanced to Tier 3 analysis were classified as low erosion risk. Of the segments advanced to Tier 3 analysis, 2 were classified as low, 14 were classified as a medium, and 4 were classified as high erosion risk primarily due to channel velocity, erodible soil, and levee geometry. This report showed that the Sacramento River levees have a medium to high risk of breach due to erosion.

1.9.2 Fugro WLA Surficial Geologic Mapping and Geomorphic Assessment

William Lettis and Associates developed a technical memorandum to present the results of surficial geologic mapping and geomorphic assessment along the Sacramento River (East Side) from the confluence with the American River south to the town of Freeport. The goal was to provide information on the type and distribution of surface and shallow subsurface deposits that underlie the levee for

assessing potential levee underseepage, and to develop a conceptual model that allows reasonable stratigraphic interpretations between widely-spaced subsurface explorations. Data on potential geologic and geomorphic controls on levee underseepage were developed primarily to help guide geotechnical explorations, and secondarily to provide a geologic basis for characterization of levee foundation materials. This study involved integration and analysis of aerial photography, topographic, geologic, and soil maps, other historical documents, and review of available geotechnical exploration data and helicopter-based geophysical imaging data. Synthesis of these data allows for assessing the primary geomorphic processes responsible for the distribution of surficial deposits within the project area, and constructing a preliminary conceptual geomorphic model with shallow stratigraphic interpretations.

1.10 Hydraulic and Sedimentation Studies

Based on the expert panel recommendations above in paragraph 1.7.2.1 "Lower American River, Panel of Experts Findings Report (West Consultants, December 2010), new studies were started. These studies include characterizing and mapping the geology and erosion resistance properties as described below in Section 1.8 "Background of Geotechnical Studies Completed to Date." A bank migration analysis was also completed and is discussed below. In addition, the HEC-6T model of the American River was converted from NGVD 29 vertical datum to NAVD 88 vertical datum and updated to include new geologic and sediment data. This effort is ongoing but draft results and report are available. However, this effort has not been reviewed by USACE for quality and therefore the results should be used with caution. These draft results are further discussed below. In addition, the Sacramento River Bank Protection project included a larger scale sediment study of the Sacramento, Feather, and American Rivers along with relevant weirs and inflows/outflows. These studies are also discussed below.

1.10.1 Sacramento River Sediment Study Phase II – Sediment Transport Modeling and Channel Shift Analysis Lower American River. Common Features - Completed tasks.

This task updated previous bank migration analysis by Ayres with current information, reviewed the approach used by Ayres, and summarized findings and implications. This new approach used new LiDAR information to assist with defining the top of bank in GIS, an issue identified during the expert panel review. Previously, Ayres concluded that the Lower American River had not exhibited significant lateral shifting due to natural river processes from 1957 to 1998, and that significant changes in bankline location were the result of sand and gravel mining operations. NHC confirmed Ayres findings of no significant recent bankline migration by using aerial photos combined with survey data from 1998 to 2010 to develop more accurate banklines. NHC noted that significant differences shown in the previous Ayres analysis were the result of Ayres incorrectly identifying the top of bank from aerial images without the aid of relatively accurate topographic data. NHC concludes that there are no actively migrating meander bends on the Lower American River, although large floods have caused significant instream changes between the channel banklines in the past. Annual river surveys show that lateral erosion and bankline shift is occurring on the Lower American River, but on a scale too small to be accurately identified by air photo interpretation. NHC also collected bed material samples along the Lower American River and compared the data with past measurements. While the report notes there is a lot of variability in the data, the range of the data is typical for natural gravel-bed rivers and does not appear to show any obvious trends (coarsening or fining) since 1993.

1.10.2 Sacramento River Sediment Study Phase II – Sediment Transport Modeling and Channel Shift Analysis Lower American River. Common Features Tasks in-progress (June 2013 draft information report).

This information is based on draft results that have not been fully reviewed by USACE and should be viewed with caution as they are subject to change. However, the information is included here as the results seem reasonable and can be informative. NHC updated the Ayres HEC-6T model by converting it NAVD88 vertical datum, by adding more recent surface and sub-surface bed material gradations and gage data, and by incorporating results from geotechnical investigations of erosion resistant material in the bed and banks (see section 1.9.2). The model was calibrated to the 1997 high water marks and to observed vertical channel changes between 1997 and 2006. The calibrated model was run for multiple synthetic hydrologic scenarios designed to mimic short-term and long-term morphological conditions. This does not include a full set of hydrographs over decades of future conditions but uses a series of individual events to approximate short-term and long-term conditions. This hydrologic approach to the sediment modeling is useful for relative comparison purposes and should not be used to estimate actual future conditions. Other studies have found that trends from a single flood event may be opposite of the long-term trend and therefore these results should not be used for estimating long-term aggradation/degradation trends.

NHC conducted HEC-6T sediment modeling for the Sacramento and Lower American rivers (NHC 2012) that included long-term hydrology (1997 - 2008) from actual gage data as well as n-year specific events (e.g. 1/50 ACE, 1/100 ACE). A comparison of the results for the same reach (Sacramento River between the Lower American River confluence and Freeport) shows that the reach is degradational during a specific n-year flood event but aggradational over the long-term. The implication is that using single event hydrology (e.g. the 1/100 ACE event) or hydrology composed of a series of single n-year events (e.g. 1/100 ACE event followed by a 1/200 ACE event) may provide evidence for the opposite trend (degradation) than if a wider range of flows (e.g. 1997 - 2008 "continuous" hydrology) is used for the same reach. So while specific event modeling is likely more conservative for design and cost of erosion counter-measures for this reach, it may not be helpful if long-term trends are needed for other purposes, such as for determining if future sedimentation will bury spawning gravel.

Despite this limitation, the results enhance the understanding of sedimentation trends in the Sacramento River and may still be informative and perhaps conservative relative to feasibility level designs and costs. There is a lot of uncertainty associated with all sediment models as noted in the comment. However, the Sac Bank Sediment Study shows that using event specific hydrology vs. long-term hydrology for the exact same model can lead the model to show opposite trends. Therefore the relative differences may lead to incorrect conclusions even though both models are subject to considerable inaccuracies.

The results from this study (NHC 2013) include:

- Most of the Lower American River is actively degrading and the degradation increases with increasing flood magnitude and is greater in the upstream reaches (particularly above about RM 14).

- Computed maximum channel degradation is 8-10 ft upstream of RM 19, 2-7 ft between RM's 5-19, and less than 1 ft downstream of RM 5. The results from the updated model of the lower American River are generally consistent with the original Ayres (2010) model. However, there is

limited geologic information below river mile 5 and above river mile 11.5 and results in these reaches may include some uncertainty.

- Modeling results indicate that for all the flows simulated the shear stress in the reach with locally exposed hard material (between RM 7 and RM 11) is below the critical stress for erosion of moderately resistant materials (clay and cemented sand with silt). Therefore, significant scour below this erosion resistant material/surface is not anticipated. However, this is for general reach wide trends and local erosion such as at bridge piers may occur. Local scour should be further evaluated during future studies.

- The simulations generally indicate a coarsening of the surface bed material due to flood events.

1.11 Levee Screening Tool

As part of the USACE Risk Assessment Framework, the levee segments along the American and Sacramento Rivers were assessed using the Levee Screening Tool, a part of the USACE Levee Safety Program. Through this approach a Levee Safety Action Classification (LSAC) was assigned to the American River North (American River North Bank, NEMDC East Bank, Arcade Creek North and South Bank, and Dry Creek North and South Bank levees) and South (American River South Bank and Sacramento River East Bank levees) Basins by the Levee Senior Oversight Group (LSOG). The USACE Risk Assessment Framework process for assigning LSAC ratings entailed a series of presentations and reviews at the District level (relative risk assessment), consistency level (National QA Cadre), and senior-level (LSOG) for each levee segment. Each segment was evaluated on up to six performance modes depending on the features that were present in the segment. The performance modes were: Embankment and foundation seepage and piping, embankment stability, embankment erosion, closure systems, floodwall stability, and floodwall underseepage and piping. Following the presentation and input from the National QA Cadre and LSOG panels, a final LSAC classification was assigned for each segment. The presentation process encompasses segments within the same levee system and following all presentation and assignment of ratings per segment, an overall LSAC rating was given to the system. The final recommendation was then forwarded to the USACE levee safety officer for approval, action, and dissemination.

The USACE Levee Screening Tool Application Guide and User's Manual: Levee Safety Action Classification (LSAC) provides reference documentation and further details the rating process. The system rating is consistent with the highest risk segment within the levee system. Levee systems were assigned one of five classes which are described below:

- Class I – Very high risk warranting "urgent and compelling" actions to reduce risk,
- Class II – High risk warranting "urgent" actions to reduce risk,
- Class III – Moderate risk warranting "high priority" actions to reduce risk,
- Class IV – Low risk warranting "priority" actions to reduce risk,
- Class V – Normal risk considered tolerable, requiring only that "normal" levee safety activities continue.

The overall system rating assigned to the American River North Basin was an LSAC I. The main contributing factor is embankment erosion on the American River North Levee. This performance mode

coupled with the high population at risk, critical infrastructure within the basin, and expected loss of life during a breach contributes heavily to the overall rating.

The overall system rating assigned to the American River South Basin was an LSAC I. The main contributing factors included embankment seepage and stability on the Sacramento River South Levees, and embankment erosion on both the American River South Levee and Sacramento River South Levees. These performance modes, in conjunction with the high population at risk, residential and critical infrastructure, and expected loss of life during a breach contributes to the overall rating.

2 Completed Bank Protection Work

As discussed in Section 1.5, erosion has continued on both the Sacramento and Lower American Rivers and ongoing repairs have been performed to maintain channel integrity (i.e., the ability of the channel to convey the design discharge). Figure 2-1 depicts the modern revetment repair sites (shown in green) and a series of historic revetment sites (shown in orange), many of which consist of cobbles. In the Lower American River, these cobble sites are considered ineffective as erosion protection for large discharges which approach 160,000 cfs. For completeness, revetment segments for both left and right levees on the Sacramento River are included on Figure 2-1 to illustrate the magnitudes of the erosion problem on these mainstem channels and levees. As will be shown in Figure 6-3, the tentatively selected plan is to replace the historic revetment (e.g. cobble) with modern revetment to protect the banks from anticipated future flows.

In general, the repair sites provide insight into the bank protection features proposed for the subject ARCF GRR study. Specifically, as will be presented below in Section 6, the proposed bank protection features use design concepts adopted from several of the existing repair sites along the Lower American and Sacramento Rivers.

Sample repair sites along the Lower American River are illustrated on Figure 2-2 and Figure 2-3. Figure 2-2 shows the left bankline, looking downstream, at the repair site near RM 0.3 in 2010. This is the same erosion site shown in Figure 1-3 located on the left bank of the LAR upstream of the Interstate 5 crossing. Figure 2-3 (2010) is looking downstream at the repair site near RM 4.3 which is the bank and levee erosion site shown in Figure 1-6 located on the left bank upstream of the Capitol City Freeway. Erosion during the 1986 flood event nearly failed the levee at this site. In some cases, the bank repair consists of re-grading the slope and placing riprap with an emphasis on ensuring that the toe rock meets design criteria. In other cases, woody material is placed with the toe rock for fish habitat.

On the Sacramento River located at RM 62.5 (just downstream of the Interstate 80 crossing), Figure 2-4 shows bank erosion on the right bank on the Sacramento River in 2009. The repair for this site is shown in Figure 2-5 which was completed under the SRBPP.

Another Sacramento River erosion site is illustrated in Figure 2-6. Specifically, this photo shows the erosion and slope stability problems along the left bank at RM 53.2 in 2005. The repair for this site is shown in Figure 2-7 which was completed under the SRBPP.

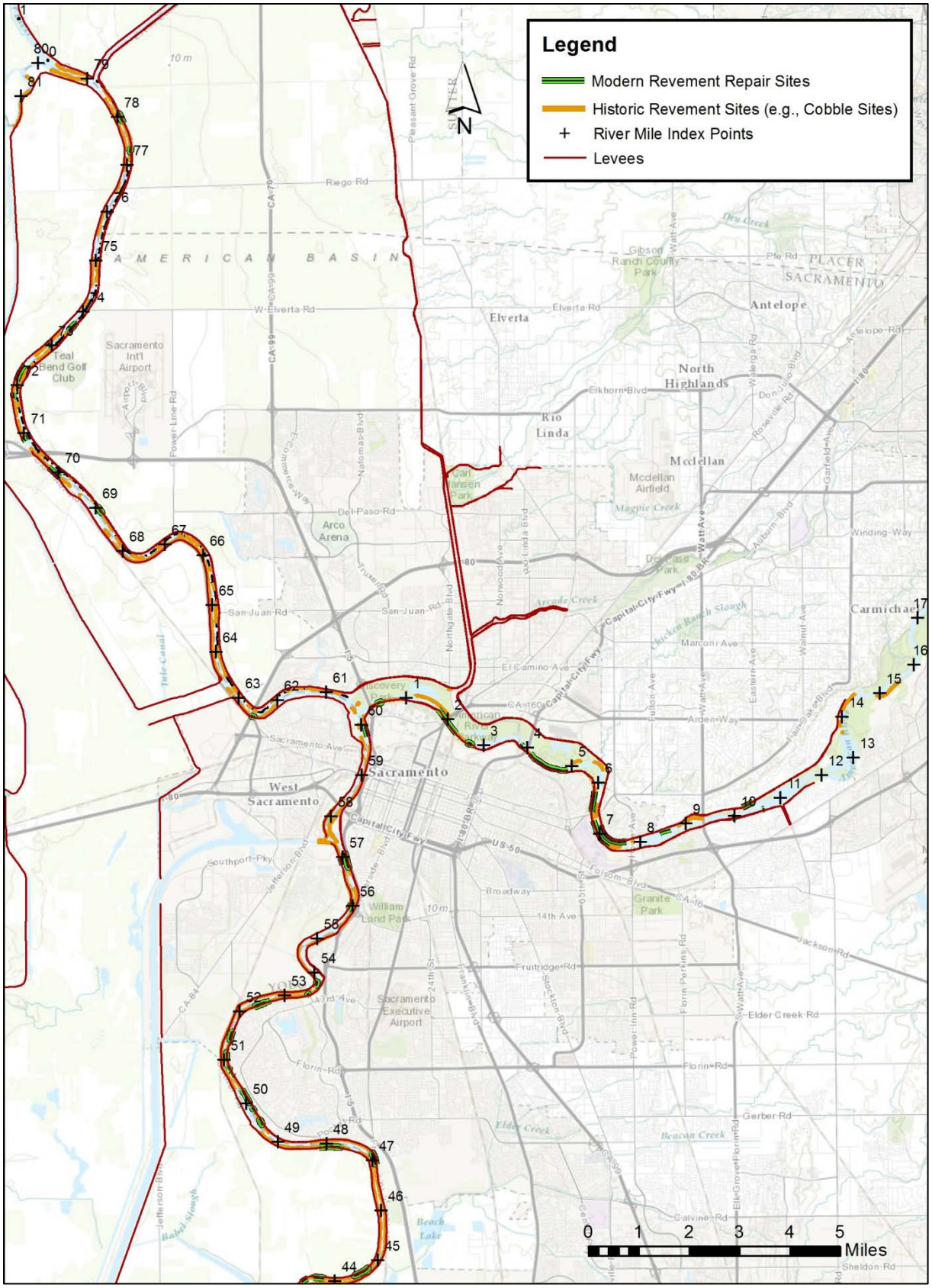

Figure 2-1. Historic and modern revetment sites along the Sacramento and American Rivers

Figure 2-2. View of repair site on the left bankline near LAR RM 0.3 (2009)

Figure 2-3. View of repair site on left bankline near LAR RM 4.3 (2010)

Figure 2-4. Erosion site of the right bank of the Sacramento River at RM 62.5 (2005)

Figure 2-5. Repaired site at Sacramento River right bank RM 62.5 (2009)

Figure 2-6. Erosion site of the left bank of the Sacramento River at RM 53.2 (2005)

Figure 2-7. Repaired site at Sacramento River left bank RM 53.2 (2009)

3 Geologic and Geotechnical Characterization

3.1 Geologic and Geomorphic Mapping and Analyses of the Lower American River

Regional geologic and geomorphic mapping show that the floodplain of the LAR is inset into (topographically lower than) older late Tertiary to Quaternary age alluvial deposits that form steep bluffs along the north (i.e. right) bank of the river from about Folsom Dam downstream to about Watt Avenue. Within the LAR study area, the middle Pliocene to Pleistocene (< 5.3 million to pre-Riverbank age) Fair Oaks, and the Pleistocene (1.8 million to 11,000 years old) Riverbank, and Modesto Formations underlie or are directly adjacent to the LAR. The Fair Oaks formation forms the steep bluffs along the north side of the American River with its contact dipping into the subsurface west of Watt Avenue while the Riverbank and Modesto Formations are expressed as a series of progressively younger and topographically lower alluvial fan deposits that make up most of the surficial geology of the LAR study area. The Riverbank Formation forms several broad, gently sloping alluvial fan surfaces south of the river, and the Modesto Formation forms the terraces closest to the river. To a large extent, the present-day levees along the American River have been constructed on the top of the river's banks, and overlie geologically young (i.e., late Pleistocene to Holocene), unconsolidated sand and silt-rich floodplain sediments, including post 1850 mining spoils.

Detailed geologic mapping, as well as petrographic and pedogenic analyses, completed during this study demonstrated the presence of two potentially erosion-resistant units within the stratigraphy of the LAR. These were: (1) a moderately cohesive silty and sandy interbed of relatively limited lateral and longitudinal extent within a thicker package of loose Holocene sediments (the "upper" unit); and (2) much thicker, more widespread relatively erosion-resistant deposits associated with the Pleistocene-aged Fair Oaks formation of Shlemon (1967) (the "lower unit"). Figure 3-3 presents a generalized stratigraphic section.

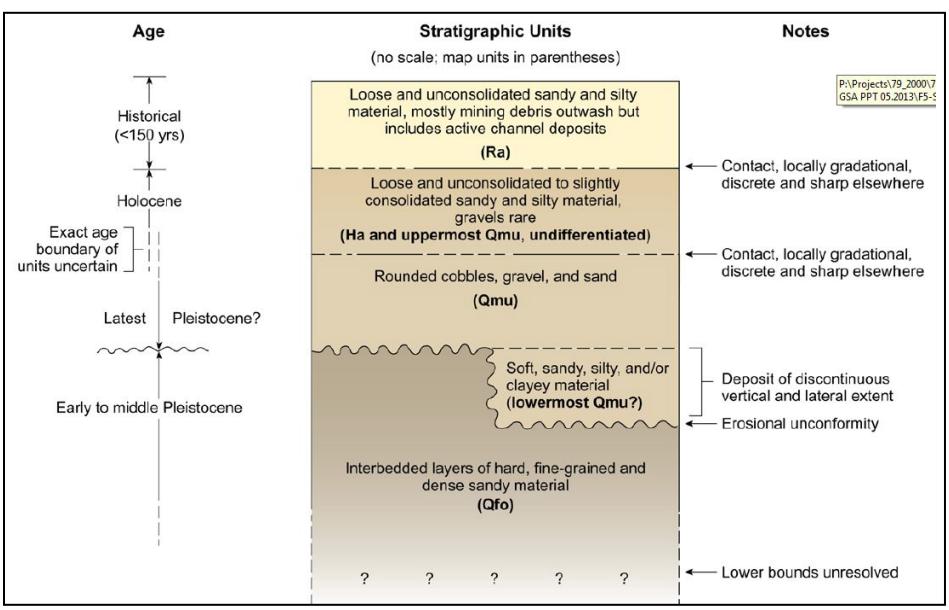

Figure 3-1. Generalized, composite stratigraphic section of the Lower American River

The upper unit was mapped in the banks of the LAR from RM 5.2 to 5.7 and may also exist near the Fairbairn water intake structure near RM 7.2 to 7.3. The upper unit was interpreted to be a geologically young deposit that is only slightly more cohesive than the surrounding early Holocene or the latest Pleistocene upper Modesto Formation sandy and gravelly sediments, and may be only weakly resistant to erosion.

Surficial geologic mapping and synthesis of geotechnical data show that the Plio-Pleistocene age Fair Oaks formation is exposed in the channel bed and banks locally upstream of Watt Avenue (RM 9.0 to 11.0) and intermittently exposed in the channel bed downstream of Watt Avenue to near RM 6.7 (slightly downstream of the Guy West pedestrian bridge). Prominent outcrops upstream of Watt Avenue occur at RM 10.1 and from RM 9.4 to 9.7. Downstream of Watt Avenue, the formation lies mostly below the modern bed elevation of the river and is not readily visible. Generally, a variable thickness of modern and/or upper Modesto Formation-age gravels and cobbles overlie the Fair Oaks formation in this reach. In some locations, the bathymetric data suggest that localized scour has removed most of the overlying gravels and cobbles and the Fair Oaks formation may be present in the channel bed (e.g., RM 8.2–8.3). Downstream of the Howe Avenue Bridge, between approximately RM 6.6– 7.5, bathymetry data show broader areas of scour where the formation is likely more widely exposed in the channel bed or lies concealed beneath a thin cover of active channel gravel only a few feet thick. The unit likely is continuous in the north-south directions beneath the levees, but at elevations below the present day thalweg, and thus the unit provides no bank resistance to lateral erosion and will not contribute to levee stability.

No paleosols containing well-developed, laterally continuous pedogenically-derived, clay-rich hardpans or silica-cemented duripans were observed in the detailed study area. Based on a review of the geotechnical data, inspection of a limited number of boxed core samples collected via sonic drilling in late 2011, examination of in-stream outcrops, and petrographic analysis, the erosionally resistant materials in the detailed study area have undergone only limited pedogenesis. Petrographic study supports field observations that there is little precipitated chemical cement in these sediments and shows the coarser grains to be held together at least partly by minor amounts of clay and fine silt, which occurs as secondary pedogenic coatings on grains and pores in some samples.

Multiple geologic processes likely are responsible for the relatively indurated nature and apparent erosion resistance of the sediments composing the lower unit (i.e., the Fair Oaks formation). The results of this study suggest that silica cementation is not responsible for the relatively high apparent density / hardness of the sediments. Rather, it is more likely that multiple lithification processes, including (but not limited to) partial cementation, compaction, desiccation, and authigenesis (i.e., recrystallization), occurring over geologic time (i.e., 10^5 to 10^6 years) in aggregate, contribute to the induration presently observed. An additional factor contributing to the high apparent density / hardness of these sediments may be the natural angularity of the glacially-derived silt and fine sand component. In our opinion, the relatively old age of the Fair Oaks formation is likely the greatest single factor contributing to the high apparent density / hardness of the sediments that make up the formation. The process of consolidation, acting over hundreds of thousands of years, may result in materials that are sufficiently dense and compact as those observed in the detailed study area.

Although the terminology “erosion resistant” is used to refer to the outcrops of the relatively indurated material in the river channel, the outcrops do erode. Field observations suggest several mechanisms of erosion are currently occurring at both the granular- and outcrop-scale, including tension cracking and

block-topple, scour resulting in potholes and development of flutes or grooves, and potentially wet-dry and freeze-thaw cycles.

3.2 3-Dimensional Stratigraphic Model of the Lower American River

The general goal was to develop a 3-dimensional (3D) stratigraphic model of the LAR study reach by incorporating both existing and newly collected geotechnical and geologic data, and utilizing geologic principles to place the stratigraphy into a depositionally based framework. The model was intended to describe the stratigraphy and subsurface conditions of the study reach and help evaluate the stratigraphic susceptibility of this reach to erosion near the levee banks.

URS created a 3D stratigraphic model of the LAR study reach using Environmental Visualization System (EVS) software (version 9.6, developed by C Tech Development Corporation). For the geographic information systems (GIS) component of the task, URS used ESRI's ArcGIS (version 10) to produce ESRI file geodatabases, shapefiles, and GRID geospatial data formats in ArcGIS (version 9.3.1) format, per USACE's specifications. URS used Microsoft Excel and EVS utilities to translate tabular data, comprising the interpretation of the stratigraphic units into EVS input file formats.

Stratigraphy was interpreted through review of the boring logs and surficial outcrops. To create the 3D model, the stratigraphic contacts were manually drawn on 24 hardcopy cross sections approximately perpendicular to the American River channel axis and 12 profiles. The sections and profiles included surface topography and exploratory boring stick logs. The stick logs contain abbreviated boring information, including; USCS soil classification, hammer blowcounts, laboratory fines content, collar elevation, bottom elevation, and offset distance from section or profile line. The sections and profiles were converted to x, y, z tables in Microsoft Excel and imported into the EVS data format.

Seven general stratigraphic units are described below, based upon consolidation of numerous sample descriptions within each layer. The descriptions are necessarily broad because they describe alluvial deposits that have some degree of variability with depth and lateral extent, both parallel and perpendicular to the channel.

- **Fill:** This unit is primarily levee construction soils excavated from nearby channel, composed of mixtures of sand, silt, and clay. Locally, this includes fill placed for roads or other purposes.
- **Post-1850 Alluvium:** This uppermost stratigraphic unit is sandy and crops out mainly between the current channel banks except downstream of the Howe Avenue bridge where it extends to the right edge of the model, beyond the land side toe of the right bank levee. This unit is primarily composed of silty fine sand, fine sandy silt, silt, and clean fine to medium grained micaceous sand. This unit is not defined by exploratory soil boring data primarily because it is located where it was difficult to drill soil borings: on mid-channel bars and along the inner edges of the high-flow channel margins.
- **Silty sand, sandy silt, silt, sand (three SS subunits):** This unit is primarily composed of sand and silty sand with SM and SP-SM classification with lesser amounts of poorly-graded sand (SP) and sandy silt (ML). This unit locally was described as containing thin lenses of clayey gravel (GC) and low-plasticity clay (CL).
- **Sand (three S subunits):** This unit is primarily composed of poorly-graded sand (SP) with slightly lesser amounts of silty sand (SM) and sand with silt (SP-SM). Thin, discontinuous lenses of low-plasticity sandy clay (CL), clayey sand (SC), and gravels (GM to GP) are occasionally present.

- **Silty clay, sandy clay, clay, and silt (five CS subunits):** This unit is primarily composed of low-plasticity clays and silts (CL) and (ML) with varying amounts of sand. Locally. this unit contains thin, discontinuous lenses of gravelly clay to clayey gravel (CL to GC), clayey sand (SC), and silty sand (SM).
- **Boulders, cobbles, gravel with sand (three BCG subunits):** This unit is primarily composed of well-rounded very coarse materials. These materials were difficult to sample, even with the sonic drill rigs because of the hardness of the cobbles and boulders. The boring logs classify these materials primarily as poorly- to well-graded gravels (GP to GW), and silty gravels (GM), with lesser amounts of poorly-graded gravels and silty gravels (GP-GM), and boulder/cobbles. Lenses of other finer grained materials were occasionally present within these coarse layers.
- **Clay (one C subunit):** This unit was only differentiated in two borings on the left bank near LM 9.6. It consists of a 3-to 4-foot-thick layer of fat clay.

The areal distribution and grain size of the alluvial deposits beneath the study reach reflect a complex history of erosion and deposition. There are clayey deposits, bouldery/cobbley deposits, and a variety of sedimentary layers with grain sizes in between. Relatively thin, discrete layers of alluvium can be identified in the boring logs. These layers are not always traceable between exploratory borings that are many hundreds of feet apart and are too thin for resolution of the model, but are important to identify as they relate to depositional and erosional processes. The larger-scale stratigraphic units composed of predominantly similar materials (but containing thin, heterogeneous lenses) can be projected from beneath one levee, across the river, and under the levee on the opposite bank. These larger packages of mostly similar deposits are what make up the units in the 3D model.

Each of the main stratigraphic units except the Post-1850 Alluvium appear to accrete in a downstream direction, where they are then overlain by the next younger unit. There is no unit younger than the Post-1850 Alluvium. This shows that at certain times, deposition of units of differing grain sizes was happening concurrently along the American River. However, the presence of the study area-wide lower clay and silt layer in the model appears to indicate that nearly this entire area was a distal fan environment for an extended period of time earlier in the Pleistocene epoch. The nearly continuous boulder/cobble/gravel layer reflects a period when discharge was sufficiently high that flow velocity and depth created shear stresses capable of transporting these large clasts. This may reflect the influence of climate change at the end of the last glacial period, about 10 to 15 thousand years ago.

The erosionally-resistant surface appears to be relatively continuous across the site and to have a downstream slope that is roughly parallel to but slightly steeper than the alluvial deposits and the modern active channel. The erosionally resistant materials observed exposed in the channel are relatively fine-grained silty sands and sandy silts that are predominantly uncemented. The top of the erosionally-resistant surface appears to have relief that may be the result of several factors. The most likely is the possible erosion that may have occurred in the past before this surface was buried or in modern time once the surface became exposed. This explanation fits areas where the erosionally-resistant boundary cuts sedimentary units (see Figure 3-4). The nearly ubiquitous presence of a coarse boulder/cobble/gravel layer on top of the erosionally-resistant surface would have required high discharge velocities and shear stresses to mobilize, and these forces could have eroded the top of the erosionally resistant surface. Another possible source of the relief visible on the top of the erosionally-resistant surface is due to the limitations of the input data, primarily the dependence on boring log information and the challenge of extrapolating a potential erosionally-resistant surface elevation where little information related to cementation or resistance to erosion is provided.

Figures 3-4 and 3-5 are examples of cross sections generated from the 3D stratigraphic model depicting the layer discussed above. Figure 3-6 provides a graphical legend for stratigraphic units displayed in the cross sections. Figures 3-4 and 3-5 are looking downstream.

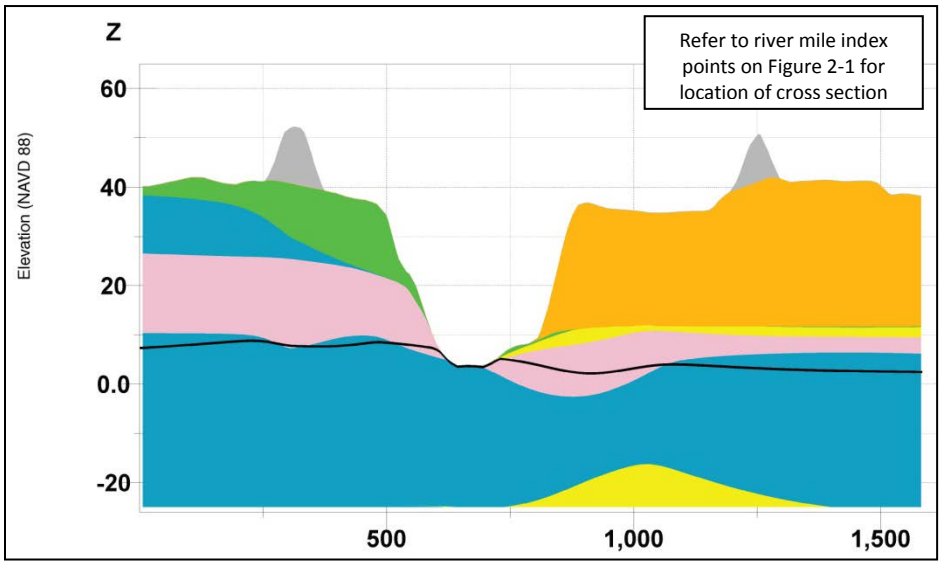

Figure 3-2. 3D Stratigraphic Model Section 11 Near RM 7.2

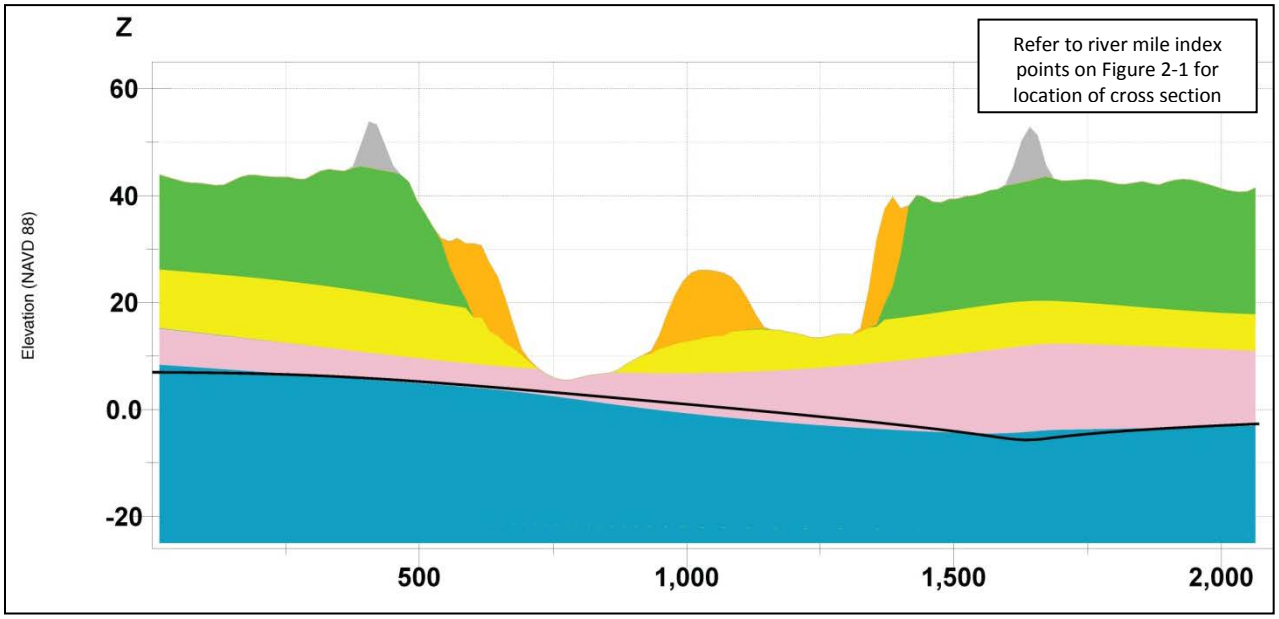

Figure 3-3. 3D Stratigraphic Model Section 15 Near RM 7.9

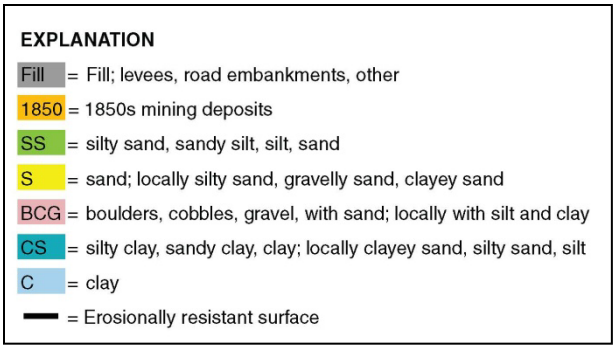

Figure 3-4. 3D Stratigraphic Model Unit Legend

3.3 Sacramento River South Geologic and Geotechnical Characterization

The Sacramento River has irregular sinuosity south of the confluence with the American River, with both large and small radius-of curvature meander bends. The river has, in places, laterally migrated over the past thousands of years, with erosion occurring on the outsides of bends, and deposition of younger sand-rich sediment occurring on the insides of the river bends. Geologically older and erosion-resistant Riverbank Formation is present at the ground surface south and east of the city of Sacramento, and younger alluvium is inset into this formation. Additionally, because of the low topographic position and proximity to the confluence of the two large rivers, the Sacramento area has been subjected to repeated inundation by floodwaters during the past several thousand years. The floodwaters deposit fine sand and silt-rich alluvium along the flanks of the river bank and finer-grained clay and silt are carried in suspension onto the distal floodplain. This hydraulic sorting process creates a 'natural levee' landform with a topographic gradient that slopes away from the river. Consequently, the levee is underlain by a variable, relative thick, and relatively young, sandy and silty, unconsolidated alluvial deposits.

South of the confluence of the American River, the Sacramento River demonstrates a complex relationship of fluvial deposits at the surface and beneath the eastern floodplain of the Sacramento River. The surface and subsurface distributions of sandy and clayey deposits are a function of former river positions on the landscape, and present-day geomorphic processes adjacent to the river channel. The levees are underlain entirely by geologically young, unconsolidated, silty and sandy fluvial deposits.

In general, the deposits beneath the eastern floodplain of the Sacramento River consist of three or four fluvial stratums in the following sequence, described from ground surface downward. The top-stratum, consists of very loose and very soft silt, sandy silt, with thin, laterally discontinuous clay and sand lenses. This stratum was laid down during the Holocene as overbank and flood basin deposits and represents vertical accretion of the natural levee and floodplain surface over the past several thousand years. Beneath the silty top-stratum is a stratum of coarser-grained sediment that ranges in consistency from medium dense fine-to-coarse grained clean sand, sandy silt, and localized occurrences of pebbles, gravels, and cobbles. This stratum is interpreted as latest Pleistocene Modesto Formation (upper member), which was deposited as meander scrolls and channels from lateral migration of river channel(s) across the former valley surface. Underlying this sandy unit is a stratum of gravel that may or may not be the lower member of the Modesto Formation. The gravel is laterally extensive near the American River confluence. In the south part of the study area (Pocket area), this gravel is not present or it exists only in local patches within older channels. Within the Pocket area, a medium stiff to stiff fine-grained (clayey silt, silty clay) stratum, with local gravel patches, discontinuously underlies the

more-permeable sands of the second stratum. This fine-grained stratum is distinctly denser than the top-stratum, and may represent lower Modesto Formation flood basin deposits on the earlier valley floor, in former low lying areas adjacent to the river channel. Underlying the upper three unconsolidated sequences is a hard, moderately-cemented silt to siltstone. This unit has been correlated to the upper member of the Riverbank Formation. Thus, the upper member is inset to the lower member of the Riverbank Formation. It is permissibly older, perhaps the latest Pliocene-early Pleistocene Laguna Formation.

4 Hydrology and Hydraulics

4.1 Flow Frequency and Duration

As discussed previously, the American River levee system was originally intended to convey a discharge of 115,000 cfs. When the Joint Federal Project (JFP) is completed at Folsom Dam, in combination with levee repairs currently being completed under the Common Features Project (and other authorities) and the dam 3.5 foot raise, the intent is for the river to be able to convey a discharge of 160,000 cfs, assuming that the levees do not fail from one or more of the potential failure modes (i.e., seepage, stability, insufficient height, or erosion). Please refer to Section 6.5 for a discussion on the feasibility design considerations.

In addition, modifications of Folsom Dam operations will shift the way floods are released into the lower river from Folsom Dam. Specifically, frequent flood events, that is, floods which occur say once in every ten to twenty-five years, will have a larger peak discharge compared to those under current dam operations. Table 4-1 lists a sample of the current and future peak discharges for a range of n-year flood events. This information is taken from the ARCF GRR study to remain consistent. The Folsom Water Control Manual Update will likely update these values as part of their evaluation.

In addition, modifications of Folsom Dam operations will shift the way floods are released into the lower river from Folsom Dam. Specifically, frequent flood events, that is, floods which occur say once in every ten to twenty-five years, will have a larger peak discharge compared to those under current dam operations. Table 4-1 lists a sample of the current and future peak discharges for a range of n-year flood events. These values are from the ARCF GRR study to maintain consistency and it is anticipated that the values will be updated as part of the Folsom Water Control Manual Update evaluation.

Table 4-1. Comparison of peak discharges between with- and without-project conditions

Flood Event	Peak Discharge (cfs)	
	Current Conditions[2]	Future Conditions[3]
50% (1/2) ACE (2-year)	30,200	25,200
10% (1/10) ACE (10-year)	43,100	71,700
4% (1/25) ACE (25-year)	99,700	115,000
2% (1/50) ACE (50-year)	115,000	115,000
1% (1/100) ACE (100-year)	145,000	115,000
0.5% (1/200) ACE (200-year)	320,000	160,000

The important point here is that under future operating conditions to meet the goal of increased flood damage reduction, larger flood flows will need to be conveyed through the American River with greater frequency compared to past operating conditions. These higher flood flows will exert additional pressure on the banklines and levees resulting in greater erosion, sediment transport, and potentially, modest changes to the planform of the low-flow channel.

[2]Draft values based on NA1 HEC-RAS modeling using the American River storm centering.
[3]Draft values based on the American River Common Features "With-Project Condition" HEC-RAS modeling using the American River storm centering and assuming that the dam 3.5' raise is in place.

In addition, durations of the larger peak flows have been tabulated for both the without-project condition (see Table 4-2) and for the with-project condition (see Table 4-3). The values for the without-project condition are of the same order magnitude as the durations listed in Table 1-1 for the significant historic flood events in which significant volumes of channel erosion occurred. However, the with-project durations (Table 4-3) are much greater for the 1 and 0.5% ACE events compared to the without-project values (Table 4-2). Duration of the flow is directly related to the volume of erosion which can occur. The flow durations are a source of uncertainty in the project performance since the channel will be expected to convey large peak flows (i.e., some in excess of historic floods) for durations substantially longer than the durations of historic peak flood flows.

Graphical comparisons of with- and without-project hydrographs are illustrated in Figures 4-1 through 4-3 for selected n-year events. The without-project hydrographs are depicted with blue lines and the with-project hydrographs with red lines.

Table 4-2. Durations of without-project peak discharges for n-year events

Synthetic Flood Event	Approximate Duration (hrs)[4]			
	90,000 cfs	115,000 cfs	>115,000 cfs	160,000 cfs
50% (1/2) ACE	---	---	---	---
10% (1/10) ACE	---	---	---	---
4% (1/25) ACE	23		---	---
2% (1/50) ACE	63	48	---	---
1% (1/100) ACE	120	91	43	---
0.5% (1/200) ACE	135	103	60	29

Table 4-3. Durations of with-project peak discharges for n-year events

Synthetic Flood Event	Approximate Duration (hrs)[5]			
	90,000 cfs	115,000 cfs	>115,000 cfs	160,000 cfs
50% (1/2) ACE	---	---	---	---
10% (1/10) ACE	---	---	---	---
4% (1/25) ACE	50	41	---	---
2% (1/50) ACE	88	74	---	---
1% (1/100) ACE	142	133	---	---
0.5% (1/200) ACE	171	163	55	31

[4] Draft values based on the American River Common Features "Without-Project Condition" HEC-RAS modeling using the American River storm centering.
[5] Draft values based on the American River Common Features "With-Project Condition" HEC-RAS modeling using the American River storm centering and assuming that the 3.5 ft dam raise is in place.

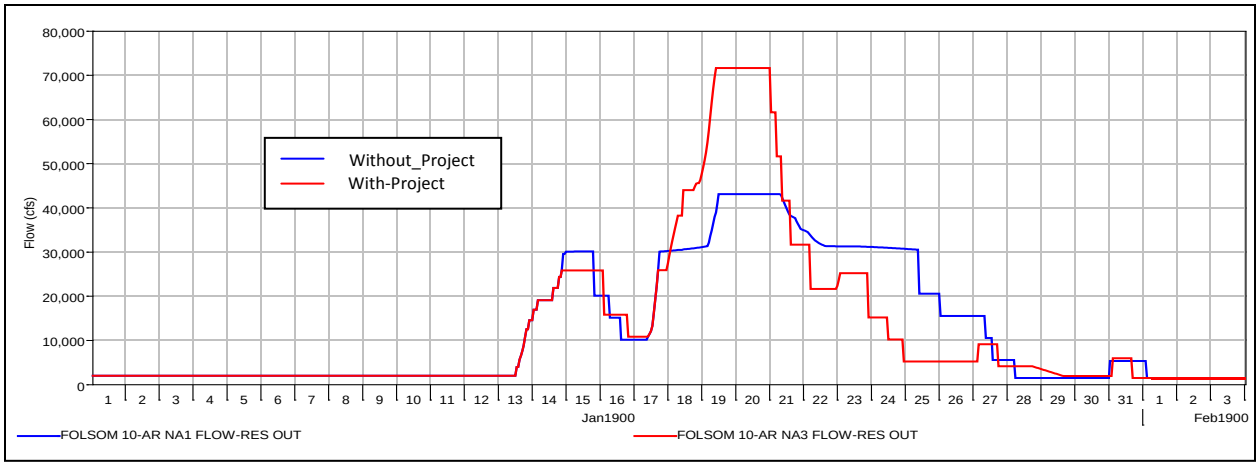

Figure 4-1. With- and without-project hydrographs for the 10% (1/10) ACE event on the LAR

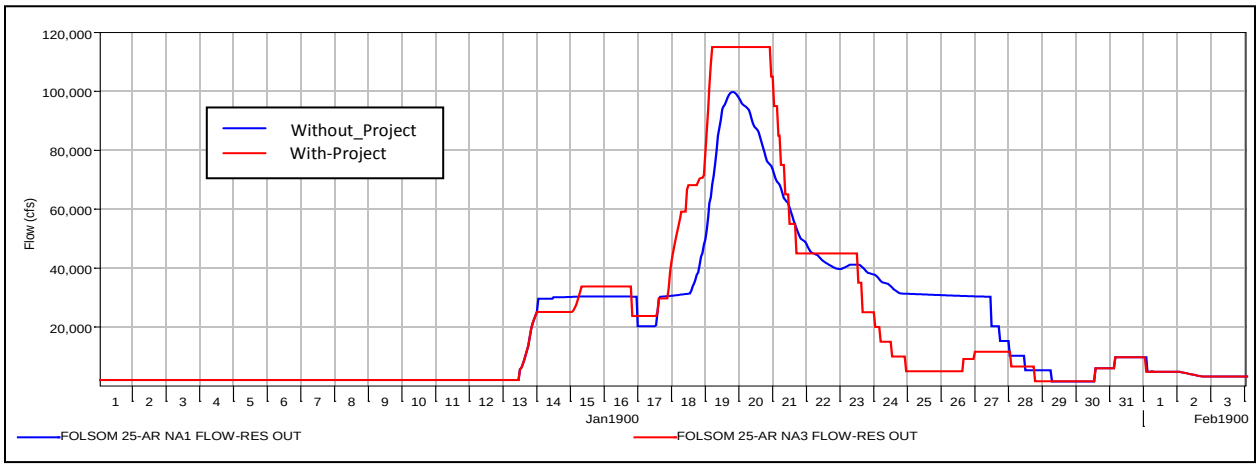

Figure 4-2. With- and without-project hydrographs for the 4% (1/25) ACE event on the LAR

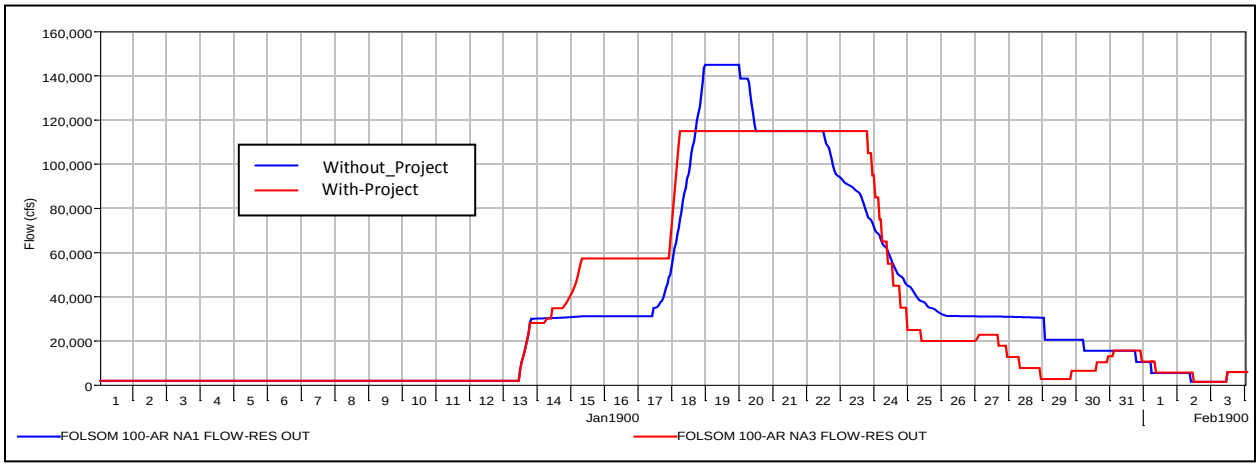

Figure 4-3. With- and without-project hydrographs for the 1% (1/100) ACE event on the LAR

4.2 Hydraulic Modeling Results

With- and without-project hydraulic analyses are presented in the Hydraulic Appendix Executive Report dated May 2013. Technical analyses therein consist of one-dimensional, unsteady HEC-RAS modeling for the channel hydraulics and quasi two-dimensional FLO-2D modeling for the overbank floodplains. Also included are analyses for quantifying uncertainties in the various hydraulic parameters and results. Please refer to that report for details and documentation of those efforts.

In order to get a more detailed estimate of the velocity and shear in the American River upon which the likelihood for erosion may be estimated, Ayres Associates performed two-dimensional modeling of the Lower American River using RMA-2 (Ayres 2004). This analysis was conducted for infrequent flood events specifically consisting of peak flows of 115,000, 130,000, 145,000, and 160,000 cfs. The areal extent of the modeling included the Lower American River between RM 0 and 14 and the Sacramento River approximately between RM 59.2 and 61.4.

Results of the two-dimensional modeling are presented in the report titled "Lower American River, Erosion Susceptibility Analysis for Infrequent Flood Events" dated July 2004 by Ayres Associates. Samples of the results from this analysis are shown in Figures 4-4 and 4-5. Specifically, Figure 4-4 shows the velocities for a discharge of 115,000 cfs which average about 6 to 8 ft/sec in the channel with maximum velocities ranging up to about 12 ft/sec. Figure 4-5 shows the velocities for a discharge of 160,000 cfs which average about 5 to 9 ft/sec in the channel with maximum velocities ranging up to about 13 ft/sec.

Of concern in both of these figures are the proximities of the relatively high velocities to the levees along the Lower American River. Additionally, the range of the computed velocities is of concern since the magnitude of the velocities is great enough to erode many of the relatively fine grained material present in the channel lining. Table 4-4 is an excerpt from Fischenich (2001) which lists the permissible shear and velocity for various materials. A review of this list coupled with the computed 2-D velocities and shears indicates that the large discharge events are capable of eroding the material typically found lining the Lower American River channel.

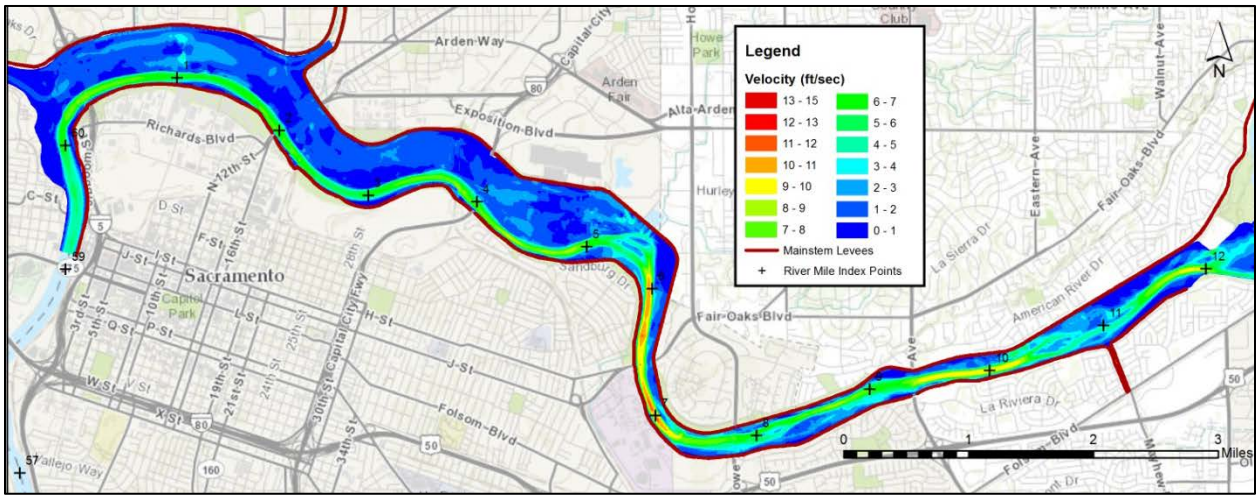

Figure 4-4. Two-dimensional velocities for a discharge of 115,000 cfs in the Lower American River

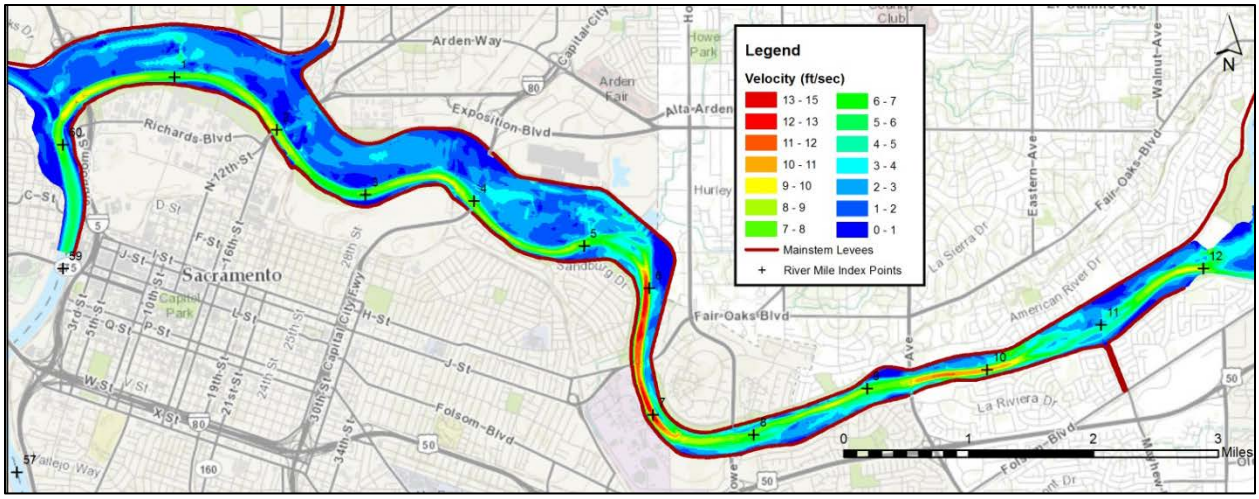

Figure 4-5. Two-dimensional velocities for a discharge of 160,000 cfs in the Lower American River

Table 4-4. Permissible shear and velocity for selected lining materials (Fischenich 2001)

Permissible Shear and Velocity for Selected Lining Materials[1]

Boundary Category	Boundary Type	Permissible Shear Stress (lb/sq ft)	Permissible Velocity (ft/sec)	Citation(s)
Soils	Fine colloidal sand	0.02 - 0.03	1.5	A
	Sandy loam (noncolloidal)	0.03 - 0.04	1.75	A
	Alluvial silt (noncolloidal)	0.045 - 0.05	2	A
	Silty loam (noncolloidal)	0.045 - 0.05	1.75 – 2.25	A
	Firm loam	0.075	2.5	A
	Fine gravels	0.075	2.5	A
	Stiff clay	0.26	3 – 4.5	A, F
	Alluvial silt (colloidal)	0.26	3.75	A
	Graded loam to cobbles	0.38	3.75	A
	Graded silts to cobbles	0.43	4	A
	Shales and hardpan	0.67	6	A
Gravel/Cobble	1-in.	0.33	2.5 – 5	A
	2-in.	0.67	3 – 6	A
	6-in.	2.0	4 – 7.5	A
	12-in.	4.0	5.5 – 12	A
Vegetation	Class A turf	3.7	6 – 8	E, N
	Class B turf	2.1	4 - 7	E, N
	Class C turf	1.0	3.5	E, N
	Long native grasses	1.2 – 1.7	4 – 6	G, H, L, N
	Short native and bunch grass	0.7 - 0.95	3 – 4	G, H, L, N
	Reed plantings	0.1-0.6	N/A	E, N
	Hardwood tree plantings	0.41-2.5	N/A	E, N
Temporary Degradable RECPs	Jute net	0.45	1 – 2.5	E, H, M
	Straw with net	1.5 – 1.65	1 – 3	E, H, M
	Coconut fiber with net	2.25	3 – 4	E, M
	Fiberglass roving	2.00	2.5 – 7	E, H, M
Non-Degradable RECPs	Unvegetated	3.00	5 – 7	E, G, M
	Partially established	4.0-6.0	7.5 – 15	E, G, M
	Fully vegetated	8.00	8 – 21	F, L, M
Riprap	6 – in. d_{50}	2.5	5 – 10	H
	9 – in. d_{50}	3.8	7 – 11	H
	12 – in. d_{50}	5.1	10 – 13	H
	18 – in. d_{50}	7.6	12 – 16	H
	24 – in. d_{50}	10.1	14 – 18	E
Soil Bioengineering	Wattles	0.2 – 1.0	3	C, I, J, N
	Reed fascine	0.6-1.25	5	E
	Coir roll	3 - 5	8	E, M, N
	Vegetated coir mat	4 - 8	9.5	E, M, N
	Live brush mattress (initial)	0.4 – 4.1	4	B, E, I
	Live brush mattress (grown)	3.90-8.2	12	B, C, E, I, N
	Brush layering (initial/grown)	0.4 – 6.25	12	E, I, N
	Live fascine	1.25-3.10	6 – 8	C, E, I, J
	Live willow stakes	2.10-3.10	3 – 10	E, N, O
Hard Surfacing	Gabions	10	14 – 19	D
	Concrete	12.5	>18	H

[1] Ranges of values generally reflect multiple sources of data or different testing conditions.

A. Chang, H.H. (1988).
B. Florineth. (1982)
C. Gerstgraser, C. (1998).
D. Goff, K. (1999).
E. Gray, D.H., and Sotir, R.B. (1996).
F. Julien, P.Y. (1995).
G. Kouwen, N.; Li, R. M.; and Simons, D.B., (1980).
H. Norman, J. N. (1975).
I. Schiechtl, H. M. and R. Stern. (1996).
J. Schoklitsch, A. (1937).
K. Sprague, C.J. (1999).
L. Temple, D.M. (1980).
M. TXDOT (1999)
N. Data from Author (2001)
O. USACE (1997).

ERDC TN-EMRRP SR-29

5 Channel Stability and Erosion Assessment

Channel stability and erosion are interconnected but the terms “channel stability” and “erosion” need to be discussed for clarity. An unstable channel can be a channel with morphological changes that are so rapid that it generates public concern (ASCE 2008). A more scientific definition of an unstable channel is a channel that has abrupt, episodic, or progressive changes in location, geometry, slope, or planform pattern because of changes in water or sediment inputs or outputs (ASCE 2008). Channel erosion consists of erosion of the bed and banks by flowing water or collapse, slumping, or toppling of large masses of bed and bank material (ASCE 2008). While perhaps not typically considered erosion, slumping and toppling associated with river banks and sometimes in cohesive bed materials is an important consideration.

Channel stability depends on the time and space scale. The entire channel reach may be stable even though there are locations of instability, such as around bridges. Similarly, the channel may appear to be unstable over shorter periods of time but when viewed over a longer time frame the observed instabilities are oscillating around a long-term mean value. This last condition can be considered to be a state of dynamic equilibrium.

Channel stability and erosion of the Lower American River and Sacramento River in the Common Features GRR project area are discussed below in terms of vertical and lateral erosion, including some of the inter-connected nature of vertical and lateral erosion.

5.1 Vertical Erosion

Vertical erosion potential can be demonstrated for the American River by applying a qualitative general relationship originally proposed by Lane in 1955 (Lane 1955):

$$QS \approx Q_s d_s$$

Where:
Q = Water discharge
S = Slope of the channel
Q_s = Sediment discharge
d_s = Sediment diameter

Applying this to the Lower American River, the reduction of available sediment supply from construction of dams and erosion of the mining debris overtime (reduced Q_s), and increasing the magnitude of the lower discharge flood events that move the most sediment (i.e. cause the most erosion) over time corresponds to a coarsening of the river bed (increased sediment size), erosion of the channel (reduced slope), and increased flow depth with unpredictable shifts in channel width (ASCE 2008 page 476).

The evidence shows this expected vertical erosion occurred as anticipated from Lane’s relationship above. According to thalweg profiles compiled by various researchers, the channel of the lower American River degraded by up to 15-30 ft from the early 1900s to the late 1990s (NHC 2012). The reader is referred to NHC 2012 and NHC 2009 for other studies that corroborate this finding. See also Figure 5-1 and Figure 5-2 (Note elevations are in meters). The Sacramento River Bank Protection project’s sediment study indicates the Lower American River has degraded between 1997 and 2008 by

an average of 0.67 feet over the lower 3.7 miles. This degrading trend is shown in Figure 5-3 below (NHC 2012) (Note elevations are in meters). A similar degrading trend is also observed further upstream using a different approach. A plot of the changes in rating curve for the Fair Oaks gage on the American river indicates a general trend of erosion from 1986 to 2008 as shown in Figure 5-4 (NHC 2009). This general erosional trend is expected to occur in the future as indicated in Figure 5-5.

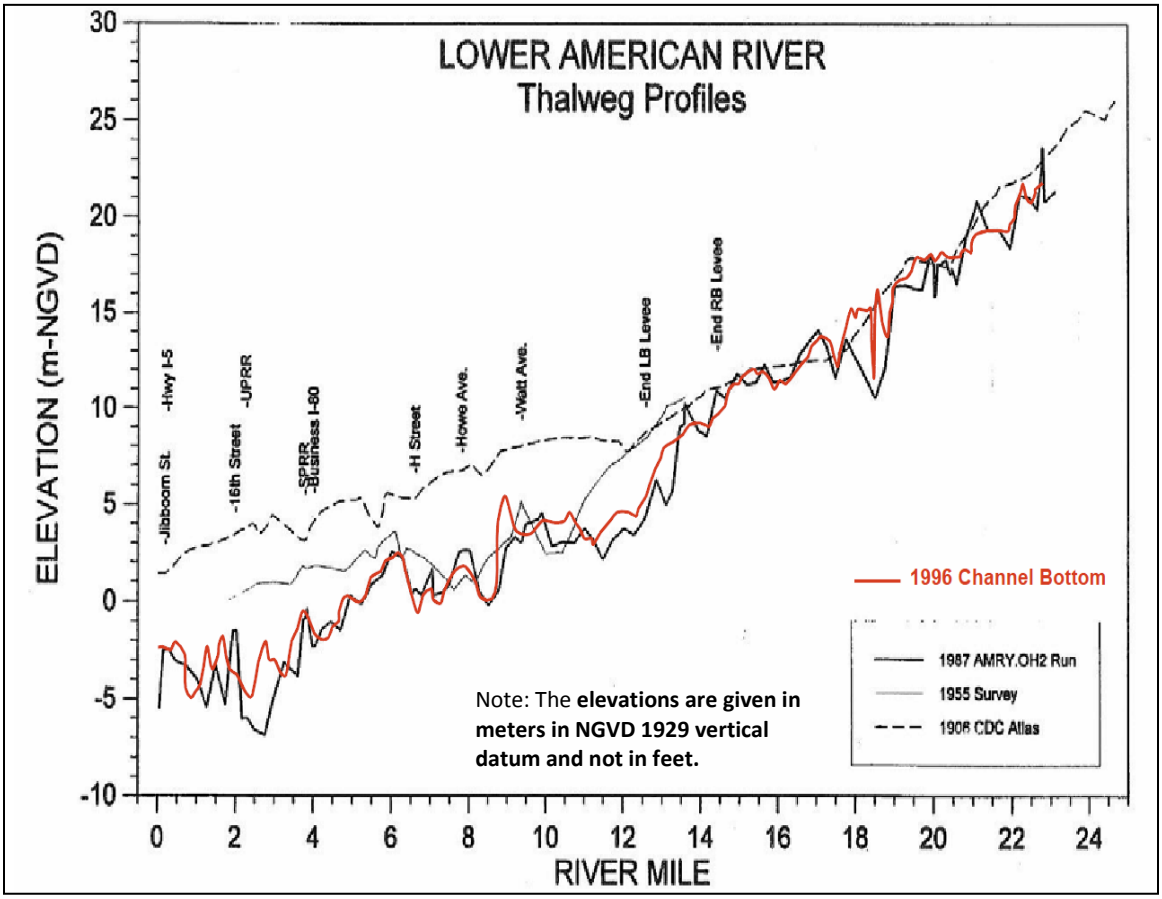

Figure 5-1. Historical profile of the Lower American River showing general degrading trend since 1906 (NHC 2009)

The Sacramento River discharge is also controlled by dams and should experience similar response to construction of dams as the American River. The same studies referenced above corroborate this trend for most of the Sacramento River. However, some reaches are aggrading and others degrading. The Sacramento River between Verona and the Sacramento Weir experienced a slight degradation trend between 1997 and 2008 while the portion from the Sacramento Weir to Freeport experienced aggradation as indicated in Figure 5-6. This may be due to the interaction of the Sacramento and American Rivers. During large flood events on the American River, water flows upstream in the Sacramento River and discharges over the Sacramento Weir. The sediment flowing from the American River and Sacramento River likely deposit in the reach between the Sacramento Weir and Freeport, contributing heavily to the aggradational trend noted between 1997 and 2008. This is a trend that seems likely to continue well into the future if no modifications are made to the system. Long term HEC-6T simulations show this same pattern after 50 and 100 years of simulation as shown in Figure 5-7.

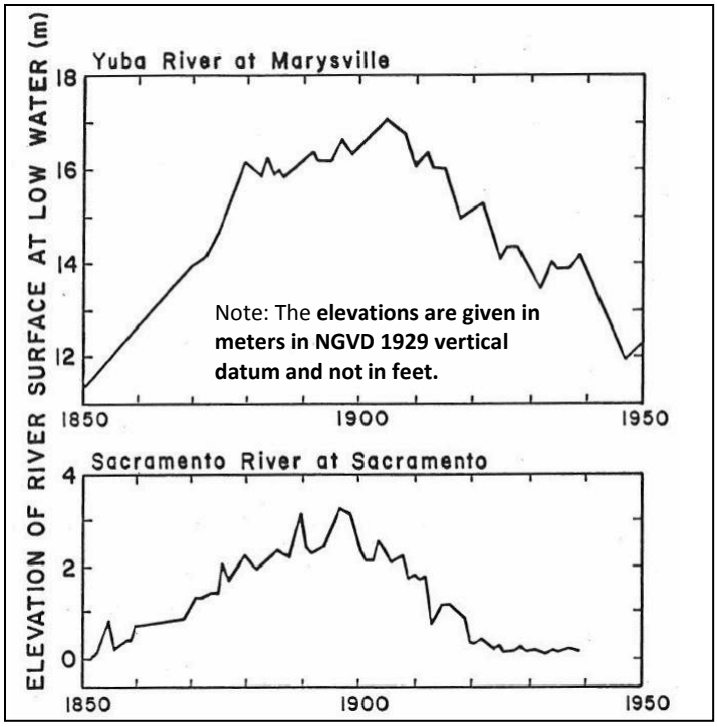

Figure 5-2. Historical water surface elevations on Yuba and Sacramento Rivers showing effects of deposition and erosion of hydraulic mining debris (developed by Meade 1982 from NHC 2009)

It is estimated that between 1 and 2.3 feet of aggradation will occur downstream of the Sacramento weir in the next 50 years. Implications for this aggradation are reduced capacity to pass flood flows. However, event specific simulations show this same reach degrades (0 – 1 ft of degradation estimated) following flood events (Figure 5-8). It is therefore possible that this long term aggradation does not significantly impact channel capacity during flood events as the floods may mobilize this sediment. This information together with estimated relative sea level rise and other pertinent information should be used to inform risk based decisions for both feasibility and design level study phases.

The future trend noted in Figure 5-5 does not include more recent data collected on the erosion resistant formation beneath the American River that could limit future vertical erosion. A more recent update of the model includes this new geotechnical information and draft results are shown below in Figure 5-9. The model used in Figure 5-9 includes the updated geotechnical information but has other differences with the model used in Figure 5-5. The significant differences between the models used for Figure 5-5 and Figure 5-9 are:

- Figure 5-9 model includes the updated geotechnical information while Figure 5-5 model does not

- Figure 5-9 model is based on synthetic event hydrology while Figure 5-5 model is based on actual historical hydrology

- Figure 5-9 model is "fixed" at the downstream boundary by a rating curve while the Figure 5-5 model is allowed to adjust dynamically based on changes to the Sacramento River (i.e. Figure 5-9 is not "linked" to the Sacramento River HEC-6T model while Figure 5-5 is).

Therefore the results depicted in Figure 5-9 cannot be compared directly with those shown in Figure 5-5. The amount of scour seems to be much less than previously predicted, which may be partially explained by model differences noted above. Despite these model differences, the average expected channel erosion for the Lower American River for 50 to 100 years of simulation is about 5 to 7 feet (see in Table 5-1). The results show it is possible the channel will degrade to the erosion resistant material between RM 6.5 and 10 (as shown in Figure 5-9). It is also possible that the bed will erode to the erosion resistant surface for portions of the reach above RM 15 (above where the current federal levees end); especially since the depth of active erosion likely exceeds that observed or predicted by the models. This makes protecting the levee toe critical for flood risk reduction and future degradation upstream of the levees may have detrimental impacts on environmental and recreational interests in that reach.

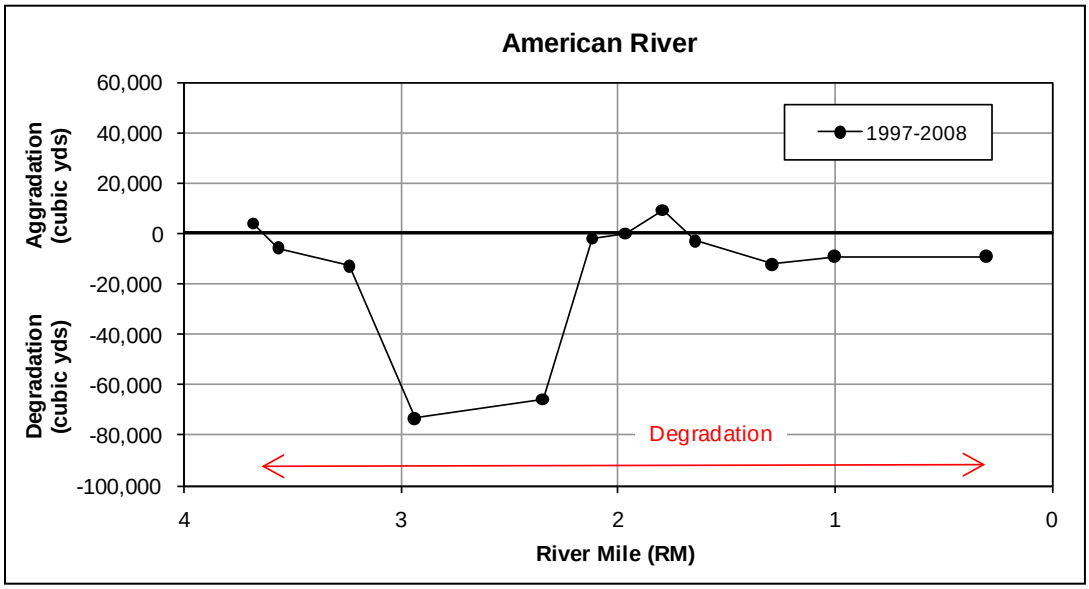

Figure 5-3. Aggradation/degradation trends for lower portion of the American River showing degradation between 1997 and 2008, supporting the trend noted in long-term HEC-6T simulations

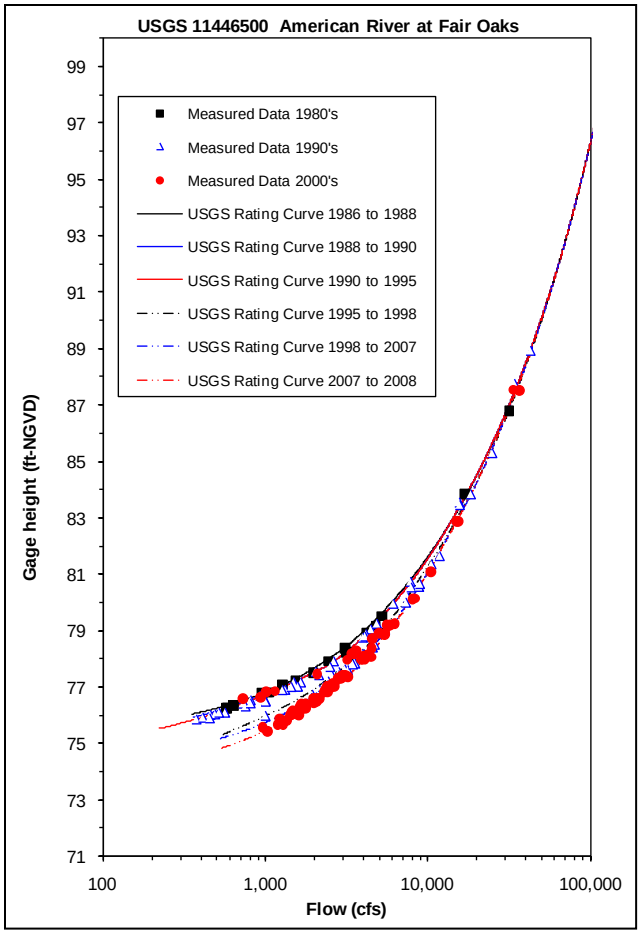

Figure 5-4. Stage versus flow plot of Fair Oaks gage on the American river indicating vertical erosion (reduction of water surface for the same discharge) from 1986 to 2008 (from NHC 2012)

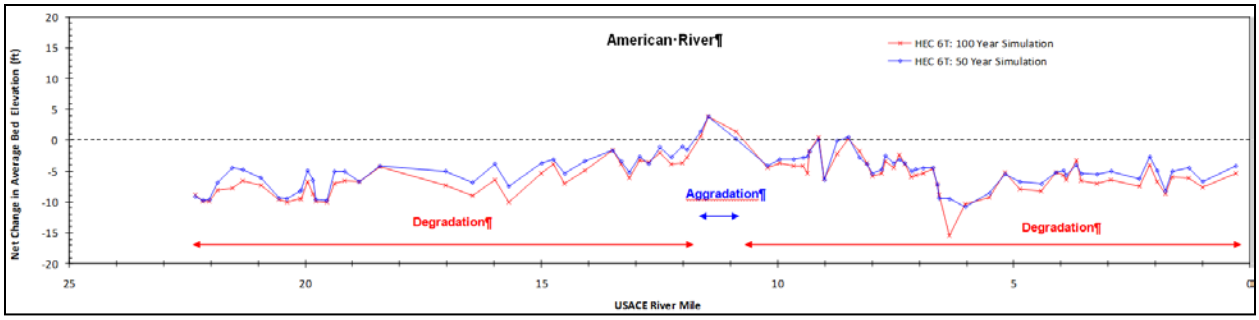

Figure 5-5. Net change in thalweg elevations and section-average bed elevations in American River (long-term simulations)

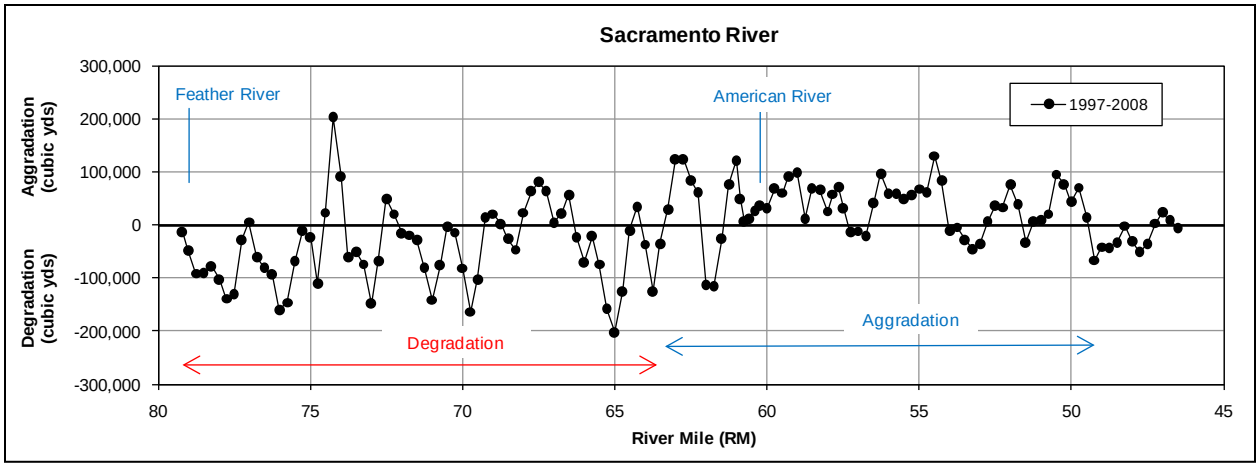

Figure 5-6. Aggradation/degradation trends of a portion of the Sacramento River showing aggradation between the Sacramento Weir and Freeport between 1997 and 2008, supporting the trend noted in long-term HEC-6T simulations

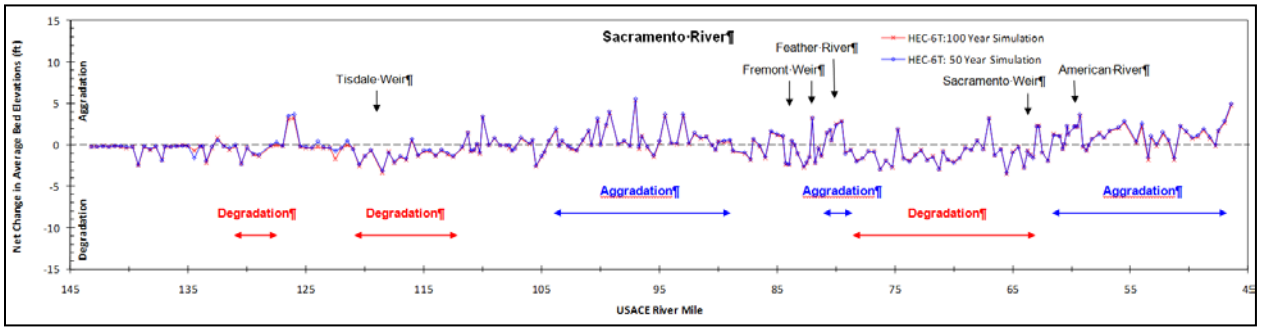

Figure 5-7. Net change in thalweg elevations and section-average bed elevations in Sacramento River (long-term simulations)

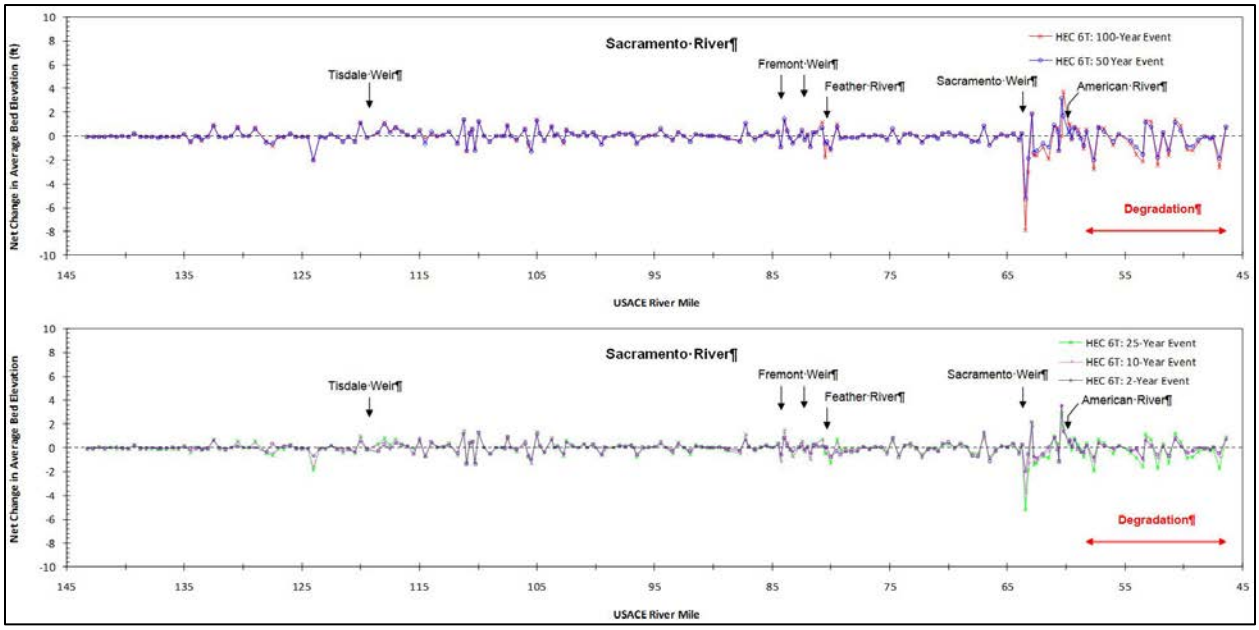

Figure 5-8. Results from single event HEC-6T simulations showing degradation between the Sacramento Weir and Freeport during individual flood events.

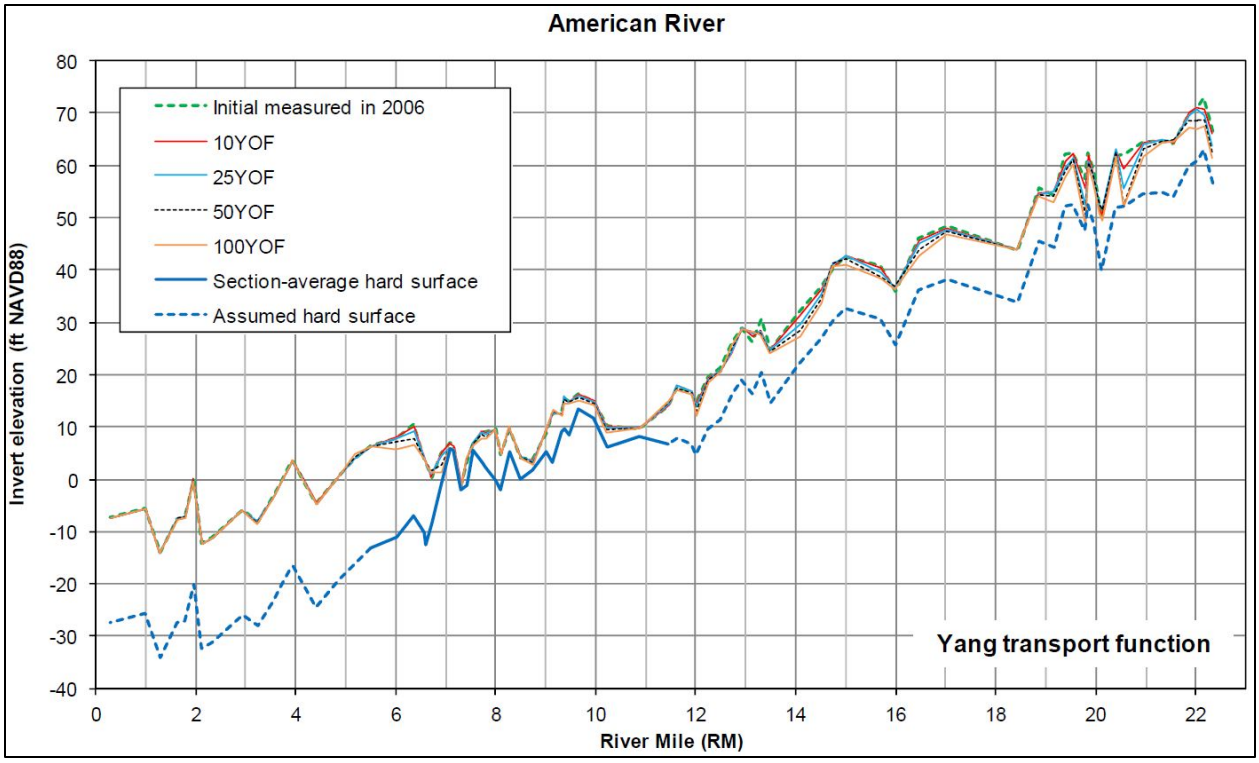

Figure 5-9. Draft results from simulation of a series of high flow flood events showing estimated erosion resistant material (e.g. Section-average hard surface).

Table 5-1. Simulated long-term bed aggradation and degradation for the American River by reach

American River				
River Mile	50-year simulation		100-year simulation	
22-20	-7.48	-7.30	-8.67	-8.48
20-15	-6.99	-5.70	-8.61	-7.21
15-10	-2.88	-2.08	-3.70	-2.72
10-5	-5.50	-4.88	-6.10	-5.57
5-0	-5.35	-5.67	-6.37	-6.79
Average	**-5.39**	**-4.83**	**-6.42**	**-5.84**

5.1.1 HEC-6T Model Sensitivity and Limitations

A series of sensitivity runs was performed for the 50-year period to evaluate effects of changing sediment supply on simulated bed profiles. Model sensitivity to changes in sediment supply was evaluated by increasing and decreasing upstream sediment inflows on the Sacramento, Feather, and American Rivers by 30%. The sensitivity test shows that the simulated hydrological changes generally tend to slightly increase the magnitude of long-term bed adjustments. The American River simulations are not sensitive to the upstream sediment supply because the supply is so small. For the Sacramento River, simulated degradation or aggradation generally increase from 1 to 5 ft, with a prevailing aggrading trend in the lower half of the study reach (less than 1 ft in the lower portion – which is the lower ½ of the reach from Colusa to Freeport).

A series of sensitivity runs was performed for the 50-year period to evaluate effects of climate changes on simulated bed profiles. Model sensitivity to climate changes was simulated by arbitrarily increasing the 30 highest flows in a given year by 1/3 and decreasing the other flows such that the total annual runoff did not change. The effect of future sea level rise on sediment transport conditions was assumed to be insignificant. This assumption is validated by a relative sea level rise analysis conducted for the Sacramento River Bank Protection project. The sensitivity test shows that the simulated hydrological changes generally tend to slightly increase the magnitude of long-term bed adjustments. The overall pattern in long-term evolution of the bed profile, however, does not change significantly. For the Sacramento River, simulated degradation or aggradation generally increase from 1 to 5 ft, with a prevailing aggrading trend in the lower half of the study reach. In general the simulated changes in hydrological conditions appear to have less significant effect on channel evolution trends compared to the simulated changes in sediment inflow. For the American River, bed degradation for the climate change scenario increases by up to 1-4 ft, particularly for the lowermost portion of the study reach.

These results assume that the hydrology, including operation of Folsom Dam, are identical to the years 1997 – 2008 and repeated for the next 50 and 100 years. Actual results will be different due to uncertainty in future hydrology, anticipated changes to operations of Folsom Dam, and uncertainty of sediment and geology conditions. In general, increased discharge from Folsom Dam is expected to exacerbate the amount of aggradation/degradation in the Sacramento and Lower American River. The HEC-6T model developed by the ARCF GRR (e.g. Figure 5-9) used hydrology that is thought to be representative of changes to operations at Folsom Dam.

It is important to consider that HEC-6T does not simulate local scour or local deposition, bank erosion, natural adjustments in channel widths, or lateral movement of the channel. These other factors are important considerations but are not possible to model concurrently at this time. It should be noted that the channel of the lower American River is highly irregular at many locations (especially in braided reaches upstream of RM 8). These irregular reaches may not be adequately represented in the 1-d HEC-6T model. Therefore, results obtained for the irregular reaches may be subject to simulation errors and should be treated with caution. In general, however, degradation predicted by the model for the lower American River (the HEC-6T model developed for the Sac Bank Project, see Figure 5-5) agrees with the stage-discharge records obtained for the American River gage at Fair Oaks which shows ongoing channel degradation. It should be noted that the HEC-6T model was developed and calibrated primarily for long-term simulations with gradually varying flows and gradual bed adjustments and therefore may be inaccurate for flood-event simulations with rapid changes in flows and rapid bed elevation changes. Along with these limitations, natural variability adds uncertainty to the results. Therefore, results obtained from flood event simulations should be regarded as approximate. The results should also be viewed as reasonable approximations of future trends.

The HEC-6T erosion studies do not consider risk to project levees from other sources such as boat wakes, wind waves, local scour at tree roots or fallen trees, etc. The degradation can also undermine bridges and other structures in or crossing the channel. Site-specific analysis is needed during design for structures such as bridge piers to account for local scour and overall erosion.

5.1.2 Grade Control Considerations

Erosion into the cohesive resistant material is affected by water quality, material history such as weathering, and macro-scale properties such as zones of weakness. The modeling indicates that

expected erosion into the erosion resistant layer is minimal to none. However, there is spatial variability in the material properties and weak zones within the material that may accelerate the overall erosion of this material due to macro-scale processes such as toppling of weakened exposed blocks. In addition, sediment movement during floods can increase erosion beyond the expected clear-water scour limits since the sediment acts as a "sand-blaster" on the erosion resistant material. Given this uncertainty, it is important to consider the possibility of some scour into this erosion resistant layer during future studies, such as for analysis of bridge piers. The underlying erosion resistant layer likely will erode more slowly than less resistant material, but the ultimate equilibrium depth of scour may not be different from a less erosive resistant layer. However, the time required to erode to the equilibrium depth may exceed the expected life of the project and is not expected to occur under a single event. Therefore, it is reasonable to proceed without structural features at this time. Monitoring of the various sites should be included as part of the Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRRR) effort under the project.

The addition of any grade control features on the American River is not currently part of Alternative 1 or 2, or the recommended plan. While the need for future grade control due to erosion of the erosion resistant layer cannot be ruled out, it is considered a lower risk to not include this feature in the tentatively selected plan. It is expected that any issues with erosion into the erosion resistant material will be noticed during regular infrastructure monitoring and necessary OMRRR actions taken in a timely manner to protect levees and other infrastructure as needed due to the expected relatively slow rate of erosion. As previously mentioned, the analysis does not indicate significant erosion of this layer and so the rate of erosion is likely small enough to allow for timely future remedial action if necessary. The panel experts are in disagreement over the need for grade control, with a majority not recommending any features, and the rest saying that there is not enough information to make a conclusion. In addition, including a grade control structure guarantees financial expenditure to address an issue that may not be needed and will create additional impacts to the channel and environment, such as accelerated local erosion downstream of the structure and reduced ecosystem function (e.g., impaired aquatic organism movement). Therefore, not including grade control in the Alternative 1 or 2, or the recommended plan is considered lower risk than including it in the same plans. Not including the grade control is a residual risk to be addressed at some point in the future.

Overall the Sacramento and American River reaches in the Common Features GRR are in an overall degrading state with the American River expected to degrade much more than the Sacramento River. Grade control is not anticipated to be necessary but the need for this should be monitored as part of routine operation of the constructed project.

5.2 Lateral Erosion

Lateral erosion can be the result of channel planform adjustments, changes to the vertical channel profile, or from localized features such as bridges and pipes in the channel. Lateral erosion from local features needs to be considered during future studies and will not be discussed further in detail. Channel planform adjustments that can cause lateral erosion may include river bends migrating outward toward the banks and/or downstream, braided channels attacking the banks, and channel avulsion during a flood event. Changes to the vertical channel profile include aggradation or degradation in response to river channel changes.

5.2.1 Lateral Erosion Potential from Vertical Erosion

As indicated in Section 5.1, the LAR downstream of Folsom Dam has incised into the sediment deposited from the gold mining of the 1800's. An appropriate conceptual model therefore is the Channel Evolution Model (CEM) shown in Figure 5-10. As the channel incises (stage II), the banks are steepened until the banks fail, widening the channel (stage III). Eventually the erosive shear stresses along the channel are reduced along with the ability of the water to remove the sediment from the failed banks. This leads to accumulation of material within the channel that begins to form a new floodplain but also continues to erode the banks (stage IV). Finally a new stable state of dynamic equilibrium is reached (stage V).

Based on the Channel Evolution Model, it is anticipated that channel widening will occur downstream of Folsom Dam as a result of Folsom Dam construction. This is a simplification of complex local processes but shows the long-term expected response for the Lower American River. Similarly, the degradation of the Sacramento River between Verona and the Sacramento Weir noted in Section 5.1 indicates this reach is at risk of lateral erosion as well.

Historic cross-sections at Hazel Street on the Lower American River (see Figure 5-11) illustrate the general trend of the channel degrading and widening consistent with the channel evolution model. This cross-section appears to show this channel at this location in 1992 was in stage III or IV of the channel evolution model and is not stable. Other historical cross-sections show a similar trend indicating possible channel instability. There could also be local instabilities in these selected cross-sections that are not indicative of the entire reach. However, the overall collective information seems to indicate the Lower American River has been unstable in the past and may be widening or stabilizing (phase III or IV) now and in the future.

While some of the levees may be protected from lateral erosion, the 1986 flood indicates that unprotected levees on the Lower American River are still at risk of failure from lateral erosion (see Figure 1-6).

Similar to the Lower American River, the Channel Evolution Model indicates channel widening potential between Verona and the Sacramento Weir due to degradation. The reach between the Sacramento Weir and Freeport is already relatively confined by levees and it is possible the long-term aggrading trend shown in Figure 5-7 becomes degradational during individual flood events. This is supported by HEC-6T model results that show long-term aggradation for this reach (Figure 5-7) but degradation during an individual flood event (Figure 5-8). The Channel Evolution Model is applicable to long-term trends and not individual flood events. However, it is reasonable to conclude the degradation expected in this reach during a single flood event could destabilize channel banks that exceed a critical height threshold, leading to bank failure and channel widening at least in localized areas. Further, Therefore channel widening could be a possible long-term result for this reach as well due to destabilization of channel banks from degradation during flood events. This observation indicates lateral erosion and channel widening can reasonably be expected for both the Lower American River and Sacramento River within the Common Features GRR project.

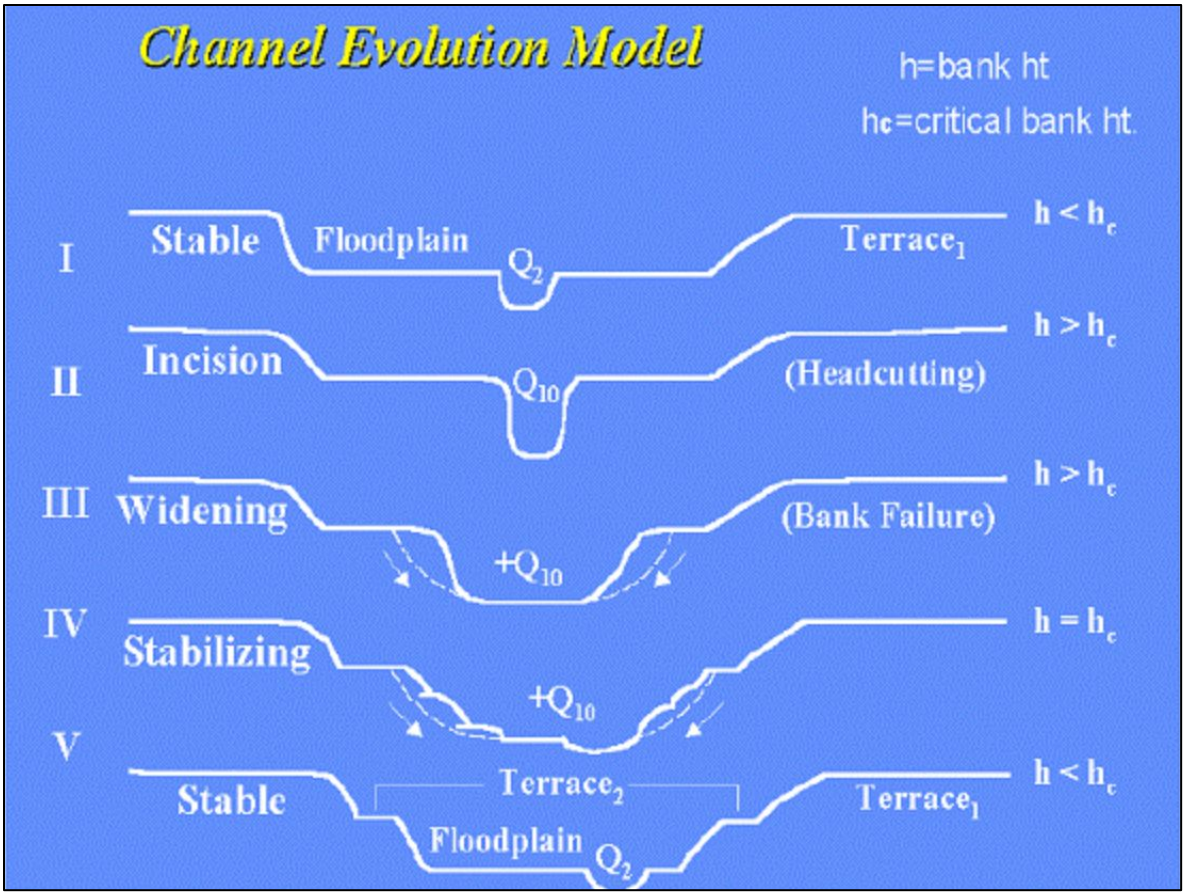

Figure 5-10. Channel Evolution Model describing how a stable channel responds to a disturbance that causes channel incision before reaching a new stable dynamic equilibrium

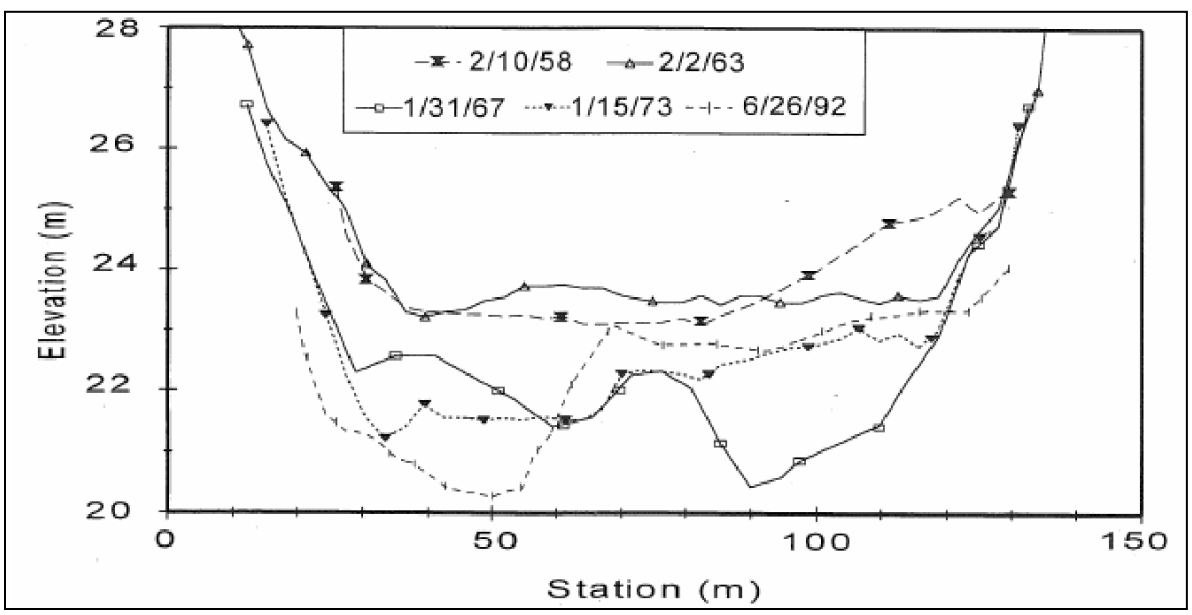

Figure 5-11. Historical erosion at Hazel Street showing vertical and lateral erosion, which shows Channel Evolution Model trends (developed by James 1997 in NHC 2009). Note distances elevations are in meters

This assessment is consistent with the findings of a bankline migration analysis conducted by NHC using historical maps and aerial photography from 1949 to 2005. This analysis shows that the average low flow channel width of the Sacramento River reach between Verona and Freeport increased about 5% to 10% during this time period. Confinement of flows by levees and changes in hydrologic conditions, caused principally by Shasta Dam and the Trinity Diversion, are thought to have contributed to the observed width increase during this time period. Similarly, the analysis of the channel shift maps indicates that there has been about 4% decline in surface area at the 40 largest overbank berm sites in the Sacramento River between Colusa and Freeport. The observed loss of the overbank berms is mostly related to the increase in channel width between 1949 and 2005.

5.2.2 Lateral Erosion Potential from Planform adjustments

Lateral erosion can also occur as a result of natural river channel planform movement such as actively migrating river meanders, braided channels directing flow at the banks, and channel avulsions during flood events. Ayres conducted a bankline shift analysis of the Lower American River from 1957 to 1998 which was updated by NHC in 2010. The NHC analysis indicates that there was no observed bankline shift in the Lower American River between 1998 and 2010. NHC concluded that while there are currently no actively migrating meander bends on the Lower American River, large floods have caused significant instream changes between the channel banklines in the past. It is also noted that lateral erosion and bankline shift is occurring on the Lower American River, but on a scale too small to be accurately identified by air photo interpretation. This is because erosion is often occurring in vertical cutbanks obscured by tree canopy, making them difficult or impossible to see in air photos. In addition, the rate of erosion may not be discernible due to the resolution of the air photos.

NHC also conducted bank migration analysis for the Sacramento River using air photos from 1949 – 2005. Analysis of these maps indicates that significant (>150 ft) river channel shifting has occurred since 1949 over only about 12% of the Sacramento River between Colusa and Freeport. These areas of significant channel shifting are located out of the ARCF GRR study location in areas where one or both levees are set back from the river channel. Lateral channel evolution is limited for the study reach of the Sacramento River from Verona to Freeport because the river channel is closely bordered by revetted levees that limit lateral channel evolution. However, this does not mean that bank erosion is not occurring in this reach. As noted previously the American River is experiencing erosion that is not clearly identifiable from aerial photographs due to steep banks and vegetation obscuring the erosion. This is also likely the case for portions of the Sacramento River between Verona and Freeport as demonstrated in erosion sites along this reach identified during annual reconnaissance surveys of the Sacramento River Bank Protection Project.

5.2.3 USDA BSTEM Analysis

A comprehensive analysis of streambank- and levee-erosion rates over a 48-year period was conducted by USDA-ARS for the Sacramento River Bank Protection Project. The work was conducted along 300 miles (483 km) of the Sacramento River main stem and selected reaches, including the Lower American River. Reconnaissance was conducted by boat and helicopter with fifty sites selected for site-specific intensive analysis. In-situ geotechnical data was collected at these sites including Jet Erosion Tests (JET), borehole shear tests (BST), and soil samples of soil layers for particle size analysis. The percent reach failing along the reaches was estimated using GPS referenced video and a Modified Rapid Geomorphic Assessment.

The 50 intensive sites were analyzed for sediment loading and bank retreat using the Bank Stability and Toe Erosion dynamic model (BSTEM). This model estimates bank retreat and sediment loading by linking hydrology, hydraulics, slope stability failures, erosion from moving water, multiple layers of different soil types, and root reinforcement of the soil. The dynamic version of the model was used that incorporates hydrographic data. Hydrographs from 12 years of record were used (1996 – 2008). BSTEM results were extrapolated to the reach using the estimated percent failure and the results compared to actual gage data of suspended sediment load. This verified the model was producing reasonable results. With this verification of the model, the 12 years of hydrology were repeated 4 times to simulate 48 years of future erosion. This model assumed that the channel is vertically stable which for the purpose of the USDA analysis was found to be an adequate assumption.

The USDA analysis estimated that about 44% of the total suspended sediment load in the Lower American River is from the banks although continued erosion could reduce this to about 20% in about 48 years. The report concludes that it is important that analysis use continuous simulation of streambank processes to predict loadings and rates of lateral retreat to capture the dynamics of erosion processes. The report notes a couple of points:

- Magnitude of lateral retreat are not well correlated with sediment loadings for a site possibly because significant erosion can occur at the toe of a bank without bank retreat at the top of the bank. However, subsequent flows may lead to bank retreat at these over-steepened banks.

- Bank failures are not well correlated with high discharge events because antecedent soil moisture conditions are important and failures often occur on the receding limb of the flood as the confining pressure of the flood water is removed from the relatively saturated and weaker bank.

The study found that in general the portion of the Sacramento River between Verona and Freeport and the Lower American River have between 20% - 40% of the banks failing. One of the highest estimated sediment loadings was found to be near Lower American River USGS RM 16 even though this bank was relatively far from a levee. A relatively moderate sediment loading was found at Lower American River USGS RM 5.5 while a low sediment loading was found at the mouth of the American River. This indicates a general upstream trend of progressively more erosion the closer a location is to Folsom Dam. Of the seven sites analyzed within the Common Features project area on the Sacramento River, 2 had relatively high loadings (between USGS RM 55 – 57), three had relatively moderate loadings (USGS RM 64 – 79), and two had relatively low loadings (USGS RM 48 – 50). The loadings were extrapolated using the percent of the reach failing to estimate the sediment loading from each 2-mile segment of the study area. One site on the Sacramento River between USGS RM 73 and 74 was found to erode such that the river would impinge on the levee within 48 years. However, there could be other sites where this could occur that were not analyzed.

Of the 50 intensive sites analyzed, seven are within the Common Features GRR study area along the Sacramento River and three are located in the Common Features GRR study area along the Lower American River. While this may be appropriate for large scale studies like the Sacramento River Bank Protection Project, it is likely not a large enough sample for more narrowly focused feasibility studies such as the Common Features GRR. Also, no sites were located in the area constricted by levees between RM 5 and 10 on the Lower American River. In addition, the hydrology used for estimating erosion 48 years into the future generally had higher flow rates than long-term averages and therefore

may over predict long-term sediment loading and bank retreat. However, the study still provides valuable insight into erosion in the Common Features GRR project area. The estimated percent of total sediment derived from the banks agrees remarkably well with the results from a historic channel shift analysis (NHC 2012). This study by the USDA confirms the results of the Channel Evolution Model and the observations from annual erosion surveys and air photo analysis.

The magnitude of the erosion does not always correlate well with erosion risk to levees. Distance of the levee from the channel as well as geology need to be considered. For example, a levee set back 300 feet from the channel is not in danger from a channel that only moves a maximum of 200 feet. Similarly, A levee could be set back 300 feet but be at risk of erosion failure if the soil between the levee and the river channel is highly erodible. However, a levee with a 30 foot berm may not be at risk if the soil between the levee and the channel is erosion resistant. See Section 5.4 for more on levee risk from erosion. So while the distance of the levee from the channel is important for estimating levee risk from erosion, soil properties also need to be considered.

5.2.4 Channel Stability and Erosion Risk Findings

The channel evolution model, historical data, and modeling of future conditions indicates that the levees of the Lower American River, and to a lesser extent the Sacramento River between Verona and Freeport, are at risk of erosion related failures. According to NHC (NHC 2012), it is appropriate to say that the Sacramento River between Colusa and Freeport is in a state of dynamic equilibrium. However, there are portions of this channel that appear to be actively degrading (NHC 2012). So while these sub-reaches may not be considered stable by themselves, the entire reach as a whole is considered to by dynamically stable. The Sacramento River between Verona and Sacramento Weir is expected to degrade slightly in the future and un-revetted portions of the levees are at risk from erosion. The Sacramento River between Sacramento Weir and Freeport is expected to aggrade overall in the future but may degrade during individual flood events. Potential implication of the simulated long-term changes in bed profiles can be increased stress along the toe of the project levees or overbank berms in the degrading reaches, which may result in increased scour along un-revetted channel sections. In the aggrading reaches, increase in bed elevations may result in higher flood stages, reduced flood conveyance, and possibly increased local bank and levee erosion from flows re-directed to the sides of the channel due to the deposited sediment. Therefore, levees not protected adequately from erosion between the Sacramento Weir and Freeport are at risk from erosion.

In contrast, the American River does not appear to have reached a state of dynamic equilibrium in the leveed portion of the reach based on recent analysis. A relatively erosion resistant layer may limit vertical erosion, leading to increased bank and levee erosion. Therefore, the levees on the Lower American River not protected adequately may be at risk from erosion. The presence of riprap may increase the rate of erosion into the erosion resistant material in the channel bed at some locations. Erosion protection designs will therefore need adequate toe protection to prevent undermining the toe of the erosion protection.

For both the Lower American River and the Sacramento River, infrastructure encroaching in the floodway, such as bridges and pipelines, need to be adequately protected from reasonably anticipated scour during design and construction. This effort is not included in the tentatively selected plan. It is assumed this effort will occur during future analysis and design efforts and likely needs to be coordinated with multiple agencies and infrastructure owners. Civil Design has also determined that the additional cost of the scour and erosion counter measures for the infrastructure is not significant

compared to the overall cost of the erosion protection currently included in the tentatively selected plan and is well within the associated cost contingency. The tentatively selected plan also does not include grade control as the consequences of including it are higher than the risk of not including it. However, protecting the levees along Sacramento River and Lower American River from erosion is important to reduce the probability of erosion related levee failure and to improve flood damage risk reduction for the protected areas.

5.3 Other Erosion Sources

Other sources of erosion include wind-wave, boat, vegetation, recreational, and bridge scour. These sources are expected to be minor compared to the fluvial process, but are discussed herein for completeness.

5.3.1 Wind Wave Erosion

The potential for wind waves to overtop and erode flood control features (principally levees) near the City of Sacramento was analyzed and alternatives to reduce risks associated with wind wave erosion developed, including costs (USACE 2010). The analysis is based on coincident 1/200 ACE event water levels and extreme wind events. 34 sites were selected where local wave conditions are expected to be maximized yet representative of nearby levee sections. The analysis follows Engineering Circular 1110-2-6067 and other technical publications related to wind wave analysis. This analysis represents the latest guidelines for wind wave erosion analysis adopted by USACE, Sacramento District. Each site was assigned the highest risk computed for the site for either levee face erosion or overtopping for any wind direction at the site. The risk from this site was then generalized to nearby levee locations with similar wave heights, geometry, and erosion protection.

This report identified those study sites where potential erosion due to wind waves could affect levee performance during a 200-year storm event. The report then presented methods to assess the potential for the waterside levee face to erode and determine if the maximum erosion would encroach on the minimum levee dimensions, and evaluate the potential for levee overtopping to threaten levee stability. Results of the quantitative analysis at each site were interpreted to assign a low, moderate, or high wind wave erosion risk at each site. Because the analysis is conservative and general in nature, it is recommended that detailed wind wave analysis be conducted during future studies at sites that may benefit from reduced repair requirement or the extent of the repair due to wind waves (See USACE 2010 for additional information). The study included reaches that are part of the Natomas PAC.

5.3.2 Boat Wave Erosion

Boat wave erosion has not been accounted for in this analysis because the impact of boat wave erosion in the project area is unlikely to be significant. Only smaller recreational boats operate in the Sacramento and lower American Rivers, and the other project reaches do not have enough consistent depth or width of channel to sustain boat traffic. Any repairs needed from boat waves would likely be addressed as part of standard operation and maintenance of the levees.

5.3.3 Vegetation Erosion (Tree Scour)

The preliminary designs for erosion protection include leaving some of the vegetation in place, an option made possible by a waiver process included in ETL 1110-2-571. A pier scour analysis to represent tree scour (likely using HEC-18) is included in the application for waiver. This effort is considered part of the erosion analysis, and is expected to be performed during future studies.

5.3.4 Recreational Erosion

Local bank and berm erosion due to a combination of recreational activities (e.g., biking, hiking, fishing, etc.) and the corresponding infrastructure features including bike paths and maintenance facilities is expected to be minimal compared to fluvial sources of erosion and should be addressed as part of the normal O&M activities.

5.3.5 Bridge Scour

There are over 15 bridges crossing the channel on multiple reaches in the project area. Bridges along the Sacramento and American rivers will likely need an analysis during design or refinement of the selected alternative to account for bridge scour protection. This effort is considered part of the erosion analysis and is expected to be done as part of future studies.

5.4 Expected Levee Performance

5.4.1 American River

As presented in Section 18 of the ARCF GRR Geotechnical Report (Attachment C), plots depicting the combined probability of poor levee performance (a.k.a. fragility curves) for with- and without-project conditions were developed at a series of index points along the various study watercourses. These curves communicate the cumulative (or combined) probability of levee failure versus the water surface elevation of flow in the river channel. Specific considerations taken into account when these curves are developed include underseepage, through-seepage, slope stability, and engineering judgment. Furthermore, the engineering judgment component consists of considerations for vegetation, animal burrows, encroachments, utilities, and erosion. It should be noted that the erosion component was not estimated based on any analyses, but on the experience of an expert elicitation panel, considering the location of the index points, the conditions of the foundation and levee material, the water velocity at that specific location, and on past history. For more information on the expert elicitation process a summary of the document “Geotechnical Office Report, Geotechnical Expert Elicitation Meeting Minutes,” dated July 2009, is available upon request.

The levee performance curves were finalized in 2011 with the judgment curves (erosion as a component) that were developed using an expert elicitation in June 2009. The validity of the erosion component of the performance curves was discussed at the expert panel and project team meetings. It was found that the estimated levee performance captured by the curves was reasonable based on the available data and expertise. In consultation with the project team the decision was made not to develop more rigorous analytical methods to refine the erosion portion of the curve.

Sample fragility curves for the American River at two locations are illustrated for the north levee in Figure 5-12 and for the south levee in Figure 5-13. Inclusion of both the with- and without-project

fragility curves in these figures indicates the change, or reduction, in probability of failure due to with-project improvement measures. Both the with- and without-project fragility curves account for the reduction in probability of poor performance due to the cutoff walls constructed as part of the ARCF WRDA 1996-1999 project. Therefore, the combined fragility curve at these two locations represents the judgment curve, of which erosion is the primary contributor to the without-project curve. The with-project curve accounts for residual risk due to vegetation, animal burrows, encroachments, and utilities that may not be addressed by the project alternatives or structural improvements. In both sample figures, the cumulative probability of poor performance, or levee failure, is less than 20 percent for the condition where the water surface elevation is at the top of the levee crest once the project is constructed. Without the project, the cumulative probability of poor performance is greater than 50% and indicates the erosion protection provided by this project is needed to reduce flood damage risk.

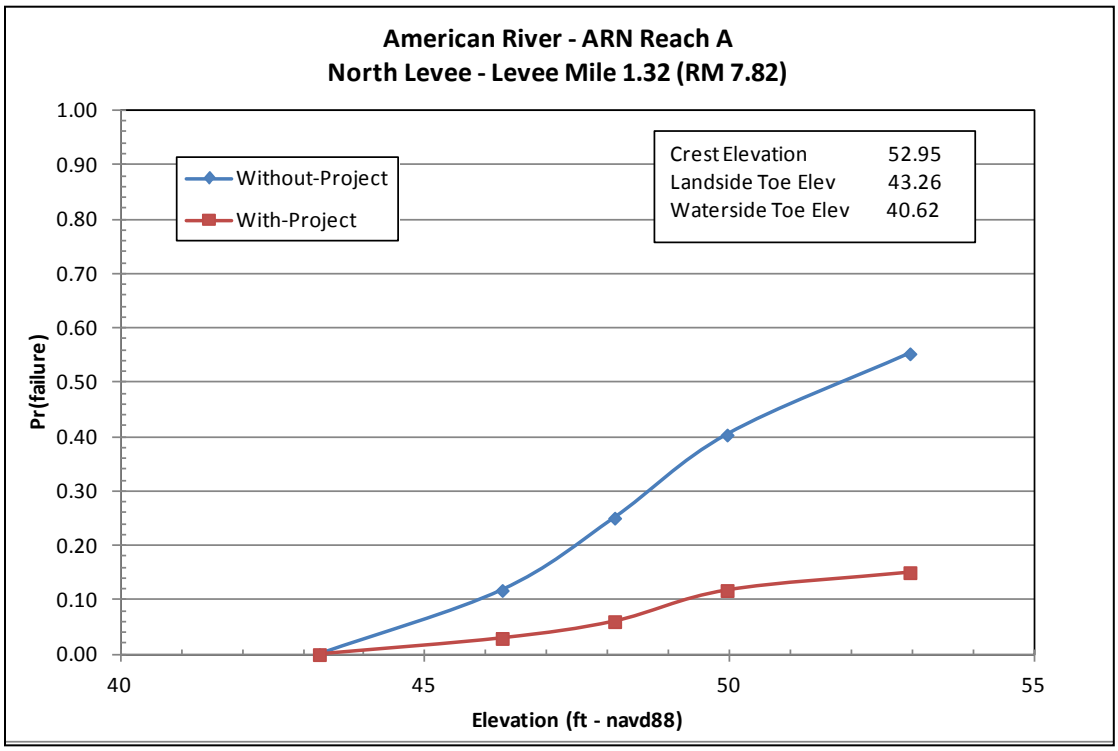

Figure 5-12. "Judgment" component of the levee fragility curves for the American River north levee at RM 7.82

5.4.2 Sacramento River

As discussed above, a series of plots depicting the combined probability of poor performance (a.k.a. fragility curves) for with- and without-project conditions were developed at a series of index points along the various study watercourses. These plots are presented in Section 18 of the ARCF GRR Geotechnical Report (Attachment C). Sample fragility curves for the Sacramento River at one location are illustrated for the east, or left, levee in Figure 5-14. Similar to the above figures for the American River, this figure shows the "judgment" component of the fragility curves. There remains a residual risk due to vegetation, animal burrows, encroachments, and utilities that may not be addressed by the project alternatives or structural improvements. In the sample figure, the cumulative probability of

poor performance, or levee failure, is reduced from a little over 20 percent down to less than 10 percent for the condition where the water surface elevation is at the top of the levee crest.

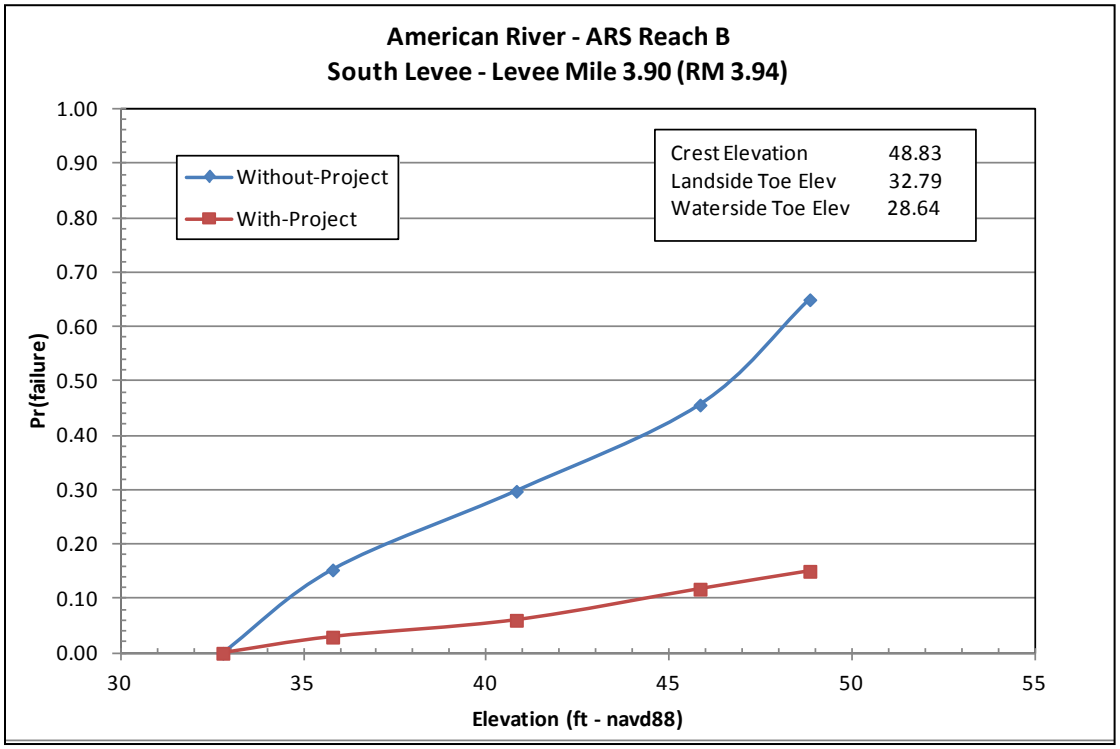

Figure 5-13. "Judgment" component of the levee fragility curves for the American River south levee at RM 3.94

Historic aerial photos in combination with a riprap database showing known riprap locations (as of 2007) was used to develop a rating of relative levee risk from erosion by channel shifting. The results of this effort by NHC (NHC 2012) are shown in Table 5-2 for the portion of the Sacramento River in the ARCF project footprint. This data shows about 18% of the levees in this reach are at higher risk from future erosion from channel shifting. However, this may be overstated as some higher risk sites have since been repaired with large riprap.

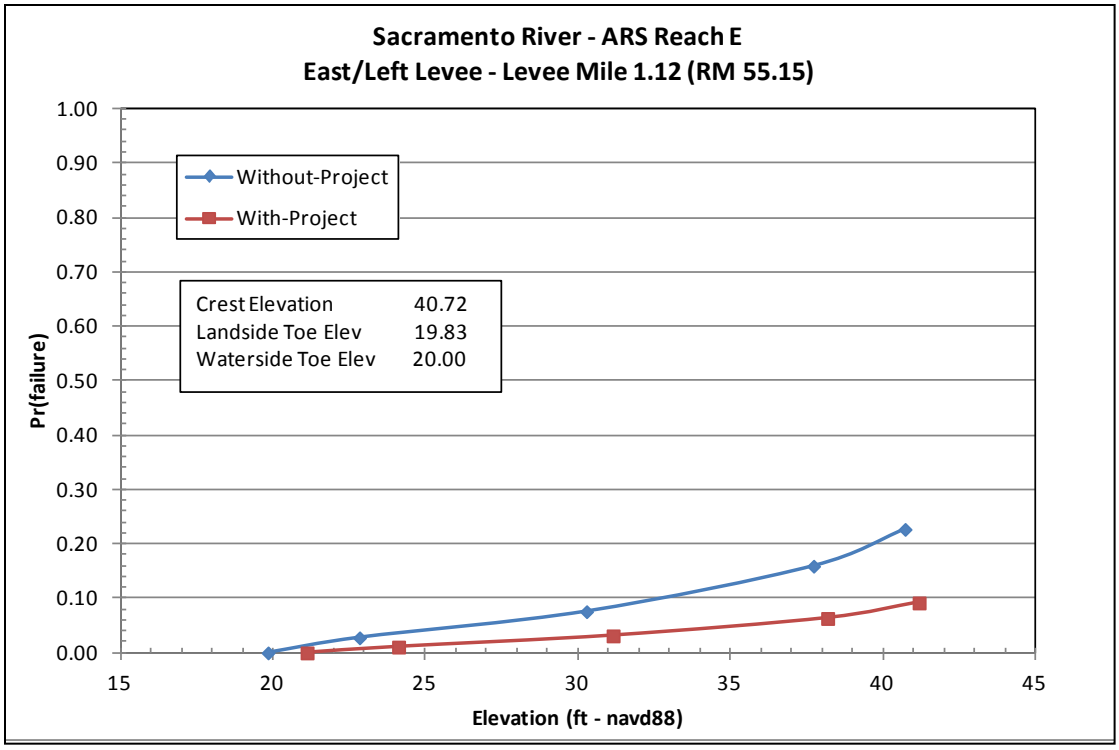

Figure 5-14. "Judgment" component of the levee fragility curves for the Sacramento River east/left levee at RM 55.15

Table 5-2. Levee risk ratings for Sacramento River by reach

Levee risk rating	Feather River to Freeport	
	Cumulative Miles	% total
R1	38.3	55
R2	2.6	4
U1	18.9	27
U2	10.0	14
U3	0.0	0
Total	**69.8**	**100**

Where:
R1 = Revetted bank, lower erosion risk
R2 = Revetted bank, higher erosion risk
U1 = Un-revetted bank, lower erosion risk
U2 = Un-revetted bank, higher erosion risk
U3 = Un-revetted bank, higher erosion risk, higher uncertainty

6 Bank Protection Basis of Design

6.1 General

The erosion protection features to support preliminary cost estimates were developed with input from the PDT with the objective of developing a reasonable cost to support plan selection. The erosion protection features are the same for alternatives 1 and 2. Two methods were used in an attempt to minimize the environmental impact of the features: Bank Protection and Launchable Rock Trench.

While the Bank Protection method is applicable in all areas, the Launchable Rock Trench method is applicable only in areas where there is sufficient bench between the levee toe and river. Both methods have similar rock quantities and costs are roughly equivalent, but the Launchable Rock Trench initially appears to have less environmental impact. For the purposes of the feasibility study, the Launchable Rock Trench was selected as the preferred method when either was technically feasible. It is expected that future studies will take into account many factors including the environmental impact to determine the final design.

The erosion protection was designed to convey the 0.5% ACE (1 in 200) future condition as described in Section 4.

6.2 Bank Protection

The bank protection design concept was adopted from the Lower American River (LAR) Sites I-V which was constructed shortly after the 1998 flood event. The design was developed by Ayres Associates and incorporated a rock protected slope with launchable rock bench. The rock bench has a trapezoidal soil trench “burrito wrapped” in geotextile. The soil trench would house a variety of woody tree species; offer shaded riparian area, and other beneficial habitat. This type of fix has performed well over the last decade and has required very little maintenance.

Several cross sections were analyzed along the American and Sacramento Rivers to develop typical sections that reasonably represented river conditions. For preliminary analysis, two sections were developed and used to develop quantities.

The typical sections were evaluated against project design parameters to ensure they meet minimum criteria. Design criterion was governed by EM 1110-2-1601 “Hydraulic Design of Flood Control Channels” with stone weight data from ETL 1110-2-120. Use of the Engineering Research and Development Center (ERDC) software CHANLPRO was used to develop some example gradations. Table 6-1 is a summary of the design parameters used for multiple cross sections along the American River.

After further evaluation, it was noted that the minimum geometries associated with the design sections resulted in rock quantities that exceeded minimum requirements for launchable rock and mitigation features. Rock gradations were deemed less important for determining costs for this design level. The geometry of the bank protection design (refer to Figures 6-1 and 6-2) yielded sufficient volumes of rock to meet anticipated launchable rock requirements and sufficient mitigation features to offset environmental impacts. The launchable rock volume requirements were determined based on average velocities for above-mentioned typical sections. Site-specific design for erosion protection sites will occur in future studies.

Table 6-1. Summary of the design parameters used along the American River

Description	Typical Section Locations	
	Downstream of Paradise Beach & Upstream of Howe Ave. (Includes all of the Sacramento River)	**Between Howe Ave & Paradise Beach**
Depth of Flow (ft)	37 to 50	47
160k cfs Velocity (ft/s)	7	12
Minimum Rock Thickness (ft)	3	3
Scour Depth => Launch Dist (ft)	10 to 20	10
Design Slopes (upper/lower)	2:1	2:1-3:1
Riparian Bench Slope	10:1	10:1
Minimum Launchable Rock Area per ft (underwater placement) (ft^2)	100 to 200	100

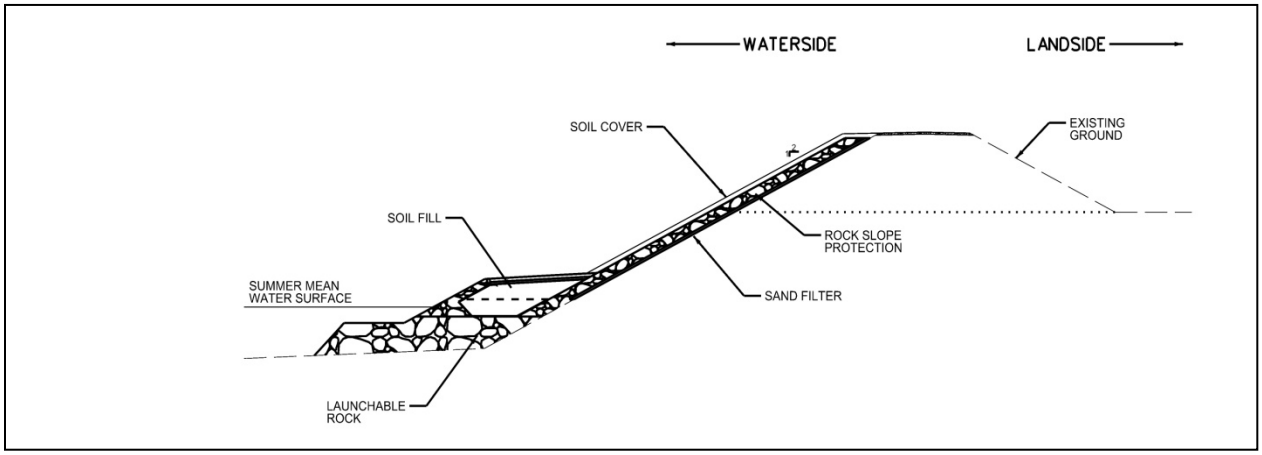

Figure 6-1. Bank protection generic design section and assumptions (insufficient bench)

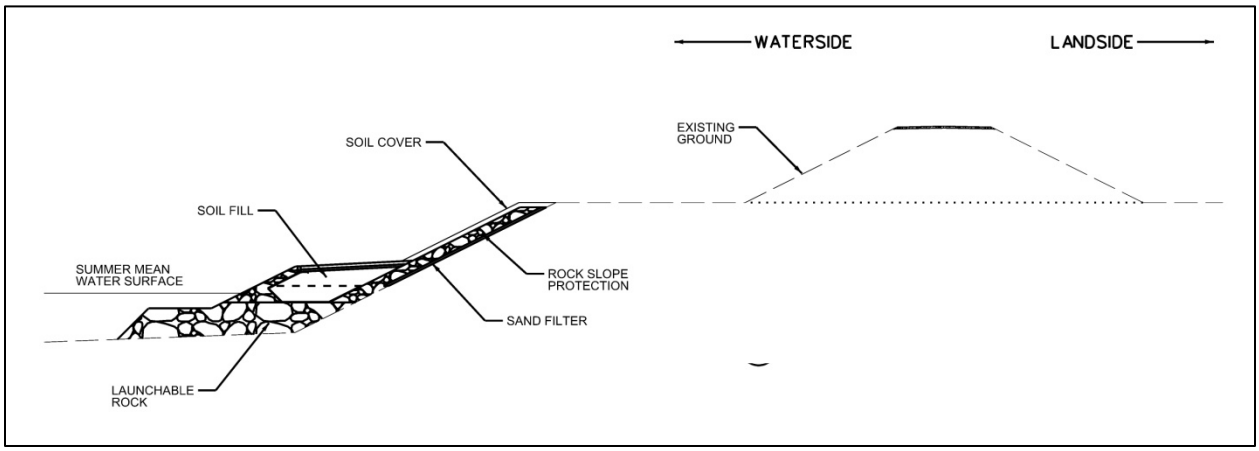

Figure 6-2. Bank protection generic design section and assumptions (sufficient bench)

6.3 Launchable Rock Trench

The rock trench design concept (depicted below in Figure 6-3) comes from the Windrow trenching method of erosion protection widely used along the Mississippi and Missouri Rivers. The trench design was only considered when the width of the existing waterside berm (if any) was enough to accommodate the construction of the trench. This form of passive erosion protection allows the existing berm to erode away naturally and does not require wet work or the disruption of shaded riparian habitat. The design includes trenching waterward of the levee, placing rock, and providing a soil cover for vegetation and other mitigation features.

The rock trench design used many of the same parameters shown under Table 6-1 for bank protection. The placement of the trench invert was a key design parameter and often dictated the required width of the berm. The invert was placed at the Summer Mean Water Surface Elevation (SMWSE) to remove the trench out of the vadose zone and eliminate the need to place rock in the wet. The SMWSE invert also reduced the launching distance and therefore the quantity of rock needed for scour. The reduced launching depth also increased the reliability of the launchable rock trench to launch uniformly and perform as intended. The generic design section and assumptions are shown below prior to any specific section edits.

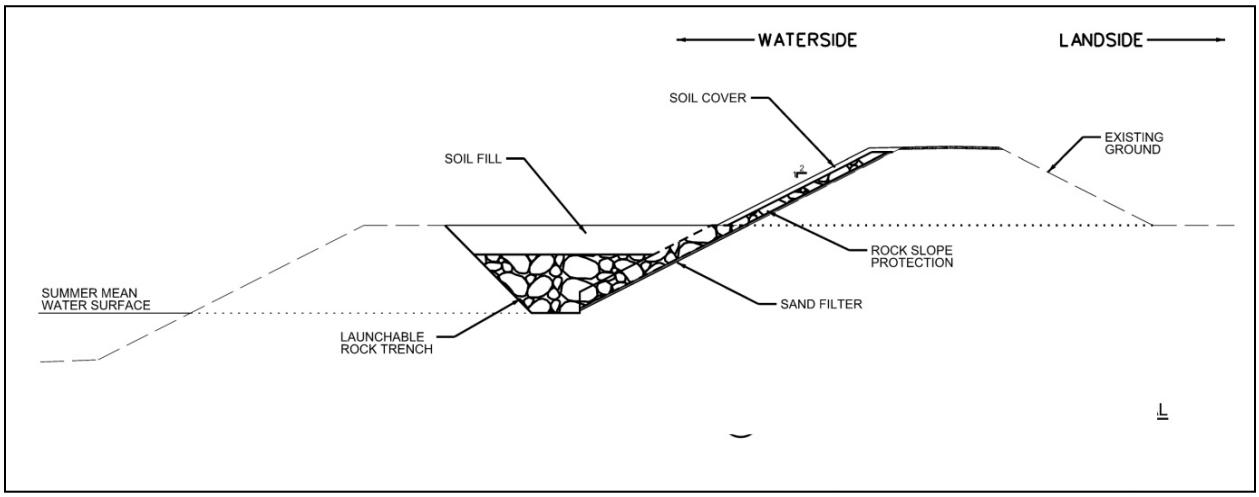

Figure 6-3. Launchable rock trench generic design section and assumptions

The design section would be lowered to the depth of the assumed SMWSE for that location. Rock slope protection was also provided on the waterward slope of the levee and carried all the way to the waterside hinge point. Excavation and fill quantities would vary because of the SMWSE and its relation to the existing elevation of the waterward berm.

It should be noted that the performance of windrow trenches can be compromised in high scour and velocity areas. EM 1110-2-1601 engineering criteria take these into account, however, there's still a level of risk that cannot be mitigated. In the mentioned conditions, the rock may launch all at one time or non-uniformly in such a way that will provide decreased erosion protection performance. The consequences of this situation are greater than bank protection because the existing bank will have already eroded away back towards the toe of the levee. There will be very little time to flood flight and

respond to the eroding site, which could lead to failure or breach of the levee. Conversely, if bank protection fails (undermined, flanked, etc) or stops providing its intended function, there is still bank available to flood fight and prevent the erosion from propagating towards the levee. Both methods offer a proven history of performance, however, the launchable rock trench will inherently have more risk that should be acknowledged by design team, and project sponsors.

6.4 Erosion Protection Footprints

Along the American River, the rationale used to determine where bank protection was required for the feasibility study involved consideration of several factors. The most important factors included: 1) the velocity computed by Ayres' 2-dimensional hydraulic modeling (Ayres 2004) for a discharge of 160,000 cfs, 2) the erodibility of the material near the levee prism, and 3) the past performance of the levee segment with respect to erosion. Figure 6-3 depicts the footprints of the proposed erosion protection for both the Lower American and Sacramento Rivers.

Using the above criteria, bank protection was determined to not be required along two segments of the right bank of the American River. The upstream segment, extending between the upstream end of the levee (~RM 14.4) and RM 10.3 and the downstream segment extending between a point near Cal Expo (RM 5.5) and the confluence with the Sacramento River (RM 0). In addition to following the above criteria, a portion of the upstream segment contains a 4000 foot-long reach wherein the channel includes a wide right overbank consisting of high ground (i.e., the location of a sewage treatment plant) in which the water surface elevation for a discharge of 160,000 cfs does not get near the levee and the levee essentially exists as a "freeboard" levee.

In addition, there are no proposed erosion protection features located along the left levee of the Sacramento River upstream of the American River confluence. The rationale for this approach is the assumption that, as recommended by the 2010 feasibility study for the Natomas PAC, a new levee will be constructed located adjacent to and on the landside of the existing Sacramento River levee (i.e., as a future without-ARCF GRR project condition). Furthermore, it is assumed that with the new proposed levee in place, the new levee template is located sufficiently far enough away from the existing bank that some bank erosion could occur along the entire Sacramento River reach, including into the existing levee prism, without threatening the new levee (e.g., analogous to erosion buffer zone). Nonetheless, O&M of the river bank will still need to occur. These assumptions will need to be verified during site-specific design of the ARCF project to ensure that the subject "new" levee does/or will in fact be constructed and that erosion "buffer" zones are adequate to preclude erosion which could lead to levee failure for flow into the Natomas Basin floodplain.

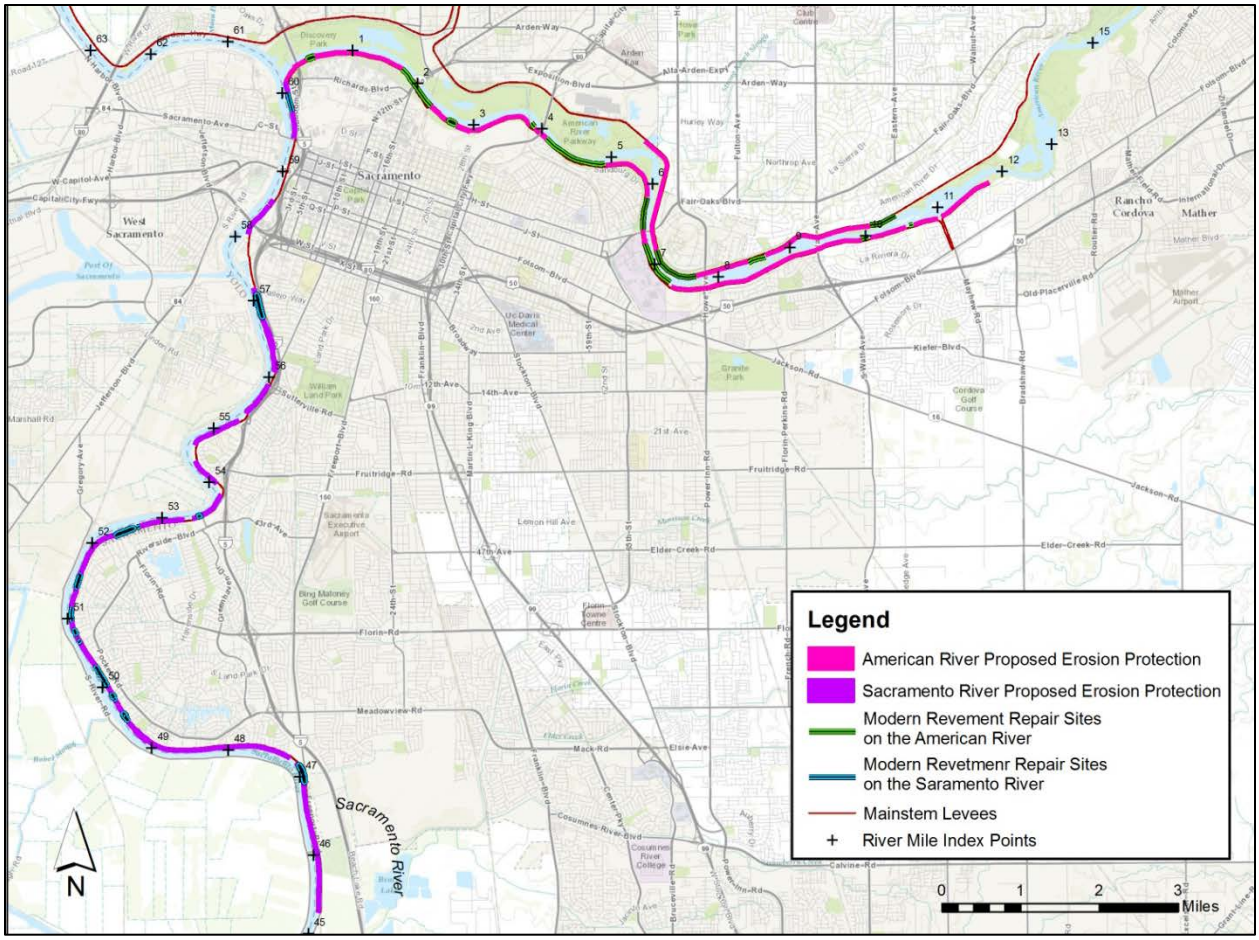

Figure 6-4. Footprints of the proposed erosion protection along the mainstem channels

Table 6-2 lists the cumulative lengths of the existing and proposed erosion protection features along the Lower American River. As illustrated by this table, about 100% of the left bank of the leveed reach will include some form of erosion protection features and about 35% of the right bank of the leveed reach will include erosion protection features.

Table 6-2. Cumulative length of existing and proposed erosion protection features along the Lower American River

	Left Bank		Right Bank	
	Levee Miles	Percent	Levee Miles	Percent
Existing Modern Revetment	3.1	28%	1.3	9%
Proposed Revetment	8.1	72%	3.7	26%
No Protection Proposed	0.0	0%	9.3	65%
Totals	11.2	100%	13.0	100%

Table 6-3 lists the cumulative lengths of the existing and proposed erosion protection features along the left (eastern) bank of the Sacramento River in the GRR study area. As illustrated by this table, about 84% of the left bank will include some form of erosion protection features.

Table 6-3. Cumulative length of existing and proposed erosion protection features along the left (eastern) bank of the Sacramento River

	Left Bank	
	Levee Miles	Percent
Existing Modern Revetment	2.7	18%
Proposed Revetment	9.8	66%
No Protection Proposed	3.3	16%
Totals	14.8	100%

A channel stability analysis (Ayres Associates, 2010) was used to determine areas requiring revetment with the assumption that all areas without modern bank protection will be protected. Modern protection was determined by areas defined as rock riprap with overall condition of good or very good. Additionally, there are some areas of high ground and areas with significant existing berm where protection is not required as shown in Figure 6.3.

6.5 Feasibility Design Considerations

The assumption of the feasibility study is that all modern revetments in the project area are designed to reliably and safely convey the design discharge of 160,000 cfs. The feasibility study assumes older revetments (e.g. “cobblestone” revetments) are unable to reliably and safely convey the design discharge. These historical cobble sites are likely beyond their intended design life and are in varying degrees of disrepair and failure. This leads to the assumption of replacing all historic cobble sites with modern angular bank protection.

However, a few exceptions to replacing the cobble sites exist in areas of lower velocities where the feasibility study assumes new erosion protection is not needed due to the lower velocities. For example, the right bank or “North” levee downstream of RM 5.5 and upstream of RM 10.5 (see Figure 6-3). Portions of the furthest upstream right bank levee are not expected to have water against the levee on the waterside for the design discharge.

These assumptions will need to be checked during implementation using site-specific analysis. Sites needing bank protection will need to be identified, prioritized, and designed for the design discharge during implementation. This may require additional environmental documents as the extent and location of the rock protection could change based on the new analysis and site-specific designs.

The current proposed rock protection locations and rock design for the project is a reasonable approximation of future actions used to estimate a reasonably conservative project cost, associated environmental impacts, and to assist with establishing federal interest. However, site-specific analysis and design needs to occur in the future during implementation and future changes to the location, extent, and design are possible.

While the repairs are expected to be designed and constructed to commonly accepted engineering and construction standards and USACE guidelines for the design discharge, it is expected that continued operations and maintenance will be necessary including:

- Repairing damaged rock protection
- Possibly installing additional rock protection
- Monitoring during floods
- Possible flood fighting

The estimates are reasonably conservative even though uncertainty remains in the location, costs, and environmental impacts of the proposed rock protection. Continued operations and maintenance activities are needed and possibly emergency patrols and emergency response during flood events.

7 Recommendations and Considerations

7.1 Conclusions and Recommendations

This document provides a brief history of erosion along the American and Sacramento Rivers and the nature of the erosion problem given the sediment starved condition of flood flows which occur downstream of the Folsom and Nimbus Dams. A number of investigations have been conducted to quantify the erosion problem. These investigations include 2-D hydraulic analysis and mapping of velocities and shear stresses, 1-D HEC-6T sediment transport analyses, geomorphic analyses, geotechnical and geophysical surveys and investigations, laboratory testing to determine the erodibility of some of the material, and 3-D stratigraphic mapping of the channel materials. These studies were pursued as an extensive attempt at quantifying the erosion problem. The results of these studies are summarized in subsequent subsections.

The studies support the GRR and are primarily focused on providing a reasonably conservative estimate of the project costs, benefits, and environmental impacts. The studies and this document are not site selection, prioritization, or design efforts although they may serve as a useful reference for these future efforts. More detailed site selection, prioritization, and site-specific designs are needed during implementation to more efficiently utilize limited federal funds.

Additional efforts are needed in the future to support implementation. These include but are not limited to:

- Confirm that portions of the levee not included in Figure 6-3 for new bank protection are designed for the 160,000 cfs design discharge on a site-specific basis,
- Develop and implement a site-selection and prioritization process,
- Collect data necessary for site-specific analysis of existing bank protection and design of new bank protection,
- Design the needed rock protection based on site-specific data in accordance with standard engineering practice and USACE guidelines,
- Monitor bank protection performance during and after flood events.

Repair and maintain rock protection as needed on a continual basis to keep the bank protection performance level from deteriorating.

7.1.1 Prototype System Performance

Although analytical analyses can provide a wealth of information regarding expected performance of the river and levee system, the actual performance of the prototype system provides the best insight into the system performance during future large flood events. To that end, significant historical erosion events were identified and the corresponding erosion-based damage discussed. These events indicate that basically all large flood events which have occurred since completion of the Federal flood control system (e.g., the floods of 1955, 1966, 1986, and 1997) have caused considerable damage to the levee system due to erosion. All four of these large events required extensive repair after the event so that the system was ready for the next major flood event.

In the 1986 food event, discharges greater than 115,000 cfs (with a sustained peak flow of 130,000 cfs) were released from Folsom Dam for about 52 hours. Wholesale erosion went undetected during this event at a couple of locations and almost failed the south levee near the Capital City Freeway crossing as illustrated on Figure 1-6. Sacramento was fortunate during this event, for had the discharge been sustained longer, the levee would have likely failed from erosion.

In the Sacramento River system, erosion has even occurred during lower flow events, as documented by the SRBPP. Numerous emergency bank repairs and repairs completed by the SRBPP (over 800,000 linear feet) have been constructed in the last 50 years. Erosion continues along the Sacramento River banks and levees and there are currently numerous sites that are still in need of repair.

7.1.2 Updated Geologic, Geotechnical, and Geophysical Information

Input from subject matter experts was solicited and used to advise on the direction of the study and investigations. Specifically, the experts provided opinions on the current stability of the river channel with regards to erosion and on requirements for additional study, data collection, and analysis. The data collection and analyses focused on improving the geologic and geotechnical characterization of the material properties which comprise the river channel and overbanks.

Data collected as part of this study included soil borings, cone penetrometer tests and geophysics. Samples obtained from the soil borings were testing in geotechnical laboratories for classification properties and erosion rates using JET and EFA testing. The data obtained in the subsurface investigations and laboratory testing were included in geologic mapping and 3-d modeling. Geologic analyses included development of three-dimensional surface contour maps of the erosion resistant unit, and geologic cross sections and longitudinal profiles. The final 3D model contains enhanced information, especially within the area between the levees where young alluvial sediments related to hydraulic mining have been deposited. In addition to showing subsurface alluvial stratigraphy, the final model shows the top of erosionally resistant sediments that are exposed and identified in the channel at several locations.

Field observations suggested that erosion of the exposed erosionally resistant sediment occurs over time at both the granular- and outcrop-scale. However, the mechanisms and time scale associated with that erosion are not well understood and were not studied. Due to the location and properties of the material, the risk posed to the flood control structure from erosion of the erosion resistant sediment were estimated to be low and no further study of its erosion mechanisms or time scale were performed.

Cross sections generated from the 3D stratigraphic are illustrated in Figures 3-4 and 3-5 and indicate that highly erodible mining materials are present in the channel (as berms and channel banks) and, in some cases, underlie the levees. The Lower American River has highly erodible zones which will, in time, erode during high flow events if left unprotected. In some cases, bank and levee failure will result.

Although not conducted as part of the ARCF GRR study, the results and conclusions of the DWR Urban Levee Evaluation circumstantiate the results and conclusions of the analysis performed for the ARCF study and presented herein. Given that the ULE used a different approach and still obtained similar results (i.e., that many of the levees have medium and high erosion risks) significantly adds to the validity of the ARCF conclusions.

7.1.3 Hydrology, Hydraulic, and Sedimentation Impacts

Once the JFP auxiliary spillway is constructed and functioning, new operations criteria are planned which would result in larger flood flows being conveyed through the American River with greater frequency compared to past conditions. These higher flood flows would exert additional pressure on the banklines and levees resulting in greater erosion, sediment transport, and potentially changes to the planform of the low-flow channel. Nonetheless, it is important to note that without inclusion of the proposed erosion protection features, the flood damage reduction benefits intended for the project cannot be fully realized since the lower American River channel will likely not be able to safely convey the new larger discharges and flow restrictions from Folsom would likely be put in place.

Two-dimensional modeling of the Lower American River using RMA-2 was performed to get a more detailed estimate of the velocity and shear in the American River compared to computed one-dimensional values. Results indicate relatively high velocities adjacent to the levees. Additionally, the range of the computed velocities is of concern since the magnitude of the velocities is great enough to erode many of the relatively fine grained material present in the channel lining.

7.1.4 Summary

Given the experience gained by past floods and post-flood repairs and on review and examination of the products of the erosion analyses discussed herein, it is clear that the erosion protection measures proposed by the ARCF GRR must be included along the leveed reaches of the lower American River and along the left bank of the Sacramento River. Failure to include these features will likely result in levee failure leading to catastrophic damages and possibly lives lost. There is a substantial life safety issue related to erosion along the river channels given the magnitude of the flooding coupled with the proximity of densely populated development immediately adjacent to the river channel and levees.

The available information indicates that many of the levee segments without modern bank protection are at risk of erosion related failures along the Sacramento River and Lower American River in the Common Features project study area. The levees therefore need to be protected to provide adequate flood damage risk reduction. Past erosion on the Lower American River (Figure 1-6) indicates that impending erosion failures may be covered by water and may not be observed in time to provide adequate warning to flood fight and/or evacuate residents. This is in contrast to landside seepage or stability related failures that may be more easily visible and allow more time for adequate flood fighting and/or evacuation of residents. The potential for unobserved erosion related failures increases the potential consequences to life and property. A passive approach of fixing erosion damage to levees during or after a flood event is not likely to reduce flood damage risk substantially. A passive approach to erosion is therefore not recommended for this project as the probability of failure and potential consequences of a failure during the design flood event are high. However, an active approach of providing erosion protection as proposed in the tentatively selected plan (TSP) is appropriate and should increase flood damage risk reduction from erosion once constructed.

Future site-specific erosion related data collection, analysis, and design is necessary for implementing the GRR including confirming feasibility assumptions. Future efforts are also needed to monitor the performance of the rock protection and make the necessary repairs to maintain the performance of the bank protection for the life of the project.

7.2 Other Considerations

A number of additional considerations require annotation and will need to be addressed in future studies of the ARCF study in order for the project to be considered “whole” or “complete”. These considerations are discussed below.

Given the large increase in the design flow from 115,000 to 160,000 cfs as well as the large increase in discharge for relatively frequent events (discussed above in Section 4.1), the impacts of the project with respect to infrastructure encroaching in the floodway, such as bridges and pipelines, will need to be investigated including features needed for mitigating the impacts. It is unlikely that the subject increase in discharge will not induce a negative impact on the local bridge scour values.

The need for bed or invert protection, at one or more locations, is not a current component of the GRR plan, but has been the focus of discussion by members of the expert panels. The need for bed protection at key locations will need to be monitored in the future as part of project operations.

As discussed above, extensive investigations have been performed to quantify/predict erosion of the lower American River. In some cases, unknowns remain and recommendations are put forth for additional study to potentially fine tune the answer. There is considerable uncertainty related to predicting erosion. It is conceivable that additional investigation may optimistically lead to a reduction in length or volume of the proposed erosion protection features. However, the potential uncertainty in such favorable results may not be worth the impacts to the study schedule or budget.
As depicted in Figure 6-3, a number of existing revetment repair sites will be included as part of the complete erosion protection system. These sites must be assessed in future studies to confirm that these sites are stable, prevent erosion for discharges up to and including 160,000 cfs, and to prioritize sites to be constructed over a period of years.

Given that a primary goal of the ARCF GRR project is to increase the capacity of the American River to 160,000 cfs, the channel stability of downstream receiving channels also needs to be validated. Failure to confirm the downstream channel stability may result in stability problems being moved downstream.

7.3 Qualifications and Limitations

Given that the foundation of this report consists primarily of relevant extracts of other work efforts, coupled with the complexity of river erosion processes, as a standalone work effort the report does not constitute a rigorous analysis quantifying the erosion problem. In some cases, study conclusions on various topics have varied through time. This situation is not of great revelation since the erosion and stability problems have been under study for several years and occasionally new results, based on more detailed information, contradict older conclusions which were frequently based on lesser detailed information. However, the report is sufficient for supporting the proposed erosion protection features and cost estimates consistent with a feasibility study given the new “Smart Planning” paradigm.

It is important to note that there are several limitations in the information in this report and that additional analysis and design will be required in future studies in order to develop a complete and technically workable project.

The threshold analysis, currently ongoing, should produce information relating to how wide the American River channel could get as the availability of bed material available for transport continues to diminish. Additionally, this analysis should also provide valuable insights which will be useful in updating the Folsom Dam Water Control Manual.

The amount of erosion protection is extensive and is not expected to occur at once. During future studies, additional work will be necessary to prioritize sites to be constructed over a period of years.

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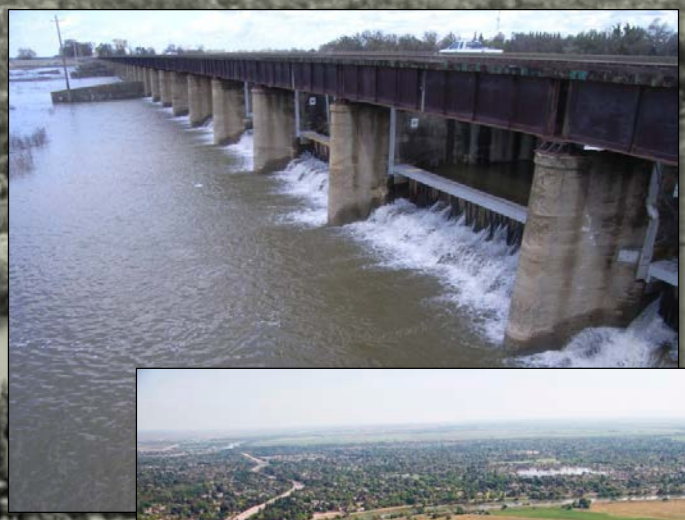
American River Watershed

Common Features
General Reevaluation Report



Appendix D
Real Estate Plan

December 2015

Sacramento Area Flood Control Agency

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:
Sacramento Weir during operation
Sacramento River facing south near the Pocket and Little Pocket neighborhoods
High flows on the American River at the Highway 160 overcrossing
Folsom Dam releasing high flows

AMERICAN RIVER, CALIFORNIA
COMMON FEATURES PROJECT
GENERAL REEVALUATION REPORT

Real Estate Plan

U.S. Army Corps of Engineers
Sacramento District

December 2015

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REAL ESTATE PLAN
For
American River Watershed
Common Features
General Reevaluation Report
Sacramento and Sutter Counties, California

1. Statement of Purpose

This Real Estate Plan (REP) is intended to support and present the real estate requirements for a general reevaluation study of the authorized American River Common Features Project (ARCF) and is for planning purposes only. Studies that were completed prior to this reevalution report include the following: Congress directed the Corps to investigate additional means to reduce flood risk to the City of Sacramento following the flood of 1986. The Corps completed a feasibility study in 1991, recommending a concrete gravity flood detention dam at the Auburn Dam site and levee improvements downstream of Folsom Dam. Congress directed the Corps to conduct supplemental analysis of the flood control options considered in the 1991 study. The resulting *Supplemental Information Report, American River Watershed Project, California* (March 1996) recommended a similar combination of a gravity flood detention dam at the Auburn Dam site with downstream levee work. It considered, but did not advance, plans for Folsom Dam improvements and a stepped release plan for Folsom Dam accompanied by downstream levee improvements. Congress recognized that levee improvements were "common" to all candidate plans in the report and that there was a Federal interest in participating in these "common features". Thus, the American River Common Features Project was authorized in Water Resource Development Act (WRDA) 1996 (Pub. L. 103-303, Section 101(a)(1)) and the decision on Auburn Dam was deferred. Major construction components for Common Features included construction of levee improvements to reduce seepage along approximately 22 miles of American River levees, and levee strengthening and the raising of 12 miles of the Sacramento River levee in the Natomas Basin. Meanwhile, improvements to other levees adjacent to the Natomas Basin were authorized in the Defense Appropriations Act of 1993 (Pub. L. 102-396, (HR 5504), Sec. 9159, 106 STAT. 1876, 1944-1946 (1992)). The Sacramento Area Flood Control Agency (SAFCA) constructed these latter improvements between 1995 and 1998.

In 1999, Congress authorized improvements to Folsom Dam to control a 200-year flood event with a peak release of 160,000 cubic feet per second. WRDA 1999 also authorized the Folsom Dam Modification Project to modify the existing outlets to allow for higher releases earlier in flood events. At the same time, Congress also directed the Corps to review additional modifications to the flood storage of Folsom Dam, indicating that Congress was looking at maximizing the use of Folsom Dam for flood damage reduction prior to consideration of any additional storage on the American River. The Folsom Dam Raise Project was subsequently authorized by Congress in 2004.

The Common Features project was modified by WRDA 1999 so that it could safely convey an emergency release of 160,000 cfs. These improvements included construction of slurry walls to reduce seepage and levee raises along four stretches of the American River, and construction of levee strengthening and raising of 5.5 miles of the Natomas Cross Canal levee in the Natomas Basin. Additional construction components for both WRDA 1996 and 1999 were authorized, and are described in Chapter 5 of main GRR document page 5-1.

All American River features authorized in WRDA 1996 and 1999 have been constructed by the Corps of Engineers or are in design analysis for construction within a year or two. Design and construction have been undertaken under a Project Cooperation Agreement with the California Reclamation Board (now known as the Central Valley Flood Protection Board (CVFPB)) executed July 13, 1998, and amended four times. Cost sharing for these features is 75% Federal and 25% non-Federal.

However, the Natomas Basin features authorized in WRDA 1996 and 1999 have been deferred. Following the flood of 1986, significant seepage was experienced on the Sacramento River from Verona (upstream end of Natomas) at River Mile (RM) 79 to Freeport at RM 45.5 and on both the north and south bank of the American River. Seepage on the Sacramento River was so extensive that soon after the 1986 flood event, Congress funded levee improvements as part of the Sacramento Urban Levee Improvement Project (Sac Urban). The Sac Urban Project constructed shallow seepage cutoff walls from Powerline Road in Natomas down to the town of Freeport. At the time, seepage through the levees was considered to be the only significant seepage problem affecting the City of Sacramento.

After construction of the Sac Urban project, the Sacramento Valley experienced a flood event in 1997. This led to a geotechnical evaluation of levees in the vicinity of the City of Sacramento which showed that deep underseepage was of concern. Considerable seepage occurred on the Sacramento River as well as on the American River. Seepage on the American River was expected because the levee improvements had not yet been constructed. However, the occurrence of significant seepage on the Sacramento River in the reach improved as part of the Sac Urban project confirmed that deep underseepage was a significant concern in this area, a conclusion later confirmed by the Levee Seepage Task Force in 2003.

Following the recognition of deep underseepage as a major concern, seepage reduction measures on the American River needed to be redesigned to reduce both through- and deep underseepage. The redesign led to considerable cost increases over what was originally authorized by Congress: increasing to $91.9 million from the originally-authorized $56 million under WRDA 1999, and to $205 million under the Energy and Water Development Appropriations Act of 2004 (Pub. L. 108-137).

Because of the considerable cost increase of reducing the seepage problem on the American River, all funds appropriated by Congress for the project in the late 1990s and the early part of the 2000s were used for construction activities on the American River instead of for design efforts in the Natomas Basin. Combining this with the recognition that all work in the Natomas Basin would also require significantly more effort than was anticipated at the time of authorization, it was decided in 2002 that a reevaluation study would be required for the Common Features project. Congress was notified in 2004 that additional authorized cost increases would be required for study, design, and construction of levee improvements in the Natomas Basin.

While the reevaluation study was beginning for the Common Features project, the Folsom Dam Post Authorization Change report (PAC) was being completed by the Sacramento District. The results of this study, and of the follow-on Economic Reevaluation Report (ERR) for Folsom Dam improvements, showed that additional levee improvements were needed on the American River and on the Sacramento River below the American River in order to truly capture the benefits of the Folsom Dam projects. These levee problems consisted primarily of erosion concerns on the American River and seepage, stability, erosion, and overtopping problems on the Sacramento River below the confluence with the American River. However, the full extent of these levee problems was not known. Because of this, it was realized that additional reevaluation studies were also needed to include the two remaining basins comprising the City of Sacramento: American River North and American River South. The reevaluation began in 2006.

The project delivery team (PDT) for the ARCF GRR had completed the Feasibility Scoping Meeting (FSM) milestone and was working towards the Feasibility Review Conference milestone. However, in July 2009 the PDT was directed to complete an interim Post Authorization Change Report for the Natomas Basin (PACR) to receive consideration in a potential WRDA 2010. In December 2010, the Natomas Basin Post Authorization Change Report (PACR) and Interim General Reevaluation Report (GRR) was completed, which focused on the problems associated with the existing levees in the Natomas Basin. The interim GRR recommended improving levee performance by addressing seepage and stability problems, but did not address measures to raise the height of the levees. The Natomas Interim GRR has been forwarded to Congress for authorization.

The cost estimates of the real estate requirements necessary to support the various alternatives is discussed in detail in the 2014 ARCF GRR. All alternatives were screened out, with the exception of Alternative 1 Levee Improvements, the National Economic Development Plan and Alternative 2 Sacramento Bypass and Weir widening and Levee Improvements which is the Recommended Plan and locally preferred plan (LPP). This REP specifically identifies the real estate requirements in support of the Recommended Plan. There may be modifications to the project and its plans that occur during Preconstruction, Engineering and Design (PED) phase, thus changing the final acquisition area(s) and or/ administrative and land costs reflected in this REP.

2. Project Authority

The basic authority for the Corps to study water resource related issues in the American and Sacramento Rivers is Section 209 of the Flood Control Act of 1962 (Pub. L. No. 87-875, § 209, 76 Stat. 1180, 1196-98 (1962)), which authorizes studies for flood control in northern California. This report was prepared as a general reevaluation study of the American River Common Features Project, which was authorized by Section 101(a) (1) of the Water Resources Development Act (WRDA) of 1996, (Pub. L. No. 104-303, § 101(a)(1), 110 Stat. 3658, 3662-3663 (1996)) and amended by Section 366 of WRDA of 1999, (Pub. L. 106-53, § 366, 113 Stat. 269, 319-20 (1999)); and Section 130 of the Energy and Water Development Appropriations Act (EWDAA) of 2008, (Pub. L. No. 110-161, § 130, 121 Stat. 1844, 1947 (2003)). Significant changes to the authorized project cost were recommended in the Second Addendum to the Supplemental Information Report of March 2002. This report was submitted to the Assistant Secretary of the Army for Civil Works (ASA(CW)), but Congress acted to raise project costs before the 2002 report could be forwarded to Congress. (*See* Section 129 of the EWDAA of 2004, (Pub. L. No. 108-137, §129, 117 Stat. 269, 1839 (2003)) raising the authorized total cost of the project to $205,000,000. The current estimated cost of the authorized project is $320,700,000.

3. Project Description

The ARCF GRR study area, shown in the map below in Figure 1, has been divided into two basins: American River North and American River South, which were furthersubdivided into study reaches. This report covers the following areas:

- 12 miles of the north and south banks of the American River immediately upstream of the confluence with the Sacramento River
- 26 miles of the Natomas East Main Drainage Canal and tributaries (NEMDC)
- 15 miles of the east bank of the Sacramento River downstream of the American River down to Morrison Creek
- Borrow and disposal sites that are within an approximate 25 mile radius of the City of Sacramento

For the purposes of the feasibility planning process, the two study area basins were further subdivided into reaches based on common properties, such as geographic features. In general, this Report presents information either by basin or reach. However, in some cases the report structure deviates from basin or reach based organization. For instance, geology and geomorphology, construction history, and past performance are better related to channel features than basin related reaches. Therefore, for those topics, the information has been presented in the following groups: American River (both banks), Sacramento River (south of the American River confluence), and East Side tributaries (Dry and Robla Creeks, NEMDC east, and Arcade Creek), and Magpie Creek.

The American River North Basin (ARN) includes levees on the north (right) bank of the American River upstream of NEMDC, the east (left) bank of NEMDC from the American River to Arcade Creek and from Arcade Creek to Dry/Robla Creeks, both banks of Arcade Creek, both banks of Dry/Robla Creek, and Magpie Creek. The levees in the American River North Basin have been divided into eight planning reaches; ARN A, B, C, D, E, F, and I.

The American River South Basin (ARS) includes levees on the south bank (left) bank of the American River upstream of the Sacramento River and the east (left) bank of the Sacramento River from the American River to Freeport. The levees in the American River South Basin have been divided into seven planning reaches; ARS A, B, C, D, E, F, and G.

The American River Common Features GRR has identified significant and extensive seepage, stability, overtopping and erosion problems with the levees that reduce the risk of flooding for the Sacramento area, and recommendations to address these problems are the focus of this Recommended Plan. Due to the potential for catastrophic consequences associated with a levee failure in this urban area, all identified problems, including vegetation and encroachment issues require correction in order to reduce the flood risk to an acceptable level. However, risk reduction measures must be implemented in a "worst first" manner in order to immediately maximize the amount of risk reduction realized for each increment of investment. The levee improvement methods would combine a variety of potential designs described in Section 4 description of lands, easements, right of way, relocations and disposals (LERRD's) of this report and keep the project features within the existing footprint of the American River Common Features Project as much as possible. The project area includes portions of the Sacramento and American River Watersheds. The floodplain includes most of the developed portions of the City of Sacramento and portions of Sacramento County. The study area also includes the Sacramento Weir and Bypass in Yolo County,

California.

The final array of alternatives includes:

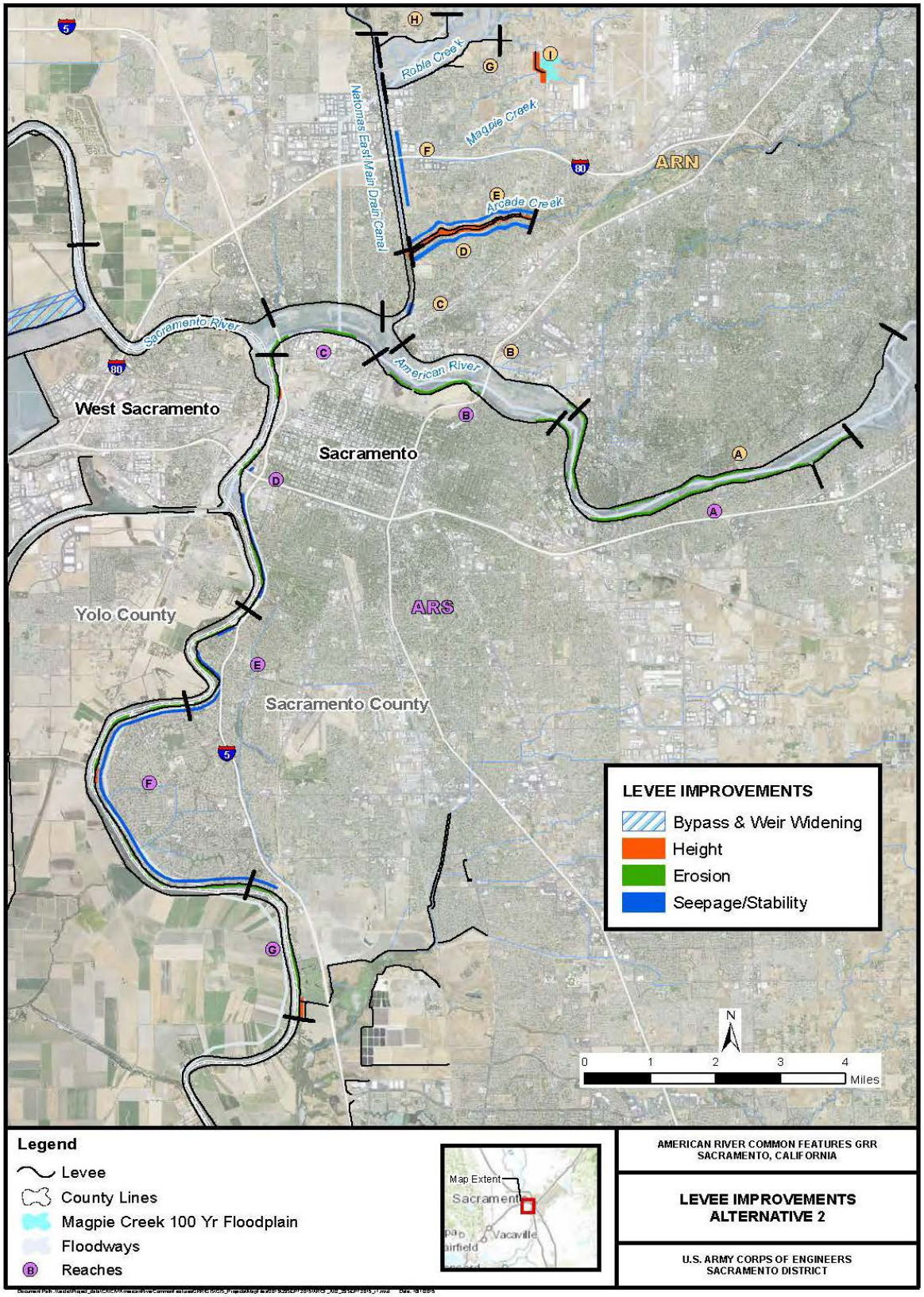
Alternative 1 would include the construction of levee improvement measures to address seepage, stability, erosion, and height measures identified for the Sacramento River, Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks. Alternative 1 would also include erosion measures for specific locations along the American River. This alternative combines construction of levee improvement measures while maintaining the present levee alignment in its existing location (fix in place). Due to the urban nature and proximity of existing development within the American River North and South basins, Alternative 1 proposes to improve the levees within their existing footprint, with minimal additional real estate requirements. The purpose of this alternative would be to improve the flood risk management system to safely convey flows to a level that maximizes net benefits.

Alternative 2 – Alternative 2 would include the levee improvements discussed in Alternative 1, except for the extent of levee raises along the Sacramento River. While Alternative 1 would include about 7 miles of levee raising, Alternative 2 would only require about 1 mile of levee raising. The Sacramento Weir and Bypass would be widened to divert more flows into the Yolo Bypass. The levees along the American River North Basin Tributaries, including the NEMDC, Arcade, Dry/Robla, and Magpie Creeks, would be improved to address identified seepage, stability, erosion, and height concerns through the methods described under Alternative 1. The levees along the Sacramento River would be improved to address identified seepage, stability, and erosion concerns though the measures described under Alternative 1. Rock erosion protection would be placed on the American River levees to reduce the risk of erosion. Due to environmental, real estate, and hydraulic constraints within the American River North and South basins, the majority of the levees would be improved within the existing levee footprint with minimal additional real estate requirements.

The project alternatives consist of components and cost estimates of the various reaches which will be described in further detail below.

This real estate plan identifies the real estate costs for the Recommended Plan (Alternative 2) – Improve Levees and Widen the Sacramento Weir and Bypass.

FIGURE 1 AMERICAN RIVER BASINS AND PROJECT REACHES



4. Description of LERRD's

The Lands, Easements, Right of Way, Relocations and Disposal (LERRD's) requirements for the REP for the Recommended Plan are estimated at $90,938,477. There are an estimated 495 parcels and 369 ownerships that equate to 1,720 acres that are included in the Recommended Plan.

Bank Protection – There are 287.31 acres of bank protection required along the Sacramento and American Rivers. This easement needed for construction and maintenance of erosion protection features. Included are the rights to trim and cut vegetation, shape and grade slope, and replace riprap. The easement includes all area required to construct and maintain erosion protection features that are outside of the Flood Protection Levee Easement. Two erosion protection measures have been proposed that could be implemented in combination along the levee alignment depending on bank geometry, existing habitat and existing land use. Rock bank protection and launchable rock trenches will address erosion problems along portions of the American River north and south levees and along the Sacramento River.

Flood Protection Levee Easement – There are 142.55 acres of flood protection levee easements needed for new levees, levee raises, flood walls, cutoff walls, and seepage berms. These include the right to construct, maintain, repair, operate and patrol the flood protection features. This easement includes all area from landside toe to waterside toe of the existing and/or proposed levee.

Permanent Road Easement – Easement for O&M inspection zone at the landside toe. .210 acre required for new access road. This easement would allow easier access for flood fighting activities as well as inspections required for the Rehabilitation and Inspection Program (RIP) under Engineering Regulation (ER) ER 500-1-1 and Public Law (PL) 84-99.

Permanent Flowage Easement – There is a total of 337.78 acres of land that will be subject to permanent flooding as a result of new levees in the Sacramento Bypass (257.22 acres) and a new levee with floodgates, levee raise, floodplain preservations with culvert improvements near Magpie Creek. (80.56 acres)

Temporary Work Area Easements – Staging is required every mile along the length of the project. Majority of the staging areas will be located in the river parkways, and other publically owned areas along the rivers. Staging areas will accommodate batch processing stations for slurry walls, construction vehicles, and temporary storage for disposal and construction materials. The total staging acres required are estimated at 40 acres. The haul routes will be existing public roads and utilizing the existing roads on top of levees. For cost estimating purposes we calculated a certain acreage for each reach of the project for staging areas. All staging areas are not yet identified on cadastral maps. The remaining temporary work area easements are located on existing federal levees for a total of over 227 acres.

Borrow Easements – Borrow easements are required for potential borrow and disposal sites as shown in the borrow map Figures 2 and 3. It is anticipated that 407.25 acres or 1,612,009 cubic yards of potential borrow sites material is required for construction of the proposed project. It is anticipated that significant quantities of material will be required for construction of the proposed project. Several different improvement measures such as seepage berms, cutoff walls, embankment construction -reconstruction, and erosion protection are proposed.

The material is expected to be sourced from several sites including; newly identified borrow sites within approximately 25 miles of the study area, existing borrow sites identified for the Natomas Basin by SAFCA, the Deep Water Ship Channel dredge disposal area, the existing levees, and existing commercial sources. Test pits and laboratory testing on materials collected from test pits were provided by SAFCA as part of the Natomas Levee Improvement Program (NLIP) for borrow sites established for the Natomas Basin. Additionally, the Sacramento District has studied the Deep Water Ship Channel spoil areas as a borrow source several time in the past, and a discussion of that borrow source is included below. Typically projects constructed by the Sacramento District utilize commercial borrow sites near the project area.

It is anticipated that the required soil fill import for the proposed project will exceed the capacities of the already identified borrow sites in the Natomas Basin, and obtaining significant quantities of material from commercial sites may be cost prohibitive. Therefore, a desktop regional borrow study was performed to identify potential borrow sites, within 25 miles of the study area, where enough soil could be sourced to satisfy the project needs. This study was performed by obtaining National Resources Conservation Service (NRCS) National Cooperative Soil Survey (NCSS) data, sorting the NCSS data based on material classification and engineering properties, using aerial photographs to identify areas of open or agricultural land, and then merging the sorted NCSS data with the open or agricultural land areas to obtain locations, acreage, and volume of potential borrow sites. Results of the desktop regional borrow study indicate adequate materials available within the assumed 25 mile area.

A map that proposed potential sites was created and several potential sites identified. The rough assumptions the Corps used was the material had to meet geotechnical requirements either by open undeveloped land or agricultural areas, and was located between ground surface and a depth of 2.5 feet below ground surface. In the high confidence areas in each basin the estimated amount of borrow needed within a 25 mile haul route radius is calculated below with costs for borrow. The high confidence areas were defined as areas where up to 48 inches of borrow could be excavated as opposed to the low confidence areas where only up to 12 inches of material would be available where 3 times the amount of land would be required. The below quantities estimate the potential quantities of material required and the cost.

American River South Basin High Confidence Area requires 69.76 AC of land for 275,743 CY of borrow = $453,400 + (35% cont + 15% severance= 226,700) = $680,100

American River North Basin High Confidence Area requires 0.64 AC of land for 2,519 CY of borrow =$4,186 (35% cont + 15% severance $2,093) = $6,279

Natomas Basin High Confidence Area requires 337.43 AC of land for 1,333,747 CY of borrow = $2,193,295 (35% cont + 15% severance = $1,096,647.50) = $3,289,942. The below map shows high confidence areas of available borrow where up to 48" of material can be excavated at one time.

The estates, project features, type of ownership and acreage required by reach for the project are shown in Table 1 with associated location maps.

TABLE 1 - LERRD'S FOR RECOMMENDED PLAN

American River South Basin

ARS REACH A	Erosion Protection		
Features	4 Ownerships	Estate	Acres
Bank Protection Rock Trench	5 City parcels, 29 County of Sacramento parcels, 5 Cal Trans parcels	Bank Protection Easement	61.41
		Total	61.41

American River South Basin

ARS REACH B	Erosion Protection		
Features	7 Ownerships	Estate	Acres
Bank Protection Rock Trench	3 Private parcels	Bank Protection Easement	.970
Bank Protection Rock Trench	1 Cal Trans parcel, 6 City of Sacramento Parcels and 2 County of Sacramento parcels, 1 DOT parcel	Bank Protection Easement	15.076
		Total	16.046

American River South Basin

ARS REACH C	Erosion Protection		
Features	6 Ownerships	Estate	Acres
Bank Protection Rock Trench	6 Private parcels	Bank Protection Easement	2.65
Bank Protection Rock Trench	1 Cal Trans parcel, 5 City parcels/6 County of Sacramento parcels, 1 DOT parcel	Bank Protection Easement	11.11
		Total	13.76

American River

ARN REACH A	Erosion Protection		
Features	8 Ownerships	Estate	Acres
Bank Protection Rock Trench	4 Private parcels	Bank Protection Easement	5.84
Bank Protection Rock Trench	3 Sponsor parcels, 27 parcels County of Sacramento	Bank Protection Easement	39
		Total	44.81

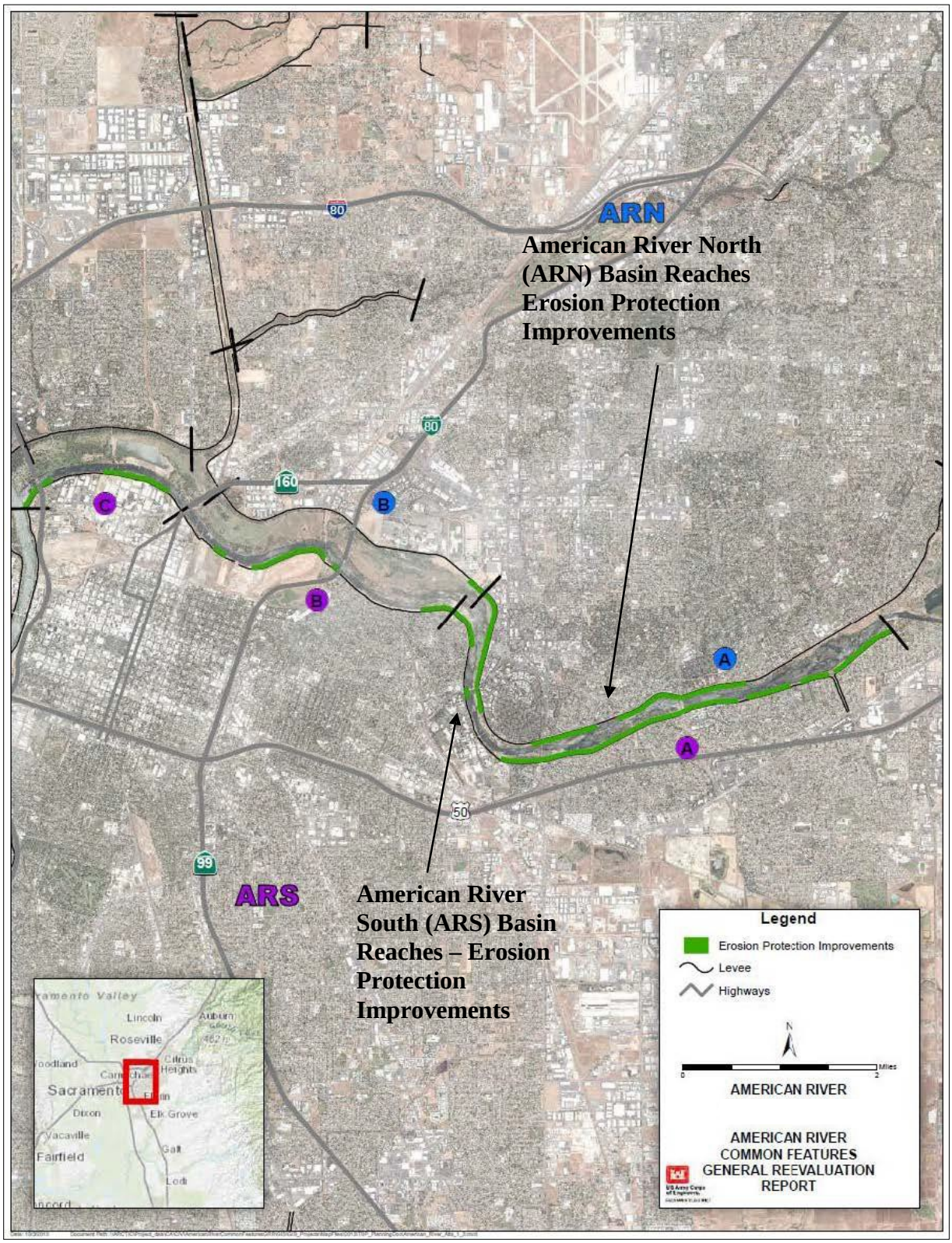
American River

ARN REACH B	Erosion Protection		
Features	2 Ownerships	Estate	Acres
Bank Protection Rock Trench	1 State of CA parcel, 1 County of Sacramento parcel	Bank Protection Easement	2.41
		Total	2.41

American River

ARN REACH C	NEMDC		
Features	2 Ownerships	Estate	Acres
Cut off Wall/Flood Wall	3 City of Sacramento parcels, 4 parcels County of Sacramento	Temporary Work Area Easement	3.71.
		Total	3.71

FIGURE 2: Location Maps of Reaches ARN A, B, and C and ARS A, B and C. Erosion Protection Improvements shown in green.



Sacramento River

ARS REACH D			
Features	9 Ownerships	Estate	Acres
Bank Protection Rock Trench 2 – 4 'Floodwall Cutoff Wall Seepage Berm at Pioneer Reservoir	5 Private parcels	Temporary Work Area Easement for Staging	.344
Bank Protection Rock Trench	2 Private parcels	Bank Protection Easement	1.57
Flood wall, Cut off Wall, Seepage Berm at Pioneer	5 State parcels, 14 City parcels	Flood Levee Protection Easement	3.87
Bank Protection Rock Trench	5 State parcels 13 City parcels	Bank Protection Easement	19.41
Bank Protection Rock Trench 2 – 4 'Floodwall Cutoff Wall Seepage Berm at Pioneer Reservoir	5 State parcels 13 City parcels	Temporary Work Area Easement for Staging	2.49
		Total	27.68

Sacramento River

ARS REACH E			
Features	59 Ownerships	Estate	Acres
120' DSM Cut off Wall	58 Private parcels	Flood Protection Levee Easement	18.02
Bank Protection	3 Private parcels	Bank Protection Easement	3.17
120' DSM Cut off Wall	3 State of CA parcels 2 City of Sacramento parcels, 1 sponsor owned parcel	Flood Protection Levee Easement	8.48
Bank Protection	3 State of CA parcels, 8 City of Sacramento parcels	Bank Protection Easement	17.17
		Total	46.84

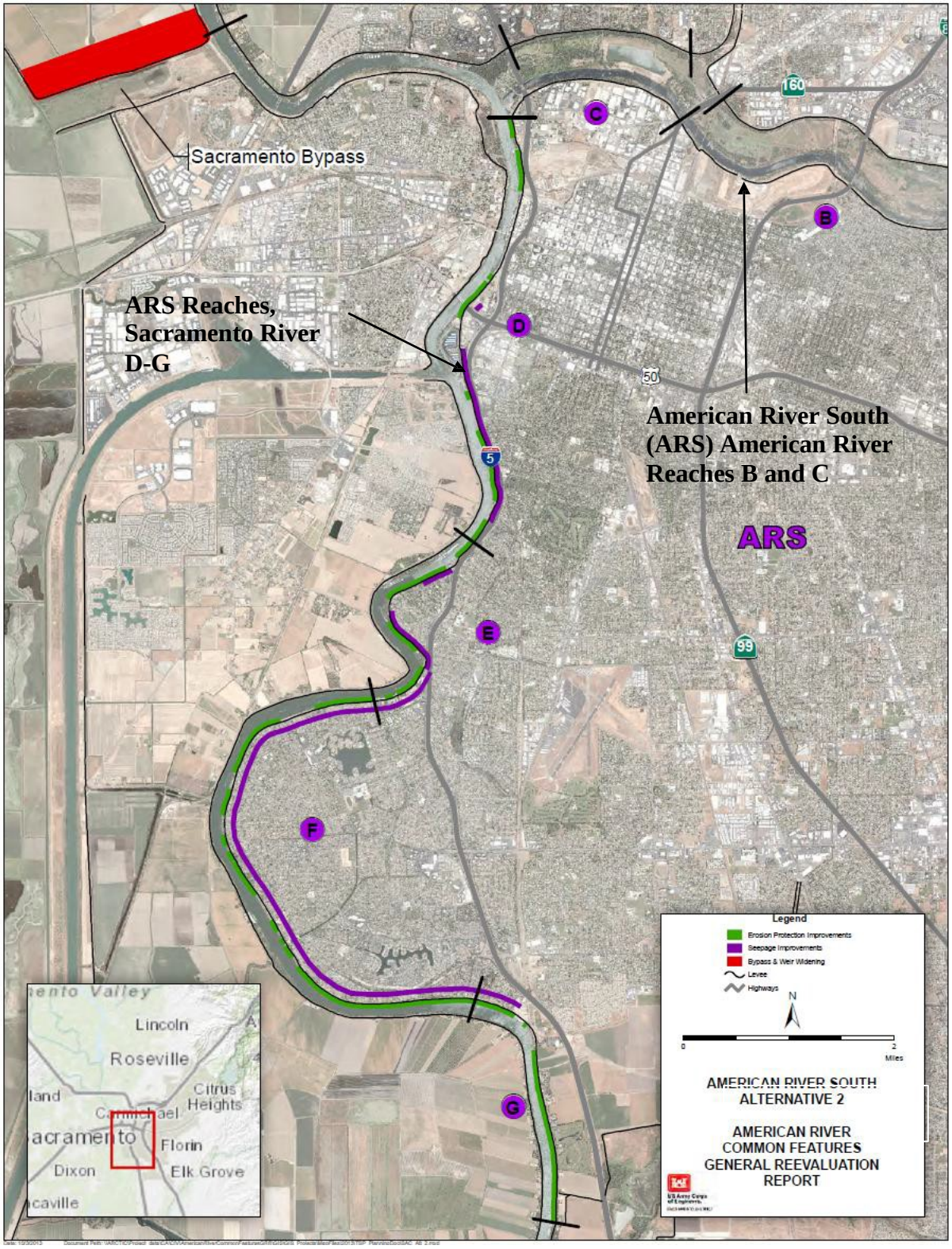
Sacramento River

ARS REACH F			
Features	128 Ownerships	Estate	Acres
Cut off Wall, Flood wall	1 Private parcels	Flood Protection Levee Easement	.499
Bank Protection	5 Private parcels	Bank Protection Easement	14.57
Existing Levee/Levee Raise	130 Private parcels	Temporary Work Area Easement	59.31
Bank Protection Rock Trench	1 State of CA parcel, 35 City of Sacramento parcels	Bank Protection Easement	23.05
Existing Levee/Levee Raise	1 State of CA parcel, 5 City of Sacramento parcels	Temporary Work Area Easement	4.69
		Total	111.32

Sacramento River

ARS REACH G			
Features	20 Ownerships	Estate	Acres
DSM Cut off Wall	Private 21 parcels	Flood Protection Levee Easement	21.20
Geotextile Stabilized Slope	Private 1 parcel	Bank Protection Easement	4.79
Raise Existing Flood Wall	Private 5 parcels	Temporary Work Easement	2.95
DSM Cut off Wall	2 State of CA, 2 City of Sacramento, 1 County parcel	Flood Protection Levee Easement	5.35
Geotextile Stabilized Slope	10 State of CA, 2 City of Sacramento, 1 County parcel	Bank Protection Easement	14.66
Raise Existing Flood Wall	2 State of CA, 2 City of Sacramento, 1 County	Temporary Work Easement	.568
		TOTAL	49.51

FIGURE 3: Sacramento River Improvements ARS Reaches D-G (Erosion Protection = green lines, Seepage improvements = purple lines, Sacramento Bypass widening = red)



Sacramento River

SAC BYPASS	Enlarge existing bypass		
Features	10 Ownerships	Estate	Acres
Bypass Flowage Area	4 Private parcels	Flowage Easement	123.46
New Levee	4 Private parcels	Flood Protection Levee Easement	107.86
Bypass Flowage Area	1 Sponsor owned parcel	Flowage Easement	133.76
New Levee	1 Sponsor owned parcel, 1 County parcel	Flood Protection Levee Easement	1.63
		TOTAL	366.71

Widening of the Sacramento Weir and Bypass to reduce the water surface elevation in the Sacramento River and allow more water to flow into the Bypass system.

Aerial View of Sacramento Weir FIGURE 4

East Side Tributaries

ARN REACH D	Arcade Creek S. Bank		
Features	28 Ownerships	Estate	Acres
Flood wall/Geotextile reinforced slope	3 Private parcels	Temporary Work Area Easement	2.40
Flood wall/Geotextile reinforced slope	20 Private parcels	Flood Protection Levee Easement	17.37
Flood wall/Geotextile reinforced slope	3 American River Flood Control District, 2 City of Sac, 1 Twin Lakes Public School	Temporary Work Area Easement	.085
Flood wall/Geotextile reinforced slope	3 American River Flood Control District, 3 City of Sac, 1 Twin Lakes, Public School	Flood Protection Levee Easement	.516
		Total	20.37

East Side Tributaries

ARN REACH E	Arcade Creek North Bank		
Features	41 Ownerships	Estate	Acres
Cut off Wall/Flood Wall/	23 sponsor owned parcels	Flood Protection Levee Easement	.541
Cut off Wall/Flood Wall	1 Private parcels	Temp work area easement	.042
Cut off Wall/Floodwall	23 Private parcels	Flood Protection Levee Easement	10.62
		Total	11.23

East Side Tributaries

ARN REACH F	NEMDC		
Features	3 Ownerships	Estate	Acres
Cut off Wall/Flood Wall/ Replace existing w/closed box culvert	7 RD 1000 parcels 9 W. Pacific Railroad parcels 1 Cal Trans, 1 City of Sacramento Parcel	Temporary Work Area Easement	20.73
		Total	25.600

East Side Tributaries

ARN REACH I	Magpie Creek		
Features	30 Ownerships	Estate	Acres
New Levee with floodgates, Levee Raise, Floodplain Preservation, Culvert Improvements	4 Sponsor owned parcels, 1 USA AF Base parcel, 3 Private parcels	Temporary Work Area Easement	1.73
New Levee with floodgates, Levee Raise, Culvert Improvements	4 Sponsor owned parcels, 1 USA AF Base parcel, 5 Private parcels	Flood Protection Levee Easement	3.41
Floodplain Preservation	4 Sponsor owned parcels, 20 Private parcels	Flowage Easement	80.37
New Levee with floodgates, Levee Raise, Floodplain Preservation, Culvert Improvements	1 Private parcel	Temporary Work Area Easement	.119
New Levee with floodgates, Levee Raise, Culvert Improvements	1 Private parcel	Flood Protection Levee Easement	.156
		Total	85.78

Figure 5: Eastside Tributaries – Levee Improvements

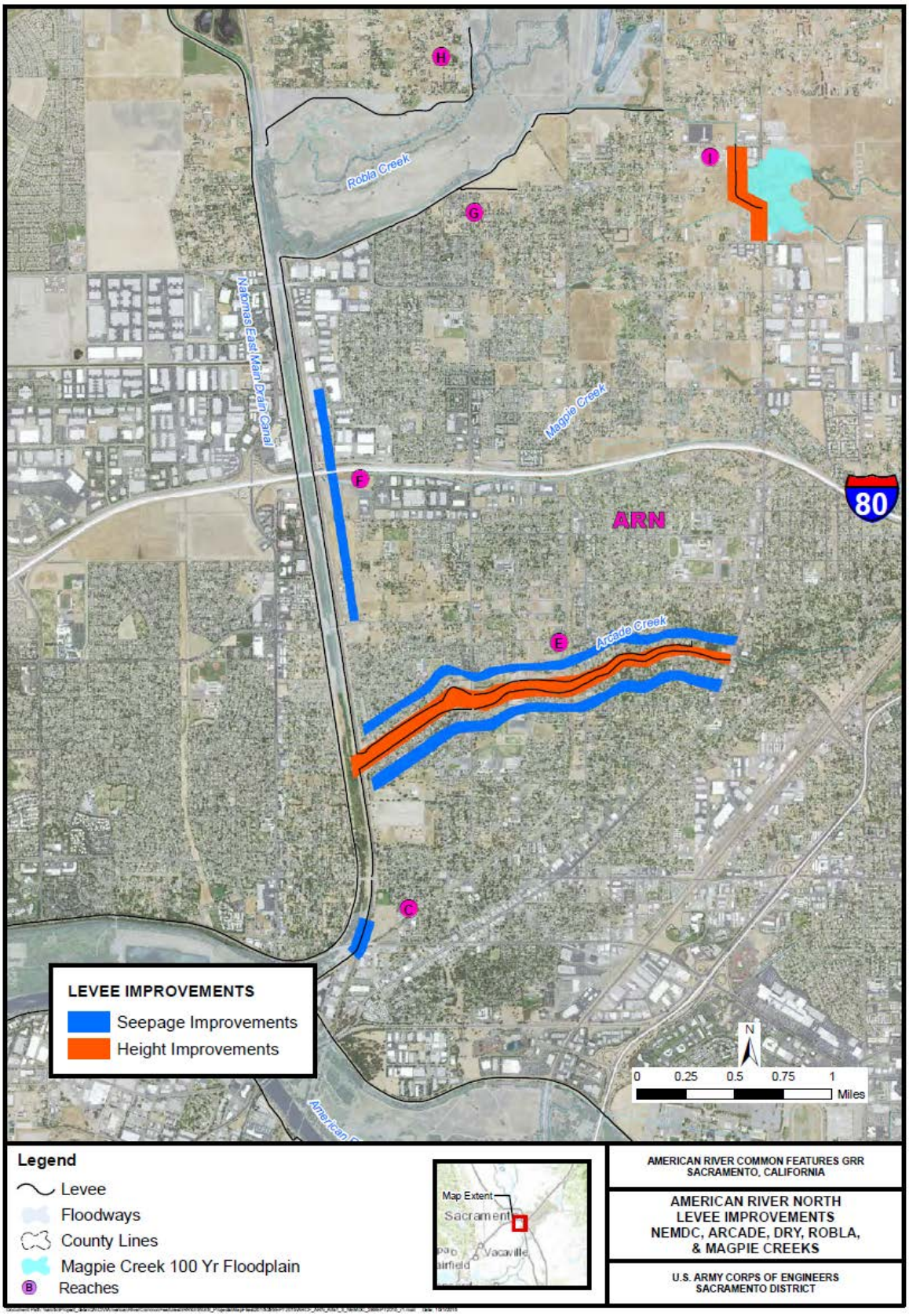
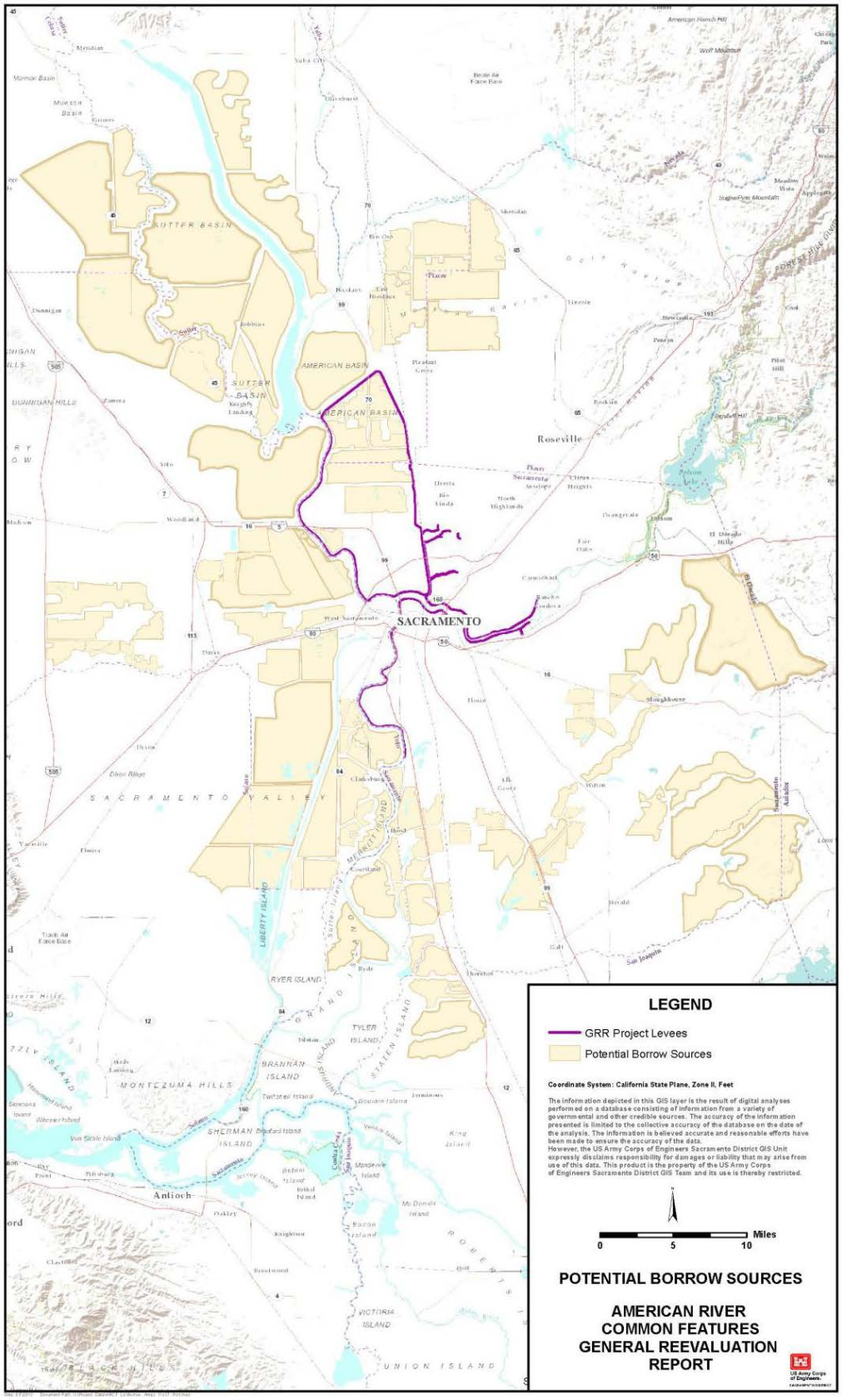


Figure 6: Proposed Borrow Sites within 25 Miles of Construction Sites



Environmental Mitigation – The following table summarizes environmental mitigation needs. Specific lands for compensation have not been identified; however, lands considered will provide similar habitat to that being impacted. The Corps has determined that mitigation for giant garter snake, Delta smelt, wetlands, and vernal pools would occur at a mitigation bank. If available, the Corps would also seek a mitigation bank for green sturgeon mitigation. Due to the significant value of the remaining mature riparian habitat along the Sacramento and American Rivers, and the significant loss of habitat value that would occur due to project impacts, the Corps would mitigate onsite for SRA, riparian, oak woodland, and elderberry habitats. If sufficient acreage is not available onsite for these habitat types, then the Corps would seek offsite options within the American River Parkway. More information regarding the Corps mitigation strategy is included in the Mitigation, Monitoring, and Adaptive Management Plan (Appendix F of the GRR).

Table 2 Environmental Impacts of and Proposed Mitigation/Compensation for the Recommended Plan (1)

Habitat Type	Potential Impacts	Duration of Impact	Mitigation (Acres/Linear Feet)	Cost at Mitigation Bank	Cost On- or Off-Site within Study Area
GGS Uplands	30 acres 75 acres	Permanent Temporary	90 acres 75 acres	$4,500,000	N/A*
GGS Aquatic	15 acres	Permanent	45 acres	$2,250,000	
Riparian	150.6 acres	Permanent	301.2 acres		$16,566,000
Shaded Riverine Aquatic Habitat	82,325 lf	Permanent	82,325 lf		$19,020,000**
Elderberry Shrubs	3,292 stems	Permanent	1,715.6 credits 70.89 acres		$6,026,000
Vernal Pools	1 acre	Permanent	1 acre	$275,000	---
Green Sturgeon	20 acres	Permanent	Restore acres, monitoring, and fish passage features		$16,259,000
Delta Smelt Spawning Habitat	34 acres	Permanent	34 acres	$4,160,000	
Shallow Water Habitat (Delta Smelt)	14 acres	Permanent	42 acres	$5,460,000	
Oak Woodland	2 acres	Permanent	4 acres		$200,000
Wetlands	0.4 acres	Permanent	0.8 acres	$130,000	---
Sub-Total				**$16,775,000**	**$58,341,000**

* 75 acres of temporary effects to GGS habitat from the relocation of the Sacramento Bypass toe drain would consist of standard site restoration erosion control features such as hydroseeding. This is contained within construction costs and is not considered a mitigation cost.

** SRA habitat mitigation is provided in the project's cost estimate as a separate construction cost rather than a mitigation cost, since it is a feature of the bank protection designs and would be included as a part of the construction contract. The cost is displayed under the Fish and Wildlife Facilities account as "Construction" costs and is estimated to be approximately $231 per linear foot.

Additionally, during the design phase of the project, opportunities will be taken to choose a design that will minimize effects to the American River Parkway where feasible. After coordination with federal and state agencies, potential mitigation sites will be displayed in the design memorandum and refined during design phase.

Overall, after implementation of mitigation components, the mitigation sites would be monitored throughout the year for a minimum of 3 years, or until the mitigation sites are considered successful. A mitigation, monitoring, and adaptive management plan was developed and is included as Appendix I of the EIS/EIR.

In an effort to modernize the levee system to meet current engineering standards, vegetation and encroachment issues (including landside levee access) in the study area will be resolved through a combination of construction actions associated with implementation of the recommended plan and formal agreements such as a System Wide Improvement Framework Policy (SWIF) which allows specific vegetation and/or encroachments to remain in place permanently or defer their resolution to some future date. A SWIF provides committed sponsors the opportunity to transition their levees over time to USACE standards. By using a SWIF, sponsors can prioritize deficiencies to address the highest risk first to achieve system-wide risk reduction.

In preparing the requirements for a SWIF, USACE recognized that sponsors may engage at the federal, state, and local levels to address complex levee system issues in a more long-term, comprehensive approach to identify solutions that optimize resources; prioritize improvements and corrective actions based on risk; and coordinate overlapping or competing programs and requirements.

A SWIF is appropriate when a longer-term, holistic approach may be necessary to address multiple engineering deficiencies and operation and maintenance deficiencies; when broader improvements involve multiple levee segments/systems; or when additional time and coordination are needed to consider complex, endangered species habitat or Native American concerns, or encroachment concerns in highly urbanized areas while meeting requirements for levee safety.

In the case of construction associated with the recommended plan, vegetation and encroachment removal is anticipated as ancillary to the primary flood risk management measure (i.e. seepage cutoff barrier, levee raise, slope flattening) being constructed. In the case of a formal agreement, the integrated use of a SWIF and a variance from vegetation standards would both be required to ultimately assure compliance with Engineering Technical Letter (ETL) 1110-2-571 "*Guidelines for Landscape Planting and Vegetation Management at Levees, Floodwalls, Embankment Dams, and Appurtenant Structures*".

The SWIF would address vegetation and encroachment issues (including landside levee access) not removed as part of construction associated with the recommended plan but deemed unacceptable in terms of compliance with the engineering technical letter (ETL). A variance to vegetation management will be developed during PED to allow for vegetation to remain on the lower portion of the waterside levee slope. If a variance is not approved, the recommendations for this portion of the project will be reformulated.

Complete implementation of the Recommended Plan will be assumed to occur at the same time as complete implementation of the SWIF. Based on current experience in the watershed, the complete implementation of these two plans can reasonably be expected to occur within 20 to 40

years from the approval of the Chief's Report for the GRR.

Two assumptions were made in this SWIF analysis – (1) that the existing levee easement locations are continuous and extend from waterside toe to 10 feet beyond landside levee toe which would eliminate new permanent road easements (2) The cost estimate assumes the State has existing right of way on existing levees. If it is confirmed that the state has existing rights prior to construction a temporary construction easement would be executed in lieu of a permanent flood protection levee easement.

Figure 7: Sacramento River Levee Improvements with System Wide Improvement Framework Policy no Levee raises

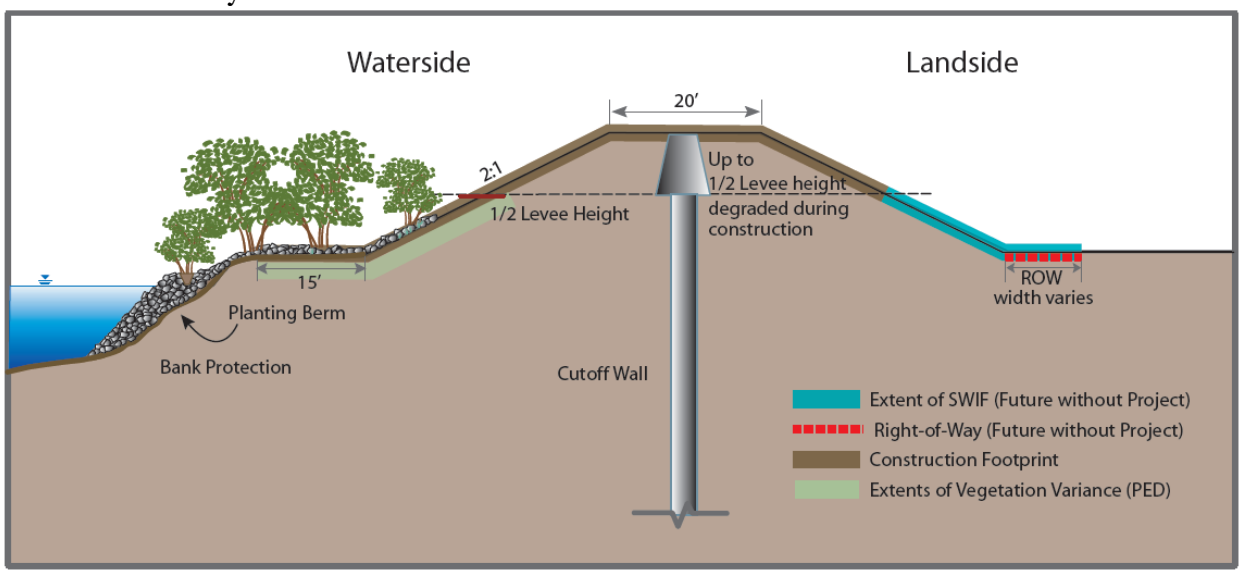
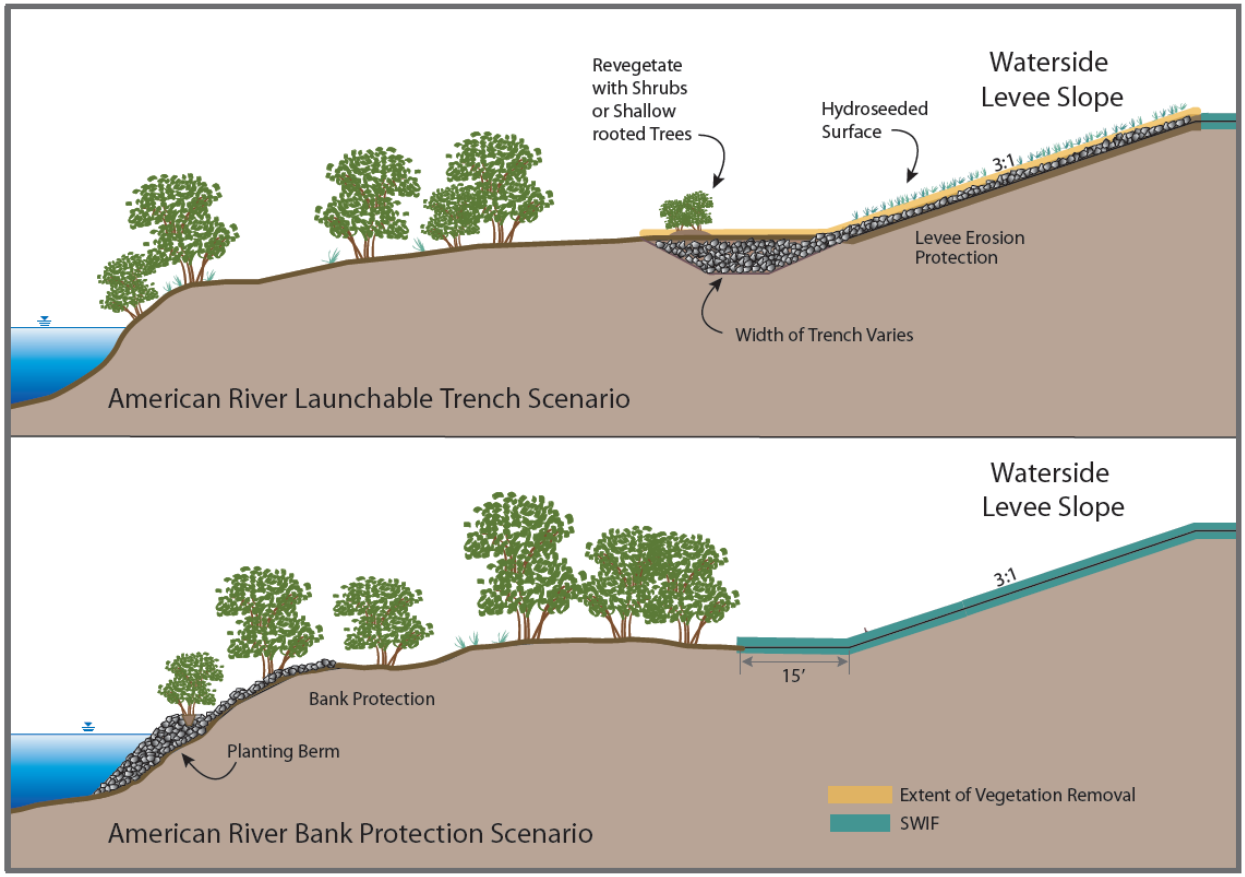


Figure 8: American River Levee Improvements with System Wide Improvement Framework Policy no Levee raises



Disposal Sites

Majority of the deconstructed levee material will be recycled and reused in this project. There may be small amounts of disposal material that will be disposed of at the local landfill. Disposal areas need to be selected on least costly areas.

Railroad Parcels

An inventory of the railroad parcels impacted by this project is as follows:

Reach	Railroad	Easement Required
ARS Reach G	Southern Pacific Railroad	Temporary easement 2 parcels
ARN Reach B	Southern Pacific Railroad	Bank Protection easement 1 parcel
ARN Reach D	Northern Sacramento Railway	Temporary Easement 1 parcel
ARN Reach F	Western Pacific Railroad	Temporary Easement 3 parcels
Sacramento Bypass	Sierra Northern Railway Trestle	Levee Easement & Flowage Easement 1 parcel

Figure 9: Sierra Northern Railway Bridge crossing over the Sacramento Weir

The construction of the widened Sacramento Weir and the adjoining railroad will likely be phased as follows. First, the new weir and railroad trestle will be constructed adjacent to the existing Sacramento River levee and the embankment of the railroad. Second, a slight jog in the railroad alignment will be constructed tying in the new trestle to the existing railroad line (both to the south tying into the existing weir/trestle structure and to the north tying into the continuation of the rail line. Then, after the new north levee has been constructed and the Sacramento River levee that would then be within the bypass has been removed, the entire widened Sacramento Bypass would be operational.

The actual disruption to the railroad is expected to be minimal because they will be kept in operation during the entire duration of construction of the new weir and trestle and would only need to be shut down during the time it takes to tie into the existing tracks which is expected to take not more than one month. With this plan, there will not need to be a temporary railroad line established and the associated costs would not need to be incurred. Coordination with Sierra Northern Railroad General Manager in Woodland will continue through the planning and construction phases of the project.

The other easements areas crossing over railroad parcels should not prevent the trains from moving and include no closure structures.

5. LERRD'S Owned by the NFS and Crediting

The following parcels represent sponsor owned lands as shown in Table 3. The primary non-Federal sponsors are the State of California Central Valley Flood Protection Board, California and the Sacramento Area Flood Control Agency (SAFCA). The State has a joint use agreement with Reclamation District 1000 in Natomas Basin for access. The State has a joint use agreement for access with the American River Flood Control District. The non-Federal sponsors already have access easements in the prior federally constructed levees. Those existing rights will not be cost- shared items. The project foot print of the levees has expanded and many additional areas

are now required for this project. Parcels already owned by Sacramento and San Joaquin Drainage District (State of California) and the SAFCA are included in this inventory as well. State owned lands associated with Department of Water Resources and Sacramento and San Joaquin Drainage District are considered to be sponsor owned and available for the project. Other California State agencies such as Cal Trans and State Parks are not considered to be sponsor owned and will require a new easement executed. For Alternative 2 the Non Federal sponsors own a total of 64.32 acres. There are two parcels in the Sacramento Bypass owned by the Sacramento and San Joaquin Drainage District but the construction footprint parcels for the Bypass expansion are owned by private farmers. However, these 64.32 acres identified in the tract registers are assumed sufficient to support project purposes/functions, and no inconsistent encumbrances and/or restrictions on said land is anticipated. The potential impact to project costs and/or plan selection as a consequence of this uncertainty is minimal inasmuch as the gross appraisal conservatively estimates the unit costs for the estates required for project purposes and includes seven incremental and improvement contingencies for various unknowns including severance damages, unknowns for level of study definition, unforeseen aspects due to inaccessibility and lack of onsite inspections, cost/value increases from time and development pressure, negotiation latitude above fair market value, potential for excessive cost/awards, potential for unknowns natural resources or minerals, improvement/building contingencies. Accordingly, this contingency assessment should reduce risk and cause no impact to plan selection.

The non-Federal sponsors have existing access easements in the prior federally constructed levees and it has been assumed for purposes of this study that the non-Federal sponsors will be required to acquire temporary work area easements to implement the Recommended Plan and the easement costs have been included in the total project cost estimate. If, during the PED Phase existing levee easements in prior Federally-constructed levees are discovered and available, those existing rights will not be cost-shared, which may lower total project costs.

TABLE 3 Sponsor-Owned Lands Summary

Location of Lands	Acreage
Total Acres Required Sponsor owned ARN	32.66
Total Acres Required Sponsor owned ARS	31.66

6. Standard Federal Estates and Non Standard Estates

Fee

The fee simple title to, subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Flood Protection Levee Easements (FPLE)

A perpetual and assignable right and easement in to construct, maintain, repair, operate, patrol and replace a flood protection levee, 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.

Temporary Work Area Easements (TWAE)
A temporary easement and right-of-way in, on, over and across for a period not to exceed 2/3 years after the execution of the construction contract, beginning with date possession of the land is granted to the Sponsor or United States, for use by the United States, Sponsor, 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 American River 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.

Permanent Road Easement (PRE)
A perpetual and assignable easement and right-of-way in, on, over and across [the lands described in the Exhibit D] for the location, construction, operation, maintenance, alternation and replacement of (a) road(s) and appurtenances thereto; together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions and other vegetation, structures, or obstacles within the limits of the right-of-way; (reserving, however, to the owners, their heirs and assigns, the right to cross over or under the right-of-way as access to their adjoining land at the locations indicated in [the lands described in the Exhibit D] subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

Borrow Easement
A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from [the lands described in the Exhibit D] subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

Bank Protection Easement
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.

Flowage Easement
The perpetual right, power, privilege and easement occasionally to overflow, flood and submerge [the lands described in the Exhibit D] (and to maintain mosquito control)in connection with the operation and maintenance of the project as authorized by the Act of Congress approved_____,

together with all right, title and interest in and to the structure; and improvements now situate on the land, except fencing (and also excepting____(here identify those structures not designed for human habitation which the District Engineer determines may remain on the land); provided that no structures for human habitation shall be constructed or maintained on the land, that no other structures shall be constructed or maintained on the land except as may be approved in writing by the representative of the United States in charge of the project, and that no excavation shall be conducted and no landfill placed on the land without such approval as to the location and method of excavation and/or placement of landfill; the above estate is taken subject to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used and enjoyed without interfering with the use of the project for the purposes authorized by Congress or abridging the rights and easement hereby acquired; provided further that any use of the land shall be subject to Federal and State laws with respect to pollution.

7. Description of Any Existing Federal Projects in or Partially in the Proposed Project

All project designs have taken into account all previous federal projects in the project area and specifically designed around those previous projects. There will be no overlapping areas with the new construction. All previous federal projects are described in the main report in section 1.5 of the main General Reevaluation Report. If any other Federal project completes work contemplated by this GRR, it will be removed from this project's footprint such as Sacramento River Bank Protection Project.

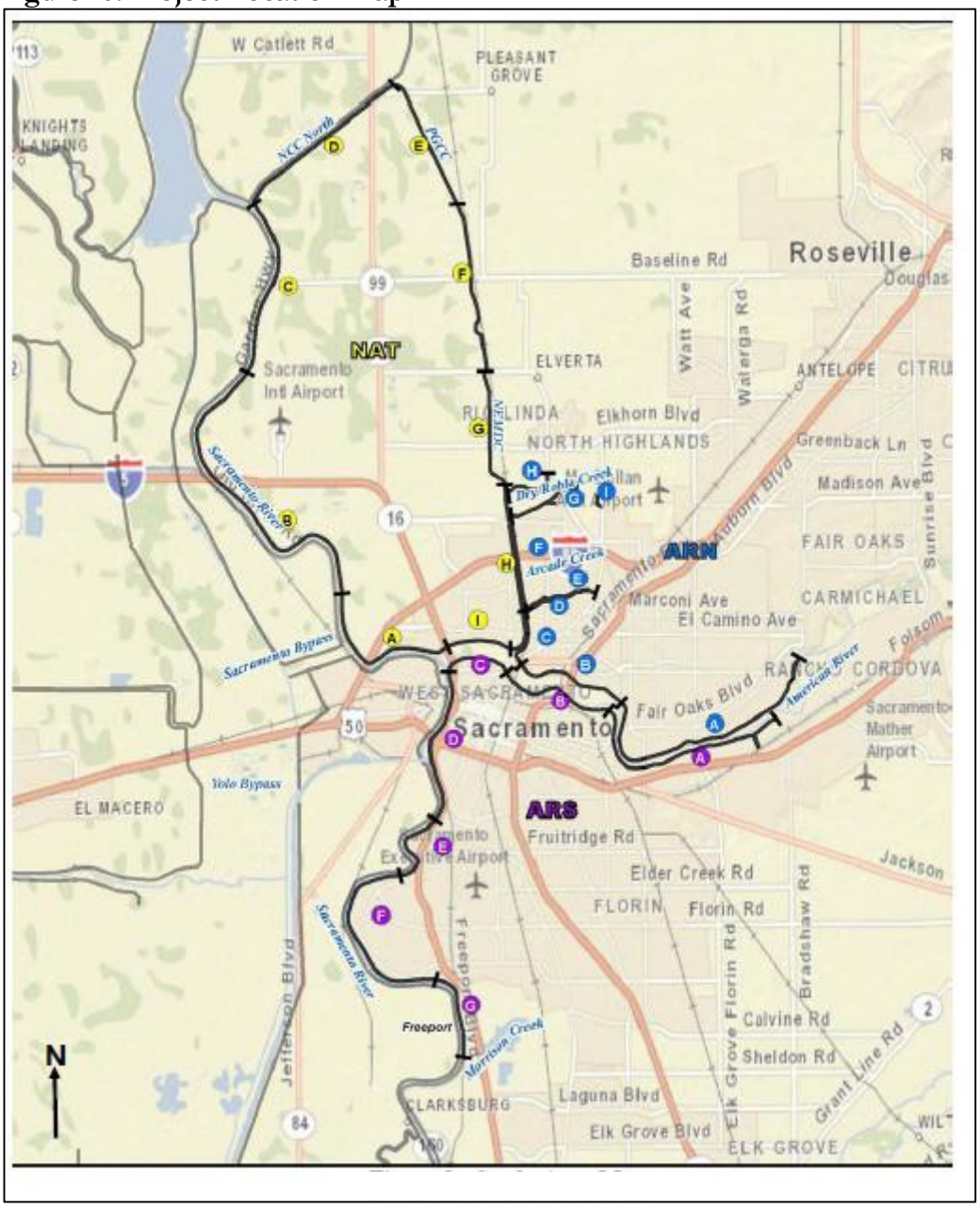
8. Description of any Federally Owned Land Needed for the Project

There is one federally owned parcel (215-0244-011) in ARN Reach I. This area was formerly McClellan Air Force Base. One parcel in the flowage easement area of Magpie creek still belongs to the base according to the county assessor's office. There is one Department of Transportation parcel near the Capitol City Freeway located near the bank protection. It is unknown if the bank protection will encroach into the freeway easement based on the conceptual design. Further refinements will be needed during PED. The remaining lands needed for the construction, operation and maintenance of the Alternative 2 are state, county, city or privately owned.

9. Application of Navigational Servitude to the LERRD's Requirement

The Recommended Plan for erosion/bank protection components meet navigational servitude criteria for rock revetment erosion improvement work completed along the Sacramento and American River (water) side of the levees below the high water mark. The first criterion the federal government must determine is whether the project features serve a purpose in the aid of commerce, navigation, flood control and hydro-electric power. The second step is to determine whether the land at issue is located below the mean or ordinary high water mark of a navigable water course. Construction barges will stay below the ordinary high water mark and the project will not acquire interests in any real property that is already possesses or over which its use or control is or can be legally exercised. Work within the navigable water way will require a permit from the State Lands Commission.

Figure 10. Project Location Map



11. Anticipated Increased Flooding and Impacts

Magpie Creek ARN Reach I – Currently a total of approximately 49 acres on both sides of Raley Blvd. experience flooding during storm events with a 10-year frequency and 70 acres for a 100-year event. The area inundated by a 170-year event with the project in place is estimated to be 72 acres (excluding roadways and channels, the inundated land would be 64 acres). Construction of the proposed improvements would slightly increase the water surface elevation during all flood events greater than a 5 year frequency. During a 170-year event, the increase in water surface is projected to be 0.5 feet at Raley Blvd and 0.1 feet at the western boundary of what was formerly known as the McClellan Business Park. This would increase the inundated area to 78 acres (excluding roadways and channels, 70 acres). Because this is already a floodplain, this project proposes to purchase and preserve the area as floodplain in perpetuity. The proposed project is designed to contain a flood

with a 1 in a 170 chance of occurrence in any given year with 95% reliability. Our sponsors have indicated that they would like to acquire a flowage easement is this area of increased water surface elevations. A physical takings analysis was conducted in December 2000 for Magpie Creek. A final takings analysis will be conducted when the final designs are completed for the Magpie Creek.

Figure 11: Magpie Creek proposed flowage easement general area)

Sac Bypass Reach - Sacramento Bypass Reach is already a designated floodway with executed flowage easements. We will be acquiring additional acreage of flowage easement when we widen the existing bypass. No other increased flooding is anticipated for the project.

12. Cost Estimate

The following is a preliminary analysis estimating the costs of acquiring the required LERRDs to support the NED Plan and the Recommended Plan). There are only two differences between the alternatives. Alternative 2, the LPP, is the Recommended Plan. This alternative costs more than Alternative 1 which is the NED. This Real Estate Plan does not include a detailed description of the Real Estate requirements for Alternative 1 because the features are very comparable between the two

alternatives. This section describes by watercourse the differences, if any, between the two alternatives.

American River North and South Bank: For the American River north and south bank, there is no difference in real estate requirements between the two alternatives.

Natomas East Main Drainage Canal, Arcade Creek, Dry/Robla Creeks, and Magpie Creek: For the Natomas East Main Drainage Canal, Arcade Creek, Dry/Robla Creeks, and Magpie Creek, there is no difference in real estate requirements between the two alternatives.

Sacramento River: For the Sacramento River below the American River, the real estate requirements for seepage, stability, and erosion improvements are identical between the two alternatives. This footprint includes the top half of the levee for seepage and stability improvements as well as the waterside footprint for bank protection construction. On the landside, because of the extent of levee raising is where there is somewhat of a difference between the two alternatives.

Alternative 1 includes approximately 9 miles of levee raising which is being constructed on the landside of the levee. The levee raise is approximately 2 feet, and at a 2 to 1 landside slope, requires four feet of levee easement. In addition to this four feet, an additional 10 feet of access is require for construction purposes. Alternative 2 reduces the extent of levee raising from approximately 9 miles down to below 1. Therefore, Alternative 1 as compared to Alternative 2 has an additional 8 miles of landside real estate take required to accomplish the levee raise required for that alternative. The assumptions used for the reaches of levee raise on the Sacramento River for Alternative 2 were used for the additional 8 miles of levee raising needed for Alternative 1.

Sacramento Bypass: The Sacramento Weir and Bypass widening is not included in Alternative 1 but is in Alternative 2. This feature is fully described in the Real Estate Plan, Section 4, since it is part of the Recommended Plan. The NED, if it were to be fully described in the RE Plan would omit this feature.

In summary, the NED plan, if it were to be fully described in the RE Plan would include a description of approximately 15 feet of landside take (both permanent and temporary) on an additional 8 miles of Sacramento River levee beyond the one mile that is already described in the RE Plan for Alternative 2. The magnitude of these differences are included in the attached tables.

The tables below estimate the costs associated with acquiring real property interests necessary to construct, operate and maintain a local levee project primarily located along the Sacramento and American Rivers within the County of Sacramento. The date of the approved cost estimate was June 11, 2013. The appraiser conservatively estimates the unit costs for the estates required for project purposes and includes several incremental and improvement contingencies for various unknowns including unknowns for level of study definition, unforeseen aspects due to inaccessibility and lack of onsite inspections, cost/value increases from time and development pressure, negotiation latitude above fair market value, potential for excessive condemnation cost/awards, potential for unknowns natural resources or minerals, and improvement/building contingencies.

The below is a summary of Real Estate Costs provided to Cost Engineering:

TABLE 4A NED PLAN COST SUMMARY

Alternative 1 – NED Plan Features	Ownerships	Lands and Damages Incremental RE Cost 25 % Severance	Includes a 35% and

01 ACCOUNT[1] - LANDS AND DAMAGES (Non Fed)		
Non Federal RE Administrative Costs (1377 parcels)		$24,039,500
P.L. 91-646 Payment Assistance relocations		$1,907,000
Subtotal		$25,946,500
Non-Federal Lands/ Damages	Ownerships	
ARS Sacramento River Reach D	9	$1,768,000
ARS Sacramento River Reach E	59	$1,350,000
ARS Sacramento River Reach F	127	$47,090,000
ARS Sacramento River Reach G	24	$4,107,000
ARS American River A	4	$2,434,000
ARS American River B	7	$519,000
ARS American River C	6	$458,000
ARN American River A	8	$1,444,000
ARN American River B	2	$96,000
ARN American River C	2	$326,000
ARN American River D	28	$835,000
ARN American River E	41	$1,228,500
ARN American River F	3	$340,000
ARN American River G	12	$149,000
ARN American River I (Magpie)	30	$29,580,000
Ownership Total	362	
Subtotal Lands and Damages + (Non Federal Admin) Total		(Rounded) $91,724,500 $25,946,500 $117,671,000
Federal RE Admin Costs		(ROUNDED) $9,582,000
	Sub total	(ROUNDED)**$127,253,000**
02 ACCOUNT - RELOCATIONS		
*Utility/Facility Relocation Costs Contingency 28.6 % Total:		$101,612,000 $27,435,000 **$129,048,000**
TOTAL LERRD'S COSTS (01 AND 02 ACCOUNTS)		(ROUNDED) $256,301,000

Note - Total Project Cost Summary displayed in Cost Engineering Appendix will include accounts 30 and 31 for all relocations and construction items combined.

TABLE 4B RECOMMENDED PLAN COST SUMMARY

Alternative 2 –Recommended Plan Features	Ownerships	Lands and Damages Includes a 35% Incremental RE Cost and varying Severance Damages
01 ACCOUNT[1] - LANDS AND DAMAGES (Non Fed)		
Non Federal RE Administrative Costs		$24,967,975
P.L. 91-646 Payment Assistance relocations		$690,625
Subtotal		$25,658,600
Non-Federal Lands/ Damages		
ARS Sacramento River Reach D	9	$880,000
ARS Sacramento River Reach E	59	$1,190,000
ARS Sacramento River Reach F	128	$14,370,000
ARS Sacramento River Reach G	20	$2,758,000
ARS American River A	4	$2,434,000
ARS American River B	7	$519,000
ARS American River C	6	$458,000
ARN American River A	8	$1,444,000
ARN American River B	2	$96,000
ARN American River C	2	$326,000
ARN American River D	28	$835,000
ARN American River E	41	$1,228,500
ARN American River F	3	$340,000
ARN American River I (Magpie)	30	$29,580,000
Sac Bypass Widening	10	$4,000,000
Subtotal Lands and Damages + (Non Federal Admin) Total	369	(Rounded) $60,458,400 $25,658,600 $86,117,000
Federal RE Admin Costs		(Rounded) $9,216,000
		$95,333,000
02 ACCOUNT - RELOCATIONS		
*Utility/Facility Relocation Costs Contingency 29.6% Total:		$122,813,000 $34,368,000 **$157,201,000**
TOTAL COSTS (01 AND 02 ACCOUNTS)		**$**252,534,000

* Note - Total Project Cost Summary displayed in Cost Engineering Appendix will include accounts 30 and 31 for all relocations and construction items combined.

13. Relocation Assistance Benefits (PL 91-646)

In addition to Real Estate administrative costs the relocation assistance payments to the property owners is calculated separately. A Relocation Assistance Plan will be provided to the Corp for review by the non federal sponsors. Relocation is dealt with on a case by case basis and costs will vary. Real Estate costs include totaling the land value, improvement value, and severance damages. This inventory of potential full take relocations was based on a >10 percent conceptual design and actual relocations can decrease or be eliminated in design phase. This inventory is for planning purposes only to assist in the development of total project cost for relocation assistance costs. It is estimated for the Recommended Plan that approximately 17 structures will be impacted due to construction of the project. The relocations include 13 residential takes, 2 temporary marina relocations, and 2 commercial building takes.

TABLE 5 RELOCATIONS

Locations	Reach	Number of Structures	Relocation Assistance Payments
American River South	Reach E	1	$32,500
American River South	Reach F	8	$260,000
American River South	Reach G	8	$260,000
		25% contingency ($138,125)	Total = $690,625

Availability of Replacement Housing/Business Properties: There are currently hundreds of single family homes for sale in Sacramento County. At this time there is replacement housing available. There are hundreds of businesses for sale or lease available in Sacramento County as well.

The foregoing impacts and estimates relating to potential displacements, and the anticipated need to provide relocation assistance benefits, are provided exclusively for project cost estimating purposes only and are not intended to be relied upon for provision of benefits and/or the payment of the estimates referenced herein. A draft relocation assistance plan has been provided by the State of California, Department of Water Resources and will be refined during final designs.

14. Mineral/Timber Activity

There are no active timber harvesting or mineral activities currently along the American or Sacramento River along the levees in our project area at this time.

15. Non-Federal Sponsor's Ability to Acquire

The State of California, Central Valley Flood Protection Board, have partnered with the Corps on several prior projects and have a full Real Estate staff capable of fulfilling their responsibilities as the non-Federal sponsor. The State of California, Central Valley Flood Protection Board, have a local partnership agreement with Sacramento Area Flood Control Agency who participate in this project as well.

16. Zoning Anticipated in Lieu of Acquisition

The Corps does not propose use of a zoning ordinance that would essentially facilitate property acquisition by prohibiting certain uses of property instead of purchasing the property. No such ordinance is proposed. The plan assumes purchasing property along the levee.

17. Acquisition Schedule

For economic and construction assessment, it was assumed that once authorized the project would receive annual appropriations ranging from $154M to $177M for construction of the selected plan. The Sponsor cost share was assumed to range from $54M to a maximum of $77M (applied to LERRD's) with $100M as the yearly allotment for the PED and Construction.

The non-Federal sponsors will be directed to begin real property acquisition for the project only after the PPA is fully executed. A risk letter has been sent from the Corps to both the Sacramento Flood Control Agency and the State of California alerting them to the risks associated with purchasing project lands in advance of the PPA execution. The construction contracts extend out ten years. Durations of each tasking after the PPA is executed is estimated at 3 to 6 months per construction contract.

Table 6. Real Estate Acquisition Schedule

REAL ESTATE ACQUISITION SCHEDULE				
Project Name: American River Common Features General Evaluation Report	COE Start	COE Finish	NFS Start	NFS Finish
Receipt of preliminary drawings from Engineering	2011	2015		
Receipt of final drawings from Engineering	2019	2020		
Execution of PPA/Finalize Chief's Report	April 21, 2016			
Formal transmittal of final drawings & instruction to acquire LERRDS (Assumes 4-5 years before appropriations and authorities are in place for PED phase of Project)	2016	2016	2016	2018
Construction Contracts				
(Reach ARS F) Years 1 to 6	2018	2023		
(Reach ARS E) Years 4 to 7	2021	2025		
(Reach ARS A) Years 1 to 4	2018	2021		
(Reach ARS G) Years 4 to 9	2021	2026		
(Reach ARS D) Years 7 to 10	2024	2027		
(Reach ARS B) Years 4 to 5	2021	2022		
(Reach ARN A) Years 5 to 7	2022	2024		
(Reach ARS C) Years 7 to 8	2024	2025		
(Reaches ARN D) Years 4 to 8	2021	2025		
(Reaches ARN B) Years 8 to 9	2025	2026		
(Sacramento Bypass Widening) Years 1 to 7	2018	2024		
(Reach ARN F) Years 7 to 10	2024	2027		
(Reach ARN E) Years 5 to 10	2022	2027		
(Reaches ARN C, G, I) Years 8 to 10	2025	2027		
Conduct Landowner Meetings			2018	2027
Prepare/review mapping & legal descriptions			2018	2027
Obtain/review title evidence			2018	2027
Obtain/review tract appraisals			2018	2027
Conduct negotiations			2018	2027
Prepare/review condemnations			2018	2027
Perform condemnations			2018	2027
Obtain control			2018	2027
Complete/review PL 91-646 benefit assistance			2018	2027
Certify all necessary LERRDS are available for construction			2018	2027
Prepare and submit credit requests			2018	2027
Review/approve or deny credit requests	2020	2030		
Establish value for creditable LERRDS	2020	2030		

18. Description of Facility and Utility Relocations

On July 14, 1998, the Assistant Secretary of the Army issued a letter directive relating to the American River Common Elements Project which provided, in relevant part, that the removal and replacement of a utility, or other public facility, owned by the State of California, or a political subdivision thereof, (including the Sacramento Area Flood Control Agency (SAFCA) and its constituent members) and which delivers public services, should be treated as a relocation where such work is required as a direct result of the construction of the project. Such relocations, provided they met the required criteria, were to be included as a shared total project cost with credit issued to the non-federal sponsors for relocating the affected utilities/facilities. This letter applied only to publically owned utility and facilities and did not include any privately owned permitted or unpermitted encroachments.

Due to the passage of time and the current scope of the project—now known as the Common Features project—Corps RIT Vertical Team agreed that ongoing reliance upon the scope of the ASA's 1998 letter and its application to the current project must be coordinated with the current ASA-CW. Provided agreement is reached and assuming consistency with the preliminary findings set forth in the Relocation Inventory Tables, below, costs incurred in relocating eligible utilities/facilities that are owned by the following entities will be included as total project costs with credit given to the non-federal sponsors: the State, SAFCA and its constituent members (which include the City of Sacramento, the Counties of Sacramento and Sutter, Reclamation Districts, the American River Flood Control District, the Sacramento County Water Agency and the Sutter County Water Agency) and the Sacramento Municipal Utility District (SMUD). This letter is located in Exhibit C.

The Corps has drafted modifications to the Project Partnership Agreement for the Common Features Project implementing this determination. These modifications and implementation guidance have been provided to the Sacramento District for coordination with the State of California and SAFCA.

A Preliminary Opinion of Compensability was prepared regarding proposed utility/facility relocations based upon information and data submitted to the Sacramento District Real Estate Division Office for review as of September 4, 2014. Various utilities/facilities are located within the project boundaries and must be relocated to facilitate project construction. The utilities/facilities consist of electrical distribution and service facilities, telephone communication lines, irrigation facilities, roadways, water delivery facilities and natural gas pipelines. A summary of their compensability analysis, referencing the data set forth in the Relocation Inventory Table, is as follows:

The following utilities/facilities are compensable relocations under the 1998 ASA letter and have demonstrated need for the provision of "substitute facilities." Exhibit E provides the table with the utility/facility inventory.

For Relocations, utilities and various encroachments were researched and identified using a variety of sources including: State DWR Levee Logs, USACE Periodic Inspection data, and Central Valley Flood Protection Board (CVFPB) permitting data. All of these sources were compiled into a central spreadsheet for organization and priority identification purposes. Field surveys were conducted following the research in an attempt to verity description, materials and sizes. Typical fixes were created to reflect existing conditions and proposed improvements to accommodate levee construction features and USACE policy compliance. Features such as replacement/relocation of

pipe, impervious fill around pipes, and positive closure represented a majority of the reoccurring items requiring relocation. Exhibit E provides the table with the utility/facility inventory.

Utility Power Poles-ARS Reach D Item 28, ARS Reach E Item 35, ARS Reach F Item 44, ARS Reach G Item 44, ARN Reach E Item 35, ARN Reach G item 82, Sac Bypass Reach Items 7, 11
Discharge Pipes/Storm Drains/Intake Pipes/Culverts/City Sumps/- ARS Reach D Items 2, 6,7,11,12,19,24,26, ARS Reach E Items 30, 31,32,33, ARS Reach F Items 36, 37,41 ARS Reach G Item 50,ARN Reach C Item 1,4 ARN Reach D Item 12,19 ARN Reach E Items 39,44,57,60,61,62, ARS Reach G Item 83, ARS Reach H 98, 100, 101, Sac Bypass Items 9, 10
Force Main/ Sewer pipes/Water Main- ARS Reach D Items 16, 21, 23 ARS Reach E Item 34 ARS Reach G Item 52, 59, ARN Reach D Items 14, 17,18,20,24 ARN Reach E Items 38,42,43,45,49,63,64 ARN Reach G Item 94
Electrical Conduits/Electrical Pipes ARS Reach D Items 20,25, ARS Reach F Item 38, ARS Reach G Item 57, ARN Reach D Item 21, ARN Reach E Item 46
Gas Mains – ARS Reach G Item 51
Telecommunications ARS Reach G item 48, ARN Reach D Item 11, Sac Bypass Item 8
Gaging Station – Sac Bypass Reach Item 2
Railroads ARS Reach G, Remove and replace tracks 11,050 LF, ARS Reach D, Sacramento Bypass (replace rail road bridge over weir- construction cost not a relocation)
Roads – Restoring public and private haul routes if damaged back to their existing condition or replace new if needed. Levee access ramp repairs if needed. ARS Reaches A,B,C,D,E,F,G ARN Reaches A,B,C,D,E,F,G,I Description of road work located in MII report level 3, Exhibit E.

The following utilities/facilities have no public purpose or ownership and, accordingly, are not compensable relocations: All of these items are various pipe penetrations through levees the majority of which have been abandoned and are no longer needed. There is one electrical conduit and one communications conduit that are proposed to be cut and abandoned and no longer appear to be in use ARS Reach D: Item Nos. 1, 8-10, 14, ARS Reach F 39,40 ARS Reach G, Item Nos. 45- 46,47, ARN Reach C Item Nos. 2

The following utilities/facilities may have compensable interests under the 1998 ASA letter, however, there is insufficient information at this time to make a preliminary determination as to whether the utilities/facilities are compensable relocations doctrine. The submission of additional data such as ownership and public purpose is required.

ARS Reach D Nos. 3,4,27(storm drain, man hole and a culvert, ARS Reach E Nos. 29(multiple pipes near La Rivage marina), ARS Reach G: Item Nos. 58, 60, 61, (pump, pipe, electric feed), railroad stop log closure structure raise, railroad tracks remove and replace 11,050 LF – MII page 18, ARN Reach D: Item Nos. 9, 22, 28, 29(2 overhead utilities, man hole, culvert), Page 7 MII, ARN Reach E, Item Nos. 35, 47, 52, 53, 55, 56, 58, 59 (five storm drains and three overhead utilities) ARN Reach F, Item Nos. 66, 67 69, 70, 72, 73, 75, 76 (two drop inlets, four culverts, two overhead utilities) ARN Reach G: Item Nos. 80, 84, 85, 86, 87,90, 91, 92 95, 96, 97(four overhead utilities, five culverts, water well and a manhole) ARN Reach H, Item Nos. 99,102 (two overhead utilities) ARS Reaches A,B,C,D,E,F,G and ARN Reaches A,B,C,D,E,F,G,I (haul route surface road repairs/asphalt repairs, ramp repairs)

A utility inventory is provided below by basin and reach. A summary table of the cost estimate is provided and includes construction costs and engineering contingency. Utility/Facility relocation inventory with detailed unit costs are shown in Exhibit E. For cost estimating purposes the utilities were all assumed compensable.

TABLE 7. CODE OF ACCOUNTS 02 UTILITY/FACILITY RELOCATIONS SUMMARY

UTILITY/FACILITY RELOCATIONS	COST
ARS Reach A ARS Reach B	$4,899,000 $2,313,000
ARS Reach C	$400,000
ARS Reach D	$25,524,000
ARS Reach E	$4,143,000
ARS Reach F	$11,421,000
ARS Reach G	$26,383,000
ARN Reach A	$1,972,000
ARN Reach B	$81,000
ARN Reach C	$1,180,000
ARN Reach D	8,344,000
ARN Reach E	$10,665,000
ARN Reach F	4,237,000
ARN Reach I	$50,000
Sac Bypass Widening	$21,201,000
Subtotal	$12,281,3000
Contingency 28%	$34,368,000
Total	$157,201,000

Total Project Cost Summary provided by Cost Engineering Section will include accounts 30 and 31 for all relocations and construction items combined.

ANY CONCLUSION OR CATEGORIZATION CONTAINED IN THIS REAL ESTATE PLAN (AND THE REPORT) THAT AN ITEM IS A UTILITY OR FACILITY RELOCATION TO BE PERFORMED BY THE NON-FEDERAL SPONSOR AS PART OF ITS LERRD RESPONSIBILITIES AND/OR IS OTHERWISE COMPENSABLE OR NON-COMPENSABLE IS PRELIMINARY AND FOR DISCUSSION PURPOSES 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 THE FINAL ATTORNEY'S OPINIONS OF COMPENSABILITY FOR EACH OF THE MPACTED UTILITIES AND FACILITIES DURING FINAL DESIGNS.

19. Hazardous, Toxic, and Radiological Waste Impacts

A Phase 1 Environmental Site Assessment was performed in accordance with the scope and limitations of ASTM E 1527-05 and USACE ER 1165-2-132 for the American River Common Features GRR project. Any exceptions to, or deletions from, these practices have been outlined within the report. There are many contaminated properties adjacent to the levees on the dry side that are considered to be avoidable due to the nature of the contamination or the nature of the work proposed on the levees. This assessment has identified sites with recognized and probably unavoidable environmental conditions at the locations shown in Table 7 below.

TABLE 7. Sites with Recognized Environmental Conditions

Site Name	Location	Reach	Issue
1 - Full Stop Mini Mart EDR 41-5	251-0292-016 3200 Rio Linda Blvd. Sac CA 95815	ARN Arcade Creek	TPHg plume at levee bridge crossing with air sparging
2 - Old North Sacramento EDR 69-8	275-0111-001 EDR 69-8	ARN Reach B/N Natomas East Main Drainage Canal	CVOC, TPH Groundwater Plumes adjacent to levee, multiple properties
3 - TOSCO Corp. Conoco-Phillips Sacramento Terminal EDR 174-11	009-0020-001 66 Broadway Sac CA 95818	ARS_D	Petroleum release site on wet side of the levee.
4 -TOSCO Corp./ Conoco-Phillips Sacramento Terminal EDR 174-11	76 Broadway Sacramento, CA 95818	ARS_D 009-0030-054 009-0012-071 009-0012-072	Petroleum release site on dry side of the levee. Petroleum pipelines pass through the levee.
5-Robertson Harbor Sand & Gravel EDR 92-8 EDR 128-8	001-0160-001 200 28th Street Sacramento CA	ARS Reach B American River	Levee Encroachment, recycled pavement
6 -Southern Pacific Rail Yard Museum EDR 120-7	501 Jibboom St. Sacramento CA 95814	ARS Reach D Sac River	CVOC, TPH Groundwater Plume, land use restrictions
7 - Old Bryte Yard Landfill EDR Site 79-6	042-280-011 50035 County Rd 126 West Sac, CA 95691	Sacramento Bypass	Lead in Soil

The historical land uses of the region may also contribute to residual contamination of the entire project area with agricultural fertilizers, herbicides, and pesticides as well as arsenic and mercury from mining operations in the region. Additional sampling will be required during subsequent investigations to determine if project areas have been impacted by these historical contaminants.

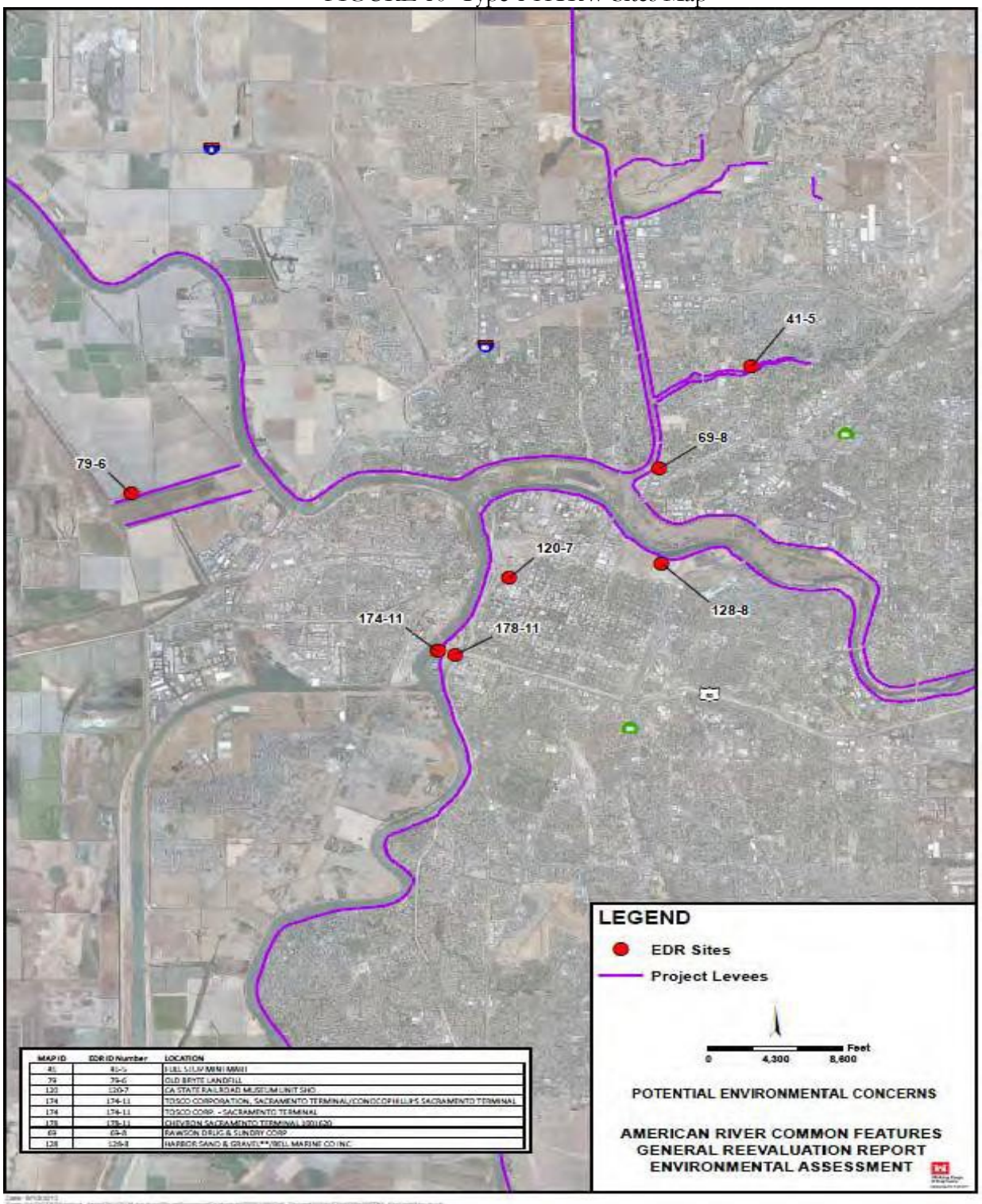
On-line records are limited. For contaminated sites identified as unavoidable under the alternatives considered by the American River Common Features GRR, a public records review is recommended at the Central Valley Regional Water Quality Control Board office and the Sacramento Regional Office of the Department of Toxic Substances Control as the next step to determine if additional investigation is required to determine the impact of these sites on the project. Current groundwater plume maps and environmental liens / deed restrictions incorporating land use controls are particularly needed. Emphasis is needed on the Sacramento Terminal bulk fuel handling facility, the old Southern Pacific rail yard, and the old Bryte yard landfill.

The subsequent Phase 1 ESA(s) during Design Phase will investigate if new sites have emerged and if existing sites still pose a threat to planned construction.

If any evidence of potential HTRW is found during construction, all work would cease, and the Corps and non-Federal sponsor would be notified for further evaluation of the potential contamination. Any unanticipated hazardous materials encountered during construction would be handled according to applicable federal, state, and local regulations. The Corps would require that a contingency plan that outlines steps to be taken before and during construction activities to document soil conditions, as well as procedures to be followed if unexpected conditions are encountered, be prepared by the contractor.

The non-Federal sponsor is responsible for 100 percent of the cost to develop the clean-up procedures (remedial action plan) and to treat the contaminates in place or relocate the material (ER 1110-2-1150).

FIGURE 10 Type 1 HTRW Sites Map



MAP ID	EDR ID Number	LOCATION
41	41-5	FUEL STOP MINI MART
79	79-6	OLD BRYTE LANDFILL
120	120-7	CA STATE RAILROAD MUSEUM UNIT SHO
174	174-11	TOSCO CORPORATION, SACRAMENTO TERMINAL/CONOCOPHILLIPS SACRAMENTO TERMINAL
174	174-11	TOSCO CORP. - SACRAMENTO TERMINAL
178	178-11	CHEVRON SACRAMENTO TERMINAL 100120
69	69-8	RAWSON DRUG & SUNDRY CORP
128	128-8	HARBOR SAND & GRAVEL**/BELL MARINE CO INC

HTRW – FIGURE 11 ARS Reach B(5)/C Asphalt Concrete Recycling Company encroaching on the levee between Sacramento City Landfill/Sutters Landing Regional Park and Scollan/Old Sacramento Landfill

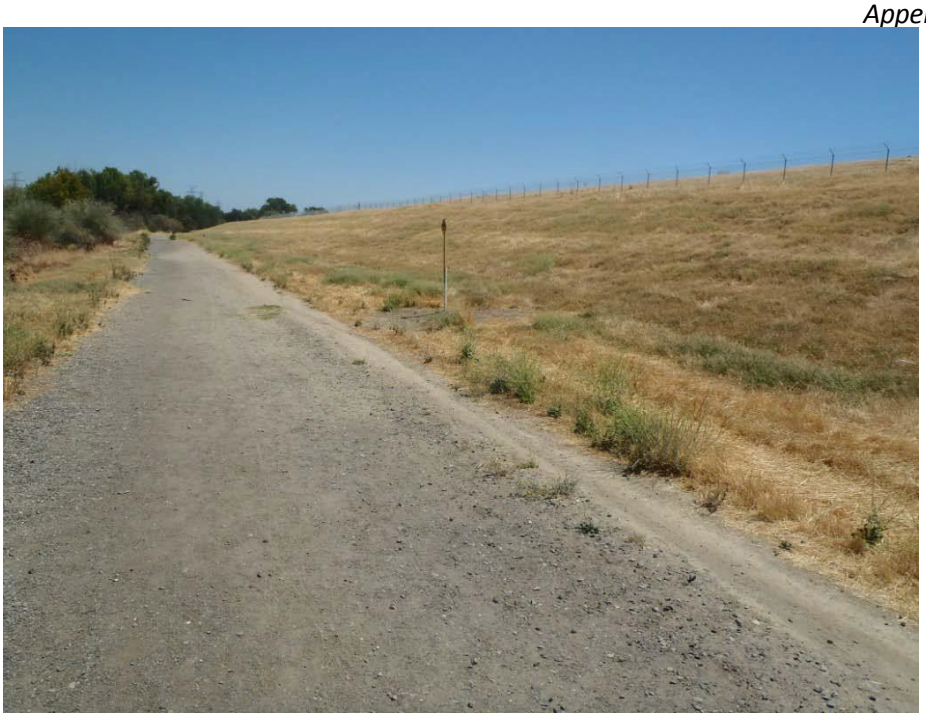
HTRW FIGURE 12 -ARN Reach N (2) Full Stop Mini-Mart SVE/AS treatment system located adjacent to levee

HTRW FIGURE 13 - ARS Reach C Monitoring well cluster in the levee crown near Martin Sprocket & Gear

HTRW FIGURE 14 -Old Bryte Landfill adjacent to Sacramento Bypass (7) north levee.

HTRW FIGURE 15 -Monitoring well between Old Bryte Landfill and Sacramento Bypass levee (7)

HTRW FIGURE 16 -ARN Reach N/I Contaminated property in old North Sacramento viewed from Dry Creek levee



HTRW FIGURE 17 - ARS Reach B(5) Kinder Morgan Energy Partners buried petroleum pipeline warning sign at the toe of the levee at Sacramento City Landfill /Sutter Landing Regional Park

HTRW FIGURE 18 -ARS Reach B (5)/C Sacramento City Landfill rises above levee crown in the left side of the photo. Stormwater collection drain is visible. Landfill gas collection system is obscured by the weeds.

HTRW FIGURE 19 -ARS Reach D (6) This former PG&E manufactured gas plant site is currently under remediation. Contamination has been solidified in place at the foot of the levee. Remediation is planned to be completed in November 2012. Active railroad tracks are also present on top of the levee in this area.

HTRW FIGURE 20- ARS Reach D (6) This site is owned by the Sacramento Redevelopment Agency and is next door to the PG&E site. The site has been certified by DTSC and has various land use restrictions. Currently, the site is used for horse carriage storage. Some empty drums are stored on site.

HTRW FIGURE 21 -ARS Reach D 66 Broadway (3) is a fuel terminal used by TOSCO Corporation. The site is located on the water side of the levee. A petroleum release that is still undergoing cleanup occurred in this area. Underground utilities and monitoring wells are present.

HTRW FIGURE 22 - ARS Reach D 76 Broadway (4) is a bulk fuel terminal used by Conoco Phillips. Underground infrastructure and at least 7 above ground storage tanks containing petroleum substances are located on both sides of the levee.

HTRW FIGURE 23- ARS Reach D (4) Fuel lines cross through the levee at 76 Broadway.

HTRW FIGURE 24 -ARS Reach D 2420 Front St This bulk fuel terminal used by Chevron is on the water side of the levee. Monitoring wells, underground infrastructure, and at least 12 above ground storage tanks containing petroleum substances were observed on site.

HTRW FIGURE 25- ARS Reach D (3&4) Fuel lines cross to and from the water and land sides of the levee to the following sites: 76 Broadway (ConocoPhillips Bulk Fuel Terminal), 66 Broadway (TOSCO Corp Sacramento Terminal), and 2420 Front St (Chevron Bulk Fuel Terminal).

20. Attitude of Land Owners

To date, the results of the outreach program from the public scoping meetings have been favorable, constructive, and supportive with the exception of the construction of the levee access corridor by residents and businesses along the Sacramento River particularly in the Pocket areas. Lands adjacent to the existing levees have been developed for several decades. The proposed plan will fix the existing levees in place in order to minimize additional land requirement.

In an effort to partner with our sponsors and minimize impacts to the public a System Wide Improvement Framework Policy (SWIF) will allow specific vegetation and/or encroachments to remain in place permanently or defer their resolution to some future date. A SWIF provides committed sponsors the opportunity to transition their levees over time to USACE standards. By using a SWIF, sponsors can prioritize deficiencies to address the highest risk first to achieve system-wide risk reduction and to meet current engineering standards, vegetation and encroachment issues (including landside levee access) in the study area. This will be resolved through a combination of construction actions associated with implementation of the recommended plan and formal agreements.

21. Cultural Resource Sites

Records searches of pertinent cultural resource information were conducted in 2006 and

2007, and updated in 2010 and 2013 for the overall study area. Most of the searches were conducted at the North Central Information Center (NCIC) of the California Historical Resources Information System, located at California State University, Sacramento. The NCIC records search covered portions of the study area in Sacramento and Yolo Counties. The northern portion of the Natomas area is within Sutter County so records searches for that area were also conducted at the Northeast Information Center (NEIC). The NEIC reported seven previous cultural resource studies in the study area within Sutter County, and the NCIC reported 278 previous studies in the Sacramento and Yolo County portions of the study area; thus a total of 285 studies have been conducted in the study area. From those previous studies, a total of 175 cultural resources (archaeological and historical sites) were identified within the overall study area.

Due to the large geographic scope of the study area, limitations in access, the alluvial nature of the watershed, because levees and other structures have been built on top of much of the original native soil of the study area, and due to the high potential for buried cultural resources that will not be discovered until during construction, a 100% pedestrian survey of the entire study area could not be completed. However, data from the records and literature search, concerns relayed by American Indians, knowledge of the prehistory and history of the study area, and recent archaeological surveys conducted as part of Natomas Levee Improvements Project provide information on the types of cultural resource sites that may be found within the study areas. The known cultural resources within the study area can be categorized as the following general types within the Sacramento Valley:

- **Mounds** – Refers to relatively low natural or anthropogenic mounds occupied by Native Americans as habitation sites and burial locations. Discarded refuse and numerous fires frequently generated significant accumulations of midden soil on these features.
- **Midden** – Refers to prehistoric or proto-historic trash deposits containing food refuse, such as discarded bone, shell, and other organic matter; along with broken, discarded or lost artifacts made of various raw materials, including stone, wood, bone, antler, etc. The organic nature of middens tends to produce softer, darker, and greasier soils in contrast to the natural soils on which they rest. Deposition of midden often expanded the size of natural knolls or mounds both horizontally and vertically. Because of the softer soils in middens, they were also used as locations for human and/or animal burials. Middens generally include the full suite of artifacts, materials, and remains that would be encountered in a lithic scatter.
- **Lithics/Lithic Scatter** – The term "lithic scatter" refers to scatters of lithic (stone) debris (or debitage) resulting primarily from manufacture of chipped stone tools such as knives, dart points, arrow points, scrapers, adzes, and other tools. The process of manufacture by chipping or "knapping" resulted in percussion and pressure flakes removed from the raw natural resources of chert, obsidian, basalt, felsite and any other stone raw materials. Lithic scatters often contain fire-cracked rock distinguished by its fire reddened colors and sharp fracture patterns. Such rocks were often used for cooking by dropping heated rocks into baskets full of water and food. The sudden temperature change would commonly cause the rocks to fracture in a distinctive way. Ground stone tools used for processing foods and pigments are also common in lithic scatters. Less commonly, baked clay artifacts and shell or bone tools and ornaments may also occur. Finally, broken fragments of tools used for lithic manufacture such as hammerstones may also be associated with lithic scatters.
- **Traditional Cultural Properties** – Often referred to as "TCPs," Traditional Cultural Properties may be geographic features, locations, rural communities, urban neighborhoods, or other areas associated with cultural practices or beliefs of a living community that are rooted in that community's history, and are important in maintaining the continuing cultural identity of the community. TCPs may include locations associated with the traditional beliefs of an Native American group about its origins, its cultural history, or the nature of the world; may include buildings and structures, objects or landscapes; and may be associated with religious or

cultural practices of Native Americans.

- **Traditional Cultural Landscapes** – As described by the Advisory Council on Historic Preservation (ACHP), the term "traditional cultural landscape" has not been formally defined by the National Park Service. Although there is no single defining feature or set of features that comprise a traditional cultural landscape, such places could be comprised of natural features such as mountains, caves, plateaus, and outcroppings; water course and bodies such as rivers, streams, lakes, bays, and inlets; views and view sheds from them, including the overlook or similar locations; vegetation that contributes to its significance; and manmade features including archeological sites; buildings and structures, circulation features such as trails; land use patterns, evidence of cultural traditions, such as petroglyphs and evidence of burial practices; and markers or monuments, such as cairns, sleeping circles, and geoglyphs.
- **Historic Debris** – This term may refer to a great number of different artifacts 50 years of age or older that may be considered historical in nature. Cans, metal fragments, nails, glass fragments, glass bottles, and a variety of remnant material may be considered historic debris. In the Sacramento Valley this occasionally includes material thrown from railroad cars as passengers passed through the area, as well as abandoned machinery and equipment. Historic debris may be linked to a number of different historic subsistence activities such as farming, irrigation, construction of infrastructure, mining, and homesteading.
- **Water Related** – The history of the Sacramento Valley is intertwined with that of flood control, reclamation, farming, and irrigation in the city of Sacramento and the surrounding areas. Much of the flood control infrastructure of the area dates back to the turn of the twentieth century. Water-related features may include levees, canals, weirs, bypass channels, drainage ditches, pump houses, wells, pipes, and farm-related structures and equipment.
- **Transportation** – A great number of roads, bridges, railroad tracks, and railroad trestles appear within the study area. These may include dirt or paved roads; bridges over canals, culverts, or other topographic features; and a variety of railroad features. Railroad features may include portions of the Transcontinental Railroad, the Walnut Grove Branch Line Railroad, raised berms that supported railroad rights-of-way, railroad trestle bridges, and lengths of railroad alignments. Within Sacramento, a number of historic railroad features are still in use today, both for the transport of goods, and recreationally and educationally associated with the California Railroad Museum in Old Town Sacramento just east of the Sacramento River.
- **Structures** – This refers to a variety of buildings or structures 50 years of age or older. Within the project area these may include government offices, farmsteads, homesteads, residential structures, barns, ranches, power plants, and sheds. These structures may be made from materials such as wood, concrete, brick, masonry, stucco, and corrugated metal.

In addition to the conclusions regarding the various cultural resources site types that may be found within the study area, an archaeological sensitivity assessment for prehistoric resources was conducted The sensitivity assessment was built using existing survey data to identify correlations between the occurrence of archaeological sites and environmental variables including proximity to water, historic vegetation, and lithology. This was accomplished in GIS using environmental data and information from the record search indicating where archaeological sites do and do not exist in areas that had been previously surveyed.

As a result of the various efforts (records and literature searches, archaeological sensitivity assessment, consultation with American Indians, consultation with the interested public, review of existing and recent archaeological inventories and discoveries) to identify cultural resources within the study area, the Corps has determined that the project will likely have an adverse effect on properties that are either included in, or are eligible for inclusion in the NRHP. Due to the large geographic scope of the project, the lack of detailed designs to determine construction specific APEs, and limitations in available funding to complete full identification of potential historic

properties prior to approval of the project, the Corps has also determined that they cannot fully determine the effects of the project on NRHP eligible properties for all phases and segments of the project at this time.

In order to provide a framework for the Corps to identify cultural resources, evaluate cultural resources for their eligibility for inclusion in the NRHP, determine possible effects to historic properties, and mitigate effects to historic properties as a result of the project, a programmatic agreement (PA) has been developed by the Corps in consultation with the State Historic Preservation Officer (SHPO) the Advisory Council on Historic Preservation (ACHP), and Native American tribes with concerns in the area as potential Concurring Parties. The draft PA was provided to the DWR, the CVFPP, SAFCA, and potentially interested American Indians for review and comment in the development of the PA. Specific individual determinations of effect for historic properties that may be affected by the selected alternative would be completed under the stipulations of the PA, which includes a framework to identify historic properties, evaluate NRHP eligibility, and assess effects.

The PA covers the ARCF Project. The PA provides a process for the identification and evaluation of historic properties and, if necessary, the resolution of adverse effects to identified historic properties. The PA also provides a process for handling post-review discoveries. Per the PA, all Corps construction activities will avoid archaeological sites/historic properties, both eligible and non-eligible, to the maximum extent practicable. Per the PA, all Corps construction activities will avoid historic properties to the maximum extent practicable. The draft PA was provided to DWR and the CVFPB on April 11, 2012 and February 22, 2013, and to SAFCA on February 12, 2013, and potentially interested Native Americans on April 5, 2013, June 6, 2013, June 12, 2014, and June 25, 2014 for review and comment as part of the development of the PA. The final PA was executed by signature by the Corps and the SHPO on September 10, 2015.

EXHIBIT A

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY
AMERICAN RIVER COMMON FEATURES GENERAL REEVALUTION STUDY

SPONSORS: The State of California, Central Valley Flood Protection Board (CVFPB) with the USACE and the local agreement between State of California, CVFPB and Sacramento Flood Control Agency (SAFCA)

I. Legal Authority:

a. Do the sponsors have legal authority to acquire and hold title to real property for project purposes? Yes CVFPB; Yes SAFCA

b. Do the sponsors have the power of eminent domain for this project? Yes CVFPB; Yes SAFCA

c. Do the sponsors have "quick-take" authority for this project? Yes CVFPB; Yes SAFCA

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary? No CVFPB; No SAFCA

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? No CVFPB

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? Yes CVFPB;

b. If the answer to a. is "yes," has a reasonable plan been developed to provide such training? Yes CVFPB

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? Yes CVFPB; Yes SAFCA

d. Is the sponsor's project in-house staffing level sufficient considering its other workload, if any, and the project schedule? Yes CVFPB; Yes SAFCA

e. Can the sponsor obtain contractor support, if required, in a timely fashion? Yes CVFPB; Yes SAFCA

Prepared by:

Laurie Parker

Laurie Parker
Realty Specialist
Acquisition Branch

Date: 25 November 2015

Reviewed and Approved by:

_____

Diane Simpson
Chief, Real Estate Division
U.S. Army Engineer District,

Sacramento

Date: _____

EXHIBIT B POLICY GUIDANCE LETTER 31- REAL ESTATE SUPPORT TO PLANNING PARADIGM (3x3x3)

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET NW
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CEMP-CR

JAN 1 0 2013

MEMORANDUM FOR SEE DISTRIBUTION

SUBJECT: Real Estate Policy Guidance Letter No. 31-Real Estate Support to Civil Works Planning Paradigm (3x3x3)

1. References.

a. Memorandum, CECW-CP, 8 February 2012, Subject: U.S. Army Corps of Engineers Civil Works Feasibility Study Program Execution and Delivery

b. ER 5-1-11, USACE Business Process, 1 November 2006

c. EC 405-1-04, Appraisal, 30 Dec 2003

d. ER 1105-2-100, Planning Guidance Notebook, 22 Apr 2000

e. ER 405-1-12, Chapter 12, Real Estate Roles and Responsibilities for Civil Works, Cost Shared and Full Federal Projects, Change 31, 1 May 1998

2. Purpose. In accordance with reference a, this memorandum provides interim policy and guidance for real estate efforts associated with feasibility studies under the new Planning Paradigm, "SMART Planning," and the 3x3x3 rule. In accordance with the 3x3x3 rule, all feasibility studies should be completed within three years, at a cost of no more than $3 million, utilize three levels of vertical team coordination, and be of a "reasonable" report size.

3. Background. Real Estate has been fully engaged in the implementation of the 3x3x3 by actively participating in each webinar, the planning modernization workshop, and serving as part of the HQ Transition Team. In accordance with references b-e, Real Estate involvement is essential to the development and implementation of any pre-authorization project. Paragraph 12-16 of reference e. outlines the significant topics that must be covered in a real estate plan (REP). The level of detail necessary to apply the requirements of real estate policy and guidance will vary depending on the scope and complexity of each project.

As outlined in Chapter 12, the minimum interests in real property necessary to support various types of projects must be identified. As projects are scoped at the beginning of the feasibility phase (via a Charette or other forum), it is essential that Real Estate become familiar with the project authority and purposes to make a determination of the minimum interests and estate(s), both standard and non-standard, necessary as projects are scoped and alternatives evaluated. If a

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non-standard estate will be needed, this should be discussed with MSC and HQ Real Estate as early as possible to ensure that the justification is sound and will serve the project purpose.

4. Policy. Typically, the attorney's preliminary opinion of compensability and gross appraisals are two areas that require more detail than may be readily available during the start of the feasibility phase, and are critical to determination of accurate estimates for real estate and total project costs. Due to the focus on 3 years or less for study duration, it will be essential for Real Estate to be adaptable and scale its requirements, decision making, and risk management in proportion to the significance of total project costs.

a. Gross Appraisals:

Specific to gross appraisals, EC 405-1-04 provides that cost estimates are utilized for preliminary planning of projects and in other cases, brief gross appraisals are acceptable. For purposes of the feasibility phase, the detail will vary as outlined below.

(1) For projects in which the value of real estate (lands, improvements, and severance damages) are not expected to exceed ten percent of total project costs (total cost to implement project), a cost estimate (or rough order of magnitude) will be acceptable for purposes of the feasibility phase.
(2) For projects in which the value of real estate (lands, improvements, and severance damages) do not exceed 30 percent of total project costs (total cost to implement project), a brief gross appraisal will be acceptable for purposes of the feasibility phase. A brief gross appraisal will follow format issued by Chief Appraiser.
(3) For projects in which the value of real estate (lands, improvements, and severance damages) exceed 30 percent of total project costs (total cost to implement project), a full gross appraisal will be prepared in accordance with the appraisal regulation and guidance provided by EC 405-1-04 and the Chief Appraiser.

b. Attorney's Opinion of Compensability:

As described in paragraph 12-17 of Chapter 12, utility/facility relocations may require preliminary attorney's opinions of compensability. While the practice of obtaining preliminary attorney's opinions of compensability provides a high degree of certainty with regard to project costs during the feasibility phase, such opinions can be time consuming and may provide more certainty than may be optimal for feasibility purposes when potential utility/facility relocation costs do not constitute a large percentage of total project costs. In support of the goals set out in the new planning paradigm described in reference a., Districts shall adhere to the following guidance:

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(1) Where the estimated total cost to modify all project utility facility relocations, including the value of any additional lands that may be required to perform the relocations does not exceed 30 percent of estimated total project costs, the District Office of Real Estate shall, in lieu of an attorney s opinion of compensability prepare a real estate assessment. Such a real estate assessment, will address the following questions:

(a) Is the identified utility facility generally of the type eligible for compensation under the substitute facilities doctrine (e.g., school, highway, bridge, water and sewer systems, parks, etc.)
(b) Does the District have some valid data or evidence that demonstrates that it has identified an owner with a compensable interest in the property

If the answer to both questions is yes, then the District Office of Real Estate shall reflect the cost of providing a substitute facility in the Real Estate Plan (REP) and all other feasibility study cost estimates. If the answer to either or both questions is no, the District shall not reflect the cost of a substitute facility in the REP or other feasibility study cost estimates. However, the REP narrative should still include a discussion on the facility with results of analysis and project impact. For cost shared projects, the non-federal sponsor must be advised that the inclusion of substitute facilities costs in the REP or other use feasibility study estimates is for planning and budgeting purposes only and does not constitute a preliminary or final determination of compensability by the agency regardless of whether the cost of substitute facilities are reflected in the feasibility study documents. Using a real estate assessment does not eliminate the need to obtain a final attorney s opinion of compensability prior to execution of the PPA.

(2) Where the estimated total cost to modify all project facility relocations, including the value of any additional lands that may be required to perform the relocations, has public or political significance or the costs exceed 30 percent of estimated total project costs, a preliminary opinion of compensability shall be prepared for each owner s facilities. The level of documentation for each relocation item should be based on the significance of the relocation item to project formulation and estimated project costs.

Real Estate products, such as the REP, must be adaptable and scaled based on the project scope. Additionally, Real Estate must utilize the risk register to highlight areas where cost, schedule or uncertainty is greater in order to manage risk. Going forward, the Real Estate Division will continue to work closely with the Planning and Policy Division, Engineering and Construction Division, the Programs Integration Division and the National Law Firm on the Planning SmartGuide. This SmartGuide will provide more on procedures, tips, techniques and tools for

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specific types of planning projects to aid in implementation of the new Planning Paradigm. All bulletins and updates on the SmartGuide can be found at: http://planning.usace.army.mil/toolbox/.

5. Duration. The policies stated herein will remain in effect until amended or rescinded by Policy Memorandums, Policy Guidance Letters, Engineers Circulars or Engineer Regulations.

FOR THE COMMANDER:

SCOTT L. WHITEFORD
DIRECTOR OF REAL ESTATE

DISTRIBUTION:
COMMANDER,
GREAT LAKES AND OHIO RIVER DIVISION (CELRD-PDS-R)
MISSISSIPPI VALLEY DIVISION (CEMVD-TD-R)
NORTH ATLANTIC DIVISION (CENAD-PD-E)
NORTHWESTERN DIVISION (CENWD-PDS)
PACIFIC OCEAN DIVISION (CEPOD-RE)
SOUTH ATLANTIC DIVISION (CESAD-PDS-R)
SOUTH PACIFIC DIVISION (CESPD-ET-R)
SOUTHWESTERN DIVISION (CESWD-ET-R)

CF:
COMMANDER,
DETROIT DISTRICT (CELRE-RE)
HUNTINGTON DISTRICT (CELRH-RE)
LOUISVILLE DISTRICT (CELRL-RE)
NASHVILLE DISTRICT (CELRN-RE)
PITTSBURGH DISTRICT (CELRP-RE)
MEMPHIS DISTRICT (CEMVM-RE)
NEW ORLEANS DISTRICT (CEMVN-RE)
ROCK ISLAND DISTRICT (CEMVR-RE)
ST. LOUIS DISTRICT (CEMVS-RE)
ST. PAUL DISTRICT (CEMVP-RE)
VICKSBURG DISTRICT (CEMVK-RE)
BALTIMORE DISTRICT (CENAB-RE)
NEW ENGLAND DISTRICT (CENAE-RE)
NEW YORK DISTRICT (CENAN-RE)
NORFOLK DISTRICT (CENAO-RE)

EXHIBIT C – WAIVER LETTER FOR COMPENSABILITY FOR PUBLICALLY OWNED UTILITIES AND FACILITIES

File: Common Elements
√ copy - John B

2/450

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

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14 JUL 1998

REPLY TO
ATTENTION OF

Mr. F. I. Hodgkins
Executive Director
Sacramento Area Flood Control Agency
1007 7th Street, 5th Floor
Sacramento, California 95814-3407

Dear Mr. Hodgkins:

This letter is in response to your letters of April 28, 1998 and May 6, 1998, relating to a cost sharing issue associated with utility relocations required for construction of the Common Elements Project in Sacramento, California.

Generally, the Corps treats relocations as creditable items of non-Federal work and includes such costs in total project costs. The exception is when the sponsor has the authority to compel relocations at no cost to the sponsor. Here, however, the authorizing documentation refers to both the State of California and the Sacramento Area Flood Control Agency (SAFCA) as the project sponsors. Requiring the State to revoke permits issued to SAFCA's member agencies would recognize neither the highly interrelated sponsorship of the project that includes the State, SAFCA, and SAFCA's constituent members, nor equitably reflect the joint contributions of these municipalities are making to project financing. Accordingly, we have determined that the removal and replacement of a utility, or other public facility, owned by the State of California, or a political subdivision thereof, and which delivers public services, should be treated as a relocation where such work is required as a direct result of the construction of the project. The Corps will include the costs incurred by the State in performing these relocations as part of shared total project costs and credit the State for such costs.

-2-

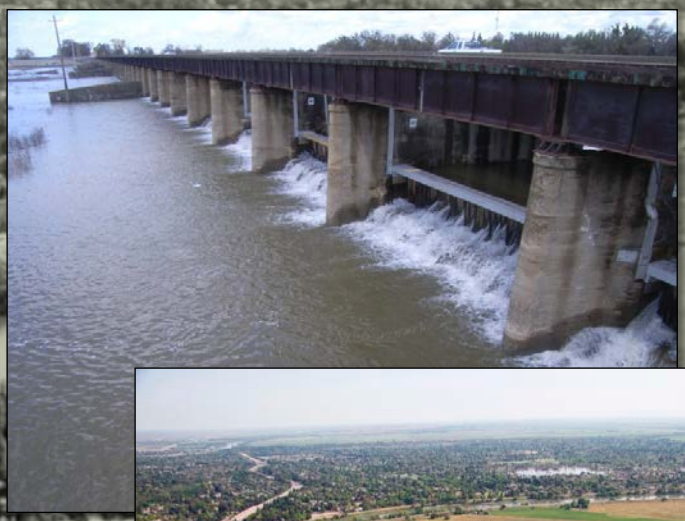
The Army Corps of Engineers has drafted modifications to the Project Cooperation Agreement for the Common Elements Project implementing this determination. These modifications and implementation guidance have been provided to the Sacramento District for coordination with the State of California and SAFCA.

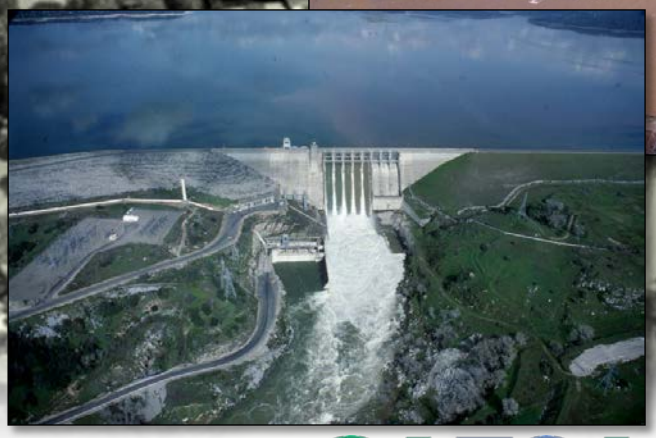
Sincerely,

Joseph W. Westphal
Assistant Secretary of the Army
(Civil Works)

American River Watershed

Common Features
General Reevaluation Report





Final Economics
Appendix E

December 2015

SAFCA
Sacramento Area Flood Control Agency

CENTRAL VALLEY FLOOD PROTECTION BOARD
PUBLIC SAFETY
FLOOD MANAGEMENT
STATE OF CALIFORNIA

US Army Corps of Engineers ®
Sacramento District

Cover Photos courtesy of the Sacramento District:

Sacramento Weir during operation

Sacramento River facing south near the Pocket and Little Pocket neighborhoods

High flows on the American River at the Highway 160 overcrossing

Folsom Dam releasing high flows

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ATTACHMENT 3 – OTHER SOCIAL EFFECTS (OSE) & REGIONAL ECONOMIC DEVELOPMENT (RED) ANALYSES

CHAPTER 1
INTRODUCTION

1.1 PURPOSE & SCOPE

This Appendix documents the economic analysis performed for the American River Common Features General Reevaluation Report (ARCGF GRR). The main purposes of this report are to:

- Describe the framework of the economic analysis, including the major assumptions, data, methodologies, and analytical tools used.
- Describe the flood risk, in terms of probability of flooding and consequence of flooding, associated with the without-project condition, which assumes that three previously authorized projects (1996/1999 Common Features, the Joint Federal Project (JFP), and the Folsom Dam Raise) are in place and functional.
- Describe the residual flood risk -- the remaining flood risk once a project is built -- associated with each alternative in the Final Array.
- Summarize the results of the net benefit and benefit-to-cost analyses for each alternative in the Final Array.
- Identify the National Economic Development (NED) Plan, which is the alternative that reasonably maximizes net benefits.

1.2 BACKGROUND

In February of 1986, major storms in Northern California caused record flows in the American River Watershed. Outflows from Folsom Reservoir, together with high flows in the Sacramento River, caused water levels to rise above the safety margin on levees protecting Sacramento. The effects of the 1986 storms raised concerns over the adequacy of the existing flood control system. These concerns led to a series of study authorizations and investigations into the need for additional flood protection for the Sacramento area. Some of the key milestones and reports in this process, spanning more than 20 years, are listed in Table 1.

Table 1: Timeline of Key Events and Reports

YEAR	KEY EVENT	REPORT
1986	Severe storms in Northern California raise concerns over level of flood protection in Sacramento area	
1988	Continuing Appropriations Act funds American River Watershed Investigation	
1989	The Sacramento Area Flood Control Agency (SAFCA) is established	
1991		American River Watershed (ARW) Investigation Feasibility Report and Environmental Impact Statement/Report (EIS/EIR) recommends levee improvements in portions of Sacramento and detention dam at Auburn
1993	Defense Appropriations Act (DAA) authorized	

	a portion of the Natomas Basin levee improvements proposed in 1991 Feasibility Report and directs USACE to conduct new FRM study	
1996	Congress defers decision on Auburn Dam, but authorizes more levee improvements common to all candidate plans outlined in SIR; these "common features" authorized in WRDA 1996; Auburn Dam rejected in late 1996/early 1997	ARW, Supplemental Information Report (SIR) and EIS/R identifies 3 plans to reduce flood risk: Folsom Dam Modifications, Stepped Release Plan, Auburn Dam Plan (NED Plan)
1997	Severe storms in the region once again highlight flood risk in the Sacramento area	
1998		SAFCA releases Folsom Dam Modifications Report – New Outlets Plan; report presents alternatives to lower spillway under 1996 SIR's Folsom Dam Modifications Plan
1999	1999 WRDA authorizes 1996 SIR's Folsom Modifications Plan (as modified by SAFCA) and directs USACE to conduct additional FRM studies	
2001		Common Features (CF) Limited Reevaluation Report (LRR) identifies improvements to reduce flood risk to Lower American River area; Section 366 of WRDA 1999 further modifies 1996 WRDA in regard to CF – specific direction is given related to levee modifications that would allow increase outflows from Folsom Dam to a sustained 160,000 cfs without high likelihood of levee failure along Lower American River
2002		ARW Long-Term Study and EIS/R recommend raising Folsom Dam by 7
2003	Energy and Water Development Appropriations Act (2004) authorizes 7-foot dam raise at Folsom Dam	Folsom Dam Modification Project LRR and Environmental Assessment (EA)/EIS reconcile conflicts between authorized Folsom Modification Project and 2002 Long-Term Study Feasibility Report recommendations
2005	Energy and Water Development Appropriations Act (2006) directs the USACE and Bureau of Reclamation to collaborate on FRM planning (USACE mission) and dam safety (Bureau mission) efforts related to Folsom Dam	
2005	In the aftermath of 2005 Gulf Coast hurricane (Katrina), the limitations of the FRM system in the Sacramento area and the need to improve this system gain increased public attention	
2007		Folsom Modification and Dam Raise Project, Post-Authorization Change (PAC) Report describes recommended changes to 2 authorized projects (Folsom Modification and Folsom Dam Raise Projects), and evaluates Joint Federal Project (JFP), which addresses both FRM and dam safety objectives

2008	Start of American River Common Features (ARCF) GRR	Folsom Modification and Dam Raise Projects, Economic Reevaluation Report (ERR) describes potential FRM alternatives at Folsom Dam; analysis revised 2007 PAC Report by updating economic inventory, economic models, and evaluating Regional Economic Development (RED) and Other Social Effects (OSE) accounts
2009	F3 without-project condition milestone conference is held in Sacramento, CA; following conference, decision made to evaluate potential FRM alternatives in Natomas Basin on accelerated schedule and separately from other basins	
2010	Continuation of ARCF GRR efforts from 2009	Natomas Basin PAC and Interim GRR approved and sent to Congress; recommends improving existing levees surrounding the basin, but defers levee raise analysis to full GRR

1.3 STUDY AREA AND BASINS

The American River Watershed drains about 2,100 square miles northeast of Sacramento and includes portions of Placer, El Dorado, and Sacramento counties. Runoff from this basin flows through Folsom Reservoir and passes through Sacramento within a system of levees. Folsom Dam and Reservoir, located on the American River about 25 miles east of the city of Sacramento, form a multi-purpose water project. The project was constructed by the U.S. Army Corps of Engineers (USACE) and is operated by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) as part of the Central Valley Project (CVP). The reservoir has a normal full-pool storage capacity of 975,000 acre-feet with a minimum seasonally designated flood control storage space of 400,000 acre-feet.

Within the watershed, the study area includes three distinct areas:

- Natomas Basin, which lies to the north of downtown Sacramento
- American River North area (hereafter referred to as ARN), which lies east of the Natomas Basin and north of the American River
- American River South area (hereafter referred to as ARS), which lies east of the Sacramento River and south of the American River.

Each area is at risk of flooding from multiple sources. Table 2 below lists these sources; Figure 1 below displays these sources on a map of the study area.

Table 2: Sources of Flooding by Basin

BASIN	SOURCES OF FLOODING
Natomas (NAT)	Sacramento River
	Natomas Cross Canal (NCC)
	Natomas East Main Drainage Canal (NEMDC)
	Pleasant Grove Creek Canal (PGCC)
	American River
American River North (ARN)	American River
	Natomas East Main Drainage Canal (NEMDC)
	Pleasant Grove Creek Canal (PGCC)
	Dry Creek
	Robla Creek
	Magpie Creek
	Arden Creek
American River South (ARS)	American River
	Sacramento River

Figure 1: Study Area, Basins, and Major Sources of Flooding

1.4 ECONOMIC ANALYSIS IN PRIOR REPORTS

Prior reports associated with the American River Watershed Study are listed in Figure 2 below. These reports serve as an historic timeline for which to better understand the basis for the economic analysis contained in this GRR. For each study listed, a brief description is given of the conclusions of the economic analysis; additionally, any parts (e.g., assumptions, data, models, etc.) of one analysis that were carried forward to subsequent analyses are also described.

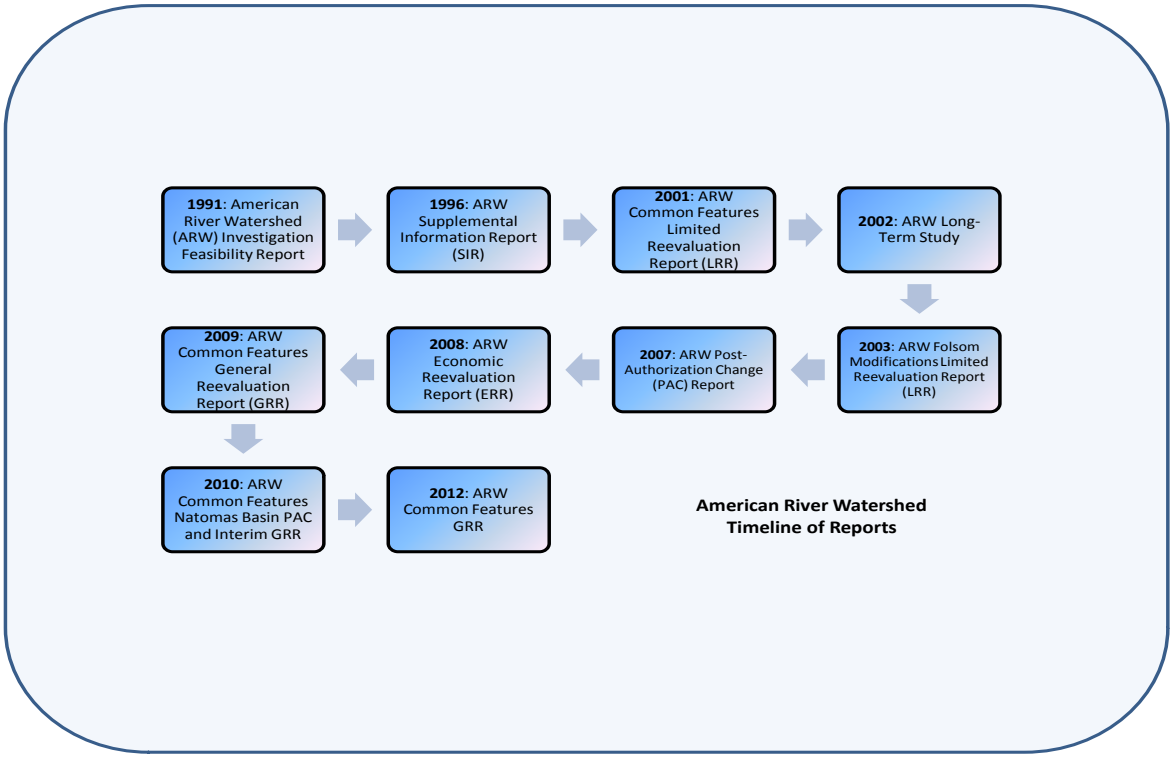


Figure 2: Prior American River Watershed Study Reports

- *American River Watershed Investigation Feasibility Report, 1991*

  This report recommended a detention dam at Auburn, which ultimately was not authorized by Congress. It was estimated that a detention dam at Auburn would have reduced Sacramento's flood risk to about a 1 in 200 chance in any given year based on non-risk analysis methodologies.[1] Following this report, two of many incremental projects, including the Sacramento Area Flood Control Agency (SAFCA) North Area Levee Improvement Project (NLIP) in Natomas and the reoperation of Folsom Dam from 400,000 acre-feet fixed flood control space to a 400,000/670,000 acre-feet variable flood control space, were adopted to help reduce flood risk to Sacramento.

  For the 1991 economic analysis, long-duration non-residential structural depth-percent damage curves were developed; these curves were used to modify the Federal Emergency Management Agency (FEMA) curves for the 2008 ERR, and were then applied to those areas prone to deep and long-duration flooding. These adjusted FEMA curves were carried forward to the 2010 Natomas PAC and Interim GRR, as well as to this current GRR effort. Much of the other engineering and economic data developed for the 1991 Feasibility Report has been replaced by more current data.

[1] Risk analysis methodologies were not implemented at the USACE until after the completion of the 1991 Feasibility Report.

- *American River Watershed Supplemental Information Report, 1996*

  This report was the first American River Watershed report to use a risk analysis methodology to determine economic benefits. The report identified three final alternatives: the Stepped Release, the Folsom Modifications, and the Detention Dam plans. While the Detention Dam was determined to be the National Economic Development (NED) Plan, it was not recommended in the Chief's report and therefore not authorized. Instead, a less controversial Common Features alternative was authorized. A benefit of this alternative, which included features that were part of all three final alternatives, was that it would not preclude future selection of any of the three final alternatives.

- *American River Watershed Common Features LRR, 2001*

  The 2001 Common Features LRR estimated that, with levee improvements in place, outflows from Folsom Dam could be increased to 160,000 cubic feet per second (cfs) for a sustained period of time without introducing a high probability of levee failure along the American River. Annual exceedance probability (AEP) on the Lower American River was estimated to be 0.0099, or about a 1 in 100 chance. Annual flood risk management (FRM) benefits of approximately $19 million and annual FRM costs of $10 million resulted in a benefit-to-cost ratio (BCR) of 1.9.

  The 2001 LRR split Common Features into the Lower American River levee improvements and the Natomas Basin area. The Natomas Basin area required significant reformulation and development of a GRR, which subsequently was included as part of the 2008 Common Features GRR, the 2010 Natomas Basin Post-Authorization Change Interim & General Reevaluation Report, and finally this current effort for the Common Features GRR.

  Additionally, levee performance assumptions documented in the 2001 LRR served as the basis for subsequent reports, including the 2007 PAC and the 2008 ERR; however, differences in the economics, hydrology, hydraulics, and geotechnical inputs preclude a direct comparison of damages, benefits, and project performance between the 2001 LRR and the 2007 PAC, 2008 ERR, and this current GRR.

- *American River Watershed Long-Term Study, 2002*

  The purpose of the Long-Term Study was to address the residual flood risk remaining once the Folsom Modifications project was completed. The Long-Term Study evaluated an array of FRM alternatives that included dam raises ranging from 3.5 to 12 feet. The study determined that a 7-foot raise of Folsom Dam that provided both additional FRM and dam safety[2] would be the most optimal economic solution, exclusive of the Detention Dam alternative.

  Congress, through the Energy and Water Development Appropriations Act for fiscal year 2004, authorized several project features which were recommended by the Long-Term Study: raising Folsom Dam by 7 feet, modifying the L.L. Anderson Dam spillway, constructing a permanent bridge downstream from Folsom Dam, and modifying the emergency release operations to permit surcharge. First costs for this project were estimated at around $249 million, with $128

[2] Dam safety in this instance refers to enabling the dam facility to pass one-hundred percent of the probable maximum flood, or PMF.

million allocated to FRM. Annual FRM benefits of $19 million and annual FRM costs of $10 million provided a BCR of 1.9 to 1. At the time, this project was estimated to reduce the risk of flooding to a 0.0057 annual exceedance probability (AEP)[3], or about a 1 in 175 chance.

Two project components of the 2002 Long-Term Study, the 3.5-foot dam raise and the 7.0-foot dam raise, were also evaluated in the 2007 PAC and 2008 ERR. The 2007 PAC recommended an alternative that included a 3.5-foot dam raise component, and the 2008 ERR confirmed this recommendation as the most optimal amongst the alternatives evaluated. Section 1.5 describes in greater detail the projects previously authorized and either have been or will be constructed.

- *American River Watershed Folsom Modifications LRR, 2003*

The 2003 LRR reconciled conflicts between the authorized Folsom Modifications Project elements and recommendations in the 2002 Long-Term Study. As directed by Congress in WRDA 1999, the plan identified in the 2002 Long-Term Study included raising Folsom Dam, modifying downstream levee improvements, and implementing other elements necessary to meet current Federal dam safety standards. These authorized features, which make up the Folsom Dam Raise Project, carry design implications for the previously authorized Folsom Modifications Project.

The 2003 LRR refined the elements related to increasing release capacity to be consistent with gate modifications in the 2002 Long-Term Study. These changes included constructing two new upper-tier outlets, enlarging the four existing upper-tier outlets to 9 feet 4 inches by 14 feet and the four existing lower-tier outlets to 9 feet 4 inches by 12 feet, and modifying the existing main spillway stilling basin.

In addition, for the surcharge storage aspect of the project, the three emergency spillway tainter gates would be replaced with larger gates, as authorized, but the design would permit expansion of these gates in the future should the Folsom Dam Raise Project be authorized (which it has been) and implemented.

The Folsom Modifications revised economics report (November 2003) identified the recommended project as new and enlarged existing outlets capable of releases of 115,000 cfs and improvements allowing for the use of surcharge storage up to Elevation 474 feet. First costs for this project were estimated at around $214 million with annual benefits of $32 million and annual costs of $16 million providing a benefit-to-cost ratio of 2.0 to 1. At the time this project was estimated to reduce the risk of flooding to a 0.0071 annual exceedance probability, or about a 1 in 140 chance.

During the construction proposal process, the cost estimates exceeded the fully funded authorized costs (Section 902 limit). Consequently, dam operations and performance and alternate structural methods to achieve the risk reduction provided by the outlet modifications were reexamined. Subsequent studies also found that modification of the two outboard lower-tier outlets was infeasible, and offered only a marginal increase in performance.

[3] In the Long-Term Study, advanced forecast releases were evaluated as part of the alternatives. With advance releases factored in, project performance (as measured by AEP -- the probability flooding will occur in any given year considering the full range of possible annual floods), improved to 0.0047. Advance releases were not considered in the 2007 PAC, 2008 ERR, or in this current GRR effort.

The alternatives evaluated in the 2008 ERR included construction measures (eight of the total 10 outlets described) included in the 2003 LRR.

- *American River Watershed PAC Report, 2007*

  The purpose of the PAC report was to document changes to two authorized projects: the Folsom Modifications Project and the Folsom Dam Raise Project. Both projects share an objective of improving flood risk management on the Lower American River, primarily through structural modifications to the existing Folsom Dam.

  In the PAC report, project elements from both the Folsom Modifications and the Long-Term Study were considered not only for the purpose of flood risk management but also for dam safety. During the design refinements for Folsom Modifications, it was believed that due to significant increases in the cost estimates that the authorized project may not be optimal or even economically feasible. During this preliminary analysis, it appeared that adding operational gates to the proposed Bureau of Reclamation dam safety auxiliary spillway may provide a more efficient way to meet two project purposes.

  The Folsom Dam Joint Federal Project was intended to meet the goals of the Corps of Engineers as well as the Bureau of Reclamation; its analysis became one of the main focuses of the PAC. As mentioned, the PAC economic analysis included elements of three authorizations, the Folsom Modifications, the Dam Raise, and Reclamation's dam safety project. The combined project's objectives in terms of economic outputs and project performance were: (1) Reduce flood damages as effectively and efficiently as possible within a limited schedule and without complete reformulation, (2) effectively pass the 200-year design flow event without levee failure (based on design non-risk-based criteria), and (3) pass the PMF without placing the dam structure in danger of failure.

  The PAC and follow-on ERR evaluated a final array of four action alternatives. Alternative C, as described below, was the recommended plan from both studies. Alternative C included six submerged tainter gate auxiliary spillway, 3.5-foot dam raise, and three emergency spillway gate replacements. The recommended plan is summarized in Table 3 below.

Table 3: Benefits, Costs, and Project Performance of 2007 PAC Recommended Plan

SUMMARY CRITERIA	RECOMMENDED PLAN
Performance:	
Passes PMF	Yes
Annual exceedance probability (AEP)	0.0054
Design flood event (non-risk-based criteria)	1 in 240
Costs and benefits:	
First costs (FRM only)	$788 million
Annual costs (FRM only)	$40 million
Annual benefits (FRM only)	$107.1 million
Net benefits (FRM only)	$67.1 million
Benefit-to-cost ratio (BCR)	2.7
Residual damages	$91.1 million
Percent damage reduction	54%

Notes: 1) Values in October 2006 prices 2) FRM = flood risk management

- *American River Watershed ERR, 2008*

  The main purpose of the ERR was to affirm that the recommended plan from the PAC was economically feasible and was the most efficient among the array of alternatives considered.

  The focus of the ERR was to update the economics and the HEC-FDA modeling (including the hydrologic and hydraulic data) from previous analyses to develop a more accurate, comprehensive, and system-wide characterization of flood risk for the study area. This update included evaluation of the National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE) accounts, development of a new structure inventory, re-estimation of structure and content values using data collected through extensive fieldwork and an expert-opinion elicitation panel, and a re-computation of damages and benefits using new, locality-specific non-residential content depth-percent damage curves, seven event-based floodplains (instead of only one as in previous analyses), and more defined consequence areas.

  The ERR estimated that total without-project expected annual damages (EAD) was approximately $277 million, not including the Natomas Basin. The with-project residual damages and benefits were estimated for the same four action alternatives that were evaluated in the 2007 PAC. The results of this alternatives analysis are presented below in Table 4.

Table 4: Net Benefit and Benefit-to-Cost Analyses from ERR

ITEM	ALT A	ALT B	ALT C	ALT D
Total Project First Costs	650.4	918.1	1,042.1	1,555.6
Annual Benefits (2018-2067)	98.1	116.3	143.8	172.2
Annual Benefits During Construction (2012-2017)	32.6	26.9	29.9	26.9
Total Annual Flood Risk Management Benefits	130.7	143.2	173.7	199.1
Annual Costs	46.6	62.3	68.0	98.2
Savings in Avoided Dam Safety Costs	0	(15.3)	(15.3)	(15.3)
Net Flood Risk Management Annual Costs	46.6	47.0	52.7	82.9
Net Benefits	84.1	96.2	121.0	116.2
Benefit-to-Cost Ratio	2.8	3.0	3.3	2.4

Notes: 1) Values in millions, October 2007 prices, 50-year period of analysis, 4.875% discount rate 2) Alternative A includes eight main dam outlets and fuse plug spillway; Alternative B includes a six submerged tainter gate auxiliary spillway; Alternative C includes a six submerged tainter gate auxiliary spillway, a 3.5-foot dam raise, and three emergency spillway gate replacements; Alternative D includes a six submerged tainter gate auxiliary spillway, a 7-foot dam raise, and eight emergency and service spillway gate replacements 3) Alternatives B, C, and D would eliminate the need for construction of the dam safety only fuse plug as part of the future without-project condition; the $15.3 million reduction in dam safety costs was taken as a savings from the net flood risk management annual costs.

The ERR confirmed the 2007 PAC recommendation of Alternative C – which included a six submerged tainter gate auxiliary spillway, a 3.5-foot dam raise, and three emergency spillway gate replacements. Total annual FRM benefits of Alternative C were estimated at $173.7 million, of which $29.9 million was attributed to benefits during construction. Residual expected annual damages of Alternative C were estimated to be approximately $133 million (American River North and South Basins).

- *American River Watershed Common Features F3 GRR, 2009*

  Key data used in the ERR were carried forward to the 2009 GRR, including the extensive structure inventory and the non-residential content valuations/depth-percent damage curves. Other data were updated for the GRR, including the number of sources of flooding (American River, Sacramento River, Natomas Cross Canal, Pleasant Grove Creek Canal, Natomas East Main Drainage Canal) used to estimate flood risk, the consequence areas considered (Natomas was included where it was not in the ERR), the levee fragility curves (geotechnical), the Folsom Dam routings (hydrology), and the rating curves/floodplains (hydraulics).

  In the economic analysis for the 2009 GRR, EAD for the future without-project condition (Authorized Common Features + Joint Federal Project + Folsom Dam Raise) for the ARN, ARS, and Natomas Basins were estimated to be approximately $27.7 million, $132.5 million, and $2.4 billion, respectively. Project performance in terms of annual exceedance probability (AEP) for each area was estimated to be approximately 0.007 (ARN), 0.008 (ARS), and 0.390 (Natomas). In March of 2009, an F3 (without-project condition) milestone conference was held at the Sacramento District office. Based on the outcomes of this conference, the path forward was determined to be to study the Natomas Basin area separately from the rest of the study area (ARS and ARN) via a Natomas Basin Post-Authorization Change & Interim GRR.

- *American River Watershed Natomas Basin PAC Interim GRR, 2010*

  Soon after the March 2009 F3 milestone conference, the American River Common Features project delivery team (PDT) was charged with studying the Natomas Basin as a separate entity from the rest of the Common Features GRR study area, recommending an alternative(s) for the Natomas Basin via a Post-Authorization Change & Interim GRR, and completing this report within a highly accelerated schedule. This report was in fact completed in December 2010, approximately 20 months following the initial charge, and subsequently was approved by the Civil Works Review Board, signed by the Chief of Engineers, sent to the Office of Management and Budget (OMB), and submitted to Congress. Congress authorized the project in 2014.

  The Natomas Basin PAC & Interim GRR focused on improving the existing levees (either in place or via adjacent levees) surrounding the Basin along all five waterways, including the Sacramento River, American River, Natomas East Main Drainage Canal (NEMDC), Pleasant Grove Creek Canal (PGCC), and the Natomas Cross Canal (NCC); analysis of levee raises were deferred to the GRR. However, the Natomas Basin has since been removed from the GRR alternatives.

  The Natomas PAC Interim GRR recommended improving the levees along all waterways surrounding the Natomas Basin. It was estimated that the Recommended Plan would reduce without-project EAD by about 96%, or from approximately $462 million in EAD to approximately $19 million in EAD, producing average annual benefits of approximately $443 million. The project cost was estimated to be approximately $67.8 million (average annual). Net benefits and the BCR were estimated to be approximately $375.2 million (average annual) and 6.5, respectively. Once completed, the improvements were expected to reduce the probability of flooding in any given year from about a 1 in 5 chance to about a 1 in 67 chance.

1.5 SUMMARY OF PREVIOUSLY-AUTHORIZED FLOOD RISK MANAGEMENT IMPROVEMENTS ALREADY CONSTRUCTED OR CURRENTLY UNDER CONSTRUCTION

Three major American River Watershed projects have been previously authorized by Congress as outlined above. These include the 1996/1999 Authorized Common Features Project, the Joint Federal Project (JFP), and the 3.5-foot Folsom Dam Raise Project. Figure 3 below lays out these improvements, starting with no improvements in place and leading up to the 3.5 foot Folsom Dam Raise (rectangles); the large oval represents the alternatives that were considered for this current GRR effort.

It is important to point out that while these projects have been authorized and/or implemented in an incremental nature, these improvements are interdependent and rely on one another to fully maximize risk reduction from a system-wide perspective.

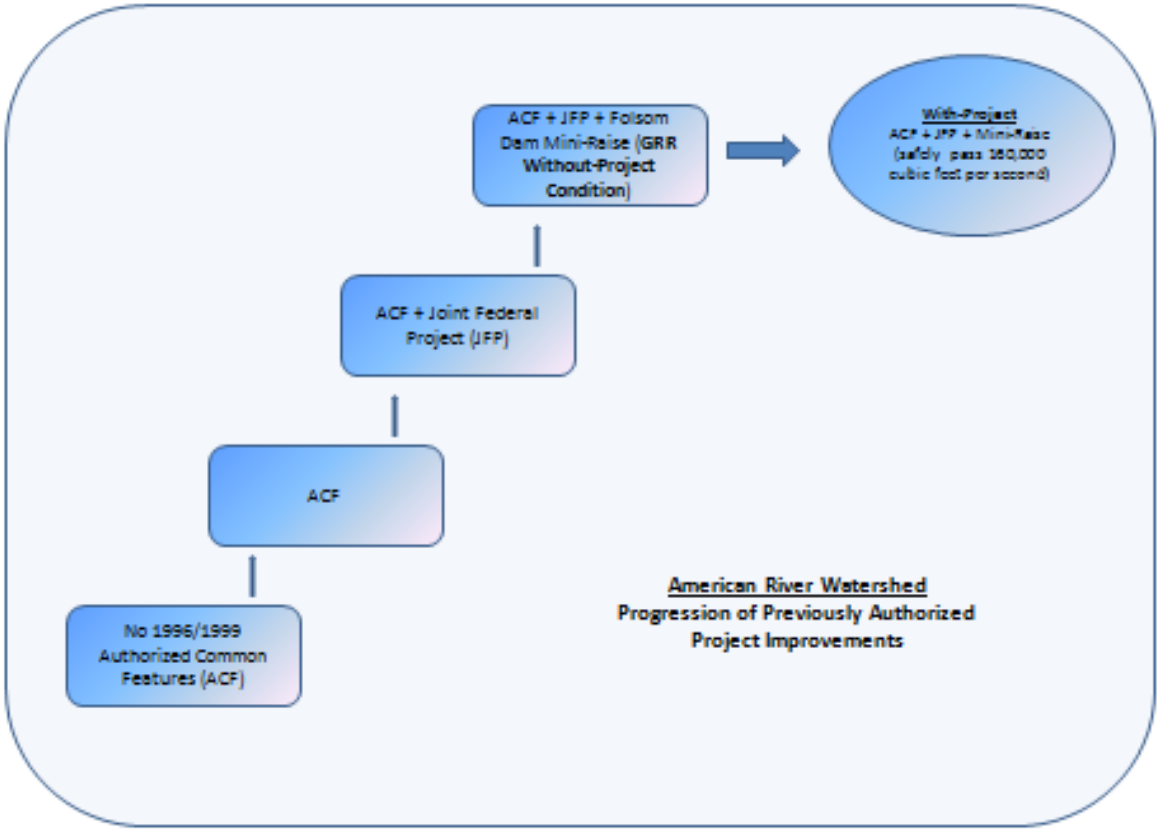


Figure 3: FRM Improvements Authorized Under the American River Watershed Study

1.6 FUTURE WITHOUT-PROJECT CONDITION

For this current GRR effort, the future without-project condition assumes that the previously authorized 1996/1999 Common Features improvements, JFP, and Folsom Dam Raise are in place and functional by the year 2020. This without-project condition is represented by the top rectangle in Figure 3. System-wide risk reduction was estimated by comparing the economic outputs of each alternative evaluated (represented by the large oval in Figure 3) against the future without-project condition.

1.7 ORGANIZATION & CONTENT

This report is organized around four main chapters. The contents of each chapter are summarized in Figure 4 below.

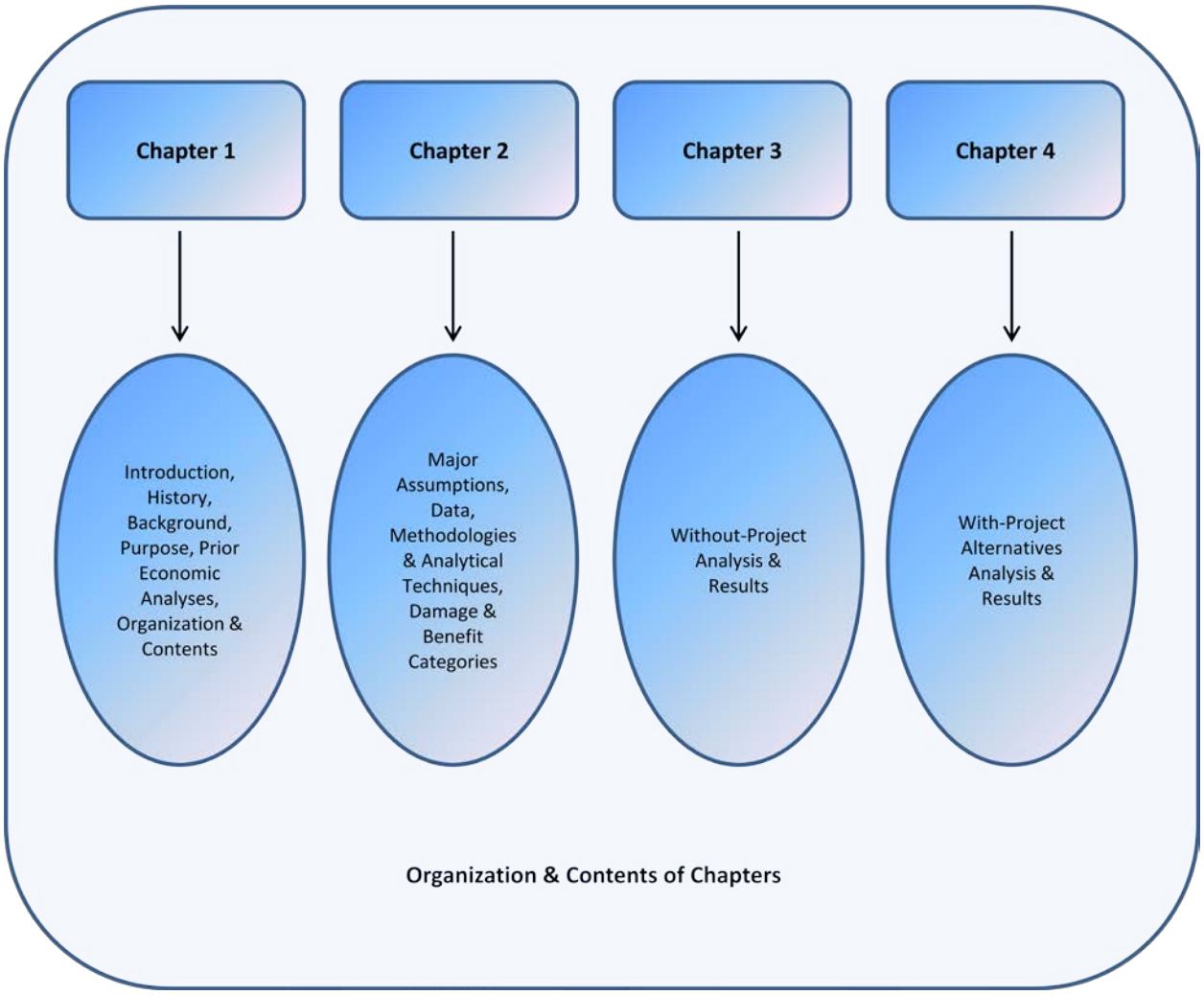


Figure 4: Content of Chapters

CHAPTER 2
FRAMEWORK OF ECONOMIC ANALYSIS

2.1 CONSISTENCY WITH CURRENT REGULATIONS & POLICIES

The analysis presented in this document was performed using the most up-to-date guidance and is consistent with current regulations and policies. Various references were used to guide the economic analysis, including:

- The *Planning Guidance Notebook* (ER 1105-2-100, April 2000, with emphasis on Appendix D, Economic and Social Considerations, Amendment No. 1, June 2004) serves as the primary source for evaluation methods of flood risk management (FRM) studies
- EM 1110-2-1619, *Engineering and Design – Risk-Based Analysis for Flood Damage Reduction Studies* (August 1996)
- ER 1105-2-101, *Planning Risk-Based Analysis for Flood Damage Reduction Studies* (Revised January 2006)
- Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships* (2000)
- Economic Guidance Memorandum (EGM) 04-01, *Generic Depth-Damage Relationships for Residential Structures with Basements* (2003)
- Economic Guidance Memorandum (EGM) 09-04, *Generic Depth-Damage Relationships for Vehicles* (2009)

2.2 PRICE LEVEL, PERIOD OF ANALYSIS, AND DISCOUNT RATE

Values listed in this document are based on an October 2015 price level. Annualized benefits and costs were computed using a 50-year period of analysis and a current federal discount rate of 3.125%. Unless otherwise noted, annualized values are presented in thousands of dollars.

2.3 MAIN ASSUMPTIONS

Several main assumptions were relied upon in order to reasonably and efficiently study the problem (i.e., flooding) and its solutions (i.e., flood risk management alternatives), and then ultimately reach a conclusion using the limited resources available:

- The without-project condition assumes that the 1996/1999 Authorized Common Features improvements, Joint Federal Project, and Folsom Dam Raise are in place and functional; this assumption is reflected in the hydrologic (transform flow), hydraulic (floodplains and rating curves) and geotechnical (levee fragility curves) engineering data used in the economic analysis
- The future without-project operations at Folsom Dam assume a target release of 160,000 cubic feet per second (cfs) for the 200-year event; this assumption is reflected in the hydrologic transform flow curves used for the without-project condition
- The with-project operations at Folsom Dam assume a target release of 160,000 cfs for the 200-year event, also known as the 0.5% annual chance exceedance (ACE) event, and which has a 1 in 200 chance of occurrence (these terms will be used interchangeably throughout this document); this assumption is reflected in the hydrologic transform flow curve used for the with-project condition

- All areas except the Natomas Basin assume build-out and no future development
- For the Natomas Basin, additional development was accounted for but only to describe the residual risk associated with a project; no benefits were claimed for future development. (A discussion on residual risk in the Natomas Basin can be found in the Economic Appendix for the Natomas Post-Authorization Change & Interim GRR.)
- That the hydrologic, hydraulic, and geotechnical conditions within the study area would remain the same between the without-project and the most likely future without-project conditions. Most likely future (without-project) hydrologic, hydraulics, and geotechnical engineering data for input into the economic modeling were assumed to be the same as the base without-project condition
- That damages resulting from out flanking from the non-leveed portions of the American River upstream of existing levees would not be reduced even with a project in place; this assumption was factored into the estimation of benefits for the ARS and ARN basins.

2.4 METHODOLOGIES, TECHNIQUES, & ANALYTICAL TOOLS

Various methodologies, analytical techniques, and tools were used to perform the economic analysis. The majority of those used for this analysis is standard to many Corps of Engineers studies and are described in the appropriate sections throughout this document. Several of the main ones used in this analysis are described below.

2.4.1 Economic Analytical Tool: HEC-FDA Software

The main analytical tool used to perform the economic analysis was the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) software, version 1.2.5a. This program stores the engineering data (hydrologic, hydraulic, and geotechnical) and the economic data (structure/content inventory and depth-percent damage curves), and is used to model the flooding problem and potential alternative solutions in the study area.

By relating the economic inventory data to the floodplain data, the HEC-FDA software computes economic stage-damage curves. Through integration of the main engineering relationships (exceedance probability-discharge curves, rating curves, and geotechnical levee fragility curves) and the main economic relationship (stage-damage curves), the HEC-FDA software computes project performance statistics and expected annual damages/benefits.

The results of the economic modeling are then used as input into the net benefit and benefit-to-cost analyses and may also aid in plan formulation, all of which are performed external to the HEC-FDA software.

2.4.2 Floodplain Data in HEC-FDA Using FLO-2D Model Output

The SPK Hydraulic Design Section developed floodplains using the FLO-2D model, which produces interior water surface elevations by grid cell. The model generates suites of FLO-2D floodplains {0.5 (1/2), 0.1 (1/10), 0.04 (1/25), 0.02 (1/50), 0.01 (1/100), 0.005 (1/200), and 0.002 (1/500) annual chance exceedance events}; suites were developed for each index point. (See Section 2.6 for discussion of representative index points).

Importing the FLO-2D data into the HEC-FDA models required file formatting. The FLO-2D files were formatted so that the HEC-FDA program would import them as a HEC-RAS water surface profile (WSP) output file. Instead of using river station numbers like in a typical HEC-RAS WSP, assignment of water surface elevations by frequency event were completed using grid cell numbers (output of FLO-2D); the grid cell assignments represent actual floodplain water surface elevations by frequency event rather than in-channel water surface elevations.

2.4.3 Computing Stage-Damage Curves in HEC-FDA

The formatted WSPs included every grid cell that contained a structure and the water surface elevations in each grid cell for each frequency event. The suite of floodplains along with the imported structure inventory was used in HEC-FDA to compute stage-damage curves.

Once the formatted floodplain 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 two-dimensional floodplain data and the in-channel stages. 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.

2.4.4 Multiple-Source Flooding into Single Consequence Area

Multiple sources of flooding within a single consequence area complicate the economic risk analysis in terms of estimating the chance of flooding and the consequences of flooding in that consequence area. Additional analytical complexity is introduced if one considers that the probability of flooding along a particular flooding source also varies (i.e., not only is the probability of flooding between various water sources not uniform but the probability of flooding along a specific water source is also not uniform), and that the same area is flooded from levee breaches at different locations but at varying magnitudes (i.e., different floodplains) depending on the location of the breach.

The risk analysis was performed using eight representative index points, with each point tied to a specific source of flooding within the study area. The same index points were used for both the without-project and with-project analysis. Section 2.6 below describes in more detail the index points used and their locations.

2.5 ECONOMIC IMPACT AREAS (EIA)

Economic impact areas (EIA) were delineated in order to facilitate the economic risk analysis. These areas enable the direct computation and reporting of consequences that result from flooding from a specific source under both the without-project and with-project conditions. Three main EIAs within the study area were identified:

- American River North Basin (ARN)
- American River South Basin (ARS)
- Natomas Basin (NAT)

During the 2007 PAC/2008 ERR, sub-EIAs within two of the main EIAs (ARN and ARS) were identified in order to more precisely (by neighborhood within a basin) analyze residual risk. These impact areas are presented below but were not carried forward to this analysis. Figures 5 and 6 display the three main EIAs (NAT, ARN, ARS) and the sub-EIAs within the ARN and ARS Basins. It should also be noted that the boundaries of the EIAs presented in Figure 6 do not correspond to any particular ACE event flood plain used in the current analysis.

ARS:

- ARS 1 Pocket/Greenhaven
- ARS 2 Fruitridge/Meadowview
- ARS 3 Land Park
- ARS 4 Downtown Sacramento
- ARS 5 East Sacramento
- ARS 6 Rancho Cordova
- ARS 7 Gold River
- ARS 8 South I-50/Florin/Watt
- ARS 9 Florin South
- ARS 10 Mather North
- ARS 11 Rosemont
- ARS 17 South of Morrison Creek

ARN:

- ARN 13 American River Drive
- ARN 14 Arden/Expo
- ARN 15 North Sacramento
- ARN 16 Dry Creek

The smaller sub-economic impact areas (neighborhoods) were not used for the current analysis but instead aggregated into two larger impact areas (ARS and ARN Basins); this aggregation is unlikely to affect the accuracy of the results in terms of damages, benefits, or plan selection. Aggregating the sub-impact areas allowed for a more streamlined approach to the analysis that required fewer models, which then translated into fewer model runs, fewer sets of output results, less documentation, and ultimately time savings.

It should also be noted that there is a trade-off in terms of detail/precision by aggregating the sub-EIAs into one FDA model/inventory/impact area. Since models are run by basin and results are also reported by basin rather than sub-impact area, seeing how a neighborhood within the basin is affected by a project is not as apparent. However, since each structure is still identified by sub-impact area (e.g., 1-17) within the aggregated inventory, this information is not lost and could be ascertained if necessary.

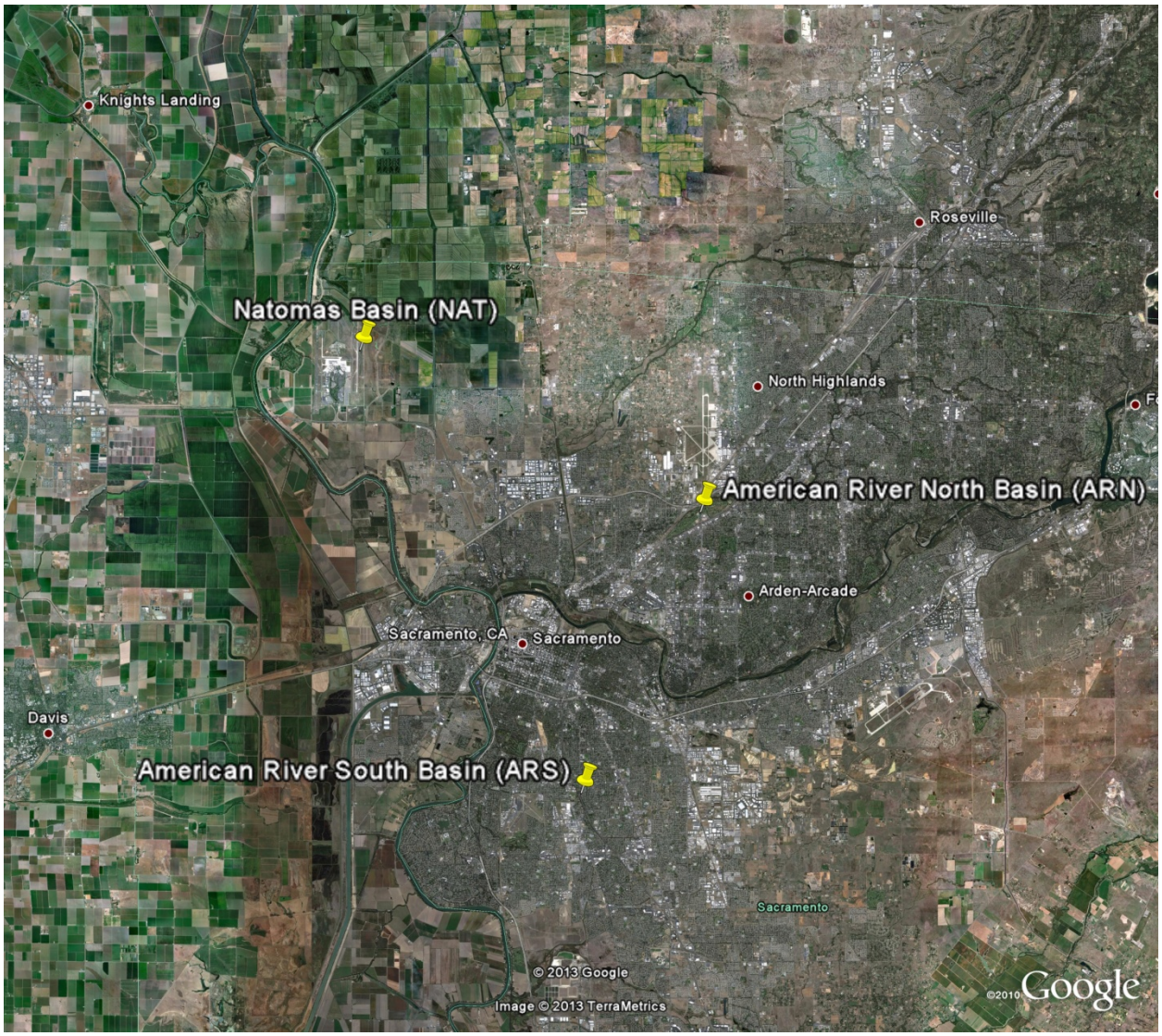


Figure 5: Main Economic Impact Areas (Basins)

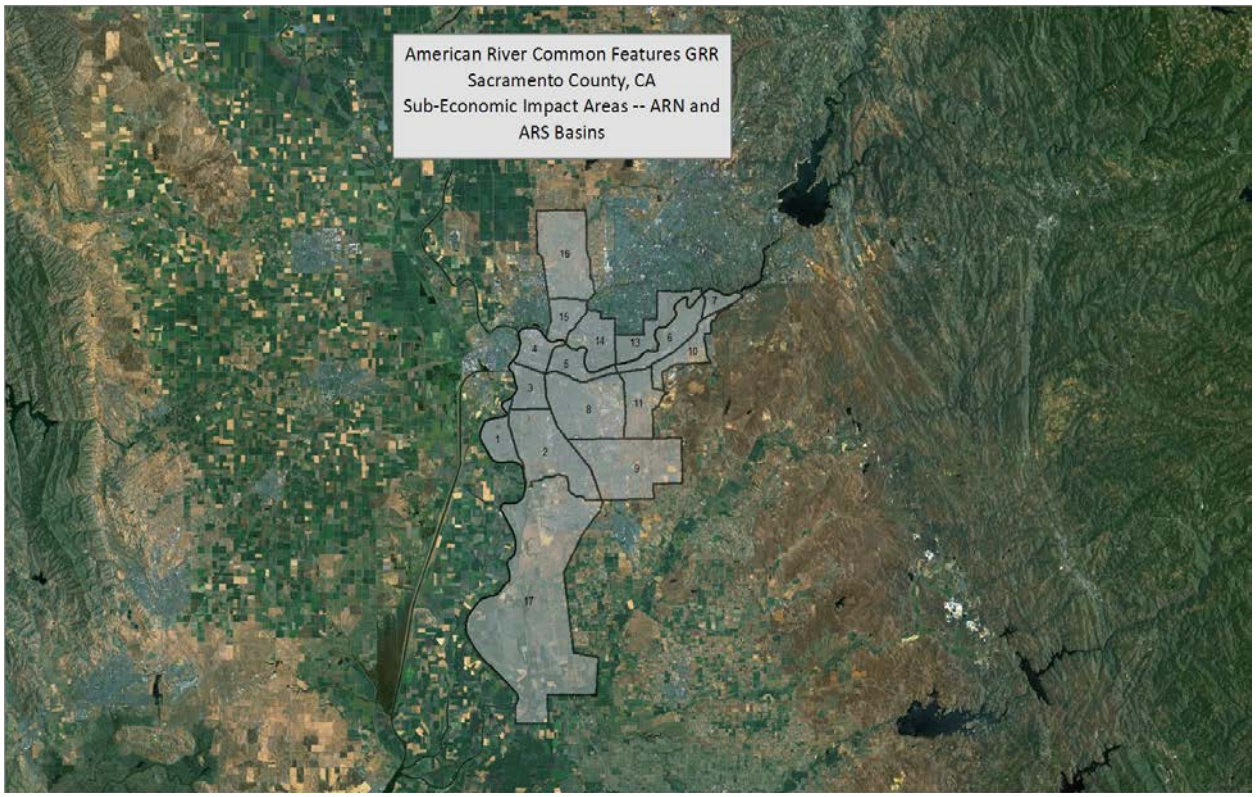


Figure 6: Sub-EIAs in the ARS and ARN Basins

2.6 HYDRAULIC REACHES & REPRESENTATIVE INDEX POINTS

Chapter 1 (Section 1.3) explained that each basin/EIA may be at risk of flooding from multiple sources. For example, the ARS Basin could be flooded from either the American or Sacramento Rivers. Additionally, along each source of flooding, the condition of the levee could vary from one location (hydraulic reach) to the next, with the probability of flooding from a particular reach varying correspondingly.

In terms of economic analysis, levee reaches are used to focus-in on those areas deemed most pertinent for developing engineering data, which feed into the economic modeling. Data are generated at representative index points within each reach and are used to estimate project performance statistics under both without-project and with-project conditions. The engineering data is also used in conjunction with economic data to estimate expected damages and benefits. Both sets of results are then used together to describe the flood risk in the study area.

Twenty-five hydraulic reaches were originally identified based on extensive geotechnical analyses of the levee conditions along each source of flooding within the study area. From these 25 reaches, the project delivery team (PDT) selected five of them, each containing one index point, for which to generate engineering data for use in the economic modeling and the associated without-project damage and with-project benefit analyses. The PDT also selected three additional index points -- two located on the right and left banks of the American River and one located on the NEMDC/PGCC (also known as the Sankey Gap) at locations where there are no levees. These index points were not part of the original 25, but were included in order to aid in a more accurate description of residual flood risk in the study area. The representative index points used in economic analysis were selected based on preliminary estimates

of the chance of flooding and consequences of flooding using flood plain extents and depths, levee fragility (geotechnical fragility curves), and estimates of ACE event damages. The index points, by basin, are shown in Figure 7 and listed below.

ARS:

- ARS A, American River, RM 9.0, left bank
- Flanking location on American River, RM 14.5, left bank
- ARS F, Sacramento River, RM 50.25, left bank

ARN:

- ARN A, American River, RM 7.82, right bank
- Flanking location on American River, RM 13.21, right bank
- ARN E, Arcade Creek, RM .88, right bank

NAT:

- NAT D, Natomas Cross Canal, RM 4.3, left bank
- Sankey Gap on the NEMDC/PGCC

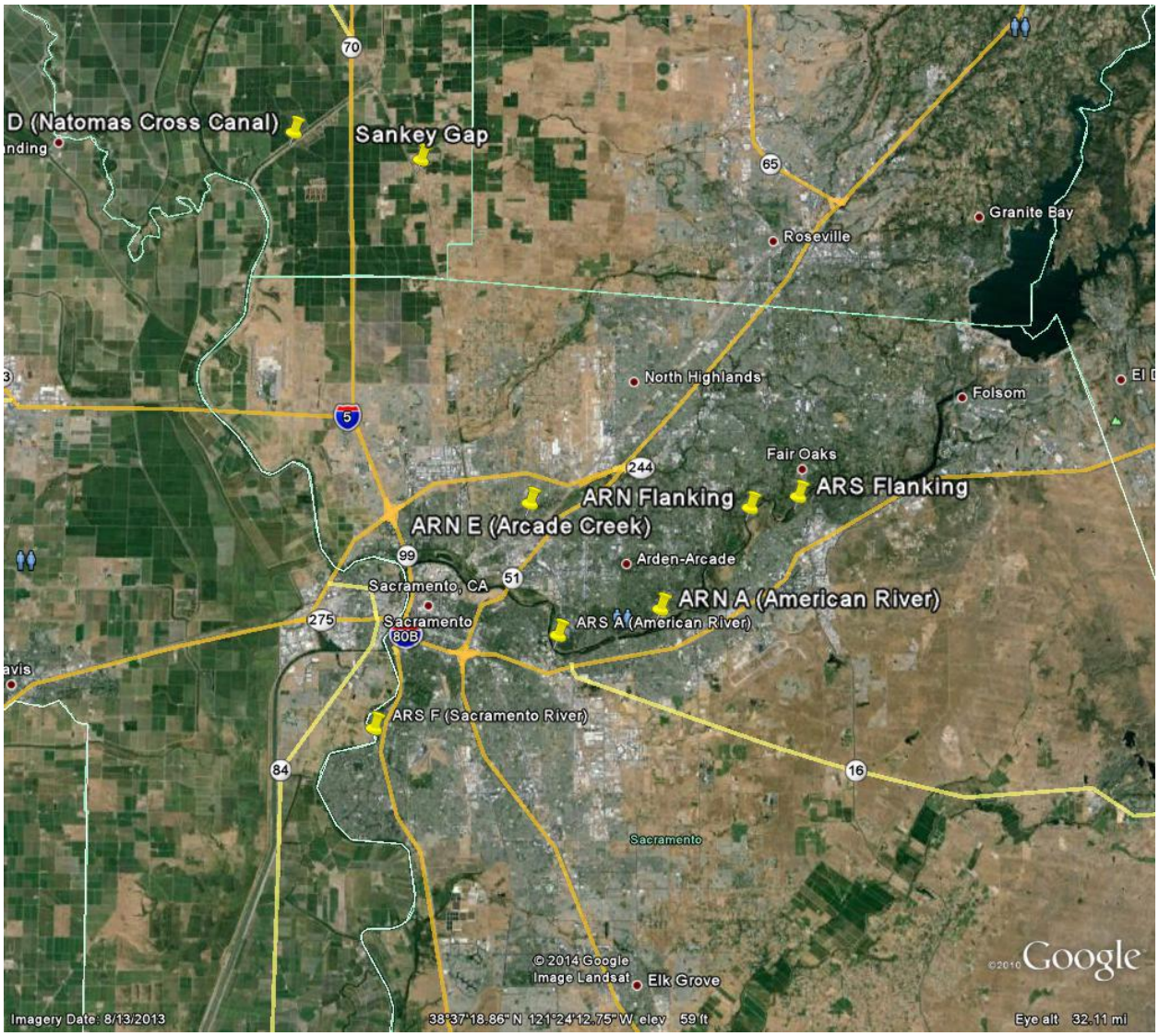


Figure 7: General Location of Eight Index Points Used in the Economic Analysis

In this analysis "representative index points" refers to those locations whereby the without-project condition (damages and performance) of the study area is best characterized. The PDT's intent was to balance rigor with practicality in choosing the number of index points to use in the analysis. Once the number of index points was determined for this GRR – essentially one index point to represent a major source of flooding (per bank side) plus several others to be able to check for residual damages (e.g., outflanking locations on the American River), the PDT then made a preliminary comparison of the chance of flooding and the consequences of flooding – in other words the overall flood risk associated with a levee breach at various locations – in selecting the representative index points. During the course of the study, two of the index points (ARS B and ARS E) that were originally selected were replaced by alternate index points (ARS A and ARS E).

As Table 5 below indicates, there's a relatively high chance of a levee performing poorly in the majority of the smaller reaches that make up the larger increments used in the final analysis. Furthermore, a breach in any of the reaches would result in deep and extensive flooding by filling up the respective basin. Taking into account the chance of flooding and consequences of flooding specific to this study

area, an incremental analysis based on a delineation of one reach/increment equal to an entire stretch of river (e.g., the Sacramento River from the confluence with the American River downstream to the boundary of the study area) or an incremental analysis based on a delineation of multiple reaches/increments along a stretch of river (e.g., ARS D, E , F, and G on the Sacramento River from the confluence with the American River downstream to the boundary of the study area) would ultimately arrive at the same conclusion: that benefits/net benefits are maximized once the entire system is improved. Residual risk would remain relatively high until the entire system is improved since flooding from various locations (reaches) affects the same consequence area.

Table 5: Probability of Poor Performance for Various ACE Events

Basin/Reach	Probability of Poor Performance (P(f))		
	2% ACE	1% ACE	Top of Levee (TOL)
ARS Basin – American River Index Points			
ARS A	~13%	~13%	~65%
ARS B	~20%	~23%	~65%
ARS C	~12%	~16%	~30%
ARS Basin – Sacramento River Index Points			
ARS D	~12%	~16%	~61%
ARS E	~25%	~25%	~45%
ARS F	~30%	~30%	~45%
ARS G	~22%	~28%	~36%
ARN Basin – American River Index Points			
ARN A	~12%	~15%	~56%
ARN B	~6%	~7%	~15%
ARN C	~28%	~45%	~60%

2.7 DESCRIPTION OF ECONOMIC DATA & UNCERTAINTIES

The economic data used in the analysis are described in the following sub-sections. These data lay the groundwork for the without-project damage and with-project benefit analyses that are described in Chapters 3 and 4, respectively.

2.7.1 Structure Inventory

An extensive, comprehensive structure inventory of the study area was performed for the 2008 American River Watershed Folsom Dam Modification and Folsom Dam Raise Economic Reevaluation Report (ERR). The 2008 ERR inventory was carried forward to this analysis with limited updating for price level (all basins) and foundation heights (Natomas Basin).

Structure data was collected using standard USACE practices. For the ERR, a base geographic information system (GIS) inventory with parcel attribute data for both Sacramento and Sutter counties was provided by the non-federal partner. Numerous field visits were taken to collect the base inventory data, including number of stories, foundation heights, building use (residential, commercial, industrial, public), occupancy types (more specific building use, such as commercial restaurant or single-family residential), class (per Marshall & Swift Valuation Service's grades of construction), construction rating (per Marshall & Swift's categories of "low cost" to "excellent" construction), and condition ("poor" to "new" condition), which was used to estimate depreciation.

The data collected for the ERR produced a structure inventory encompassing an area larger than the current 0.2% (1/500) annual chance exceedance (ACE) floodplain for the ARS and ARN basins. Structure counts for the four main building categories are listed in Table 6 below, and represent only those structures falling within the 0.2% (1/500) ACE floodplain.

Table 6: Number of Structures by Category and Basin in Impact Areas Delineated in 2008 ERR

CATEGORY	STRUCTURE COUNT			
	ARS BASIN	ARN BASIN	NATOMAS BASIN	TOTAL
COMMERCIAL	3,210	754	292	**4,256**
INDUSTRIAL	1,064	224	149	**1,437**
PUBLIC	819	147	82	**1,048**
RESIDENTIAL	104,513	14,018	22,247	**140,778**
TOTAL	**109,627**	**15,143**	**22,770**	**147,540**

2.7.2 Structure and Content Values

Structure attribute data collected during field visits and obtained from the non-federal partner were used to determine valuation of structures and contents.

2.7.2.1 Structure Values

For all residential structures classified as single-family residential (SFR), Sacramento County provided detailed information regarding square footage of the buildings. This included total square footage, basement square footage, 2nd-floor square footage, and garage square footage; this same data was not available for the non-residential and multi-family residential (MFR) categories. For many of the larger buildings and in some of the commercially-dense areas, the county provided GIS data that included digitized building footprints. The GIS data was used to identify each structure's square footage. For those buildings not included in the GIS data, high-resolution aerial photographs were used in conjunction with GIS to measure the building footprint. In both cases, the measured first floor square footages were used along with the number of damageable floors (limited to no more than three floors) to estimate the maximum possible damageable square footage for structure valuation purposes.

Depreciated replacement value of structures were estimated based upon building square footage, estimated cost per square foot (from the Marshall & Swift Valuation Handbook), and estimated depreciation. Values per square foot were based on building use, class, and type as outlined in the Marshall and Swift Valuation Handbook.

2.7.2.2 Content Values

For SFR residential structures, depth-percent damage curves developed by the USACE Institute for Water Resources (IWR) and presented in Economic Guidance Memorandum (EGM) 01-03 and 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 report 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 prior American River Watershed studies. It should be note that the residential content-to-structure value ratio (CSVR) of 0.5 (50%) was used to derive an order of magnitude estimate of the value of damageable property (contents) for reporting purposes only and was not used to estimate actual residential content values for use in the calculation of expected annual damages (EAD) or annual benefits. While it is understood that the 0.5 CSVR cannot realistically be applied broadly to all homes in the study area, it has been used in past District studies as a simple but adequate way to help derive an estimate of the total value of property in the study area and as a way to gage the magnitude of content damages should a flood event occur.

For non-residential categories, an expert elicitation was performed to develop content values and content depth-percent damage curves for specific occupancy types for the 2008 ERR. The results of that expert elicitation were used for this analysis. The values and curves were developed specifically for structures in the American River Watershed study area. In total, there were 22 different occupancy types with values ranging from $22 to $235 per square foot with uncertainty. Content values for non-residential structures were generated as a function of building use, damageable square footage, and content value per square footage per occupancy type. Additional information regarding non-residential dollar-per-square foot values and depth-percent damage curves can be found in the 2008 ERR.

Tables 7, 8 and 9 show the value of damageable property, by basin, for structures, contents, and combined, respectively.

Table 7: Value of Damageable Property (Structures) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (IN $1,000S, OCTOBER 2015 PRICE LEVEL): STRUCTURES			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
COMMERCIAL	5,758,255	2,181,880	665,735	8,605,870
INDUSTRIAL	2,123,101	433,933	439,682	2,996,716
PUBLIC	5,516,293	633,479	489,049	6,638,821
RESIDENTIAL	18,195,458	2,648,052	4,259,542	25,103,052
TOTAL	**31,593,107**	**5,897,343**	**5,854,008**	**43,344,459**

Table 8: Value of Damageable Property (Contents) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (IN $1,000S, OCTOBER 2015 PRICE LEVEL): CONTENTS			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
COMMERCIAL	3,095,566	1,052,296	280,247	4,428,109
INDUSTRIAL	1,452,267	364,061	232,758	2,049,086
PUBLIC	1,503,087	201,622	282,486	1,987,195
RESIDENTIAL	9,097,730	1,324,026	2,134,367	12,556,123
TOTAL	**15,148,650**	**2,942,005**	**2,929,857**	**21,020,512**

Table 9: Value of Damageable Property (Structures & Contents) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY (IN $1,000S, OCTOBER 2015 PRICE LEVEL): STRUCTURES & CONTENTS			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
COMMERCIAL	8,853,821	3,234,176	945,982	13,033,979
INDUSTRIAL	3,575,368	797,994	672,440	5,045,802
PUBLIC	7,019,380	835,101	771,535	8,626,016
RESIDENTIAL	27,293,188	3,972,078	6,393,909	37,659,175
TOTAL	**46,741,757**	**8,839,349**	**8,783,865**	**64,364,972**

2.7.3 First-Floor Elevation of Structures

For structure and content damages, depth of flooding relative to the structure's first floor is the primary factor in determining the magnitude of damages. The current analysis uses HEC-FDA's internal processes for the determination of structural inundation. The process combined a geographic information system (GIS) database containing spatially-referenced polygons for each parcel in the study area with water surface elevations (per grid cell) from the FLO-2D modeling. Parcels/structures were then tied to a specific grid cell in which the parcel was located.

A representative ground elevation was assigned to each parcel/structure using GIS. Foundation heights for each structure were estimated during numerous field visits. First-floor elevations were computed in HEC-FDA using the foundation height and ground elevation data.

Using the ground elevation and foundation height data from the economic structure inventory in conjunction with the water surface elevation data from the WSP, depths of flooding above the first floor at each structure for each annual chance exceedance event were computed within HEC-FDA. As explained previously, water surface elevations (WSE) from the FLO-2D modeling were provided for each grid cell for the 0.5, 0.1, 0.04, 0.02, 0.01, 0.005, and 0.002 ACE events and were imported into the HEC-FDA model in the form of a water surface profile.

2.7.4 Emergency Cost Losses

Depreciated replacement values of structures are used to assess structure and content damages and to gage the cost of replacing damaged portions of structures and contents of similar use and condition. However, there are other costs/damages directly associated with structure and content damages that may result from a flood event but which are not captured in the estimate of structure and content damages. These additional damage categories were considered in the assessment of without-project damages and with-project benefits for the American River Common Features GRR, and include:

1. Clean-up costs
2. Temporary evacuation, relocation and housing assistance (TERHA)

The sub-sections below describe in greater detail these additional flood damage/benefit categories. The assessment method used for this report follows the one used in the Sutter Basin Feasibility Study. In the Sutter study, both clean-up and TERHA costs were included in the estimate of without-project damages

and with-project benefits. Further, the Sutter study has been approved by the USACE Civil Works Review Board (CWRB) as well as by the Office of the Assistant Secretary of the Army, which adds some legitimacy to both the damage/benefit categories and methodology.

The without-project damages and with-project benefits (alternatives in Final Array) associated with clean-up and TERHA costs are summarized in Table 17 in Section 3.3.2 (without-project condition) and Tables 45-46 in Section 4.10 (without-project and with-project conditions).

Clean-Up Costs: Flood waters leave debris, sediment, salts and the dangers of diseases throughout flooded structures, making the cleaning of these structures a necessary post-flood activity. Clean-up costs for the extraction of flood waters, dry-out, and decontamination vary significantly based upon various factors, including depth of flooding. Studies conducted by both Sacramento and New Orleans Districts indicate a maximum value of ten dollars per square foot ($10/ft^2) for such clean-up costs. This maximum per square foot cost covers clean-up costs associated with mold and mildew abatement, which entails having professional firms apply fans, chemicals, and other techniques to eliminate and prevent mold/mildew in inundated areas. The maximum clean-up cost of $10/ft^2 was used for the American River Common Features economic assessment and was applied for flood depths equal to and exceeding five feet, with damage percentages scaled down for depths between zero and five feet. Figure 8 below displays per square foot clean-up costs as a function of flood depths; Figure 9 displays the depth-percent damage curve used in the HEC-FDA analysis.

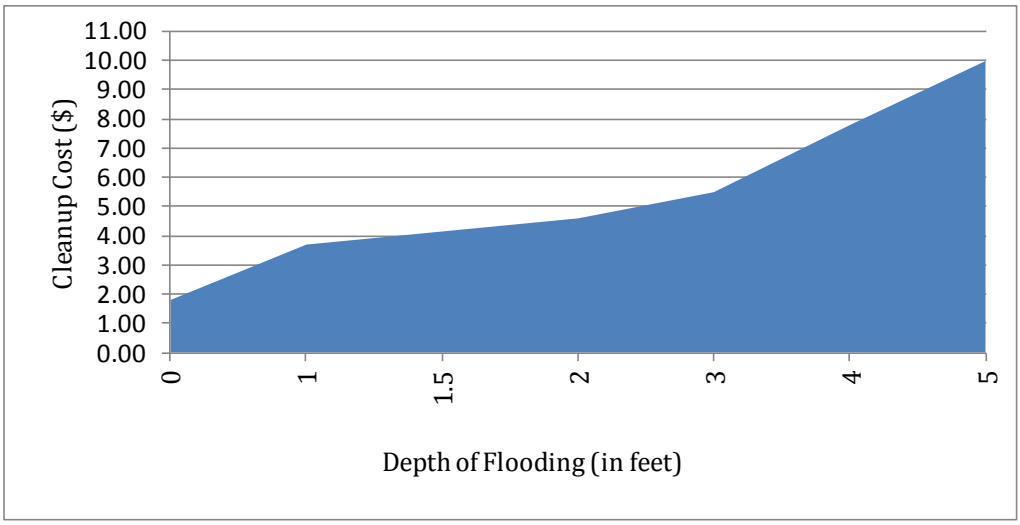


Figure 8: American River Common Features GRR, Dollar-Per-Square Foot Clean-Up Costs as a Function of Depth of Flooding

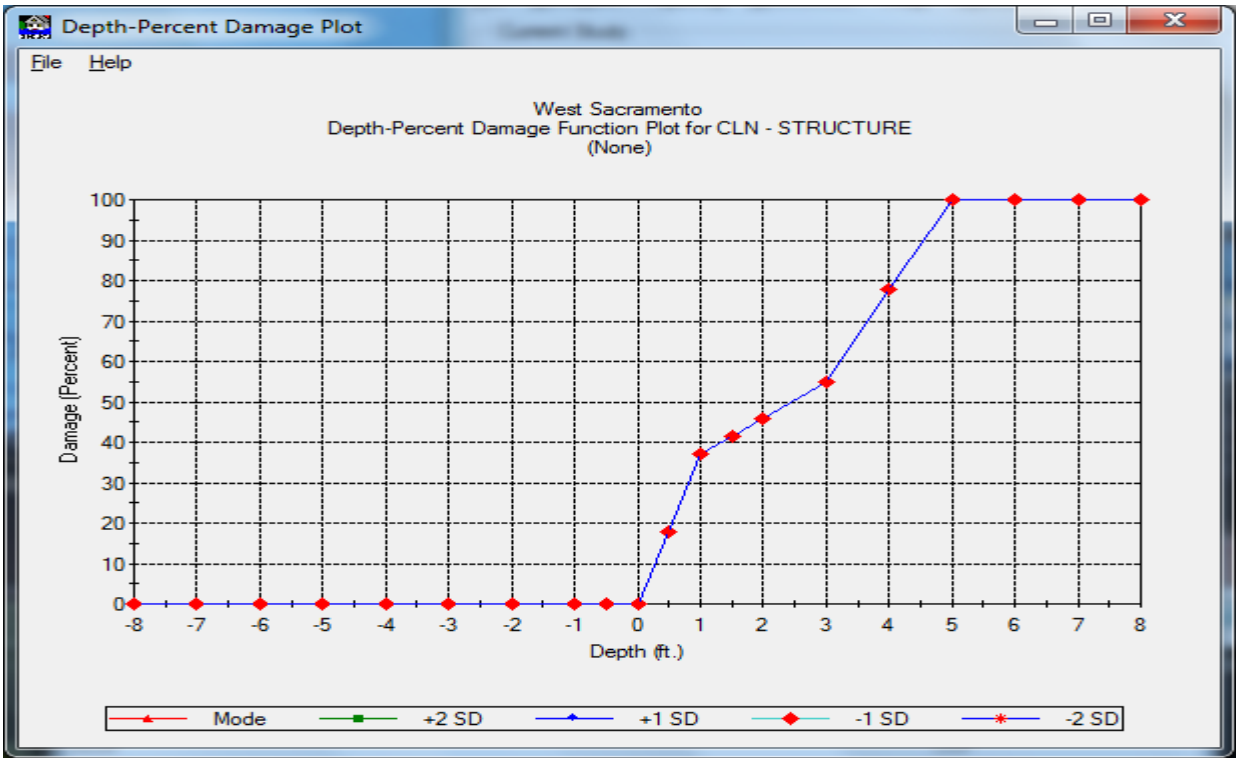


Figure 9: American River Common Features GRR, Depth-Percent Damage Curve for Clean-Up Costs Used in HEC-FDA Analysis

Temporary Evacuation, Relocation, and Housing Assistance (TERHA): ER 1105-2-100 states, "Flood damages are classified as physical damages or losses, income losses, and emergency costs." The ER then defines emergency costs as "those expenses resulting from a flood what would not otherwise be incurred…" The ER further requires that emergency costs should not be estimated by applying an arbitrary percentage to the physical damage estimates.

The Federal Emergency Management Agency (FEMA) provides grants to assist individuals and families to find suitable housing when they are displaced in cases of federally declared disasters. The program assures that people have a safe place to live until their homes can be repaired. This assistance is directly attributable to the disaster, since it is an expenditure that is only undertaken when a disaster occurs. Therefore, it falls under the emergency cost guidance of ER 1105-2-100, and the funds expended by FEMA for temporary evacuation, relocation, and housing assistance (TERHA) in the event of a flood are a legitimate flood damage category under the NED account.

Cost estimates for the relocation and emergency services provided to floodplain residents displaced during peak flood events and post-flood structural renovations were based on FEMA's methodology for evaluating TERHA costs. This methodology relates TERHA costs to relocation costs, structure damage percentages and the number of days residents spend displaced from their structures. The maximum TERHA costs of $11,244 correspond with one year of FEMA evacuation, relocation and/or housing assistance costs. These costs are based on the median rent of a two bedroom apartment, and were derived for this assessment using rent prices in the Sacramento area as posted on the website www.rent.com. The maximum cost of $11,244 was applied to structures sustaining at least 50 percent damage, with scaled down costs being computed for less damaging flood events. Figure 10 below shows percent of maximum TERHA damages as a function of the depth of flooding. The depth-percent damage

relationship for a one-story single family residential (SFR) structure is also shown as a point of reference; however, unique depth-percent damage relationships for one-story residential, two-story residential, and mobile homes were applied in HEC-FDA to derive damages and benefits for TERHA.

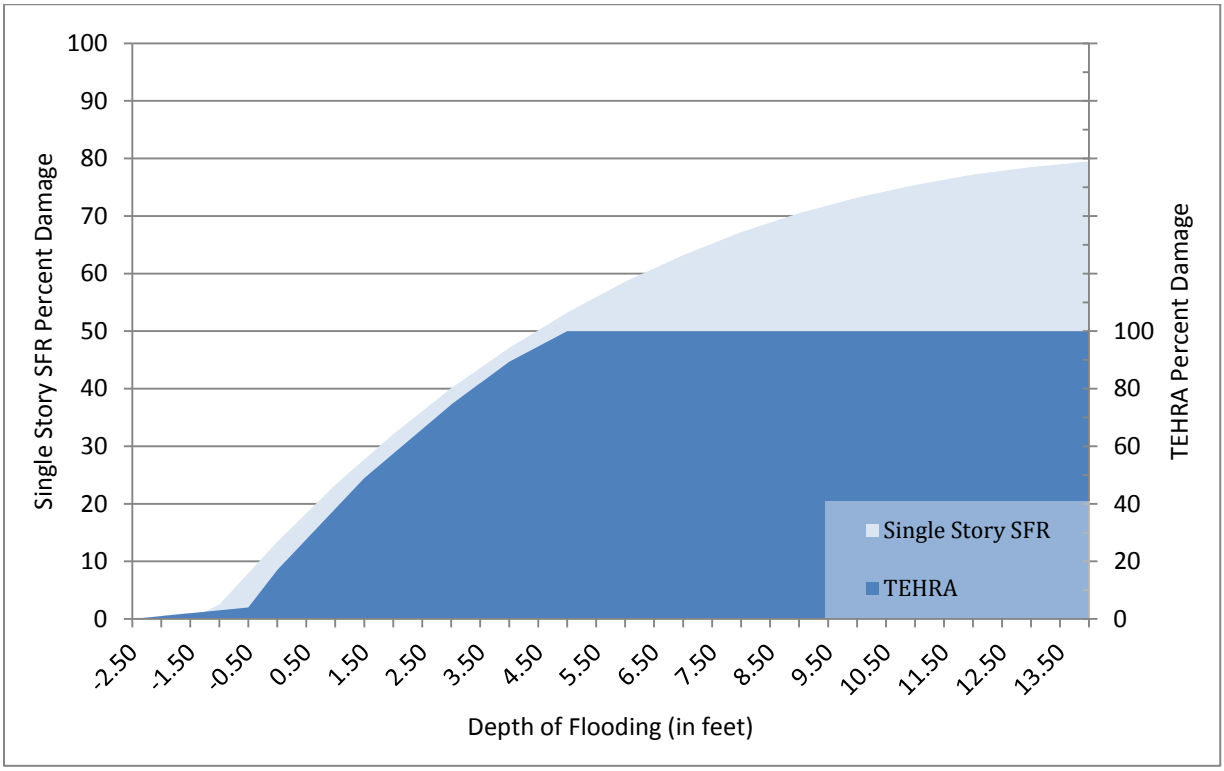


Figure 10: American River Common Features GRR, Depth-Percent Damage Curve for TERHA Overlaid onto Depth-Percent Damage Curve for One-Story Residential

2.7.5 Automobiles

In the 2010 Natomas Post-Authorized Change and Interim Reevaluation Report (NPACR) an average automobile value of $7,988 was obtained from the Bureau of Transportation Statistics. This value was updated for price level ($8,308) and used in this analysis.

The number of cars impacted was based on the number of cars per residential unit (1.93), which in turn was based on the total number of automobiles and trucks registered in the Sacramento Area (source: California Department of Finance) divided by the number of households. Automobile counts for car dealerships were based on discussions with local dealers and comparisons with spot inventories from aerial photos. The analysis assumed that, based on relatively short evacuation times, about 50% of residential-based vehicles would be removed from the flood area prior to the event and only 20% would be removed from dealerships. This is consistent with EGM 09-04, which recommends a removal rate of 50.6% for areas where the warning time is less than 6 hours.

Table 10 displays the estimated value of automobiles in the 0.2% annual chance exceedance (500-year) floodplain.

Table 10: Value of Damageable Property (Automobiles) by Category and Basin in 0.2% Floodplain

CATEGORY	VALUE OF DAMAGEABLE PROPERTY: AUTOMOBILES (IN $1,000S, OCTOBER 2015 PRICE LEVEL)			
	ARS BASIN (ARS A)	ARN BASIN (ARN E)	NATOMAS BASIN (NAT D)	TOTAL
AUTOMOBILES	1,408,337	274,254	186,905	**1,869,496**

2.7.6 Depth-Percent Damage Curves

The depth of flooding is the primary factor in determining potential damages to structures, contents, and automobiles. Depth-percent damage functions were used in the HEC-FDA models to estimate the percent of value lost for these categories. Residential depth-damage curves (structures and contents) were taken from Economic Guidance Memorandum (EGM) 01-03, *Generic Depth-Damage Relationships,* and 04-01, *Generic Depth-Damage Relationships for Residential Structure with Basements,* 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 structure curves were based on revised Federal Emergency Management Agency (FEMA) Flood Insurance Administration (FIA) curves. Two sets were used: 1) standard FEMA FIA curves for impact areas with shorter-duration flooding and 2) adjusted curves for areas where inundation depths are deep and flooding durations are long (exceeding three days); these curves were based on the prior Natomas Basin studies and the 1997 Morganza Study. As previously described in Section 2.7.2.2, non-residential content depth-percent damage curves for 22 occupancy types were developed based on an expert elicitation; these curves were developed specifically for building types in the Sacramento area and for American River Watershed analyses.

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*.

All of the depth-percent damage curves used in the analysis can be found in the American River Common Features GRR HEC-FDA models.

2.7.7 Economic Uncertainties

The valuation of residential and non-residential structures and contents along with automobile losses were estimated with uncertainty. In the estimation of structure value, three variables were considered to have a possible range of values: 1) dollar per square foot 2) building square footage and 3) percent of estimated depreciation. Using triangular distributions to describe the range of these three variables, a Monte Carlo simulation was run on typical structures by category and the mean and standard deviations were compared to derive coefficients of variation (COV) for structure values by category. Content value uncertainties for non-residential structures were based on data from the expert elicitation mentioned previously. The program Best Fit was used to determine what would be a reasonable distribution, and using the model data, it was determined that a normal distribution best described uncertainty in the structure and content valuation. These uncertainty parameters for valuation were imported into the HEC-FDA program.

Several factors contributed to the uncertainty associated with automobile damages. These factors include the average unit value, the number of vehicles per residence/dealership assumed, and the evacuation rate. It was assumed that the average number or automobiles per residential unit was about 2 and the evacuation rate was 50%. An average value of an automobile was determined to be $8,308. While uncertainty in these variables was not considered, uncertainty in the percent damage by depth (as reflected in the depth-percent damage curve) was taken into account.

Uncertainty in first floor elevation was also included in the model. During the field inventory, first floor (foundation height) estimates were made by visual inspection and assigned to structures in one half-foot increments. For example, the average SFR built on slab without any fill might be listed as ground elevation + 0.5 foot to 1.0 foot; raised foundations either 1.5, 2 or 2.5 feet. Based on this level of precision, it was assumed that 0.5 foot standard deviation would capture the potential uncertainty in this first floor elevation adjustment.

The uncertainty associated with the percent damages at specific depths of flooding for automobiles and structures/contents were entered into the HEC-FDA model. Residential structure and content depth-percent damage curves are normally distributed and include standard deviations of percent damages by depth of flooding. Non-residential content depth-percent damage curves are triangularly distributed and include a minimum, most likely, and maximum percent damage by depth of flooding.

All of the value and depth-percent damage uncertainty associated with structures, contents and automobiles can be found in the American River Common Features GRR HEC-FDA models.

2.8 DESCRIPTION OF ENGINEERING DATA & UNCERTAINTIES

The following sub-sections briefly describe the engineering data used in the economic analysis. More details about each discipline-specific engineering analysis can be found in the following appendices: Appendix B – Hydrology, Appendix C – Hydraulics, and Appendix F – Geotechnical.

2.8.1 Hydrologic Engineering Data Used in HEC-FDA

The Sacramento District's Water Management Section provided the hydrologic data used in the HEC-FDA modeling. This includes the equivalent record length at each index point, the exceedance probability-discharge curve or the statistics required to compute the exceedance probability-discharge curve in HEC-FDA (depending on the index point), and the transform flow curves for those index points on the American River, where outflow is regulated by operations at Folsom Dam. These data and curves can be found in the Hydrologic Engineering Attachment in the Main Engineering Report or in any of the American River Common Features GRR HEC-FDA models.

2.8.2 Hydraulic Engineering Data Used in HEC-FDA

The SPK Hydraulic Design Section used the HEC-RAS model to determine stages in the channel, to model levee breakout locations, and to develop breakout hydrographs; it used the FLO-2D model to determine water surface elevations in the floodplain (i.e., develop suites of floodplains). More details about the data and assumptions used by the Hydraulic Design Section for their HEC-RAS and FLO-2D modeling efforts can be found in the Hydraulic Design Attachment to the Main Engineering Report.

For this analysis, a suite of floodplains was generated for each of the eight index points. For each index point, the Hydraulic Design Section provided data for input into the HEC-FDA model. These include:

- Discharge-stage (rating) curves with uncertainty for the without-project and with-project conditions for four index points (those on the American River)
- Exceedance probability-stage curves with uncertainty for the without-project and with-project conditions for three index points (NAT D, ARS F, and ARN E)
- Suites of floodplains for each index point; these were formatted from FLO-2D water surface elevation data for direct import into HEC-FDA

2.8.3 Geotechnical Engineering Data Used in HEC-FDA

A geotechnical levee fragility curve shows the probabilities of failure at different water surface elevations against a levee. Fragility curves are a main component of the economic modeling and in determining the performance of a project, which is often described in terms of annual exceedance probability (AEP) or the chance of flooding in any given year.

For this analysis, five sets of geotechnical levee fragility curves were used in the economic analysis, one set for each index point located on a levee reach, with each set including a without-project and with-project curve. (Since there are no levees on the upper portion of the Lower American River or at the Sankey Gap, no fragility curves associated with these three index point locations were developed.) The levee fragility curves used in the economic analysis can be found in the American River Common Features GRR HEC-FDA models. The Geotechnical Engineering Attachment in the Main Engineering Report describes in detail the development of these curves.

2.8.4 Engineering Uncertainties in HEC-FDA

There were three main engineering uncertainties incorporated into the HEC-FDA modeling:

- Uncertainty in within-channel discharges was computed in HEC-FDA using data provided by the District's Water Management Section. This data was in the form of either an equivalent record length (for graphical curves) or Log Pearson Type III Statistics (for analytical curves). In both cases, the data is entered into HEC-FDA, which uses the data to compute uncertainty in discharge for a range of exceedance probability events.
- Uncertainty in discharges from Folsom Dam was accounted for in HEC-FDA by using transform flow (regulated versus unregulated) curves containing minimum values and maximum values around the regulated discharges for a range of exceedance probability events.
- Uncertainty in stages (in-channel) was captured in the hydraulic rating curves, which were entered into HEC-FDA. Stage uncertainty was provided by the District's Hydraulic Design Section.

All of the data used to describe the uncertainty in the main engineering relationships can also be found in the Common Features GRR HEC-FDA models or in the respective engineering attachments to the Main Engineering Report.

CHAPTER 3
WITHOUT-PROJECT ANALYSIS & RESULTS: AUTHORIZED COMMON FEATURES + JOINT FEDERAL PROJECT + DAM RAISE

3.1 FUTURE WITHOUT-PROJECT CONDITION

Expected annual damages (EAD) and engineering project performance results for the without-project condition, which assumes that the WRDA 1996/1999 Authorized Common Features Project, the Joint Federal Project (JFP), and the Folsom Dam Raise Project are in place and operational, are summarized in this chapter. The without-project condition serves as the baseline for which all with-project alternatives are measured against. The with-project alternatives analysis is presented in Chapter 4.

3.2 FLOODING CHARACTERISTICS

The without-project analysis and results are based predominantly on estimates of the flooding extent, the depth of flooding, and the property that may be damaged from flooding within a particular area. Tables 11 to 13 display key characteristics of flooding associated with specific annual chance exceedance events for the three basins within the study area. The flooding characteristics of a basin may differ depending on the assumed levee breach location (reach/index point). For example, structures in the Natomas Basin (NAT D breach location) would experience significant flooding above the first floor elevation; the average depth of flooding above the first floor exceeds 10 feet, even for relatively higher frequency events such as the 25-year. In the ARS basin, average depth of flooding above the first floor exceeds 6 feet (ARS F breach location) for the 25-year event. In all basins, flooding would be deep and potentially catastrophic.

It is important to note that it would be incorrect to sum the number of structures inundated per index point within a basin to derive a total number of structures at risk (Tables 11 to 13 below); this would result in double counting. The same structures may in fact be at risk from flooding from more than one location (index point). For example, in the Natomas Basin and the ARS Basin, flooding from one location (ARS A and NAT D) will result in essentially the entire inventory extent for the respective basin (i.e., flooding from ARS A essentially includes all structures in the south basin and flooding from NAT D includes all structures in the Natomas Basin); on the other hand, in the ARN Basin there is substantial overlap between flooding that occurs from ARN A and from ARN E, but flooding from either does not totally encompass the full structure inventory for the ARN Basin. Estimates of the total number of structures at risk from flooding in each basin were presented in Chapter 2.

Plates displaying the full suite of floodplains for each of the index points are located in the Hydraulic Design Attachment of the Main Engineering Report.

Table 11: Flooding Characteristics by Index Point and Annual Chance Exceedance (ACE) Event Floodplains Under Levee Breach Scenario: ARS Basin

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	0.01	0.002	0.04	0.01	0.002
A	1.6	4.1	6.7	11,405	23,888	109,627
FLANKING	0	0	5.8	0	0	95,560
F	6.7	7.0	7.6	37,759	49,374	96,019

Table 12: Flooding Characteristics by Index Point and ACE Event Floodplains Under Levee Breach Scenario: ARN Basin

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	0.01	0.002	0.04	0.01	0.002
A	4.4	7.1	7.7	8,009	13,437	14,837
FLANKING	0	0	6.4	0	0	13,758
E	4.1	3.9	8.1	2,247	3,346	15,143

Table 13: Floodplain Characteristics by Index Point and ACE Event Floodplains Under Levee Breach Scenario: Natomas Basin

REACH/INDEX POINT	AVERAGE DEPTH OF FLOODING ABOVE 1ST FLOOR BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT (IN FEET)			NUMBER OF STRUCTURES INUNDATED BY INDICATED ANNUAL CHANCE EXCEEDANCE (ACE) EVENT		
	0.04	0.01	0.002	0.04	0.01	0.002
D	10.0	12.2	17.6	22,547	22,677	22,770
SANKEY GAP	0	0	1.8	0	0	2,821

A full set of floodplain plates can be found in the Hydraulic Design Appendix. These include floodplains for a range of events (2yr to 500yr) and for each index point.

3.3 FLOOD RISK: PROBABILITY & CONSEQUENCES

Risk can be described in terms of the chance of some undesirable event occurring and the potential consequences should that undesirable event occur. In FRM National Economic Development (NED) analysis, risk is described in terms of the chance of flooding (the undesirable event) and the potential damages (consequences) from flooding. The following sections describe the flood risk associated with the without-project condition.

3.3.1 Annual Chance Exceedance (ACE) Event Damages

Annual chance exceedance (ACE) event damages, sometimes referred to as single-event damages, were computed in HEC-FDA. Single-event damages assume that a breach from a specific probability event

occurs; it does not take into account the likelihood of this event actually happening. Single-event damages are useful in that they show the magnitude of consequences, within a particular consequence area, *should* a specific flood event occur in that area. Table 14 below shows the damages that may occur for a range of events within the three main basins. These damage values include automobiles, structures, and contents, and represent damages based on flooding from one index point per basin – ARN A in the north basin, ARS F in the south basin, and NAT D in the Natomas Basin. While damages reported in the table for the ARS basin are based on flooding from the ARS F location, it should be noted that flooding from a 0.2% ACE event (500-year) from the ARS A location on the American River would result in greater damages to the ARS basin – about $24.6 billion in damages – than sustained at the ARS F location ($21.6 billion).

Table 14: Damages by Annual Chance Exceedance Event

BASIN	ACE EVENT DAMAGES (IN $1,000s, OCTOBER 2015 PRICE LEVEL)						
	50%	10%	4%	2%	1%	.5%	.2%
ARS (F)	6,660,369	8,427,409	8,427,409	9,197,846	13,302,749	14,288,782	21,612,855
ARN (A)	0	0	2,824,045	2,908,650	4,654,995	4,970,941	5,456,034
NATOMAS	4,404,922	5,579,812	5,784,706	6,109,155	6,271,056	6,403,807	6,896,591
TOTAL	**11,065,291**	**14,007,221**	**17,036,160**	**18,215,651**	**24,228,800**	**25,663,530**	**33,965,480**

3.3.2 Expected Annual Damages (EAD)

Expected annual damage (EAD) is the metric used to describe the consequences of flooding on an annual basis considering a full range of flood events – from high frequency/small events to low frequency/large events over a long time horizon (years). It is the main economic statistic used to describe the flooding problem in the study area; it is also used as the baseline to measure potential benefits from proposed FRM alternatives.

Table 15 displays the EAD results for each index point and by major damage category. Table 16 condenses the information from Table 15 and displays the EAD results by basin. Since the economic incremental analysis is being performed from a system perspective, the basin EAD results in Table 15 were used as the baseline without-project damages (per each basin) for which to measure with-project outputs.

For the ARS basin, the without-project EAD used as the starting point for the economic analysis is the EAD associated with the index point (per basin) that produced the highest without-project EAD. This is index point ARS F on the Sacramento River.

For the ARN basin, the without-project EAD used as the starting point for the economic analysis is the sum of the EADs associated with the ARN A (American River) and the ARN E (Arcade Creek) index points. Based on information from the SPK Hydraulic Design Section, the American River and Arcade Creek are uncorrelated from both a hydrologic and hydraulic perspective.

For the Natomas Basin, the without-project EAD used as the starting point for the economic analysis is the EAD associated with the NAT D index point. In the prior 2010 NPACR analysis, EAD for Natomas was computed using the HEC-FDA model as well as a supplemental model (N@RM) that accounted for flood plain occupant behavior. The N@RM model was used to adjust EAD results obtained from HEC-FDA by taking into account reduced inventory, reduced value of damageable property, and a decrease in the

number of flood plain occupants as floods occurred over time. The adjustment factor using the N@RM model turned out to be, on average, around 67% (i.e., 67% reduction in damages). This factor was carried forward to the current analysis; the EAD results for the Natomas Basin presented in the following tables reflect adjusted values.

Table 15: Without-Project EAD by Index Point

INDEX POINT	WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES (EAD) (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	AUTOS	COMMERCIAL	FARM	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
ARS A	4,171	15,338	30	3,704	11,760	56,327	**91,330**
FLANKING	806	2,898	3	1,121	2,051	9,858	**16,737**
ARS F	15,080	42,514	395	11,197	35,644	227,555	**332,383**
ARN A	2,171	18,967	0	5,257	4,937	19,796	**51,128**
FLANKING	206	1,702	0	476	535	2,077	**4,995**
ARN E	1,050	8,416	0	4,044	2,023	10,642	**26,175**
NAT D	863	3,294	36	2,328	2,774	19,300	**28,595**
S. GAP	87	0	0	0	36	913	**1,036**

Table 16: Without-Project EAD by Basin

BASIN	WITHOUT-PROJECT EXPECTED ANNUAL DAMAGES (EAD) (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	AUTOS	COMMERCIAL	FARM	INDUSTRIAL	PUBLIC	RESIDENTIAL	TOTAL
ARS	15,080	42,514	395	11,197	35,644	227,555	**332,383**
ARN	3,221	27,383	0	9,301	6,960	30,438	**77,303**
NATOMAS	863	3,294	36	2,328	2,774	19,300	**28,595**
TOTAL	**19,164**	**73,191**	**431**	**22,826**	**45,378**	**277,293**	**438,281**

Emergency cost losses: Expected annual damages (EAD) under the without-project condition were computed using HEC-FDA. For the ARS Basin, damages were computed using the engineering data from Index Point ARS F (Sacramento River), since this location serves as both the starting point for measuring without-project damages and the ending point for measuring with-project residual damages in the incremental analysis presented in Chapter 4. For the ARN Basin, damages were computed using the engineering data from Index Points ARN A (American River) and ARN E (Arcade Creek). The Emergency Cost analysis was performed after the determination of the Final Array of Alternatives. Since none of the alternatives include the Natomas Basin, the emergency cost analysis did not include the Natomas Basin. More information about the Final Array of Alternatives is presented in Chapter 4.

Table 17 below display the results of the HEC-FDA analysis. Expected annual damages associated with clean-up activities are estimated to be approximately $44 million; EAD associated with TERHA is estimated to be approximately $21.5 million. Total EAD for both emergency cost categories combined is estimated to be around $65 million.

Table 17: Without-Project EAD -- Emergency Cost Losses (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

Emergency Loss Category	Without-Project Expected Annual Damages (EAD)		
	ARS Basin	ARN Basin	Total
Clean-UP	36,860	6,893	43,753
TERHA	17,933	3,566	21,499
Total	**54,792**	**10,459**	**65,251**

Table 18 below summarizes the total without-project EAD by basin and category. It includes all damage categories (structures and contents, automobiles, and emergency cost losses) but does not include the Natomas Basin, which was ultimately removed from the analysis (see Chapter 4). An EAD of approximately $475 million was used as the basis to measure benefits of the proposed alternatives.

Table 18: Total Without-Project EAD by Basin and Category (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

Total Without-Project EAD by Basin and Category			
Category	ARS Basin	ARN Basin	Total
Structures and Contents	317,303	74,082	391,385
Automobiles	15,080	3,221	18,301
Emergency Costs	54,792	10,459	65,251
Total	387,175	87,762	474,937

3.3.3 Annual Exceedance Probability (AEP) by Index Point and Basin

Annual exceedance probability (AEP) is a statistic used to describe the chance of flooding in any given year within a designated area. It is often used to describe one aspect of flood risk, with the other being the consequences (e.g., damages and loss of life) of flooding. Annual exceedance probability is computed in HEC-FDA using engineering data at an index point; these input data include exceedance probability-discharge, stage-discharge, and geotechnical levee failure relationships, and in some cases transform flow (inflow-outflow discharges associated with dams/reservoirs) curves.

Table 19 below displays the AEP values associated with each index point. Annual exceedance probability values differ depending on the location along the levee due primarily to the differing geotechnical conditions of the levees protecting the basin. Each basin is considered to be protected by a system of levees, and flooding to the basin could potentially occur from various sources. For example, in the ARS Basin, flooding can occur from the American River or the Sacramento River; further, the risk of flooding along either river varies depending on the location along the river. In this respect, the AEP values listed in Table 19 for each index point represent the probability of a flood event occurring when considering only one failure location (one failure mechanism). Generally, evaluating AEP information at multiple points at which flooding into an area could occur typically provides a more complete characterization of the chance of flooding for that particular area.

Table 19: Annual Exceedance Probability (AEP) by Index Point -- Without-Project Condition

BASIN	INDEX POINT	AEP	1/AEP
ARS	ARS A	0.0103	1 in 97
	ARS Outflanking	0.0034	1 in 294
	ARS F	0.0310	1 in 32
ARN	ARN A	0.0104	1 in 96
	ARN Outflanking	0.0010	1 in 1000
	ARN E	0.0165	1 in 61
NATOMAS	NAT D	0.0150	1 in 67
	Sankey Gap	0.2070	1 in 5

3.3.4 Long-Term Risk by Index Point and Basin

Another statistic that the HEC-FDA program computes is long-term risk. Long-term risk describes the chance of flooding over a given time period, such as 30 years; HEC-FDA computes long-term risk statistics for 10-, 30-, and 50-year periods. Table 20 displays the without-project long-term risk results for each index point/basin. For each basin, the long-term risk over a 30-year period is relatively high and exceeds 25%.

Table 20: Long-Term Risk by Index Point/Basin -- Without-Project Condition

BASIN	INDEX POINT	LONG-TERM RISK		
		10 YEARS	30 YEARS	50 YEARS
ARS	ARS A	10%	27%	41%
	Outflanking	4%	11%	18%
	ARS F	27%	61%	79%
ARN	ARN A	10%	27%	41%
	Outflanking	1%	3%	4%
	ARN E	15%	39%	57%
NATOMAS	NAT D	9%	36%	52%
	Sankey Gap	90%	99%	99%

3.3.5 Assurance

Assurance, formerly known as conditional non-exceedance probability (CNP), describes the likelihood of a stream/river being able to pass a specific flow event, for example the 100-year flow. The assurance statistics provide relevant information to decision makers in that it helps describe both how well the flood system currently performs and how well the system could potentially perform under various with-project scenarios.

The assurance statistics for each index point/basin under the without-project condition are listed in Table 21 below. Taking ARS B index point as an example, the information indicates that there is an 84% assurance of passing the 4% flow event, but a lower 75% assurance of passing the 1% flow event.

Table 21: Assurance by Index Point -- Without-Project Condition

BASIN	INDEX POINT	ASSURANCE		
		4%	1%	0.2%
ARS	ARS A	93%	77%	18%
	Outflanking	99%	80%	9%
	ARS F	75%	69%	24%
ARN	ARN A	92%	75%	22%
	Outflanking	99%	98%	40%
	ARN E	90%	68%	7%
NATOMAS	NAT D	93%	84%	37%
	Sankey Gap	3%	1%	1%

CHAPTER 4
WITH-PROJECT ALTERNATIVES ANALYSES

4.1 WITH-PROJECT ANALYSIS: BASIN AS BASIC ANALYTICAL UNIT

Without-project expected annual damages were computed at eight representative index points throughout the study area. As was explained in Chapter 2, the project delivery team (PDT) selected these index points, which are located on the main flood sources, in order to be able to reasonably characterize the flood risk associated with each of the three main basins by accounting for the multiple sources of flooding in each basin.

Similarly, with-project damages reduced (benefits) associated with various project alternatives were also computed at each representative index point for each basin. If the flood risk in a basin (or any other consequence area) could be attributed to one and only one flood source, then the total benefits computed at an index point along a particular flood source would represent the benefits of building a project on that flood source. This is not the case, however, for the Common Features study area as flood risk in each basin/consequence area can be attributed to multiple flood sources. Under this scenario, benefits were computed first at each index point (source), and then estimated for the whole basin using the appropriate calculation method as determined by assessments of the hydrologic/hydraulic correlation between the flood sources within a basin. Table 22 below summarizes the methods used to estimate benefits for each basin.

It should be pointed out that while the results for the Natomas Basin are presented in some of the following tables, the Natomas Basin is not part of any alternative in the Final Array. Therefore, any potential benefits associated with improvements to the Natomas Basin are not included in the final net benefit analysis. Section 4.7 discusses the rationale for leaving out the Natomas Basin from each of the alternatives as well as the implications of this decision on residual risk in the basin.

Table 22: Method of Benefit Calculation by Basin

BASIN	INDEX POINT	METHOD USED TO ESTIMATE BENEFITS
ARS	A	Compare risk at multiple index points and use highest EAD/residual EAD to estimate benefits (A and F)
	Flanking	
	F	
ARN	A	Compute risk at multiple index points and add EADs using joint probabilities (A and E)
	Flanking	
	E	
NAT	D	Estimate benefits using single index point (D) and information from prior analysis (NPACR)
	Sankey Gap	

4.2 DESCRIPTION OF FINAL ARRAY OF ALTERNATIVES

At the start of the plan formulation process, the project delivery team (PDT) assessed an Initial Array of alternatives. This array was then narrowed down to a Focused Array of alternatives (Table 23), which

was evaluated in more detail. The alternatives in the Focused Array are described in the following paragraphs below, with the decision whether or not to carry forward each alternative into the Final Array. More detail about the Initial and Focused Arrays of Alternatives is presented in the GRR (Chapter 3).

- **Alternative 0.5** – Improve levees within the existing geometry (Minimum Plan): This alternative would incorporate levee improvements for seepage, stability and erosion but not include any levee raises or other conveyance improvements. This is considered to be the minimum amount of levee improvements needed to substantially reduce the flood risk.

- **Alternative 1** – Improve levees: Focused Alternative 1 adds levee raising to the previous alternative. Focused Alternative 1 involves the construction of in-place levee improvement measures to address seepage, slope stability, erosion, and overtopping concerns identified for the American and Sacramento River levees, NEMDC, Arcade, Dry/Robla, and Magpie Creeks.

- **Alternative 2** – Improve levees and widen Sacramento Weir and Bypass: Focused Alternative 2 adds widening of the Sacramento Weir and Bypass which negated the need to include most of the levee raising in Focused Alternative 1. It accomplished this by rerouting flow that would have gone down the Sacramento River instead to the widened Sacramento Weir and Bypass. The levees along the American River, NEMDC, Arcade, Dry/Robla, and Magpie Creeks would be improved to address identified seepage, stability, erosion, and height concerns through the methods described under Alternative 1. The levees along the Sacramento River would be improved to address identified seepage, stability, erosion, and overtopping concerns through the measures described under Alternative 1.

- **Alternative 3** – Improve levees and construct I-Street diversion structure: Focused Alternative 3 would include the construction of a diversion structure just upstream of the existing I-Street Bridge on the Sacramento River. This diversion structure would restrict flows going down the Sacramento River past the cities of Sacramento and West Sacramento, and would cause a large portion of the flows from the Sacramento and American Rivers to be forced upstream through the Sacramento Bypass out to the Yolo Bypass. The Sacramento Bypass and Weir would be widened to accommodate the increased flows to the bypass system. The effect of this diversion structure would be to reduce the water surface elevation of the Sacramento River downstream of the structure to the point at which seepage, stability, height, and erosion improvements would not be needed.

- **Alternative 4** – Upstream storage on the American River: This alternative involves construction of a flood control dam near the town of Auburn on the north fork American River for the purpose of attenuating flows continuing downstream into Folsom Reservoir and the lower American River. Additionally, levee improvements to address seepage, stability, erosion, and overtopping concerns are included where they exist in various stretches of levee protecting the city of Sacramento.

- **Alternative 5** – Maximum Plan: This alternative would reduce flood risk to the city of Sacramento and the surrounding area and would include most of the measures previously discussed, including levee improvements from Alternative 1, the Sacramento Weir and Bypass

widening of Alternative 2, the I-Street Diversion Structure from Alternative 3, and the Auburn Dam from Alternative 4.

- **Alternative 6** – Non-structural: The non-structural alternative would consist of measures such as raising or relocating structures where practical and economically feasible. Also, flood proofing critical infrastructure features and individual structures where inundation depths are lower may be an efficient means of reducing flood risk.

Table 23: Summary of Focused Array of Alternatives

Focused Alternative	Evaluation Summary	Carried Forward?
0.5. Improve Levees within Existing Geometry (Minimum Plan)	This alternative does not maximize net benefits and is on the rising portion of the net benefits curve. It was therefore dropped from further consideration.	No
1. Improve Levees	Improving the existing levees to address seepage, stability, erosion and height issues is the first increment to reducing flood risk for the Sacramento area. Because this alternative increases system performance and appears to have the highest net benefits, it was carried forward for further consideration.	Yes
2. Improve Levees & Widen Sacramento Weir and Bypass	This alternative reduces the flood risk to the urbanized area and has high net benefits and is therefore carried forward for further evaluation. This is the sponsor supported plan.	Yes
3. Improve Levees and Construct I-Street Diversion Structure	This alternative is not efficient. Does not meet worst-first implementation strategy. The implementation sequencing would leave the densely populated areas of Sacramento at risk of flooding until the end of the construction timeframe. The Yolo and Sacramento Bypass levee work would be constructed first in order to accept the higher flows associated with this alternative. Once this was completed, then work on the diversion structure itself would begin. Since no levee work is recommended on the Sacramento river levees as part of this alternative, this high risk area would remain exposed throughout implementation of the project.	No
4. Upstream Storage on American River	Construction of an upstream storage facility does not address the high frequency flood risk associated with the poor performance of levees in the study area. It also does not reduce the risk for the highest risk area along the Sacramento River since this is dominated by Sacramento River flows. All downstream levee improvements contained in Alternatives 1 and 2 would need to be included to effectively reduce the high frequency flood risk for the study area. Other alternatives offer more efficient methods to reduce the flood risk.	No
5. Maximum Plan	Other plans offer more efficient ways to reduce risk.	No
6. Non-Structural	These measures reduce the consequences of flooding, but do not reduce the probability of flooding and therefore do not significantly reduce the overall risk of flooding.	No

From this Focused Array of alternatives, the most promising alternatives were carried forward into a Final Array of alternatives. Summary descriptions of each alternative in the Final Array are presented below:

- **Alternative 1 – Fix Levees**: Alternative 1 would include the construction of levee remediation measures to address seepage, stability, erosion, and height measures identified for the Sacramento River, Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks. Alternative 1 would also include erosion measures for specific locations along the American River. Alternative 1 does not include levee raises in the Natomas Basin. (Although the results of the benefits analysis are shown in this document.)

- **Alternative 2 – Sacramento Bypass and Fix Levees:** Alternative 2 would include widening the Sacramento Weir and Bypass to divert more flows into the Yolo Bypass and reduce the need to raise levees along the Sacramento River downstream of the bypass. The levees along the American River, the Natomas East Main Drainage Canal (NEMDC), Arcade, Dry/Robla, and Magpie Creeks, would be improved to address identified seepage, stability, erosion and height concerns through some combination of repairing the levees in place (fix in place) or construction of an adjacent levee with measures to address the concerns. The levees along the Sacramento River would be improved to address identified seepage, stability, and erosion concerns through some combination of repairing the levees in place (fix in place) or construction of an adjacent levee with measures to address the concerns. Alternative 2 would also include erosion measures for specific locations along the American River. Alternative 2 does not include any levee raises in the Natomas Basin. (Although the results of the benefits analysis are shown in this document.)

4.3 WITH-PROJECT RESULTS: RESIDUAL EAD AND BENEFITS BY INDEX POINT AND ALTERNATIVE

The following tables show the without-project EAD and with-project residual EAD results computed in HEC-FDA for each index point/breach/outflanking location. The benefits shown for each alternative in each table are the damages reduced at a respective index point/breach/over flanking location, and represent the benefits to the associated basin if improvements were to occur on the source of flooding where the index point is located and if there were no other sources of flood risk. It should be pointed out that damages and benefits associated with the prevention of emergency cost losses are described and reported in Section 4.6, separately from the other categories, which are reported in Sections 4.3-4.5.

For example, in Table 24, the benefits of Alternative 1 are approximately $25.5 million. All of these benefits could be claimed if improvements to the American River (left bank) were made, and if there were no other sources of flood risk. While the first condition (improvements to the levees) would be met under this scenario, the second condition under this scenario has not yet been met – there is still flood risk from the Sacramento River. Since there is still flood risk from the Sacramento River, the full $25.5 million in benefits cannot be claimed for the entire ARS Basin. (In the next section, the benefits for each basin are estimated by considering all of the sources of flood risk in that basin.)

Tables 24 to 28 show three sets of with-project data. The first set is associated with outputs derived from improvements only to the Sacramento River levees downstream of the confluence with the American River and not from any Sacramento levee raises (Alternative 1) or the Sacramento Bypass widening (Alternative 2). This scenario only applies to the ARS F index point (Table 25), but the columns were added to the other tables for consistency purposes.

Table 24: Without-Project EAD and With-Project Residual EAD (ARS A, left bank American River)

DAMAGE CATEGORY	ARS A INDEX POINT – AMERICAN RIVER SOUTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	4,171	N/A	N/A	2,986	1,185	2,966	1,205
Commercial	15,338	N/A	N/A	11,258	4,080	11,136	4,202
Farm	30	N/A	N/A	27	3	27	3
Industrial	3,704	N/A	N/A	3,238	466	3,203	501
Public	11,760	N/A	N/A	8,402	3,358	8,338	3,422
Residential	56,327	N/A	N/A	39,900	16,427	39,664	16,663
TOTAL IP	**91,330**	N/A	N/A	**65,814**	**25,519**	**65,331**	**25,996**

Table 25: Without-Project EAD and With-Project Residual EAD (ARS F, left bank Sacramento River)

DAMAGE CATEGORY	ARS F INDEX POINT – AMERICAN RIVER SOUTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	15,080	5,474	9,606	3,084	11,996	2,997	12,083
Commercial	42,514	16,303	26,211	8,403	34,111	8,295	34,219
Farm	395	142	253	79	316	75	320
Industrial	11,197	5,090	6,107	2,051	9,146	2,053	9,144
Public	35,644	13,372	22,272	7,207	28,437	7,091	28,553
Residential	227,555	80,268	147,287	47,213	180,342	45,566	181,989
TOTAL IP	**332,383**	**120,650**	**211,733**	**68,037**	**264,346**	**66,078**	**266,305**

Table 26: Without-Project EAD and With-Project Residual EAD (ARN A, right bank American River)

DAMAGE CATEGORY	ARN A INDEX POINT – AMERICAN RIVER NORTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	2,171	N/A	N/A	1,177	994	1,260	911
Commercial	18,967	N/A	N/A	10,316	8,651	11,043	7,924
Farm	0	N/A	N/A	0	0	0	0
Industrial	5,257	N/A	N/A	2,781	2,476	2,982	2,275
Public	4,937	N/A	N/A	2,621	2,316	2,809	2,128
Residential	19,796	N/A	N/A	10,928	8,868	11,699	8,097
TOTAL IP	**51,128**	N/A	N/A	**27,823**	**23,305**	**29,793**	**21,335**

Table 27: Without-Project EAD and With-Project Residual EAD (ARN E, right bank Arcade Creek)

DAMAGE CATEGORY	ARN E INDEX POINT – AMERICAN RIVER NORTH BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	1,050	N/A	N/A	724	326	666	384
Commercial	8,416	N/A	N/A	6,280	2,136	5,866	2,550
Farm	0	N/A	N/A	0	0	0	0
Industrial	4,044	N/A	N/A	2,079	1,965	1,777	2,267
Public	2,023	N/A	N/A	1,646	377	1,523	500
Residential	10,642	N/A	N/A	7,376	3,266	6,735	3,907
TOTAL IP	**26,175**	N/A	N/A	**18,105**	**8,070**	**16,567**	**9,608**

Table 28: Without-Project EAD and With-Project Residual EAD (NAT D, left bank Natomas Cross Canal)

DAMAGE CATEGORY	NAT D INDEX POINT – NATOMAS BASIN (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS)						
	WITHOUT EAD	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALTERNATIVE 1 (FIP)		ALTERNATIVE 2 (SBW)	
		RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS	RESIDUAL EAD	BENEFITS
Autos	863	N/A	N/A	382	481	370	493
Commercial	3,294	N/A	N/A	1,511	1,783	1,469	1,825
Farm	36	N/A	N/A	19	17	18	18
Industrial	2,328	N/A	N/A	1,081	1,247	1,051	1,277
Public	2,774	N/A	N/A	1,274	1,500	1,238	1,536
Residential	19,300	N/A	N/A	8,845	10,455	8,595	10,705
TOTAL IP	**28,595**	N/A	N/A	**13,113**	**15,482**	**12,742**	**15,853**

4.4 RANGE OF BENEFITS BY INDEX POINT & ALTERNATIVE

The following tables present ranges of benefits for each alternative and at each index point. HEC-FDA computes damages reduced (benefits) at specific probabilities (25%, 50%, and 75%); the intersection of the probability and the dollar value in the table can be read as, "There is an X chance that damages reduced (benefits) exceeds Y." The benefits in these tables provide a broader picture of the possible range in benefits that may be realized considering all of the hydrologic, hydraulic, geotechnical, and economic uncertainty.

Table 29: Range of Benefits at ARS A (In $1000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	91,330	--	--	--	--	--
Alt. 1 FIP	91,330	65,814	25,519	17,001	21,266	30,223
Alt. 2 SB	91,330	65,331	25,996	16,944	21,166	30,816

Table 30: Range of Benefits at ARS F (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	332,383	--	--	--	--	--
Alt. 1 FIP	332,383	68,037	264,346	148,191	194,802	372,595
Alt. 2 SB	332,383	66,078	266,305	151,059	202,639	378,927

Table 31: Range of Benefits at ARN A (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	51,128	--	--	--	--	--
Alt. 1 FIP	51,128	27,823	23,305	8,459	17,492	34,125
Alt. 2 SB	51,128	29,793	21,335	7,281	15,667	31,414

Table 32: Range of Benefits at ARN E (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	26,175	--	--	--	--	--
Alt. 1 FIP	26,175	18,105	8,070	4,573	7,128	10,783
Alt. 2 SB	26,175	16,567	9,608	4,874	8,102	12,670

Table 33: Range of Benefits at NAT D (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

PLAN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	EXPECTED BENEFITS	PROBABILITY BENEFITS EXCEED INDICATED VALUE		
				75%	50%	25%
No action	28,595	--	--	--	--	--
Alt. 1 FIP	28,595	13,113	15,482	10,847	14,297	19,378
Alt. 2 SB	28,595	12,742	15,853	11,106	14,652	19,784

4.5 WITH-PROJECT RESULTS: BENEFITS BY BASIN AND ALTERNATIVE

Tables 34 and 35 below display the benefits of each alternative by basin. The benefit values in these tables reflect improvements made to each source of flood risk within a particular basin. For example, in the ARS Basin, FRM improvements are made to reduce risk from both the American and Sacramento Rivers. These tables reflect benefits that would be realized in a basin (i.e., in a single consequence area)

by thinking of the flood problem from a broader system perspective rather than from just individual, discrete sources of flood risk.

Table 34: Average Annual Benefits for Alternative 1 (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

BASIN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	AVERAGE ANNUAL BENEFITS
ARS	332,383 (ARS F)	68,037 (ARS F)	**264,346**
ARN	77,303 (ARN A + ARN E)	45,928 (ARN A + ARN E)	**31,375**
NATOMAS	28,595 (NAT D)	13,113 (NAT D)	**15,482**
TOTAL	438,281	127,078	**311,203**

Table 35: Average Annual Benefits for Alternative 2 (In $1,000s, October 2015 Price Level, 50-Year Period of Analysis)

BASIN	WITHOUT-PROJECT EAD	WITH-PROJECT EAD	AVERAGE ANNUAL BENEFITS
ARS	332,383 (ARS F)	66,078 (ARS F)	**266,305**
ARN	77,303 (ARN A + ARN E)	46,360 (ARN A + ARN E)	**30,943**
NATOMAS	28,595 (NAT D)	12,742 (NAT D)	**15,853**
TOTAL	438,281	125,180	**313,101**

As explained throughout the preceding sections, the benefits of FRM improvements in the study area have been computed using simplifying assumptions and simplified computations in order to make reasonable estimates using available resources, which include time, money, data, as well as software applications. Simplifications were necessary considering that the study area may flood from multiple water sources.

As an example, the method used to compute benefits for the ARS Basin was selected based on information that the American and Sacramento Rivers are moderately correlated in terms of hydrology and hydraulics. While it is believed that the method used (compute risk at multiple index points and use the highest EAD) accurately accounts for damages, residual damages, and benefits associated with the ARS Basin, it also should be noted that this may not be the most rigorous method to estimate benefits for this basin. The most rigorous method to compute benefits given the multiple-source flooding situation in the ARS Basin would be to use a model that fully represents the system and could account for various “what if” scenarios:

- What if there is a levee breach along the American River first? Would this affect the probabilities of flooding along the Sacramento River downstream of the confluence?
- What if there is a breach along the Sacramento River first? Would this affect the probabilities of flooding along the American River?
- What if there is a levee breach along both rivers at the same time?

While a true systems approach is ideal, it may not be practical until more sophisticated analytical tools are developed and tested by FRM practitioners. In the meantime, it is believed that the method used to estimate benefits for this current analysis balances rigor with practicality without sacrificing accuracy.

4.6 BENEFITS ASSOCIATED WITH THE PREVENTION OF EMERGENCY COSTS

Prevention of Emergency Cost Losses: Tables 36-39 display the without-project EAD (repeated from Section 3.3.2) and the with-project benefits achieved under each alternative and for each basin. Both Alternatives 1 and 2 reduce the frequency of flooding to Sacramento and therefore prevent a significant amount of emergency-related costs from being incurred. Under each alternative, EAD would be reduced by about 75%, or to about $16.7 million for Alternative 1 and $17.8 million for Alternative 2. Therefore the annual benefits of Alternative 1 are approximately $48.6 million and those of Alternative 2 are approximately $47.4 million. For either alternative, the prevention of clean-up and TERHA costs comprise about 13% of total benefits for the Sacramento study area.

Separately, the benefits from the prevention of emergency cost losses associated with the Tributaries increment in the ARN Basin are approximately $1.25 million (Alternative 1) and $1.45 million (Alternative 2); the benefits associated with the American River increment are approximately $3.2 million (Alternative 1) and $2.9 million (Alternative 2).

Table 36: Expected Annual Damages and Benefits – Alternative 1, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level)

Category	Without-Project			With-Project (Alternative 1)			Average Annual Benefits
	ARS Basin	ARN Basin	Total	ARS Basin	ARN Basin	Total	
Clean-UP	36,860	7,653	44,513	7,161	4,418	11,579	32,934
TERHA	17,933	2,805	20,738	3,478	1,617	5,095	15,643
Total	**54,793**	**10,458**	**65,251**	**10,639**	**6,035**	**16,674**	**48,577**

Table 37: Expected Annual Damages and Benefits – Alternative 2, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level)

Category	Without-Project			With-Project (Alternative 2)			Average Annual Benefits
	ARS Basin	ARN Basin	Total	ARS Basin	ARN Basin	Total	
Clean-UP	36,860	7,653	44,513	7,873	4,465	12,338	32,175
TERHA	17,933	2,805	20,738	3,839	1,627	5,466	15,272
Total	**54,793**	**10,458**	**65,251**	**11,712**	**6,092**	**17,804**	**47,447**

Table 38: Expected Annual Damages and Benefits – Alternative 1, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level) Separated by American River and Tributaries Increments

Category	Without-Project			With-Project (Alternative 1)			Average Annual Benefits
	American River (ARN Basin)	Tributaries (ARN Basin)	Total	American River (ARN Basin)	Tributaries (ARN Basin)	Total	
Clean-UP	5,088	2,565	7,653	2,738	1,680	4,418	3,235
TERHA	1,805	1,000	2,805	978	639	1,617	1,188
Total	**6,892**	**3,565**	**10,458**	**3,717**	**2,319**	**6,035**	**4,423**

Table 39: Expected Annual Damages and Benefits – Alternative 2, ARCF Clean-Up and TERHA Costs (In $1,000s, October 2015 Price Level) Separated by American River and Tributaries Increments

Category	Without-Project			With-Project (Alternative 2)			Average Annual Benefits
	American River (ARN Basin)	Tributaries (ARN Basin)	Total	American River (ARN Basin)	Tributaries (ARN Basin)	Total	
Clean-UP	5,088	2,565	7,653	2,931	1,534	4,465	3,188
TERHA	1,805	1,000	2,805	1,048	579	1,627	1,178
Total	**6,892**	**3,565**	**10,458**	**3,980**	**2,113**	**6,092**	**4,366**

4.7 NATOMAS BASIN – NO ADDITIONAL IMPROVEMENTS (LEVEE RAISES) RECOMMENDED

The Natomas Basin had largely been an agricultural area until recent times. After having been given assurances that the levees provided adequate flood protection, residential and commercial development increased in this area in the late 1990s and mid 2000s. Subsequent investigations and signs of levee distress during high flows have shown that the area is still at significant risk of flooding. Further flood risk reduction is needed, not only to meet the FEMA regulatory requirements, but also to meet the State of California requirement for 200-year level of protection for urban areas. The Natomas 2010 PAC report includes recommendations for Federal involvement in flood risk reduction through levee improvements which would provide a 1 in 67 annual exceedence probability (a 1 in 67 chance of being exceeded in any given year). These recommendations were authorized by WRRDA 2014. State and local agencies implemented improvements to more than a third of the perimeter levee system in advance of the Federal authorization. Some of those improvements were previously approved for consideration for credit under Section 104 (WRDA 1986). This GRR considered further flood risk reduction features (levee raises) for the Natomas Basin.

Initially assessments of both of the final alternatives included additional flood risk reduction for the Natomas Basin in the form of levee raises. The final alternatives included measures that would attain FEMA level accreditation as well as meet the State of California's requirement for 200 year level of protection for urban areas. The Administration has concerns with USACE projects enabling growth in floodplains. This additional growth would increase the consequences of flooding within the Basin and therefore increase the future flood risk. In fact, a preliminary assessment completed for the 2010 Natomas PACR (2010 Natomas Post-Authorization Change and Interim GRR, Economic Appendix H, Attachment 8) indicated that by the year 2035 there could be an additional 40,000 people and 16,000 structures worth about $6 billion located in the Basin, which would translate into additional flood damages of approximately $3.3 billion from a 1% annual chance exceedance (ACE) event. Discussions with the project partners determined that, in light of ongoing locally-driven regional planning efforts that are investigating regional-scale flood risk reduction measures to deal with large flood events, this ARCF GRR would not make further recommendations for the Natomas Basin. This is because the other local regional planning efforts could recommend implementation of other measures that would render levee raises around the Natomas Basin unnecessary.

Raising levees around the Natomas Basin is a separate element common to both of the action alternatives in the final array. As such, removal of those features from both alternatives does not change the identification of the NED Plan. Therefore, as a final step following plan comparison, the final array of alternatives was reformulated to remove the Natomas levee raise features.

4.8 BENEFITS OUTSIDE THE IMMEDIATE STUDY AREA: CITY OF WEST SACRAMENTO

Widening the Sacramento Bypass (Alternative 2) provides benefits to the city of West Sacramento, which is located on the right bank (west side) of the Sacramento River adjacent to the confluence with the American River and directly across the river from the city of Sacramento. The benefits are achieved through lower flows and stages in the Sacramento River downstream of the Sacramento Bypass, effectively decreasing the computed frequency of flooding from the Sacramento River into the city of West Sacramento and thereby reducing expected annual damages from flooding along the Sacramento River. However, these potential benefits are not effectively realized because the highest damages within the West Sacramento study area are instead driven by flooding coming from the Yolo Bypass, which does not see any decrease in water surface elevation from widening of the Sacramento Bypass.

A General Reevaluation Report (GRR) is currently being completed for the West Sacramento area.

4.9 WITH-PROJECT PERFORMANCE RESULTS: AEP, LONG-TERM RISK, & ASSURANCE

Tables 40 to 42 present the performance statistics under both without-project and with-project conditions for each index point, basin, and alternative.

The AEP values under with-project conditions indicate that each alternative provides significant risk reduction in terms of the chance of flooding in any given year. For example, in the ARS Basin, without-project AEP is about 1 in 32 (1 in 97 for ARS A on American River and 1 in 32 for ARS F on Sacramento River). With improvements made to both risk sources, flood risk is reduced to about a 1 in 135 (Alternative 1) and 1 in 147 (Alternative 2).

The long-term risk statistics indicate that the chance of flooding over a certain time period is also reduced. In the ARS Basin, the chance of flooding over a 10-year and 30-year period improves significantly with a project in place, while in the ARN Basin this improvement isn't as great. Like the ARS Basin, the Natomas Basin would also experience a significant reduction in long-term risk with levee improvements.

Table 40: AEP -- Without-Project and With-Project Conditions

BASIN	INDEX POINT	ANNUAL EXCEEDANCE PROBABILITY (AEP)			
		WITHOUT	FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)	ALT. 1 (WITH SAC RAISES)	ALT. 2 SBW
ARS	ARS A	0.0103	0.0051	0.0051	0.0051
	Flanking	0.0033	--	--	--
	ARS F	0.0310	0.0104	0.0074	0.0068
ARN	ARN A	0.0104	0.0055	0.0055	0.0058
	Flanking	0.0009	--	--	--
	ARN E	0.0165	0.0165	0.0050	0.0039

Table 41: Long-Term Risk -- Without-Project and With-Project Conditions

BASIN	INDEX POINT	LONG-TERM RISK							
		WITHOUT		FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)		ALT. 1 (WITH SAC RAISES)		ALT. 2 SBW	
		10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS	10 YEARS	30 YEARS
ARS	ARS A	13%	27%	5%	14%	5%	14%	5%	13%
	Flank.	3%	10%	--	--	--	--	--	--
	ARS F	27%	61%	10%	27%	7%	20%	7%	18%
ARN	ARN A	10%	27%	5%	15%	5%	15%	5%	16%
	Flank.	1%	3%	--	--	--	--	--	--
	ARN E	15%	39%	5%	14%	5%	14%	4%	11%

Table 42: Assurance -- Without-Project and With-Project Conditions

BASIN	INDEX POINT	ASSURANCE BY EXCEEDANCE PROBABILITY EVENT											
		WITHOUT			FIX SAC RIVER LEVEES ONLY (BELOW CONFLUENCE WITH AMERICAN)			ALT. 1 (WITH SAC RAISES)			ALT. 2 SBW		
		4%	1%	.2%	4%	1%	.2%	4%	1%	.2%	4%	1%	.2%
ARS	ARS A	93%	77%	18%	98%	91%	31%	98%	91%	31%	98%	91%	32%
	Flank.	99%	84%	6%	--	--	--	--	--	--	--	--	--
	ARS F	75%	69%	24%	95%	94%	36%	95%	95%	89%	95%	95%	81%
ARN	ARN A	92%	75%	22%	99%	90%	24%	99%	90%	24%	98%	89%	22%
	Flank.	99%	98%	40%	--	--	--	--	--	--	--	--	--
	ARN E	90%	68%	7%	99%	94%	23%	99%	94%	23%	99%	95%	28%

4.10 SCREENING-LEVEL COST ESTIMATES: BY ALTERNATIVE, BASIN, & SOURCE OF FLOOD RISK

Preliminary, screening-level cost estimates were provided by the District's Cost Engineering Section. Detailed costs were provided in several formats; the costs broken out by stream/river were used for this economic analysis and are summarized in Tables 43 and 44 below. In addition to project first costs, interest during construction (IDC), which is an economic cost, was also factored into the net benefit/BCR analyses. Information regarding the construction period (number of years) and the construction schedule for each alternative was provided by the Civil Design and used to compute IDC on an annual basis. The construction period for both Alternatives 1 and 2 are estimated to be 10 years; the construction schedules for each alternative identifies the timing of the improvements by reach and by year. The Total Project Cost Summaries (TPCS) for Alternatives 1 and 2 are shown in Attachment 2 and more detailed reach-by-reach cost estimates and schedules can be found in the Cost Engineering Appendix.

Table 43: Alternative 1 -- Costs

BASIN	ALTERNATIVE 1: FIX IN PLACE (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.125% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS[1]	IDC[2]	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	260,439	68,565	329,004	13,092	N/A	13,092
	Sacramento	677,122	127,289	804,411	32,010	N/A	32,010
	Sac Raises	61,088	13,948	75,036	2,986	N/A	2,986
	Total Basin	**998,649**	**209,803**	**1,208,452**	**48,088**	N/A	**48,169**
ARN	American	139,076	22,540	161,616	6,431	N/A	6,431
	Tributaries[3]	198,030	22,379	220,409	8,771	N/A	8,771
	Total Basin	**337,106**	**44,919**	**382,025**	**15,202**	N/A	**15,202**
GRAND TOTAL	**All Basins**	**1,335,755**	**254,722**	**1,590,477**	**63,290**	**286**	**63,576**

[1] Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per USACE policy
[2] Interest During Construction
[3] Includes Arcade, Dry, and Robla Creeks and the Natomas East Main Drainage Canal (NEMDC)

Table 44: Alternative 2 -- Costs

BASIN	ALTERNATIVE 2: SACRAMENTO BYPASS WIDENING (IN $1,000s, OCTOBER 2015 PRICE LEVEL, 50-YEAR PERIOD OF ANALYSIS, 3.125% DISCOUNT RATE)						
	RISK SOURCE	FIRST COSTS[1]	IDC[2]	TOTAL COSTS	AVERAGE ANNUAL COSTS (AAC)	O&M	TOTAL AAC
ARS	American	262,447	69,096	331,543	13,193	N/A	13,193
	Sacramento	677,122	127,289	804,411	32,010	N/A	32,010
	Sac Bypass	278,527	67,601	346,128	13,773	N/A	13,773
	Total Basin	**1,218,096**	**263,986**	**1,482,082**	**58,976**	N/A	**58,976**
ARN	American	140,151	22,714	162,865	6,481	N/A	6,481
	Tributaries[3]	199,266	22,530	221,796	8,826	N/A	8,826
	Total Basin	**339,417**	**45,244**	**384,661**	**15,307**	N/A	**15,307**
GRAND TOTAL	**All Basins**	**1,557,513**	**309,230**	**1,866,743**	**74,283**	**494**	**74,777**

[1] Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per UACE policy
[2] Interest During Construction
[3] Includes Arcade, Dry, and Robla Creeks and the Natomas East Main Drainage Canal (NEMDC)

4.11 NET BENEFIT AND BENENFIT-TO-COST ANALYSES: PERFORMED INCREMENTALLY BY SOURCE OF FLOOD RISK & BASIN

Incremental net benefit/benefit-to-cost analyses were performed for each basin using the major sources of flood risk within a basin as the incremental unit. The cost information presented in Tables 43 and 44 was used to perform the analyses, which are presented in Tables 45 and 46 for the ARS and ARN Basins, respectively. The incremental analysis includes damages and benefits associated with structures, contents, automobiles, and emergency cost losses.

In the ARS Basin, addressing both sources of risk (in tandem) as part of an overall system is necessary in order to significantly reduce risk to the basin as a whole. Without addressing improvements to both the Sacramento and American Rivers, the ARS Basin, which includes downtown Sacramento and the state government buildings, still faces a significant level of risk in terms of the chance of flooding and consequences of flooding. O&M Costs are not included in the incremental analysis because they are negligible and will not affect the result.

Table 45: Incremental Net Benefit and Benefit-to-Cost Analyses for Alternatives 1 and 2 in ARS Basin (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Increment	Without-Project EAD/Resid EAD	Increm. Average Annual Benefits (AAB)	Cumulat. AAB	Increm. Average Annual Costs (AAC)	Cumulat. AAC	Increm. Net Benefits	Cumulat. Net Benefits	Increm. Benefit-to-Cost Ratio (BCR)	Cumalat. BCR
Alternative 1: Fix in Place (FIP)									
0 -- No Action	387,175	0	0	0	0	0	0	N/A	N/A
1 -- Fix Sac River	140,076	247,099	247,099	32,010	32,010	215,089	215,089	7.7	7.7
2a – Raise Sac River	105,859	34,217	281,316	2,986	34,996	31,231	246,320	11.5	8.0
2b – Fix American River	78,675	27,184	308,500	13,092	48,088	14,092	260,412	2.1	6.4
Total	N/A	308,500	308,500	48,088	48,088	260,412	260,412	6.4	6.4
Alternative 2: Sacramento Bypass Widening (SBW)									
0 -- No Action	387,175	0	0	0	0	0	0	N/A	N/A
1 -- Fix Sac River	140,076	247,099	247,099	32,010	32,010	215,089	215,089	7.7	7.7
2a – Widen Sac Bypass	105,859	34,217	281,316	13,773	45,783	20,444	235,533	2.5	6.1
2b – Fix American River	77,790	28,070	309,386	13,193	58,976	14,877	250,410	2.1	5.2
Total	N/A	309,386	309,386	58,976	58,976	250,410	250,410	5.2	5.2

Walking through the incremental analysis, Table 45 shows the first increment, under both alternatives, as being improving the Sacramento River levees (but no levee raises under Alternative 1 and no widening of the Sacramento Bypass under Alternative 2). Following improvements to the Sacramento River (fix levees under both Alternatives 1 and 2) the next logical step according to the results of the HEC-FDA analysis would be to address either the raise on the Sacramento River or the widening of the Sacramento Bypass, where AEP and residual damages are the next highest. Once these improvements are made, the American River levees would be improved.

It should be pointed out that this planning-level economic analysis indicates that improvements to the American River would be completed after (or in tandem with) either the Sacramento River levee raises (Alt 1) or Sacramento Bypass widening (Alt 2) in order for the ARS Basin to realize its full benefits from either the levee raises or bypass widening.

Table 46: Incremental Net Benefit and Benefit-to-Cost Analyses for Alternatives 1 and 2 in ARN Basin (Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Increment	Without-Project EAD/Resid EAD	Increm. Average Annual Benefits (AAB)	Cumulat. AAB	Increm. Average Annual Costs (AAC)	Cumulat. AAC	Increm. Net Benefits	Cumulat. Net Benefits	Increm. Benefit-to-Cost Ratio (BCR)	Cumalat. BCR
Alternative 1: Fix in Place (FIP)									
0 -- No Action	87,762	0	0	0	0	0	0	N/A	N/A
1 -- Fix American	61,280	26,482	26,482	6,431	6,431	20,051	20,051	4.1	4.1
2 -- Fix Creeks	51,964	9,316	35,798	8,771	15,202	545	20,596	1.1	2.4
Total	N/A	35,798	35,798	15,202	15,202	20,596	20,596	2.4	2.4
Alternative 2: Sacramento Bypass Widening (SBW)									
0 -- No Action	87,762	0	0	0	0	0	0	N/A	N/A
1 -- Fix American	63,513	24,249	24,249	6,481	6,481	17,768	17,768	3.7	3.7
2 -- Fix Creeks	52,453	11,060	35,309	8,826	15,307	2,234	20,002	1.3	2.3
Total	N/A	35,309	35,309	15,307	15,307	20,002	20,002	2.3	2.3

One point of interest is the Creeks increment in the ARN Basin. While Table 46 indicates that this increment is only marginally justified (i.e., it has a BCR of 1.1 for Alt 1), the proposed improvements help to significantly reduce the residual risk to a basin where risk to human life is high.

Additionally, the increment is further justified in the Federal Interest with a social justice argument. The area receiving benefit from the Creeks increment represents one of the most impoverished locations in Sacramento County.[4] In fact, the median family income in Sacramento is more than 50 percent higher than the median family income of the affected area ($55,064 compared to $35,828); the poverty rate in the affected area is 64 percent higher that of the surrounding county (29.0% compared to 17.6%). Within some parts of the affected area more than one in three family's live below the poverty line (34.1% in zip code 95815). Furthermore, these high rates of poverty are strongly correlated with disabilities, lack of car ownership and other factors that increase life safety hazards. In the absence of this justified increment, the flood risks for this area would change very little, thereby putting this community at a further disadvantage relative to neighboring communities in the study area.

Net benefit/benefit-to-cost analyses for Alternative 1 and Alternative 2 are summarized in Tables 47 and 48 below. The calculations were performed using the information from the previous tables.

[4] The above analysis is based on the US Census Bureau 2009-2013 American Community Survey comparing Sacramento County to the zip codes most closely associated with the area affected by the increment (95815 and 95838).

Table 47: Final Net Benefits and Benefit-to-Cost Ratio – Alternative 1 (Dollar Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Alternative 1	
Without-Project Damages and With-Project Benefits	
Without-Project Expected Annual Damages (EAD)	
ARS Basin – Structures/Contents/Autos	332,383
ARS Basin – Emergency Costs	54,793
ARN Basin – Structures/Contents/Autos	77,303
ARN Basin – Emergency Costs	10,458
Total	**474,937**
With-Project Residual EAD	
ARS Basin – Structures/Contents/Autos	68,037
ARS Basin – Emergency Costs	10,639
ARN Basin – Structures/Contents/Autos	45,928
ARN Basin – Emergency Costs	6,035
Total	**130,639**
Average Annual Benefits (AAB)	
ARS Basin – Structures/Contents/Autos	264,346
ARS Basin – Emergency Costs	44,154
ARN Basin – Structures/Contents/Autos	31,375
ARN Basin – Emergency Costs	4,423
Total AAB	**344,298**
Costs	
Total First Costs[1]	1,335,755
Interest During Construction (IDC)	254,722
Total Costs	1,590,477
Average Annual Costs (AAC)	63,290
O&M Costs	286
Total AAC	**63,576**
Net Benefit and BCR Analyses	
Net Benefits	**280,722**
Benefit-to-Cost Ratio (BCR)	**5.4**

[1] Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per USACE policy

Table 48: Final Net Benefits and Benefit-to-Cost Ratio – Alternative 2 (Dollar Values in $1,000s, October 2015 Price Level, 50-Year Period of Analysis, 3.125% Discount Rate)

Alternative 2	
Without-Project Damages and With-Project Benefits	
Without-Project Expected Annual Damages (EAD)	
ARS Basin – Structures/Contents/Autos	332,383
ARS Basin – Emergency Costs	54,793
ARN Basin – Structures/Contents/Autos	77,303
ARN Basin – Emergency Costs	10,458
Total	**474,937**
With-Project Residual EAD	
ARS Basin – Structures/Contents/Autos	66,078
ARS Basin – Emergency Costs	11,712
ARN Basin – Structures/Contents/Autos	46,360
ARN Basin – Emergency Costs	6,092
Total	**130,242**
Average Annual Benefits (AAB)	
ARS Basin – Structures/Contents/Autos	266,305
ARS Basin – Emergency Costs	43,081
ARN Basin – Structures/Contents/Autos	30,943
ARN Basin – Emergency Costs	4,366
Total AAB	**344,695**
Costs	
Total First Costs[1]	1,557,513
Interest During Construction (IDC)	309,230
Total Costs	1,866,743
Average Annual Costs (AAC)	74,283
O&M Costs	494
Total AAC	**74,777**
Net Benefit and BCR Analyses	
Net Benefits	**269,918**
Benefit-to-Cost Ratio (BCR)	**4.6**

[1]Costs associated with cultural resource preservation ($8.237M) excluded from economic analysis as per USACE policy

4.12 NED OPTIMIZATION – LEVEE RAISES FOR ALTERNATIVE 1

Two alternative levee heights were evaluated to verify that the NED levee scale was properly identified.

The HEC-FDA model was used to assess a lower levee raise on the Sacramento River in the American River South (ARS) basin and to see how a lower raise would affect the benefits for Alternative 1. Currently, Alternative 1 includes raising levees in order to contain the 200-year water surface elevation (WSEL) plus 3 feet, which is equivalent to about a 1.8-foot levee height increase at the index point location (ARS F) used to model the levee raise. The analysis assessed a lower, 0.9-foot levee raise, or about one-half the height of Alternative 1's 1.8-foot raise (equivalent). The results of the analysis indicate that a lower levee raise would result in about a $21 million reduction in benefits, far outweighing the potential reduction in costs (which could not be more than about a $3.7 million

reduction, in average annual terms, since this is the estimate for the current levee raise), indicating that net benefits are lower for a 0.9-foot levee raise than for the current 1.8-foot levee raise (equivalent). Additionally, higher levee raises (i.e., higher than the 200-year plus 3 feet WSEL, at ARS F) on the Sacramento River in the ARS basin (e.g., raises to contain the 0.2% ACE event) would not make sense since any incremental benefit would likely be off-set by damages caused from flooding (outflanking) from the upstream, non-leveed reaches of the American River.

4.13 IDENTIFICATION OF NATIONAL ECONOMIC DEVELOPMENT (NED) PLAN

Based on the analysis presented above, both Alternative 1 and Alternative 2 provide positive net benefits. While the benefits for each alternative are very similar and are essentially equal from a risk and uncertainty perspective, it is clear that Alternative 1 would be considered the NED Plan given that it costs approximately $222 million less (first costs) than Alternative 2.

American River Common Features GRR
Attachments to Economic Appendix

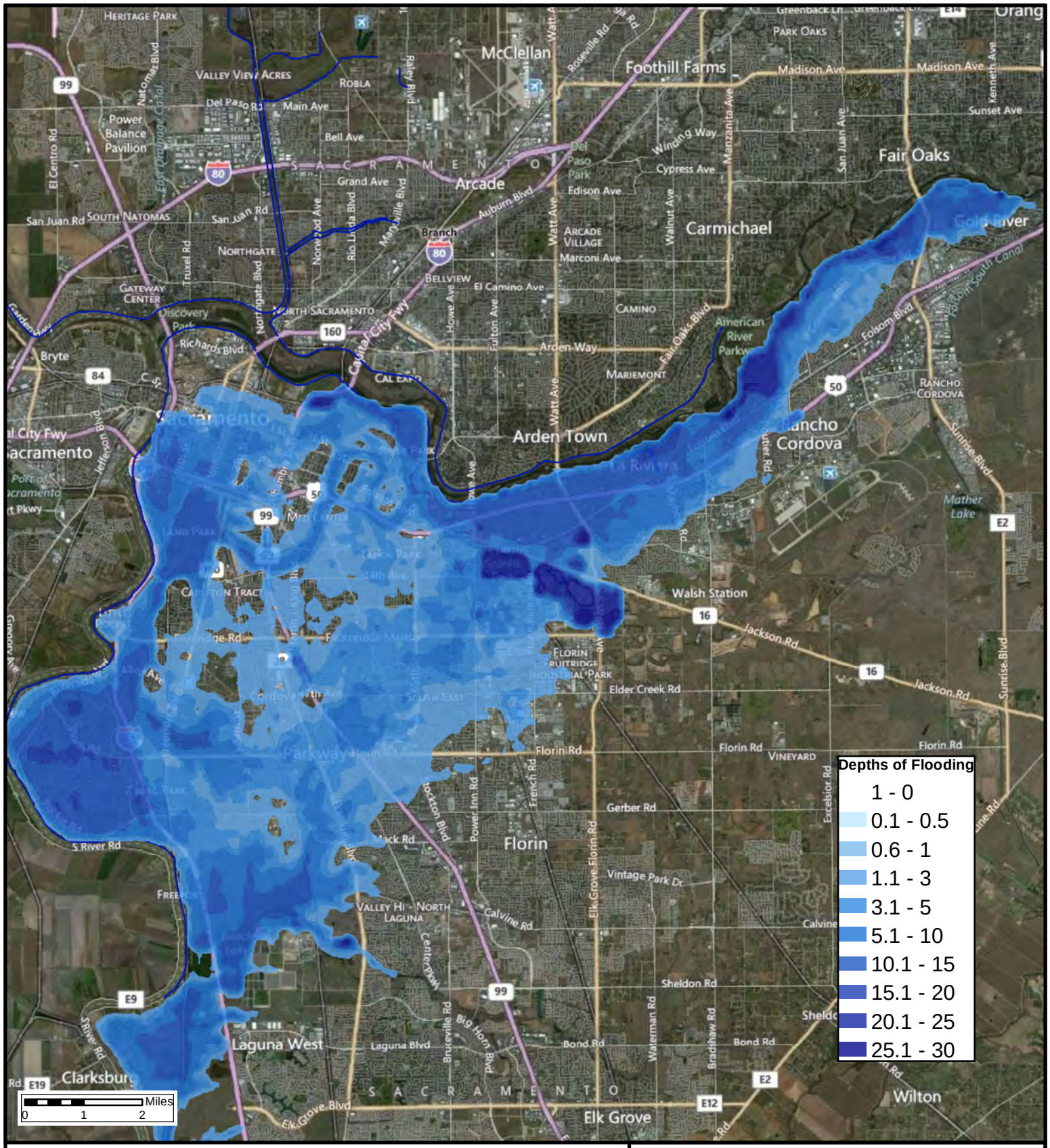
Attachment 1 - Supporting Data (Floodplain Plates, HEC-FDA Input Data)

Attachment 2 – Certified Cost Estimates

Attachment 3 - Other Social Effects (OSE) & Regional Economic Development (RED) Analyses

American River Common Features GRR
Attachments to Economic Appendix

Attachment 1 - Supporting Data (Floodplain Plates, HEC-FDA Input Data)



Legend

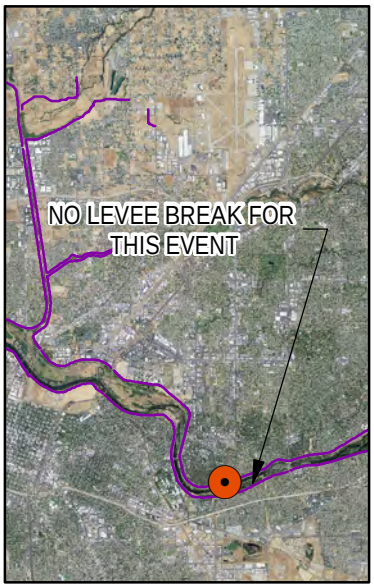
— ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Residual Flooding From Channel Outflanking Into The American River South Basin

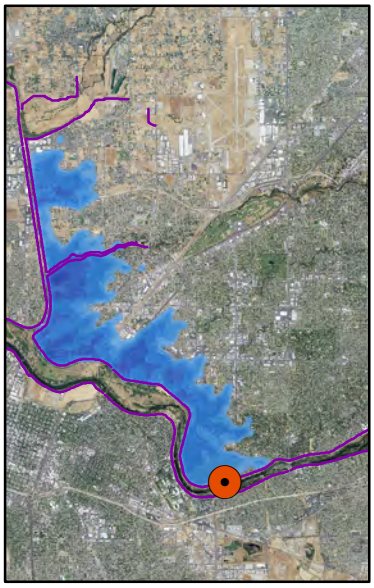
U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013



50% (1/2) ACE

10% (1/10) ACE



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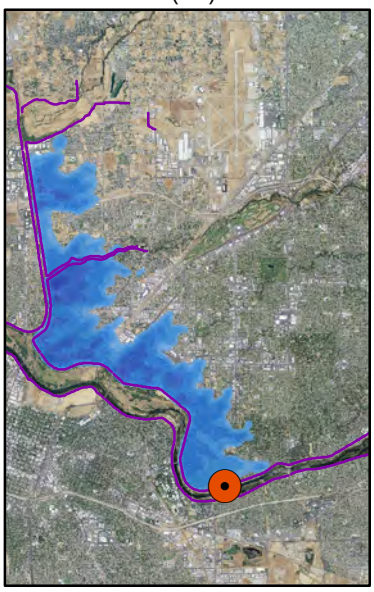

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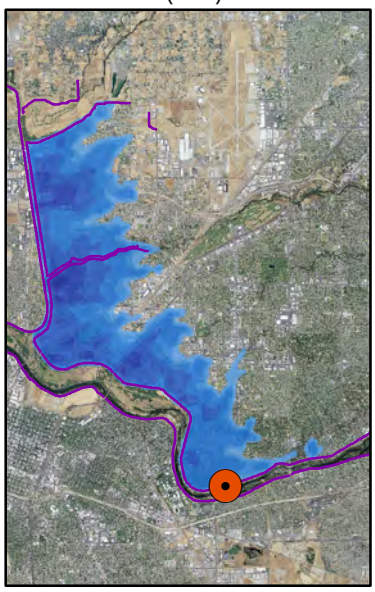

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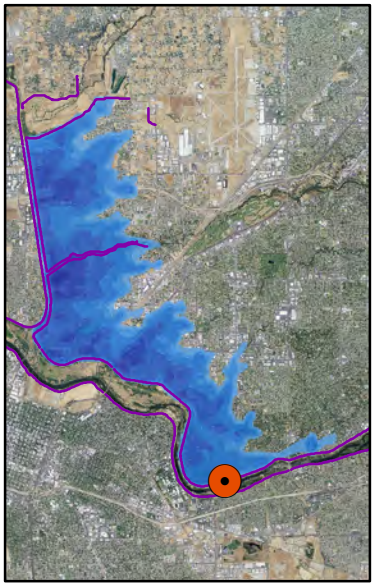
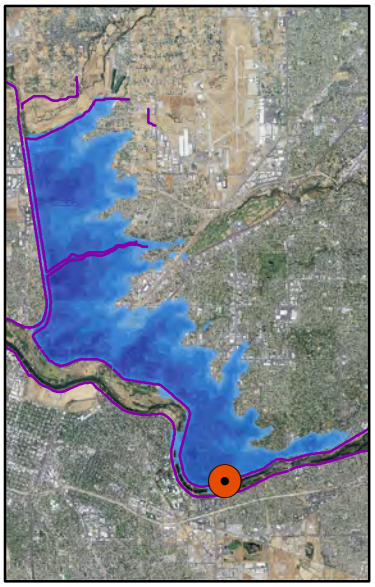


0.5% (1/200) ACE



0.2% (1/500) ACE

Legend

Depths of Flooding (Feet)

- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30

N

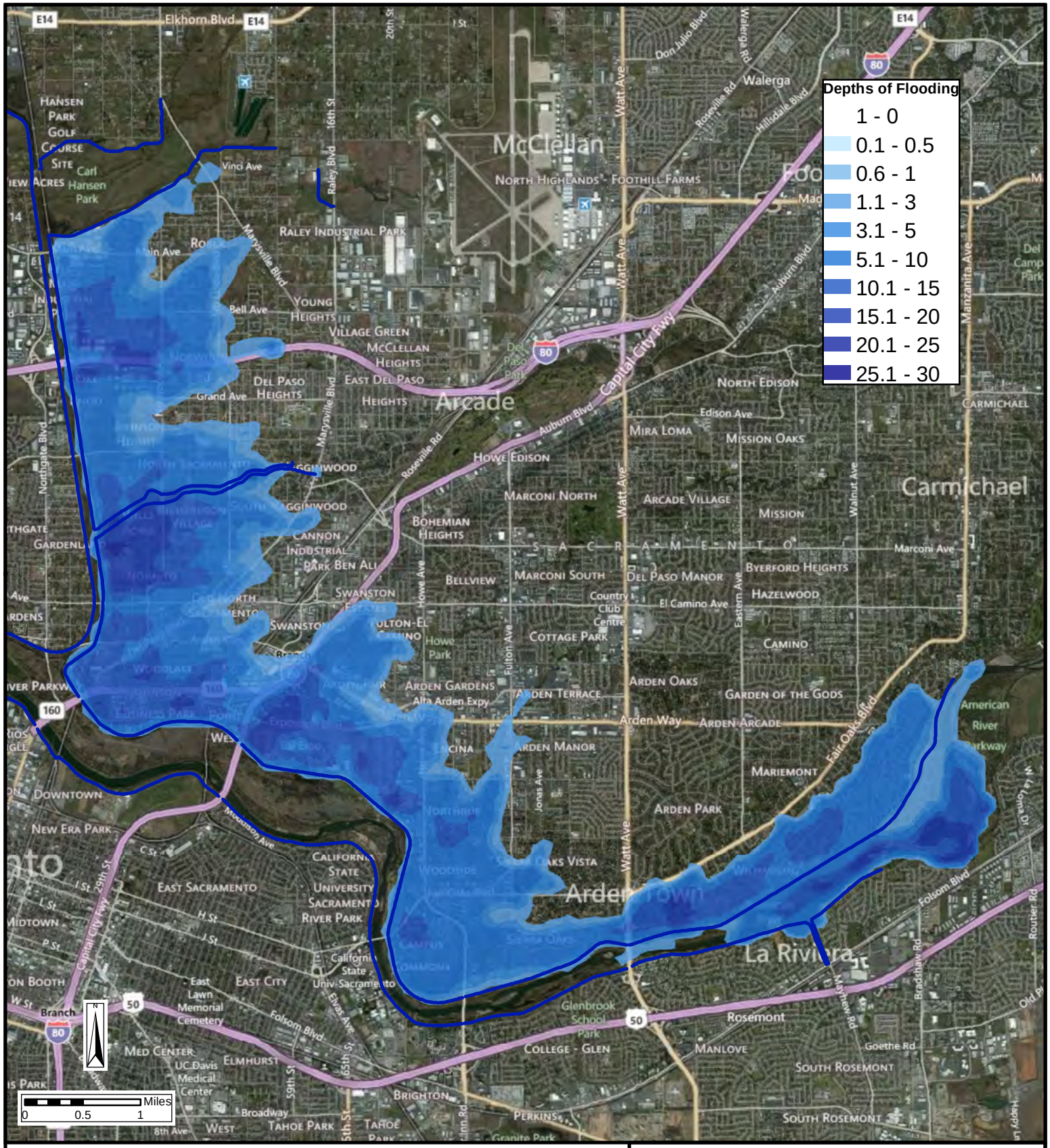
0 1.5 3 Miles

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Economic Floodplains Based on a Levee Breach Simulation American River North Index Pt A.

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Jan 2013



Legend

ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Residual Flooding From Upstream Channel Outflanking Into The American River Basin

U.S. ARMY CORPS OF ENGINEERS
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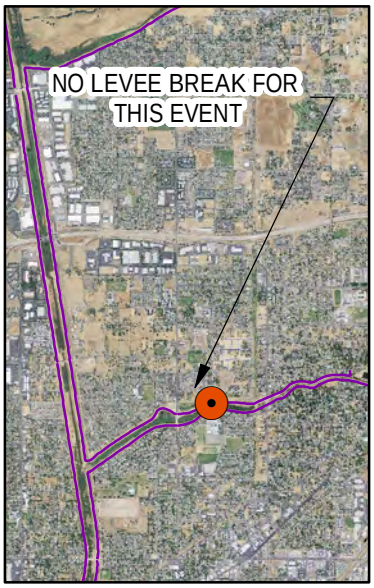
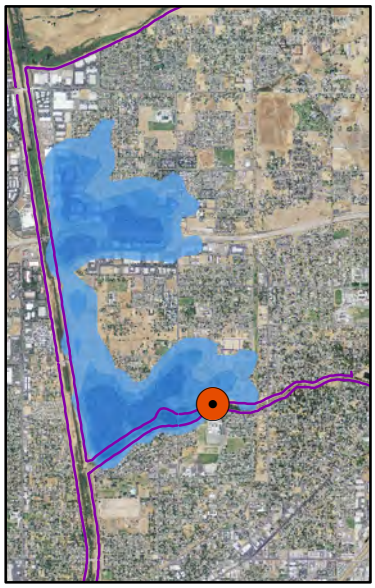
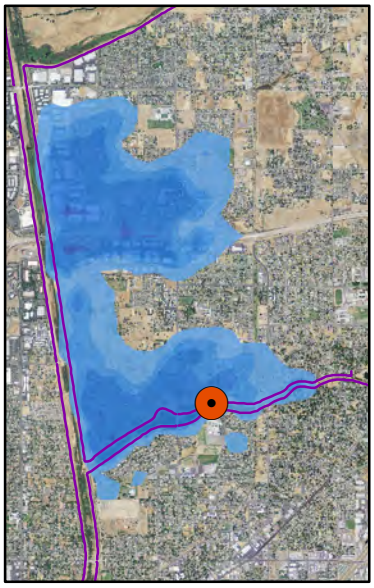
Jan 2013



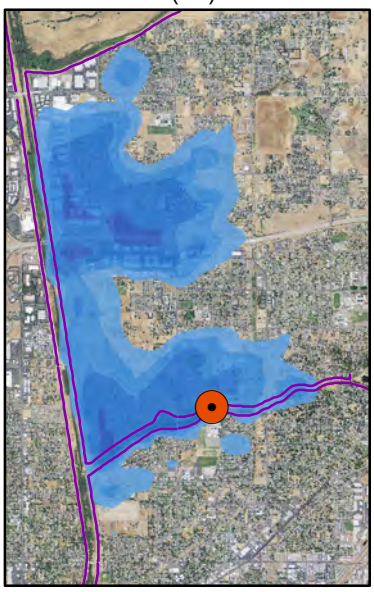
50% (1/2) ACE



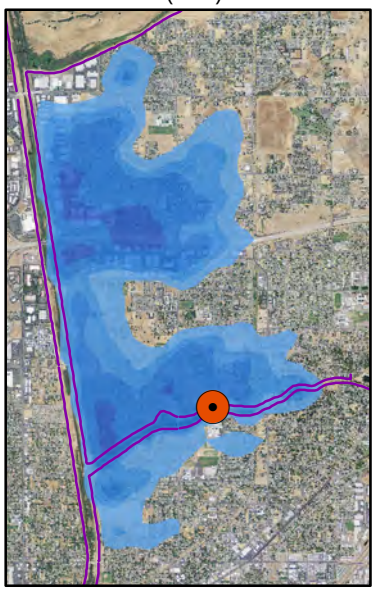
10% (1/10) ACE



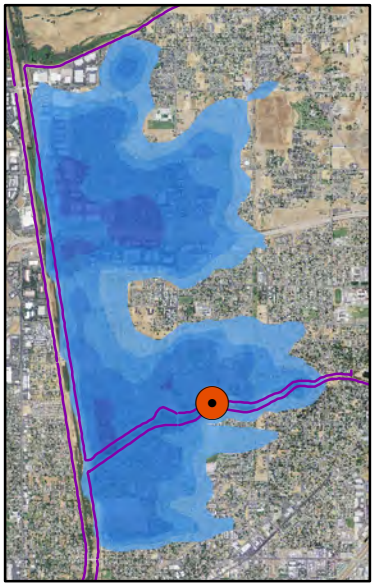
10% (1/25) ACE



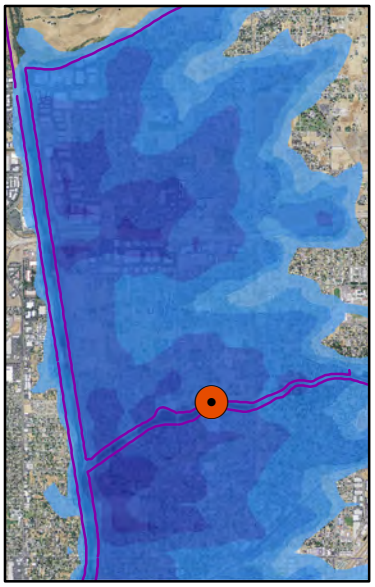
2% (1/50) ACE



1% (1/100) ACE



0.5% (1/200) ACE



0.2% (1/500) ACE

Legend

Depths of Flooding (Feet)

- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30

N

Miles

0 0.55 1.1

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Economic Floodplains Based on a Levee Breach Simulation American River North Index Pt E.

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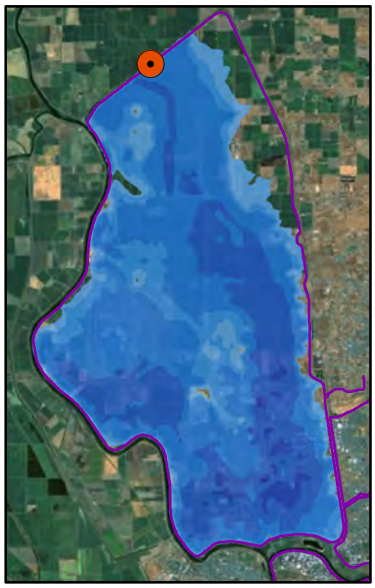
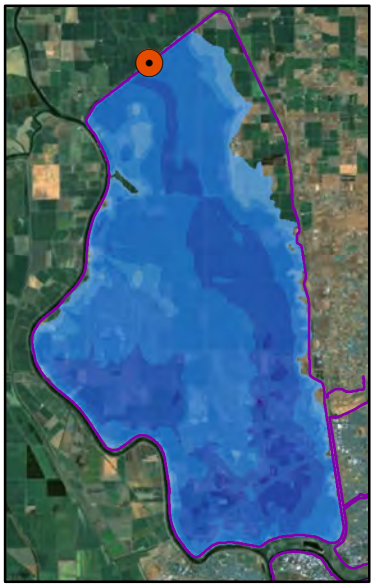
Jan 2013

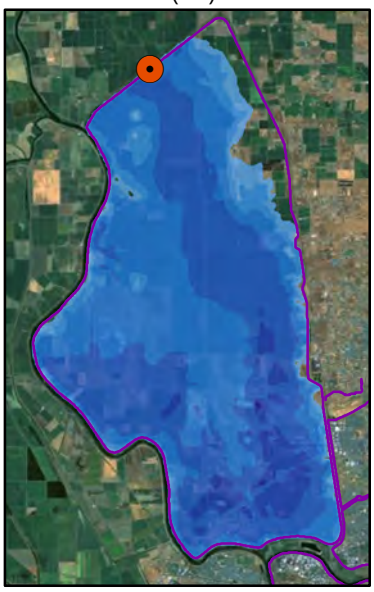
50% (1/2) ACE



10% (1/10) ACE



4% (1/25) ACE



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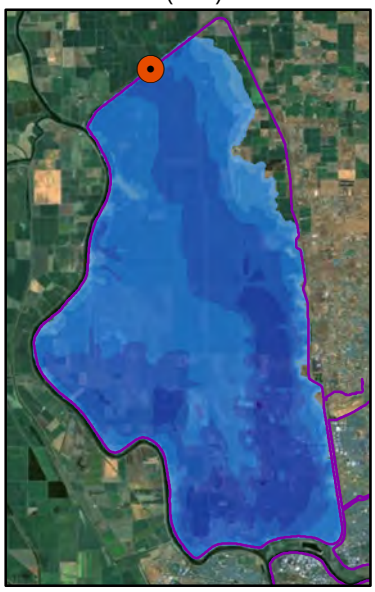
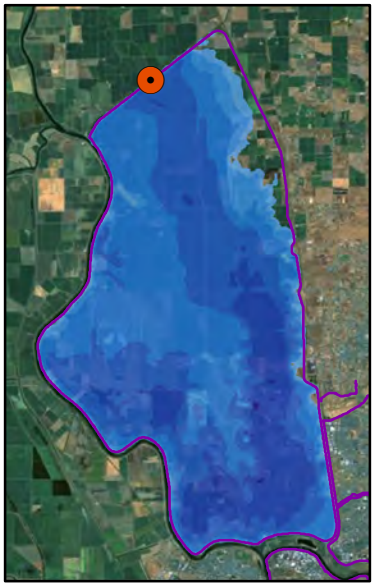


1% (1/100) ACE



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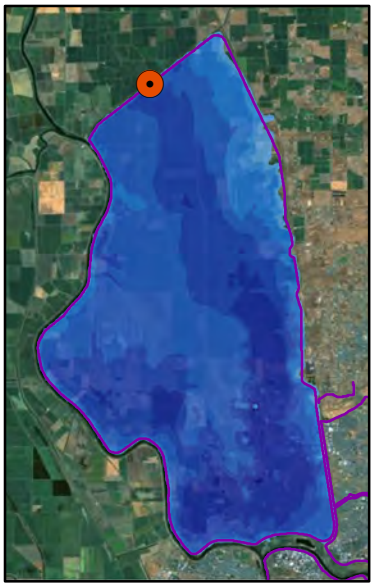

0.2% (1/500) ACE

Legend

Depths of Flooding (Feet)

- 0.1 - 0.5
- 0.6 - 1
- 1.1 - 3
- 3.1 - 5
- 5.1 - 10
- 10.1 - 15
- 15.1 - 20
- 20.1 - 25
- 25.1 - 30

N

Miles

0 2.5 5

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Economic Floodplains Based on a Levee Breach Simulation Natomas Basin Index Pt D.

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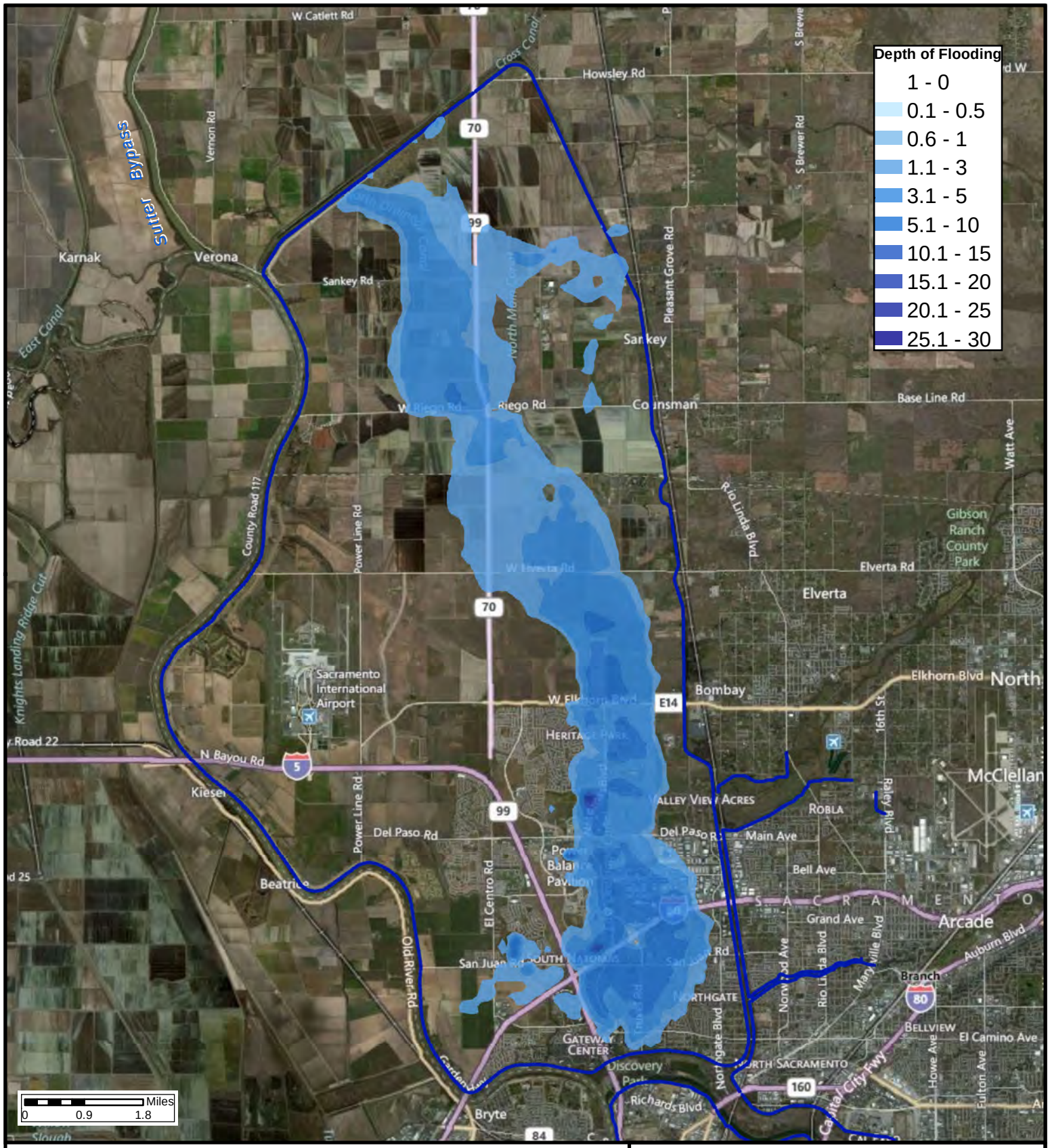
SACRAMENTO DISTRICT



Legend

ARCF Levees

AMERICAN RIVER COMMON FEATURES GRR
SACRAMENTO, CALIFORNIA

Residual Flooding From Sankey Gap Into The Natomas Basin

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SACRAMENTO DISTRICT

Jan 2013

ACF_JFP_RAISE

ARS

ARS_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1423	24.05
2yr = .5	25977	31.85
10yr = .1	71654	41.98
25yr = .04	114993	48.01
50yr = .02	115000	48.07
100yr = .01	114999	48.15
200yr = .005	159995	53.22
500yr = .002	254357	58.1

ARS_F

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	52823	11.05
2yr = .5	94600	20.75
10yr = .1	100687	26.42
25yr = .04	115395	29.04
50yr = .02	118141	29.63
100yr = .01	121788	30.3
200yr = .005	133200	32.03
500yr = .002	152523	33.87

~~ARS~~

~~ARS_B~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~1423~~	~~20.81~~
~~2yr = .5~~	~~25916~~	~~28.61~~
~~10yr = .1~~	~~71643~~	~~33.34~~
~~25yr = .04~~	~~114968~~	~~37.42~~
~~50yr = .02~~	~~114993~~	~~37.74~~
~~100yr = .01~~	~~114999~~	~~38.14~~
~~200yr = .005~~	~~144997~~	~~40.45~~
~~500yr = .002~~	~~195807~~	~~44.79~~

~~ARS_E~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~52823~~	~~10.25~~
~~2yr = .5~~	~~94629~~	~~22.55~~
~~10yr = .1~~	~~100691~~	~~28.52~~
~~25yr = .04~~	~~115549~~	~~31.21~~
~~50yr = .02~~	~~118171~~	~~31.79~~
~~100yr = .01~~	~~121790~~	~~32.46~~
~~200yr = .005~~	~~130638~~	~~33.89~~
~~500yr = .002~~	~~148615~~	~~35.79~~

ARN

ARN_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1690	23.25
2yr = .5	25968	31.05
10yr = .1	71653	40.47
25yr = .04	114992	46.57
50yr = .02	114999	46.65
100yr = .01	115000	46.74
200yr = .005	144996	49.96
500yr = .002	243028	56.28

ARN_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	26.92
2yr = .5	-	30.02
10yr = .1	-	33.02
25yr = .04	-	35.37
50yr = .02	-	37.77
100yr = .01	-	39.15
200yr = .005	-	41.46
500yr = .002	-	46.22

NAT

NAT_D

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	20.62
2yr = .5	-	33.62
10yr = .1	-	39
25yr = .04	-	41.53
50yr = .02	-	42.43
100yr = .01	-	43.49
200yr = .005	-	44.58
500yr = .002	-	45.2

Fix In Place Alternative

ARS

ARS_A

Frequency	Flow (cfs)	Stage (ft)	
1yr = .999	1423	24.05	
2yr = .5	25977	31.85	1.00
10yr = .1	71654	41.98	1.29
25yr = .04	114993	48.01	1.45
50yr = .02	115000	48.07	1.45
100yr = .01	114999	48.15	1.43
200yr = .005	159995	53.22	1.59
500yr = .002	254357	58.1	0.75

ARS_F

Frequency	Flow (cfs)	Stage (ft)	
1yr = .999	52823	11.05	
2yr = .5	94600	20.75	0.75
10yr = .1	100687	26.42	0.77
25yr = .04	115395	29.04	0.76
50yr = .02	118141	29.63	0.76
100yr = .01	121788	30.3	0.76
200yr = .005	133200	32.03	0.75
500yr = .002	152523	33.87	0.78

~~ARS~~

~~ARS_B~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~1423~~	~~20.81~~
~~2yr = .5~~	~~25917~~	~~29.99~~
~~10yr = .1~~	~~71642~~	~~33.34~~
~~25yr = .04~~	~~114967~~	~~37.42~~
~~50yr = .02~~	~~114994~~	~~37.74~~
~~100yr = .01~~	~~114999~~	~~38.15~~
~~200yr = .005~~	~~159970~~	~~41.35~~
~~500yr = .002~~	~~177027~~	~~47.81~~

~~ARS_E~~

~~Frequency~~	~~Flow (cfs)~~	~~Stage (ft)~~
~~1yr = .999~~	~~52823~~	~~10.25~~
~~2yr = .5~~	~~94602~~	~~27.22~~
~~10yr = .1~~	~~100690~~	~~28.52~~
~~25yr = .04~~	~~115558~~	~~31.21~~
~~50yr = .02~~	~~118168~~	~~31.78~~
~~100yr = .01~~	~~121789~~	~~32.46~~
~~200yr = .005~~	~~133311~~	~~34.26~~
~~500yr = .002~~	~~161306~~	~~36.6~~

ARN

ARN_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1690	23.25
2yr = .5	25969	32.43
10yr = .1	71653	40.47
25yr = .04	114991	46.16
50yr = .02	114999	46.24
100yr = .01	115000	46.34
200yr = .005	159998	51.2
500yr = .002	220684	55.91

ARN_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	26.98
2yr = .5	-	30.02
10yr = .1	-	33.1
25yr = .04	-	35.37
50yr = .02	-	37.73
100yr = .01	-	39.19
200yr = .005	-	41.41
500yr = .002	-	46.13

NAT

NAT_D

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	20.62
2yr = .5	-	33.62
10yr = .1	-	39
25yr = .04	-	41.53
50yr = .02	-	42.43
100yr = .01	-	43.49
200yr = .005	-	44.58
500yr = .002	-	45.52

Sacramento Bypass Widening (1500ft) Alternative

ARS

ARS_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1439	24.05
2yr = .5	25998	31.85
10yr = .1	71655	41.78
25yr = .04	114990	47.88
50yr = .02	114999	47.94
100yr = .01	114999	48.02
200yr = .005	159982	53.04
500yr = .002	254410	58.1

ARS_F

Frequency	Flow (cfs)	Stage (ft)	
1yr = .999	47842	11.05	
2yr = .5	87375	20.75	0.75
10yr = .1	99631	25.97	0.77
25yr = .04	107204	27.86	0.76
50yr = .02	110188	28.52	0.76
100yr = .01	113973	29.33	0.76
200yr = .005	124750	30.93	0.75
500yr = .002	144263	33.36	0.78

ARS

ARS_B

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1439	19.55
2yr = .5	25992	27.35
10yr = .1	64302	32.7
25yr = .04	114928	36.72
50yr = .02	114992	37.07
100yr = .01	114995	37.5
200yr = .005	159901	40.71
500yr = .002	182206	46.79

ARS_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	47842	8.95
2yr = .5	87474	21.25
10yr = .1	100097	28.11
25yr = .04	107546	29.95
50yr = .02	110443	30.61
100yr = .01	114819	31.42
200yr = .005	124876	33.08
500yr = .002	146686	35.75

ARN

ARN_A

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1631	22.66
2yr = .5	25996	30.46
10yr = .1	71654	40.56
25yr = .04	114987	46.42
50yr = .02	114999	46.5
100yr = .01	114999	46.59
200yr = .005	159979	51.41
500yr = .002	215253	55.66

ARN_E

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	26.58
2yr = .5	-	29.35
10yr = .1	-	33.22
25yr = .04	-	34.75
50yr = .02	-	36.11
100yr = .01	-	38.63
200yr = .005	-	40.89
500yr = .002	-	45.22

NAT

NAT_D

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	-	20.46
2yr = .5	-	33.46
10yr = .1	-	38.86
25yr = .04	-	41.43
50yr = .02	-	42.34
100yr = .01	-	43.42
200yr = .005	-	44.55
500yr = .002	-	45.51

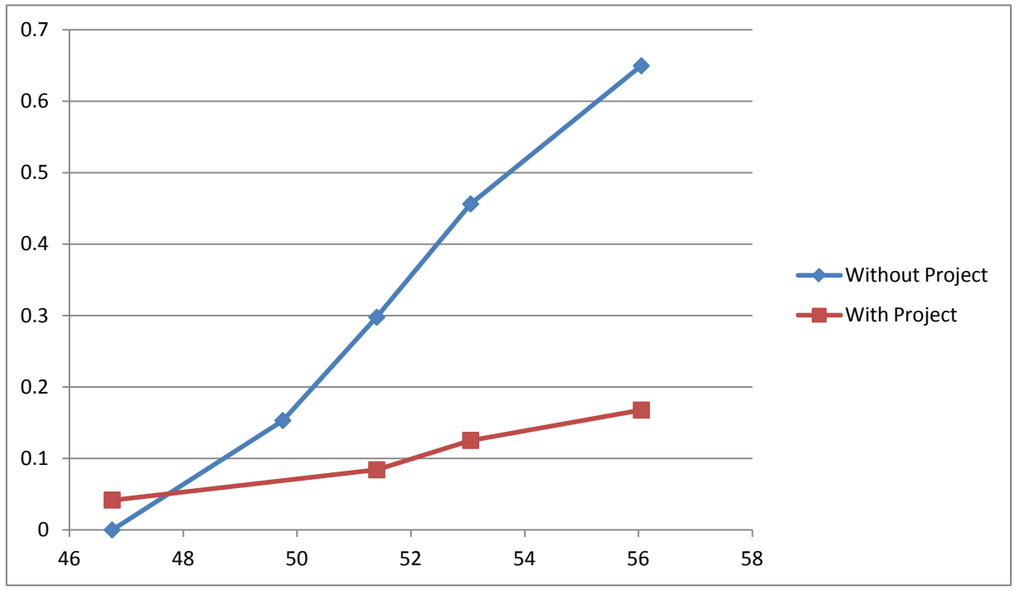
Basin ARS
Reach A
RM 9.08

Without Project		With Project Alt 1		With Project Alt 2	
Crest Elev	56.05	Crest Elev	56.05	Crest Elev	56.05
L/S Toe Ele	46.75	L/S Toe Elev	46.75	L/S Toe Elev	46.75
W/S Toe El	45.93	W/S Toe Elev	45.93	W/S Toe Elev	45.93

WSE	Pr(f)
46.75	0
49.75	0.1531
51.4	0.2976
53.05	0.4562
56.05	0.6496

	WSE	Pr(f)	
46.75			0
49.75	46.75	0.0418	0.0418
	51.4	0.0841	
	53.05	0.1253	
	56.05	0.1677	

WSE	Pr(f)
46.75	0
49.75	0.0418
51.4	0.0841
53.05	0.1253
56.05	0.1677



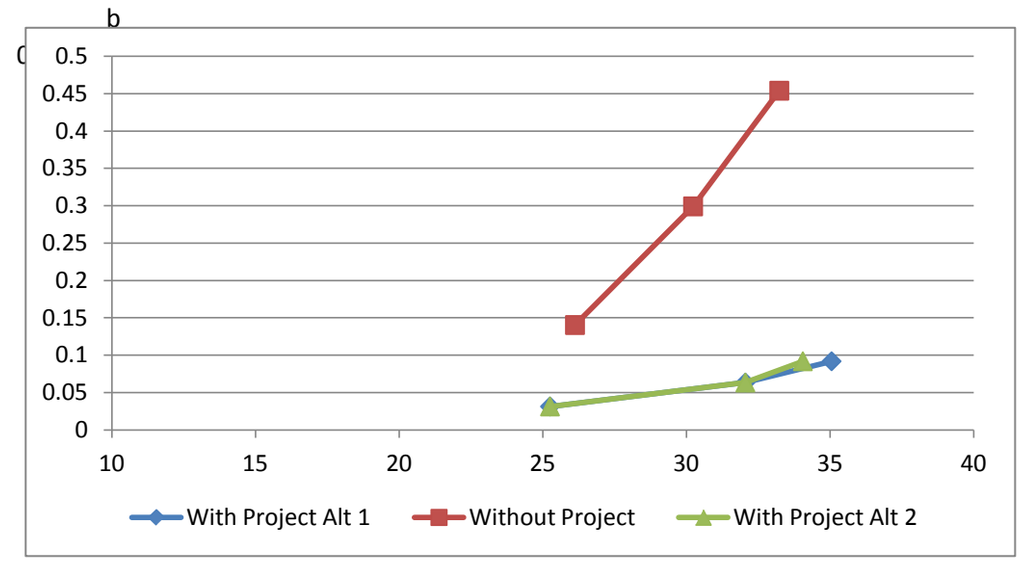
1423	20.81	0
25977	33.23	0.83
71654	41.98	0.9
114967	48.01	1.01
114994	48.07	1
114999	48.15	0.95
159970	53.55	0.83
254357	58.1	0.75

Frequency	Flow (cfs)	Stage (ft)
1yr = .999	1423	24.05
2yr = .5	25977	31.85
10yr = .1	71654	41.98
25yr = .04	114993	48.01
50yr = .02	115000	48.07
100yr = .01	114999	48.15
200yr = .005	159995	53.22
500yr = .002	254357	58.1

Basin	ARS												
Reach	F												
RM	50.21												
	Without Project						With Project Alt 1		Testing Values		With Project Alt 2		
	Crest Elev	33.23					Crest Elev	35.05			Crest Elev	34.05	1.82 0.82
	L/S Toe Ele	19					L/S Toe Elev	15.45			L/S Toe Elev	15.45	Removes a 1 foot levee increase....
	W/S Toe El	22					W/S Toe Elev	21.05			W/S Toe Elev	21.05	
	WSE	Pr(f)					WSE	Pr(f)			WSE	Pr(f)	
	19		0	15.45					0	15.45			0
	22		0.0572	18.45			22		0.0107	18.45	22		0.0107
	26.12	0.1403		25.25			25.25	0.0313			25.25	0.0313	
	30.23	0.2991		32.05			32.05	0.0633	0.1266		32.05	0.0633	
	33.23	0.4539		35.05			35.05	0.0918	0.1836		34.05	0.0918	0.0823 Confirm Interpolation with Geotech!
											35.05	0.0918	

					m	b
2SACNA3_RL	20.44	94600.12	22.55	94629.31		20.44
010SACN3_RL	26.41	100687.1	28.52	100690.5	2.11	25.41
025SACN3_RL	29.03	115394.1	31.21	115549	2.18	28.03
050SACN3_RL	29.62	118141.1	31.79	118171	2.17	28.62
100YR_SAC_RL	30.29	121788.3	32.46	121790	2.17	29.29
200YR_SAC_RL	32.02	133199.8	33.89	130637.5	1.87	31.02
500YR_SAC_RL	33.86	152522.8	35.79	148615.2	1.93	32.86

52823	11.05
94600	20.75
100687	26.42
115395	29.04
118141	29.63
121788	30.3
133200	32.03
152523	33.87



Inflow-Outflow from Folsom

NA3 160

	1 in X chance	Inflow	Base Outflow	Min Outflow	Max Outflow
1	1.01569	5,000	2,000	2,000	4,242
2	1.2977	20,002	16,328	2,000	16,967
3	1.4393	25,004	20,411	2,000	21,210
4	1.5655	29,000	24,600	2,000	23,588
5	1.8517	37,002	26,005	2,000	27,464
6	2	40,722	25,215	8,916	30,225
7	5	90,369	44,261	50,000	54,221
8	10	136,522	71,655	65,753	81,913
9	15	167,533	115,000	84,559	115,000
10	20	191,482	115,000	115,000	115,000
11	25	211,227	115,000	115,000	115,000
12	35	243,016	115,000	115,000	115,000
13	50	279,485	115,000	115,000	115,000
14	65	308,218	115,000	115,000	115,000
15	80	332,148	115,000	115,000	115,000
16	100	359,078	115,000	115,000	115,000
17	130	392,399	160,000	115,000	160,000
18	150	411,351	160,000	160,000	160,000
19	175	432,395	160,000	160,000	160,000
20	200	451,163	160,000	160,000	160,000
21	225	468,139	160,000	160,000	172,840
22	250	483,665	193,667	160,000	202,925
23	325	523,757	297,943	214,967	320,734
24	400	556,967	405,477	310,772	430,723
25	500	594,159	534,386	420,080	558,062

Converted Outflow to indexpoint location.

Frequency	1 in X chance per year	Inflow (cfs)	Outflow (cfs)	Min Outflow (cfs)	Max Outflow (cfs)
1yr = .999	1.01569	5,000	1,423	1,000	4,242
	1.2977	20,002	16,328	2,000	16,967
	1.4393	25,004	20,411	2,000	21,210
	1.5655	29,000	23,588	2,000	24,600
	1.8517	37,002	26,005	2,000	27,464
2yr = .5	2	40,722	25,977	8,916	30,225
	5	90,369	44,261	40,000	54,221
10yr = .1	10	136,522	71,654	65,753	81,913
	15	167,533	115,000	84,559	115,000
	20	191,482	115,000	115,000	115,000
25yr = .04	25	211,227	114,993	115,000	115,000
	35	243,016	115,000	115,000	115,000
50yr = .02	50	279,485	115,000	115,000	115,000
	65	308,218	115,000	115,000	115,000
	80	332,148	115,000	115,000	115,000
100yr = .01	100	359,078	115,000	115,000	115,000
	130	392,399	159,990	115,000	160,000
	150	411,351	160,000	160,000	160,000
	175	432,395	160,000	160,000	160,000
200yr = .005	200	451,163	160,000	152,705	167,295
	225	468,139	160,000	160,000	172,840
	250	483,665	189,459	160,000	202,925
	325	523,757	212,401	193,667	223,666
	400	556,967	230,558	193,667	244,407
500yr = .002	500	594,159	254,357	193,667	265,148

160,000
180,000
215,000
235,000

0.999	1yr = .999	5000	1,423
0.5	2yr = .5	40722	25,977
0.1	10yr = .1	136522	71,654
0.04	25yr = .04	211227	114,993
0	50yr = .02	279485	115,000
0.01	100yr = .01	359078	115,000
0.005	200yr = .005	451163	160,000
0.002	500yr = .002	594159	254,357

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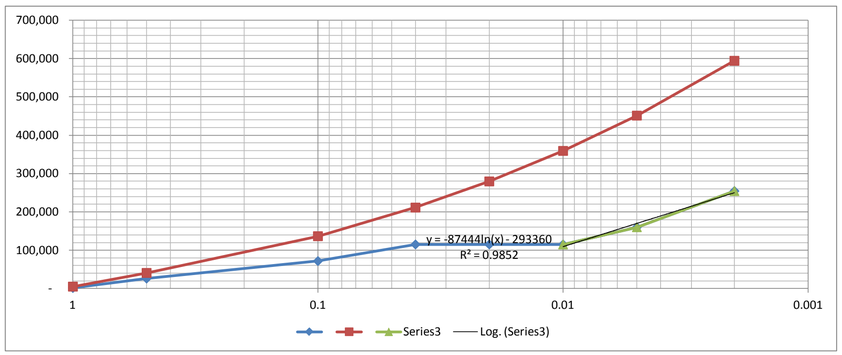

0.01	115,000
0.005	160,000
0.002	254,357

200	0.005	169,946	
225	0.004444	180,245	
250	0.004	189,459	180,000
325	0.003077	212,401	
400	0.0025	230,558	
500	0.002	250,070	

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-87444	293360

F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

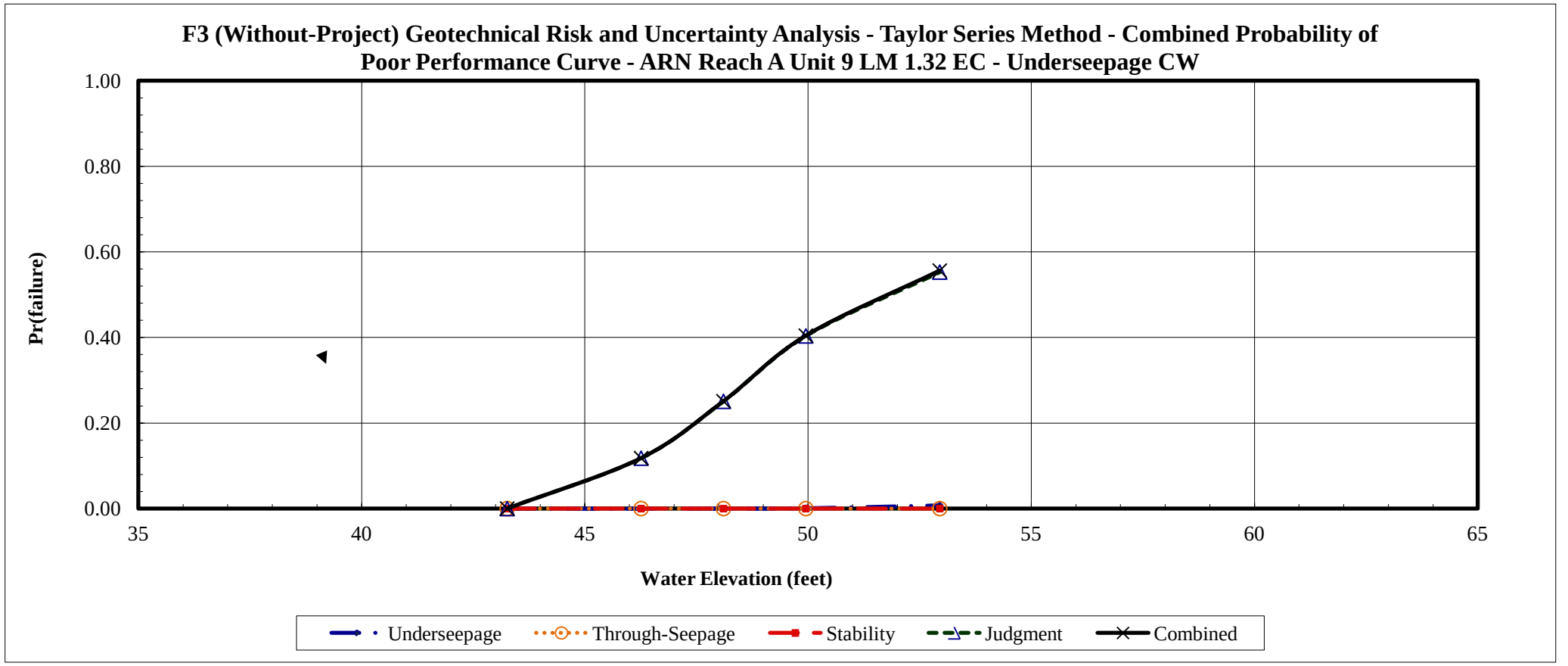
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case: EC - Underseepage CW

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1179	0.8821	0.1179	0.8821
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.2507	0.7493	0.2509	0.7491
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.4036	0.5964	0.4042	0.5958
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.5528	0.4472	0.5562	0.4438



F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

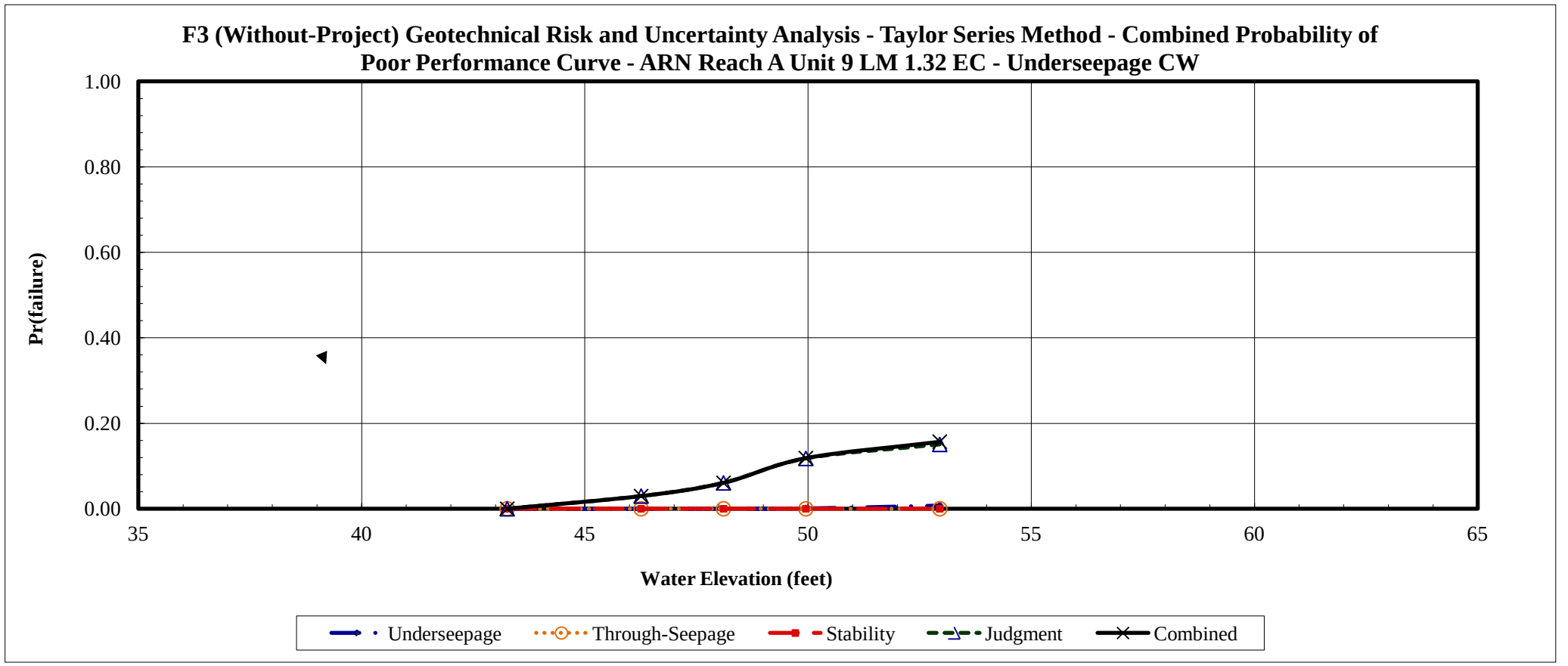
Project: American River Common Features GRR
Study Area: American River
River Section: ARN Reach A Unit 9

Levee Mile: 1.32
River Mile: 7.82
Analysis Case: EC - Underseepage CW

Crest Elev.: 52.95
L/S Toe Elev.: 43.26
W/S Toe Elev.: 40.62

Analysis By: A. Deus
Checked By: H. Mulder
Date: 7/5/2012

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
43.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
46.26	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0297	0.9703	0.0297	0.9703
48.11	0.0002	0.9998	0.0000	1.0000	0.0000	1.0000	0.0606	0.9394	0.0607	0.9393
49.95	0.0010	0.9990	0.0000	1.0000	0.0000	1.0000	0.1178	0.8822	0.1186	0.8814
52.95	0.0076	0.9924	0.0000	1.0000	0.0000	1.0000	0.1506	0.8494	0.1570	0.8430



F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

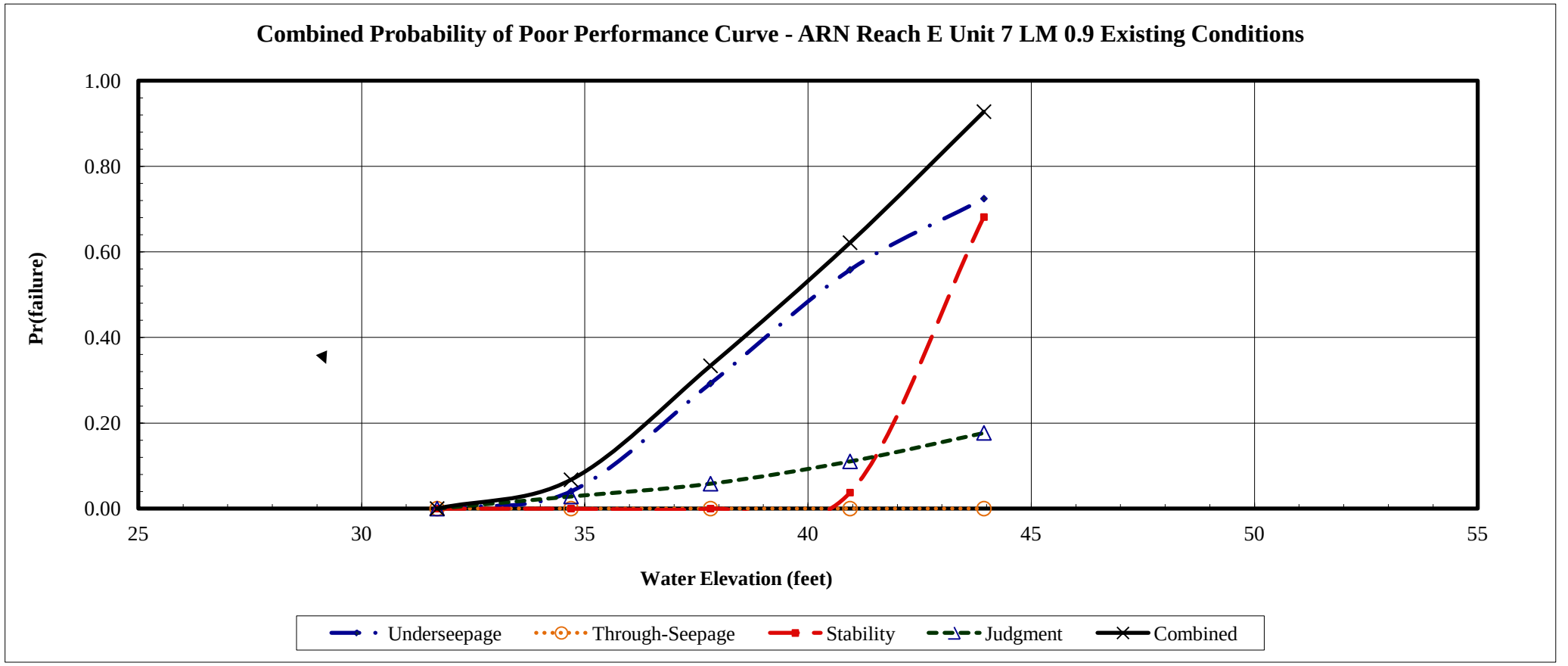
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: Existing Conditions

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000
34.69	0.0403	0.9597	0.0000	1.0000	0.0000	1.0000	0.0282	0.9718	0.0674	0.9326
37.82	0.2925	0.7075	0.0000	1.0000	0.0000	1.0000	0.0582	0.9418	0.3337	0.6663
40.94	0.5580	0.4420	0.0000	1.0000	0.0374	0.9626	0.1103	0.8897	0.6215	0.3785
43.94	0.7245	0.2755	0.0000	1.0000	0.6814	0.3186	0.1769	0.8231	0.9278	0.0722



F3 (Without-Project) Geotechnical Risk and Uncertainty Analysis - Taylor Series Method
Combined Probability of Poor Performance Curve

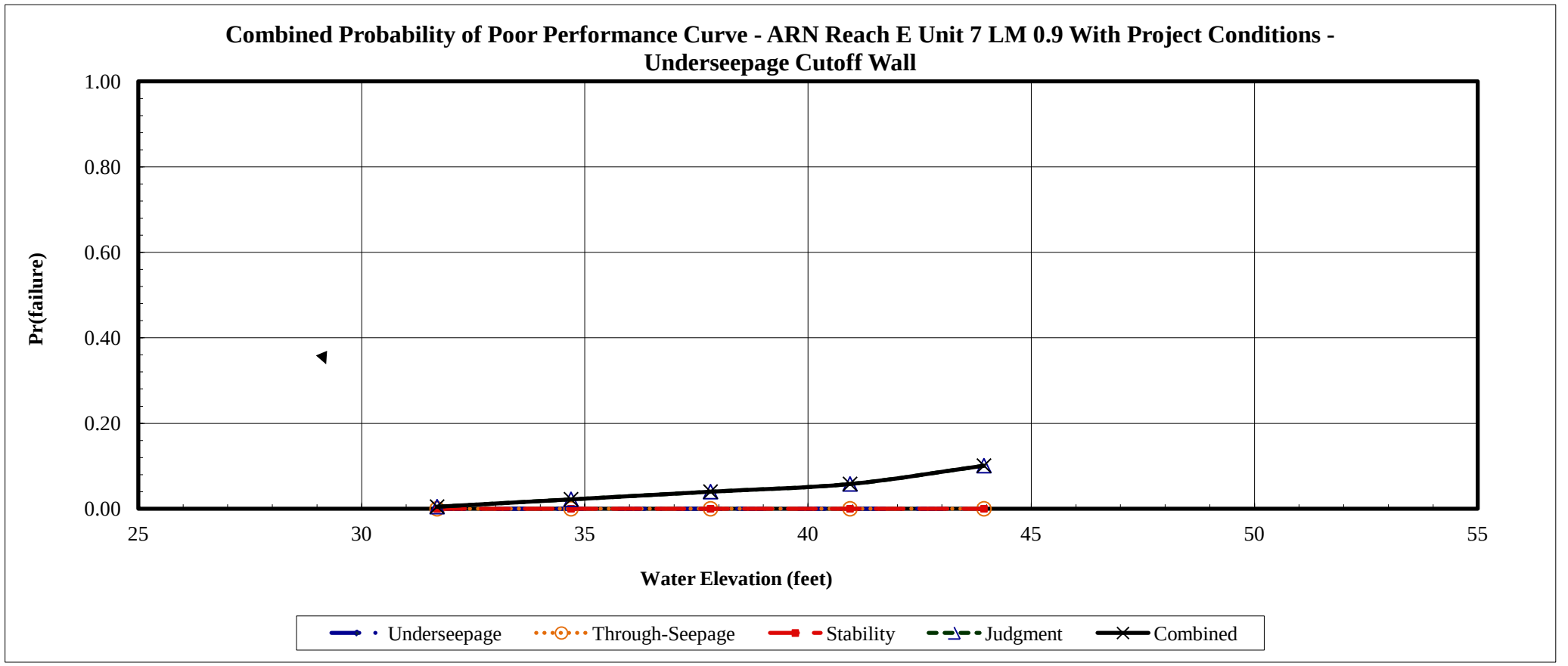
Project: American River Common Features GRR
Study Area: Arcade Creek North
River Section: ARN Reach E Unit 7

Levee Mile: 0.90
River Mile: 0.88
Analysis Case: With Project Conditions - Underse

Crest Elev.: 43.94
L/S Toe Elev.: 31.69
W/S Toe Elev.: 26.77

Analysis By: M. Kynett
Checked By: H. Mulder
Date: 4/29/2011

Water Surface Elevation	Underseepage		Through-Seepage		Stability		Judgment		Combined	
	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R	Pr(f)	R
31.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0050	0.9950	0.0050	0.9950
34.69	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0222	0.9778	0.0222	0.9778
37.82	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0401	0.9599	0.0401	0.9599
40.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.0581	0.9419	0.0581	0.9419
43.94	0.0000	1.0000	0.0000	1.0000	0.0000	1.0000	0.1009	0.8991	0.1009	0.8991



American River Common Features GRR
Attachments to Economic Appendix

Attachment 2 – Certified Construction Cost Estimates for Alternatives 1 & 2.

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW

CERTIFICATION STATEMENT

SPK - PN 149827
American River Common Features GRR
Sacramento, CA

The American River Common Features GRR, as presented by the Sacramento District, has undergone a successful Cost Agency Technical Review (Cost ATR) of remaining costs, 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 cost 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 3, 2015, the Cost MCX certifies the estimated total project costs:

Alternative 1 - NED Plan:

Total First Costs:	$1,343,992,000 (Cost ATR Certified) *
Fully Funded Costs:	$1,597,400,000 *

Alternative 2 - LPP Plan:

Total First Costs:	$1,565,750,000 (Cost ATR Certified) *
Fully Funded Costs:	$1,851,993,000 *

* Spent Costs Not Included. "Per direction from HQUSACE, the proposed elements of the American River Common Features GRR should be considered separate from the previously authorized portions including the work constructed using the WRDA 1996 and 1999 authorities as well as the Natomas levee improvements authorized by WRDDA 2014. Both cost sharing and the Section 902 limit would be established individually for the WRDA 96/99 features, for the WRRDA 2014 features, and for the GRR recommended plan."

Note: Cost ATR was devoted to remaining work. It did not review spent costs, which requires an audit process. 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.

JACOBS.MICHAEL.PIERRE.1160569537

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DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=USA, cn=JACOBS.MICHAEL.PIERRE.1160569537
Date: 2015.12.03 09:29:54 -08'00'

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

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

PROJECT: American River Common Features GRR - Alt 1 - NED
PROJECT NO: P2 # 149827
LOCATION: Sacramento, CA

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Feasibility Report

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: 10/1/2014 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*		*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*				*M*	*N*	*O*
02	RELOCATIONS *		$101,612	$27,435	27%	$129,048	0.8%	$102,411	$27,651	$130,062	$0	$130,062	22.8%	$125,718	$33,944	$159,661
06	FISH & WILDLIFE FACILITIES	Construction	$19,020	$5,135	27%	$24,156	0.4%	$19,103	$5,158	$24,261	$0	$24,261	20.5%	$23,017	$6,215	$29,232
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$48,413	$13,071	27%	$61,484	0.4%	$48,624	$13,128	$61,752	$0	$61,752	15.1%	$55,972	$15,112	$71,084
11	LEVEES & FLOODWALLS	Levees	$298,680	$80,643	27%	$379,323	0.4%	$299,871	$80,965	$380,836	$0	$380,836	17.3%	$351,674	$94,952	$446,626
16	BANK STABILIZATION		$292,672	$79,021	27%	$371,694	1.8%	$297,828	$80,414	$378,242	$0	$378,242	14.7%	$341,678	$92,253	$433,931
	CONSTRUCTION ESTIMATE TOTALS:		$760,397	$205,307		$965,705	1.0%	$767,837	$207,316	$975,153	$0	$975,153	17.0%	$898,059	$242,476	$1,140,535
01	LANDS AND DAMAGES		$88,537	$38,715	44%	$127,253	0.6%	$89,028	$38,930	$127,958	$0	$127,958	12.8%	$100,492	$43,908	$144,399
30	PLANNING, ENGINEERING & DESIGN *		$119,772	$32,338	27%	$152,110	2.3%	$122,529	$33,083	$155,611	$0	$155,611	27.6%	$156,388	$42,225	$198,613
31	CONSTRUCTION MANAGEMENT *		$59,291	$16,009	27%	$75,300	2.3%	$60,656	$16,377	$77,033	$0	$77,033	35.8%	$82,356	$22,236	$104,592
18	CULTURAL RESOURCE PRESERVATION		$6,550	$1,768	27%	$8,318	0.8%	$6,486	$1,751	$8,237	$0	$8,237	12.4%	$7,292	$1,969	$9,260
	PROJECT COST TOTALS:		$1,034,548	$294,138	28%	$1,328,686		$1,046,535	$297,457	**$1,343,992**	$0	**$1,343,992**	18.9%	$1,244,586	$352,813	$1,597,400

Mandatory by Regulation	CHIEF, COST ENGINEERING, Jeremiah Frost			
		ESTIMATED FEDERAL COST:	**65%**	**$1,038,310**
Mandatory by Regulation	PROJECT MANAGER, Dan Tibbitts	ESTIMATED NON-FEDERAL COST:	**35%**	**$559,090**
Mandatory by Regulation	CHIEF, REAL ESTATE, Stan Wallin	**ESTIMATED TOTAL PROJECT COST:**		**$1,597,400**
	CHIEF, PLANNING, Alicia Kirchner			
	CHIEF, ENGINEERING, Rick Poeppelman			
	CHIEF, OPERATIONS, Randy Olsen			
	CHIEF, CONSTRUCTION, Norbert Suter			
	CHIEF, CONTRACTING, Kim Ford			
	CHIEF, PM-PB, Mary Evans			
	CHIEF, DPM, Tambour Eller			

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.

for

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

PROJECT: American River Common Features GRR - Alt 2 - LPP
PROJECT NO: P2 # 149827
LOCATION: Sacramento, CA

DISTRICT: SPK - Sacramento District PREPARED: 11/20/2015
POC: CHIEF, COST ENGINEERING, Jeremiah Frost

This Estimate reflects the scope and schedule in report; Feasibility Report

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				Spent Thru:	TOTAL				
WBS NUMBER	Civil Works Feature & Sub-Feature Description		COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	10/1/2014 ($K)	FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	B		C	D	E	F	G	H	I	J				M	N	O
02	RELOCATIONS *		$122,813	$34,388	28%	$157,201	0.8%	$123,779	$34,658	$158,437	$0	$158,437	21.4%	$150,279	$42,078	$192,357
06	FISH & WILDLIFE FACILITIES	Construction	$19,020	$5,326	28%	$24,346	0.4%	$19,103	$5,349	$24,452	$0	$24,452	20.5%	$23,017	$6,445	$29,462
06	FISH & WILDLIFE FACILITIES	Mitigation and compensation	$55,826	$15,631	28%	$71,457	0.4%	$56,069	$15,699	$71,768	$0	$71,768	14.7%	$64,294	$18,002	$82,297
08	ROADS, RAILROADS & BRIDGES		$20,073	$5,620	28%	$25,693	0.4%	$20,155	$5,643	$25,798	$0	$25,798	5.1%	$21,192	$5,934	$27,126
11	LEVEES & FLOODWALLS	Levees	$362,348	$101,458	28%	$463,806	0.4%	$363,794	$101,862	$465,656	$0	$465,656	16.6%	$424,199	$118,776	$542,975
16	BANK STABILIZATION		$292,672	$81,948	28%	$374,620	1.8%	$297,828	$83,392	$381,220	$0	$381,220	14.7%	$341,678	$95,670	$437,347
15	FLOODWAY CONTROL & DIVERSION STRUCTURE		$42,316	$11,849	28%	$54,165	0.4%	$42,501	$11,900	$54,401	$0	$54,401	13.9%	$48,391	$13,549	$61,941
	CONSTRUCTION ESTIMATE TOTALS:		$915,069	$256,219		$1,171,289	0.9%	$923,228	$258,504	$1,181,732	$0	$1,181,732	16.2%	$1,073,050	$300,454	$1,373,504
01	LANDS AND DAMAGES		$71,078	$24,255	34%	$95,333	0.6%	$71,472	$24,389	$95,862	$0	$95,862	14.2%	$81,345	$28,148	$109,494
30	PLANNING, ENGINEERING & DESIGN *		$142,464	$39,890	28%	$182,354	2.3%	$145,743	$40,808	$186,551	$0	$186,551	25.4%	$182,808	$51,186	$233,994
31	CONSTRUCTION MANAGEMENT *		$71,303	$19,965	28%	$91,268	2.3%	$72,944	$20,424	$93,368	$0	$93,368	34.7%	$98,235	$27,506	$125,741
18	CULTURAL RESOURCE PRESERVATION		$6,550	$1,768	27%	$8,318	0.8%	$6,486	$1,751	$8,237	$0	$8,237	12.4%	$7,292	$1,969	$9,260
	PROJECT COST TOTALS:		$1,206,465	$342,097	28%	$1,548,562		$1,219,873	$345,877	**$1,565,750**	$0	**$1,565,750**	18.3%	$1,442,730	$409,263	$1,851,993

Mandatory by Regulation	CHIEF, COST ENGINEERING, Jeremiah Frost			
		ESTIMATED FEDERAL COST:	**56%**	**$1,038,310**
Mandatory by Regulation	PROJECT MANAGER, Dan Tibbitts	ESTIMATED NON-FEDERAL COST:	**44%**	**$813,683**
Mandatory by Regulation	CHIEF, REAL ESTATE, Stan Wallin	**ESTIMATED TOTAL PROJECT COST:**		**$1,851,993**
	CHIEF, PLANNING, Alicia Kirchner			
	CHIEF, ENGINEERING, Rick Poeppelman			
	CHIEF, OPERATIONS, Randy Olsen			
	CHIEF, CONSTRUCTION, Norbert Suter			
	CHIEF, CONTRACTING, Kim Ford			
	CHIEF, PM-PB, Mary Evans			
	CHIEF, DPM, Tambour Eller			

* Non-Fed 30 and 31 Account Costs associated with Relocations are summarized in 02 - Relocations Account.

American River Common Features GRR
Attachments to Economic Appendix

Attachment 3 - Other Social Effects (OSE) & Regional Economic Development (RED) Analyses

ATTACHMENT 3
AMERICAN RIVER COMMON FEATURES GRR
ECONOMICS APPENDIX
OTHER SOCIAL EFFECTS (OSE) & REGIONAL ECONOMIC DEVELOPMENT (RED)
DECEMBER 2015

A. INTRODUCTION

In the past, planning studies at the Corps of Engineers have focused primarily on the National Economic Development (NED) account to formulate and evaluate water resource infrastructure projects. In recent years, however, there has been a renewed emphasis on considering the Other Social Effects (OSE), Regional Economic Development (RED), and Environmental Quality (EQ) accounts when making investment decisions, as can be seen in the publication of Engineering Circular (EC) 1105-2-409, "Planning in a Collaborative Environment." EC 1105-2-409 encourages the use of all four accounts in order to develop water resource solutions that are more holistic and acceptable, and which take into account both national and local stakeholder interests.

The following sections describe the OSE and RED assessments developed for the American River Common Features GRR. (The EQ assessment is described in the main planning document.)

B. OTHER SOCIAL EFFECTS (OSE)

Purpose and Methodology

The OSE assessment is intended to provide a portrait of the social landscape of the American River Common Features study area and offer a glimpse into the potential vulnerability of the people that live there. In essence, the questions the OSE account tries to answer are:

How are social connectedness, community social capital, and community resiliency likely to change in the absence of a solution to a water resource issue? How are vulnerable populations likely to be affected?

The metrics commonly used to answer these questions include:

- Social connectedness, which can be described using gender, race and ethnicity, age, rural versus urban communities, rental versus owner-occupied dwellings, and occupation
- Community social capital, which can be described using education, family structure, rural vs. urban communities, and population growth
- Community resilience, which can be described using income, political power, neighborhood prestige, employment loss, residential property characteristics, infrastructure and lifelines, family structure, and medical services

The assessment compares the other social effects associated with the without-project and with-project conditions. The 1% annual chance exceedance (ACE) floodplain serves as the baseline to assess effects.

References

- *Planning Guidance Notebook* (ER 1105-2-100)
- *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (IWR 09-R4)
- *Planning in a Collaborative Environment*, (EC) 1105-2-409
- *Levee Screening Tool: Methodology and Application* (November 2011, RMC-CPD-1)
- *Social Vulnerability to Environmental Hazards (*Social Science Quarterly, Volume 84, Number 2, June 2003)
- *Economic Reevaluation Report, American River Watershed Project, CA, Folsom Dam Modification and Folsom Dam Raise Projects, Appendix D-Attachment V, Other Social Effects (May 2007)*

Early History of the Sacramento Area

The area that is now Sacramento was once inhabited, possibly for thousands of years, by the Nisenan (Southern Maidu) and Plains Miwok Native Americans. Sadly, there is little evidence of their existence in the area.

Gabriel Moraga, who was a Spanish explorer, is credited with naming the Sacramento Valley and the Sacramento River sometime near the turn on the 19th century. In 1839, pioneer John Sutter came from Liestal, Switzerland with other settlers and established a trading colony and stockade (Sutter's Fort) as New Helvetia (or "New Switzerland") soon after his arrival. In 1847, Sutter received 2,000 fruit trees, which marked the beginning of the Sacramento Valley's agricultural industry.

The town's population began to increase as more people came to the area in seek of gold, first discovered by James W. Marshall in 1848 at Sutter's Mill in the town of Coloma, which is about 50 miles northeast of Sutter's Fort (in what is now the mid-town area of Sacramento). John Sutter, Jr., along with Sam Brannan, planned the City of Sacramento and named it after the Sacramento River primarily for commercial reasons. They hired William H. Warner, who was a topographical engineer, to draft the official layout of the city. The boundary of the original city layout extended from C Street in the north to Broadway Avenue in the south and to Front Street in the west to Alhambra Boulevard in the east. Today, the city of Sacramento also includes many adjacent suburbs north (across the American River), east, and south of the original city boundary. In 1849, a city charter was adopted by the citizens, and in 1850 the charter was recognized by the State legislature. Sacramento became the first incorporated city in the state of California.

The capital of California under Spanish (and then Mexican) rule had been Monterey. The capital then moved several times – first to San Jose (1851), then to Vallejo (1852), then to Benicia (1853), and then finally to Sacramento (1854), which was named the permanent state capital in 1879. With a new status and a strategic location, the city of Sacramento quickly prospered. Most significantly, it became the western end of the Pony Express as well as the western terminus of the First Transcontinental Railroad.

The city of Sacramento has a long history of flooding. In 1850 and 1861 devastating floods crippled the city causing widespread disease such as cholera and the flu. Between 1862 and the mid-1870s, the City of Sacramento raised the level of its downtown to protect itself from flooding by building reinforced brick walls and filling the resulting street walls with dirt. What used to be the first floor of buildings had

now become its basements. (This perhaps may have been the first major non-structural flood risk management project in the city?)

Ironically, the same two rivers that devastated the city in the past would also prove to be key elements in the economic success of the city as commerce on both the Sacramento and American Rivers increased. The city effectively controlled the commerce on the rivers and benefitted from levying taxes on the goods unloaded from the boats. The tax income helped to fund many public works projects in the city.

The city has grown tremendously since the early days of the 1800s. In 1850, the population of the city was around 6,820. Today, the population in the city is over 475,000. The entire Sacramento metropolitan area is home to about 2.2 million people.

Current Social Landscape

Describing the social landscape of the area provides an understanding of who lives in the study area, who has a stake in the problem or issue, and why it is important to them. A demographic profile of the area is performed using social statistics, and the information is presented in a meaningful way through the use of comparisons and rankings. It is important to note that the profile itself is not an OSE analysis but rather a data collection step that provides a basic level of understanding about the social conditions in the area; the data provides input into a more in-depth analysis that targets areas of special concern or relevance to the water resources issue at hand. The basic social statistics discussed below and listed in Table 1 are indicators used to portray basic information about the social life and the processes of the study area.

The city of Sacramento, which lies within the American River Common Features study area, is home to nearly half a million people; the greater metropolitan statistical area (Sacramento/Arden/Arcade/Roseville), which includes Sacramento, Yolo, Placer, and El Dorado counties, is home to approximately 2.2 million people. The region has experienced tremendous growth over the last 10 to 15 years as an influx of people have moved to the area to take advantage of the relatively affordable home prices as well as the many amenities the region has to offer. Between 2000 and 2010, the city of Sacramento experienced a population increase of about 15%. The people that have moved here over the years represent many different races and ethnicities, bringing increased diversity to the area. For example, the city has seen an increase of about 15% and 25% in the Asian and Hispanic populations, respectively. This increase in the Asian and Hispanic populations may also explain the increase in the percentage of people who speak a language other than English at home; this percentage has increased approximately 13%, from about 33% of the population in 2000 to about 37% in 2010.

Additionally, based on the 2010 Census, the people that have settled in the area over the past decade have achieved greater levels of formal education, with about 29% having at least a bachelor's degree (compared to only about 24% in 2000); this is an increase of approximately 23%.

Finally, between the 2000 and 2010 Census, the data indicate that the city has experienced increased poverty and unemployment, more so than the state of California as a whole. In 2010, the unemployment rate in the city was nearly 14%, which is almost three times higher than in 2000 (4.7%). At the same time, the percentage of people living below the poverty level also increased from about 15.3% in 2000 to over 20% in 2010. Since the 2010 Census, however, the economy in the region has improved significantly and the unemployment rate has come down.

Key statistics are presented in Table 1 below.

Table 1: Basic Social Characteristic of the American River Common Features Study Area - 2000 and 2010 Census Data

Social Statistic	Sacramento			California		
	2000	2010	% Δ	2000	2010	% Δ
Population	407,018	466,488	+15%	33,871,648	37,253,956	+10%
Age						
Median	32.8	33	+1%	33.3	35.2	+5.7%
% >65	11.4%	10.6%	-7%	10.6%	11.4%	+7.5%
% <18	27.3%	24.9%	-8.8%	27.3%	25.0%	-8.4%
Race & Ethnicity						
Asian	16.6%	18.3%	+10%	10.9%	12.8%	+17.4%
Black	15.5%	14.6%	-7%	6.7%	5.8%	-13.4%
Hispanic	21.6%	26.9%	+24.5%	32.4%	37.6%	+16%
White	40.5%	34.5%	-15%	46.7%	40.1%	-14.1%
Other	5.8%	5.7%	-1.8%	4.3%	3.7%	+86%
Education						
% HS Graduates	77.3%	82.1%	+6.2%	81%	80.8%	-0.2%
% College Graduates	23.9%	29.4%	+23%	30.5%	30.2%	-0.9%
Income and Poverty						
% Unemployed	4.7%	13.9%	+296%	4.3%	7.1%	+65%
Median Household Income	37,049	50,661	+36.7%	$61,400	$61,632	0%
% Below Poverty	15.3%	20.2%	+32%	15.3%	14.4%	-5.9%
Housing						
% Own	50.1%	49.4%	-1.4%	56%	55.9%	0%
% Rent	49.9%	50.6%	+1.4%	44%	44.1%	0%
Quality of Life						
Avg. Household Size	2.65	2.68	+1%	2.98	3.45	+16%
Language Other than English Spoken at Home	32.6%	36.8%	+12.9%	43.5%	43.2%	-0.7%
Mean Travel Time to Work (in minutes)	23.4	23.7	+1.3%	27.1	27	-0.4%

Social Effects Assessment

A social effects assessment considers the social vulnerability and resiliency of a population. Social vulnerability refers to the sensitivity of a population to natural hazards, whereas social resiliency refers to the population's ability to respond to and recover from the impacts of a natural hazard. The characteristics that are recognized as having an influence on social vulnerability and resiliency generally include age, gender, race, and socioeconomic status as well as population segments with special needs or those without the normal social safety nets typically necessary to recover from a disaster. The quality of human settlements (e.g., housing type and construction, infrastructure, and lifelines) and the built environment also play an important role in assessing social vulnerability and resiliency, especially as these characteristics influence potential economic losses, injuries, and fatalities from natural hazards. Table 2 provides a discussion of factors that may influence social vulnerability and resiliency and also provides a qualitative assessment of the American River Common Features study area based on indicator statistics from the 2010 U.S. Census. The discussion column in Table 2 is from the article, *Social Vulnerability to Environmental Hazards*, which was published in the June 2003 edition of Social Science Quarterly.

Table 2: Social Vulnerability and Resiliency Indicators – Sacramento Study Area Assessment

Indicator	Discussion	Assessment
Income, political power, and prestige	This measure focuses on the ability to absorb losses and enhance resilience to hazard impacts. Wealth enables communities to absorb and recover from losses more quickly due to insurance, social safety nets, and entitlement programs.	The median household income of the area is below the median for the state of California; however, the city is the state's Capital and has access to significant amount of political resources.
Gender	Women can have a more difficult time during recovery than men, often due to sector-specific employment, lower wages, and family care responsibilities.	Women make up 49.4% of the work force while men make up 50.6%; the median income for women in the area is $42,824, which is 89% of the median income for men.
Race and Ethnicity	Race and ethnicity may impose language and cultural barriers that affect access to post-disaster funding	The area is highly diverse in terms of race and ethnicity. Over one-third of the residents speak a language other than English at home; this may contribute to the vulnerability and possibly the resiliency of the community.
Age	Extremes on the age spectrum inhibit the movement out of harm's way. Parents lose time and money caring for children when daycare facilities are affected; the elderly may have mobility constraints or mobility concerns increasing the burden of care and lack of resilience.	Those age 65 and over make up a slightly lower percentage of the community's population as compared to the percentage for the same age category for the state as a whole; the percentage of residents younger than 18 (24.9%) is about the same as the state statistic (25%).
Employment Loss	The potential loss of employment following a disaster exacerbates the number of unemployed workers in a	The latest Census indicates that the current unemployment rate in the area may be significantly higher

	community, contributing to a slower recovery from the disaster.	than the state's. A flood event which causes additional unemployment may exacerbate the current unemployment rate.
Rural/Urban	Rural residents may be more vulnerable due to lower incomes, and may be more dependent on locally-based resource extraction economies (farming and fishing). High-density areas (urban) complicate evacuation from harm's way.	The area is highly urbanized and close to many resources.
Residential Property	The value, quality, and density of residential construction affect potential losses and recovery. For example, expensive homes are costly to replace, while mobile homes are easily destroyed and less resilient to hazards.	The area is comprised of a full spectrum of homes – from average quality to excellent. Medium density neighborhoods are typical, with higher density neighborhoods in the downtown/midtown area.
Infrastructure and Lifelines	Loss of sewers, bridges, water, communications, and transportation infrastructure may place an insurmountable financial burden on the smaller communities that lack the financial resources to rebuild.	Most of the neighborhoods within the study area are well-established and would most likely have access to the many resources available within the city itself as well as within the greater metropolitan area, which includes, Davis, West Sacramento, Folsom, Elk Grove, Dixon, and many other cities.
Renters	People that rent typically do so because they are either transient or do not have the financial resources for home ownership. They often lack access to information about financial aid during recovery. In the most extreme cases, renters lack sufficient shelter options when lodging becomes uninhabitable or too costly to afford.	The number of rentals in the area is significant (about 51%), and is higher than the state average of about 44%. The high rental population may contribute to communication cohesion issues; research indicates that renters do not have the same level of community pride as owners do, which may lead to more challenges in redeveloping a community after a flood event.
Occupation	Some occupations, especially those of resource extraction, may be severely impacted by a hazard event. Self-employed fishermen suffer when their means of production is lost and may not have the requisite capital to resume work in a timely fashion and thus will seek alternative employment. Migrant workers engaged in agriculture and low skilled service jobs (e.g., housekeeping, childcare,	The number of people that live in the area and work in resource extraction occupations is fairly low; the 2010 Census indicates that around 1,226 people (or 0.6% of the total work force) work in the farming, fishing, and forestry occupations.

	and gardening) may similarly suffer, as disposable income fades and the need for services decline. Immigration status also affects occupational recovery.	
Family Structure	Families with large numbers of dependents or single-parent households often have limited finances to outsource care for dependents, and thus must juggle work responsibilities and care for family members. All affect the resilience to recover from hazards.	The literature indicates that families having greater than four persons have more financial difficulty than smaller families. Accordingly, community planners need to be aware of issues that may arise.
Education	Education is strongly linked to socioeconomic status, with higher educational attainment resulting in greater lifetime earnings. Lower education constrains the ability to understand warning information and access to recovery information.	Over 80% of the population has graduated from high school and almost a third of the population hold a bachelor's degree.
Population Growth	Counties experiencing rapid growth lack available quality housing; its social services network may not have had time to adjust to increased populations. New migrants may not speak the language and not be familiar with bureaucracies for obtaining relief or recovery information, all of which increases vulnerability.	Sacramento has grown significantly over the past fifteen years, with a majority of the growth taking place between 2000 and 2010. The growth rate between 2000 and 2010 was about 15%. Overall, growth has been significant but not rapid; there are parts of the city that have experienced rapid growth (e.g., Natomas). Rapid growth is highly correlated with low community cohesion. The sense of belonging, cooperation, and community pride are dynamic factors which help with community resilience but which may not be as strong in cities that have experienced rapid growth.
Medical Services	Health care providers, including physicians, nursing homes, and hospitals are important post-event sources of relief. The lack of proximate medical services will lengthen immediate relief and result in longer recovery from disasters.	The residents of Sacramento would have access to nearby medical facilities in the cities of Davis, Woodland, West Sacramento, Elk Grove, Folsom, El Dorado Hills, Roseville, Rocklin, Dixon, and others

Life Safety Evaluation

The Sacramento District's Levee Safety Section uses the Levee Screening Tool (LST) to assess levees within the District's geographic boundary. The LST provides an initial quantitative risk estimate to assist local, state, and federal stakeholders in identifying and prioritizing the funding needs for levees of

concern. The information and data entered into the LST are collected from existing information/data. Life loss estimates are computed in the LST based on the information/data entered and for various scenario/conditions, including life loss during the day time, life loss during the night time, life loss assuming a levee breach prior to overtopping, and life loss assuming no breach until overtopping. Additional information about the levee screening tool and its computation processes can be found in, *Levee Screening Tool: Methodology and Application,* as listed in the reference section.

The results of the levee screenings performed for the American River Common Features study area were used in this OSE assessment to make preliminary estimates of life loss. The results of two scenarios modeled in the LST, levee breach prior to overtopping and no levee breach until overtopping, are presented here. For this assessment, the levee breach prior to overtopping scenario was assigned to the without-project condition and the no levee breach until overtopping was assigned to the with-project (Alternatives 1 and 2) conditions. A comparison of potential fatalities under each condition and for various levee segments within the system is displayed in Table 3 below.

Table 3: Statistical Life Loss Estimates

Levee Segment/Impact Area	Estimated Life Loss					
	Without-Project (Assumes Breach Prior to Overtopping)			Alternative 1/Alternative 2 (Assumes No Breach Until Overtopping)		
	Day	Night	Weighted	Day	Night	Weighted
Natomas Cross Canal – Left Bank (Natomas)	669	553	605	221	183	200
Arcade Creek – Left Bank (ARN)	166	151	158	95	86	90
NEMDC – Left Bank (ARN)	164	149	156	94	85	89
American River – Right Bank (ARN)	170	156	163	97	89	93
American River – Left Bank (ARS)	503	978	764	166	461	328
Sacramento River – Left Bank (ARS)	595	1,128	888	281	645	481

In addition to life loss estimates, other metrics were used to assess the vulnerability of individuals living in the study area, as listed in Table 4 below.

In any assessment that relies on assumptions, there is uncertainty. The life loss estimates under the with-project condition shown in Table 3 above assume no levee breach until overtopping. Importantly, while the Levee Screening Tool (LST) does not compute probabilities of a potential levee breach, the economic model (HEC-FDA) used in the National Economic Development (NED) Analysis does compute the annual exceedance probabilities (AEP) under without-project and with-project conditions using available engineering data. These probabilities can be tied to the life loss estimates computed in the LST in order to provide a more complete picture of the overall flood risk (consequence and chance). For example, the HEC-FDA results indicate that in the ARS Basin, there is about a 1 in 147 chance of flooding in any given year under the with-project condition, which can be tied to the estimated life loss of between 328 and 481 shown in Table 3. For the ARN Basin, the HEC-FDA results indicate that there is

about a 1 in 172 chance of flooding in any given year under the with-project condition, which can be tied to the estimated life loss of between 89 and 93 displayed in Table 3. In both basins, the chance of flooding and therefore life loss is significantly reduced with a project in place as compared to without a project in place. (Under without-project conditions, the chance of flooding in any given year in the ARS and ARN Basins are about a 1 in 32 and 1 in 61, respectively.)

Table 4: Description of Metrics Used to Evaluate Life Safety

Evaluation Metric	Description
Population at Risk (People)	Number of people within the 1% ACE floodplain based on the 2010 census block GIS data.
Critical Infrastructure (Facilities)	Number of fire stations, police stations, hospitals, senior living facilities, and jails that are of life safety significance; also includes substations, schools, power plants, chemical industry, colleges, intermodal shipping, heliports, petroleum bulk plants, and broadcast communication which may be of regional significance
Evacuation Routes (Number of Routes)	Assesses the vulnerability of populations with regard to the number of escape routes available during flood events.
Wise Use of Floodplains (Acres)	Potentially developable land within the 0.2% ACE floodplain. Acres of land with 1% ACE flood depths less than 3 feet.

Table 5 displays the comparison for the without-project and with-project (Alternatives 1 and 2) conditions as they relate specifically to the life safety metrics summarized in Table 4.

Table 5: Summary of Life Safety Metrics

Evaluation Metric	Alternative	
	Without-Project	Alternative 1/Alternative 2
Population at Risk (People)	250,000	0
Critical Infrastructure (Facilities)	523	0
Evacuation Routes (Number of Routes)	43	43
Wise Use of Floodplains (Acres)	0	TBD

[1]Values based on 1% ACE event floodplain

Population at Risk: The population at risk of flooding from a 1% ACE flood event is about 250,000 for the without-project condition. Most of this population would be removed from the 1% ACE floodplain under either Alternative 1 or 2. Of special concern is the population segment over the age of 65 living within the study area since these individuals have been shown to be at higher risk of life loss from flood events. The Sacramento community's senior population is slightly lower (10.6% of total population) than the senior population of the state of California (11.4%).

Additionally, the area in the American River North (ARN) Basin benefitting from the improvements to the creeks (Arcade, Dry, Robla, and the NMDEC) represents one of the most impoverished locations in

Sacramento County.[1] In fact, the median family income in Sacramento is more than 50 percent higher than the median family income of the affected area ($55,064 compared to $35,828); the poverty rate in the affected area is 64 percent higher that of the surrounding county (29.0% compared to 17.6%). Within some parts of the affected area more than one in three family's live below the poverty line (34.1% in zip code 95815). Furthermore, these high rates of poverty are strongly correlated with disabilities, lack of car ownership and other factors that increase life safety hazards. In the absence of these improvements, the flood risk for this area would change very little, thereby putting this community at a further disadvantage relative to neighboring communities in the study area.

Critical Infrastructure: A significant amount of critical infrastructure is located within the Common Features study area. Critical infrastructure is a term used by governments to describe assets that are essential for the functioning of a society and economy from a national perspective. Most commonly associated with the term are fire stations, police stations, hospitals, senior living facilities, and prisons.

The numerous federal, state, county, and city offices located within the inundation area could be directly impacted. The massive loss of city and state offices would severely hamper a number of critical local government functions, at least temporarily. A significant number of records, both digital and hardcopy, have the potential to be lost. Floors of high-rise buildings above the effects of floodwaters would remain relatively untouched, but the bottom floors of large office buildings and their contents would most likely be destroyed.

The disruption of government work could have major indirect impacts to people living outside of the immediate flood zone. For state offices, the effects of flooding in the state's capitol could disrupt the lives of everyone living in California. County, city, and federal offices would also incur losses. While non-essential government workers would experience temporary unemployment, it is unlikely that government work would stop completely. Indeed, after an emergency of this scale, there would likely be a large need for more government action in the form of managing aid and organizing rebuilding efforts. Government offices outside of the flood footprint, either in West Sacramento or in the eastern part of Sacramento County, would likely increase their workloads and displaced employees could most likely find temporary workspace in these offices once security issues and logistical needs are assessed and provided.

Both Alternatives 1 and 2 significantly lowers the flood risk to critical infrastructure within the study area.

Evacuation Routes: The City of Sacramento's evacuation plan was updated as of September 2008. In their plan they have identified temporary shelters with their addresses and phone numbers within the city limits. They also have detailed maps for evacuation routes based on police beats, and they have a table for different triggers and the particular activation that needs to occur based on them and the roles and responsibilities of each agency for that trigger.

The County of Sacramento's evacuation plan was updated as of November 2008. In their plan they have identified temporary shelters with their addresses within the county limits. They also have detailed maps for evacuation routes, and they have identified different triggers and the particular activation that

[1] The above analysis is based on the US Census Bureau 2009-2013 American Community Survey comparing Sacramento County to the zip codes most closely associated with the area affected by the increment (95815 and 95838).

needs to occur based on them and the roles and responsibilities of each agency for that trigger.

Both the City and County have created detailed maps for various hypothetical levee breaks. These maps identify evacuation routes, and which evacuation routes would become inundated overtime and impassible. Depending on the location of the levee breach, up to 43 evacuation routes (all basins) have been identified which include highways and freeways, and main streets/roads.

Community awareness of the flood risk is good. Flood risk and levee safety have been covered extensively over the last few years by all the local TV stations and the Sacramento Bee newspaper. Additionally, Sacramento County has emergency sirens and a reverse-911 system. The Emergency Operations and Emergency Evacuation plans discuss communication with the local media to instruct the public during emergencies.

Wise Use of Floodplains: A determination must be made as to whether the increase in potentially developable floodplain area is acceptable under Corps policy, or can be avoided or mitigated to an acceptable level within a justified cost. It is important to remember that the floodplain metric used in this assessment is a simple index based on physical parameters. The metric does not attempt to forecast future population growth, economic conditions, or government decisions that will constrain future floodplain development. Those factors should be considered in conjunction with the metric.

Without-Project and With-Project Comparison

An assessment of the beneficial and adverse effects associated with the without-project condition and Alternatives 1 and 2 (with-project condition) was made. The social effects of the alternatives have both direct and indirect effects. Direct effects come from construction of the projects, whereas indirect effects come from the effects of the project on the existing social landscape. The alternatives are characterized using descriptors related to magnitude (number of individuals affected), location (concentration of effects), timing and duration (when the effects will start and how long they are expected to last), and associated risks. Table 6 provides a description of the effects of the without-project condition and Alternatives 1 and 2.

Table 6: Effects of Alternatives

	Without-Project	Alternative 1/Alternative 2
Alternative Description		
	No project is constructed by the Federal government	Improvements to the Sacramento River levees (left bank from confluence to south of Freeport), American River levees (right and left banks), East Side Tributaries, and Sacramento Bypass (Alternative 2 only) are made
Other Social Effects (OSE)		
Summary	Continued flood risk and high potential consequences in the West Sacramento study area	Life safety residual risk is significantly reduced
Population at Risk (PAR)	Approximately 250,000 people are at high risk from a 1% ACE flood	The risk from a 1% ACE flood is significantly reduced for all of the approximately 250,000 Sacramento residents
Loss of Life	Potential loss of life: 1,051	Potential loss of life: 574
Critical Infrastructure	523 critical infrastructure at risk	0 critical infrastructure at risk
Evacuation Routes	No evacuation routes available if flood event occurs	43 evacuation routes available in the event of a flood
Wise Use of Floodplains	0 available acres	About X acres of land would be available for future development
Social Vulnerability	The community may be characterized as having a medium level of social vulnerability based on the social vulnerability indicators presented in Table 2	Flood risk to the Sacramento community is reduced, and social vulnerability is minimized due to the decrease in chance of a flood occurring
Residual Risk and Consequences	Residual risk remains high throughout the study area.	Residual risk for life safety is significantly reduced.

It is important to realize that while either alternative would significantly reduce the overall flood risk to Sacramento, the risk will not be, and never will be, completely removed. In other words, while the alternatives would significantly reduce the chance of flooding, the tens of thousands of people and thousands of homes still remain susceptible to flood events which exceed the project design and the associated AEP.

C. REGIONAL ECONOMIC DEVELOPMENT (RED)

Purpose and Methodology

The U.S. Army Corps of Engineers (USACE) *Planning Guidance Notebook* (ER 1105-2-100) states that while the National Economic Development (NED) and Environmental Quality (EQ) accounts are required, display of the Regional Economic Development (RED) effects are discretionary. The Corps' NED procedures manual affirms that RED benefits are real and legitimate; however, the concern (from a Federal perspective) is that they are often offset by RED costs in other regions. Nevertheless, for the local community these benefits are important and can help them in making their preferred planning decisions.

Although the RED account is often examined in less detail than NED, it remains useful. For example, Hurricane Katrina caused a significant economic hardship to not just the immediate Gulf Coast but for entire counties, watersheds, and the state of Louisiana. Besides the devastating damage to homes (which are often captured by the NED account), hundreds of thousands of people lost their jobs, property values fell, and tourism and tax revenues declined significantly and were transferred to other parts of the U.S. In this example, the RED account can provide a better depiction of the overall impact to the region.

The distinction between NED and RED is a matter of perspective, not economics. A non-federal partner may consider the impacts at the state, regional, and local levels to be a true measure of a project's impact or benefit, whereas from the Corps' perspective, this may not constitute a national benefit. Gains in RED to one region may be partially or wholly offset by losses elsewhere in the nation. For example, if a Federal project enables a firm to leave one state to relocate to a newly-protected floodplain of another state, the increase in regional income for the project area may come at the expense of the former area's loss. In this case, there is no net increase in the value of the nation's output of goods and services and should be excluded from NED computations.

The following sections describe the impacts of Alternatives 1 and 2 from a regional perspective. The impacts were evaluated using the Corps' certified RECONS software.

Key RED Concepts

Econometric analysis allows for the evaluation of a full range of economic impacts related to specific economic activities by calculating effects of the activities in a specific geographic area. These effects are:

- Direct effects, which consist of economic activity contained exclusively within the designated sector. This includes all expenditures made by the companies or organizations in the industry and all employees who work directly for them.
- Indirect effects, which define the creation of additional economic activity that results from linked business, suppliers of goods and services, and provisions of operating inputs.
- Induce effects, which measure the consumption expenditures of direct and indirect sector employees.

Input-output (I/O) models are characterized by their ability to evaluate the effects of industries on each other. Unlike most typical measures of economic activity that examine only the total output of an industry or the final consumption demand provided by a given output, I/O models provide a much more

comprehensive view of the interrelated economic impacts. I/O analysis is based on the notion that there is a fundamental relationship between the volume of output of an industry and the volume of the various inputs used to produce that output. Industries are often grouped into production, distribution, transportation, and consumption categories. Additionally, the I/O model can be used to quantify the multiplier effect, which refers to the idea that an increase in spending can lead to an even greater increase in income and consumption, as monies circulate (or multiply) throughout the economy.

Flood Risk Management RED Considerations

There are particular effects for each type of project improvement as they relate to the RED account. The estimation of RED flood-related effects can be very complex. At a minimum, the RED analysis should include a qualitative description of the types of businesses at risk from flooding, particularly those that could have a significant adverse impact (output, employment, etc.) upon the community or regional economies if their operations should be disrupted by flooding and how this would be affected by the recommended project. The potential RED effects to flood risk management projects are summarized in Table 7 below.

Table 7: Potential RED Effects to Flood Risk Management

RED Factor	Potential RED Effects
Construction	Additional construction related activity and resulting spillovers to suppliers
Revenues	Increased local business revenues as a consequence of reduced flooding, particularly from catastrophic floods
Tax Revenues	Increased income and sales taxes from the direct project and spillover industries
Employment	Short-term increase in construction employment; with catastrophic floods, significant losses in local employment (apart from the debris and repair businesses, which may show temporary gains)
Population Distribution	Disadvantage groups may benefit from the creation of a flood-free zone
Increased Wealth	Potential increase in wealth for floodplain residents as less is spent on damaged property, repairs, etc.; potential increase in property values.

RECONS Software

A variety of software programs are available to measure the RED impacts of a project. The Corps of Engineers' Institute for Water Resources (IWR) along with the Louis Berger Group has developed a regional economic impact modeling tool called Regional Economic System (RECONS) that computes estimates of regional and national job creation, retention, and other economic measures. The expenditures made by the USACE for various services and products generate economic activity that can be measured in jobs, income, sales, and gross regional product. The software automates calculations and generates estimates of economic measures associated with USACE's annual civil works program spending. RECONS was built by extracting multipliers and other economic measures from more than 1,500 regional economic models that were built specifically for USACE's project locations by the Minnesota IMPLAN Group. These multipliers were then imported into a database. The software ties various spending profiles to the matching industry sectors by location to produce economic impact estimates. The RECONS program is used to document the performance of direct investment spending of the USACE, and allows users to evaluate project and program expenditures associated with annual expenditures.

RECONS Inputs and Outputs

The economic impacts presented below show the Common Features study area and the state of California's interrelated economic impacts resulting from an injection of flood risk management construction funds. For this assessment, the study area and the state of California were both used as the geographic designation to assess the overall impacts to the regional economy from constructing either Alternative 1 or Alternative 2. This places a frame around the economic impacts where the activity is internalized; leakages, which are payments made to imports or value added sectors that do not in turn re-spend the dollars within the area, are not included in the total impacts.

Table 8 summarizes the complex nature of the regional economy of the Sacramento/Arden/Arcade/Roseville, CA Metropolitan Statistical Area (MSA), which includes El Dorado, Placer, Sacramento, and Yolo counties and a population of approximately 2.2 million. There are approximately 1.2 million people employed in the MSA who provide an output to the nation worth over $158 billion annually.

Table 8: Regional Profile – Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in $Millions, October 2015 Price Level)

Industry	Output	Labor Income	GRP	Employment
Accommodations and Food Service	$4,522	$1,562	$2,384	75,155
Administrative and Waste Management Services	$4,072	$2,145	$2,665	67,557
Agriculture, Forestry, Fishing and Hunting	$1,526	$388	$671	11,783
Arts, Entertainment, and Recreation	$1,594	$489	$751	21,054
Construction	$12,733	$5,471	$5,999	82,970
Education	$4,254	$3,367	$3,811	66,272
Finance, Insurance, Real Estate, Rental and Leasing	$23,202	$5,878	$14,551	118,760
Government	$21,059	$17,612	$19,940	241,383
Health Care and Social Assistance	$10,710	$6,058	$7,029	103,062
Imputed Rents	$12,558	$2,011	$8,153	65,011
Information	$7,646	$1,442	$3,075	20,698
Management of Companies and Enterprises	$2,040	$876	$1,172	10,242
Manufacturing	$19,269	$3,263	$4,460	39,136
Mining	$562	$129	$344	1,087
Professional, Scientific, and Technical Services	$12,918	$6,688	$7,771	89,771
Retail Trade	$9,491	$4,062	$6,519	123,095

Transportation and Warehousing	$3,686	$1,470	$2,176	27,064
Utilities	$1,103	$243	$672	1,635
Wholesale Trade	$5,344	$2,022	$3,467	30,383
Total	**$158,286**	**$65,176**	**$95,610**	**1,196,119**

Input Costs: The total remaining costs of Alternatives 1 and 2 are $1,216,034,000 and $1,469,888,000, respectively (none of the costs have been expended). The RED analysis requires the adjustment of costs for two items: (1) interest during construction (IDC) and (2) purchase of land. Interest during construction is used in the NED analysis to estimate the opportunity cost of using money for one economic endeavor (e.g., building a FRM project) instead of another (e.g., building a bullet train); IDC is not actually expended within the region and therefore is not included in the RED analysis. Similarly, the purchase of land, not including administrative costs, is considered a transfer payment from one party to another and therefore is also not included in the RED analysis.

Tables 9 and 10 are based on the average annual regional expenditures that are expected over the construction period. The construction period for Alternative 1 is assumed to be 10 years; for Alternative 2 it is also assumed to be 10 years. Over that period, a total of about $1.22 billion is anticipated to be spent in the study area if Alternative 1 is built; a total of about $1.47 billion is anticipated to be spent if Alternative 2 is built. The average construction expenditure for Alternative 1 is about $122 million, which is the anticipated amount ($1.22 billion) divided by the number of years of construction (10); the average construction expenditure for Alternative 2 is about $147 million, which is the anticipated amount ($1.47 billion) divided by the number of years of construction (10).

Table 9: Alternative 1 Inputs Assumptions, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Category	Spending	Spending Amount	Local Percentage Capture		
		Alternative 1	Local	State	National
Aggregate Materials	10%	119,171,000	70	77	97
Other Materials	1%	14,572,000	99	100	100
Equipment	35%	425,612,000	69	99	100
Construction Labor	54%	656,658,000	100	100	100
Total	100%	1,216,034,000	NA	NA	NA

Table 10: Alternative 2 Inputs Assumptions, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Category	Spending	Spending Amount	Local Percentage Capture		
		Alternative 2	Local	State	National
Aggregate Materials	10%	144,049,000	70	77	97
Other Materials	1%	17,639,000	99	100	100
Equipment	35%	514,461,000	69	99	100
Construction Labor	54%	793,739,000	100	100	100
Total	100%	1,469,888,000	NA	NA	NA

RECONS Outputs: Direct expenditures expected for construction of earthen levees are spent primarily in two sectors of the economy, construction labor and equipment (both alternatives). Both accounts for 89% of the total project expenditures. Local capture rates are computed in RECONS to show where the output from expenditures is realized. As indicated in Tables 9 and 10, all of the construction labor is expected to occur within the Sacramento/Arden/Arcade/Roseville MSA (both alternatives); 69% of the equipment is expected to be provided from within the study area and 99% from within the state of California (both alternatives).

Tables 11 and 12 summarize the overall economic impacts of Alternatives 1 and 2. The USACE is planning to expend approximately $1.35 billion if Alternative 1 is built and approximately $1.57 billion if Alternative 2 is built. Of total project expenditures, approximately $1.05 billion will be captured within the regional impact area if Alternative 1 is built and approximately $1.27 billion will be captured within the regional impact area if Alternative 2 is built. For either alternative, the rest will be leaked out to the state of California or the nation. The expenditures made by the USACE for various services and products are expected to generate additional economic activity, which can be measured in jobs, income, sales, and GRP as summarized in Tables 13-18 (economic activity on regional, state, and national basis). It is important to note that the RED analysis indicates that construction of either alternative is anticipated to generate over 22,000 jobs and over one billion dollars in labor income during the construction period.

Table 11: Alternative 1, Summary of Economic Impacts, Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in October 2015 Price Level)

Total Spending		Alternative 1		
		Regional	State	National
		$1,216,034,000	$1,216,034,000	$1,216,034,000
Direct Impact	Output	$1,049,768,000	$1,184,467,000	$1,211,673,000
	Jobs	15,940	16,400	16,570
	Labor Income	$766,076,000	$802,542,000	$814,386,000
	GRP	$866,844,000	$941,704,000	$956,797,000
Total Impact	Output	$1,929,413,000	$2,382,499,000	$3,199,443,000
	Jobs	22,090	24,530	28,940
	Labor Income	$1,066,146,000	$1,214,895,000	$1,479,975,000
	GRP	$1,400,509,000	$1,656,427,000	$2,110,406,000

Table 12: Alternative 2, Summary of Economic Impacts, Sacramento/Arden/Arcade/Roseville, CA MSA (Dollar Values in October 2015 Price Level)

Total Spending		Alternative 2		
		Regional	State	National
		$1,469,888,000	$1,469,888,000	$1,469,888,000
Direct Impact	Output	$1,268,913,000	$1,431,730,000	$1,464,617,000
	Jobs	19,260	19,830	20,040
	Labor Income	$925,999,000	$970,077,000	$984,393,000
	GRP	$1,047,802,000	$1,138,290,000	$1,156,533,000
Total Impact	Output	$2,332,189,000	$2,879,859,000	$3,867,345,000
	Jobs	26,700	29,660	34,990
	Labor Income	$1,288,710,000	$1,468,511,000	$1,788,930,000
	GRP	$1,692,872,000	$2,002,215,000	$2,550,965,000

Table 13: Alternative 1, Economic Impacts – Regional Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 1			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$46,489,000	340	$17,220,000	$22,348,000
	Wholesale trade businesses	$1,292,000	1	$492,000	$976,000
	Transport by rail	$2,799,000	1	$951,000	$1,547,000
	Transport by water	$525,000	0	$106,000	$235,000
	Transport by truck	$32,908,000	250	$14,652,000	$17,718,000
	Construction of other new nonresidential structures	$14,464,000	80	$5,830,000	$7,363,000
	Commercial & industrial machinery & equipment rental/leasing	$294,635,000	940	$70,166,000	$159,998,000
	Labor	$656,658,000	14,310	$656,658,000	$656,658,000
Total Direct Effects		$1,049,768,000	15,940	$766,076,000	$866,844,000
Secondary Effects		$879,645,000	6,160	$300,069,000	$533,665,000
Total Effects		**$1,929,413,000**	**22,090**	**$1,066,146,000**	**$1,400,509,000**

Table 14: Alternative 2, Economic Impacts – Regional Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 2			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$56,195,000	400	$20,816,000	$27,013,000
	Wholesale trade businesses	$1,562,000	1	$595,000	$1,179,000
	Transport by rail	$3,383,000	1	$1,149,000	$1,869,000
	Transport by water	$633,000	0	$128,000	$285,000
	Transport by truck	$39,777,000	310	$17,710,000	$21,416,000
	Construction of other new nonresidential structures	$17,483,000	100	$7,048,000	$8,901,000
	Commercial & industrial machinery & equipment rental/leasing	$356,141,000	1,150	$84,814,000	$193,399,000
	Labor	$793,739,000	17,290	$793,739,000	$793,739,000
Total Direct Effects		$1,268,913,000	19,260	$925,999,000	$1,047,802,000
Secondary Effects		$1,063,276,000	7,440	$362,711,000	$645,070,000
Total Effects		**$2,332,189,000**	**26,700**	**$1,288,710,000**	**$1,692,872,000**

Table 15: Alternative 1, Economic Impacts – State Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 1			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$46,489,000	340	$17,220,000	$22,348,000
	Wholesale trade businesses	$1,787,000	10	$710,000	$1,362,000
	Transport by rail	$2,799,000	10	$951,000	$1,547,000
	Transport by water	$926,000	0	$188,000	$415,000
	Transport by truck	$40,223,000	310	$17,968,000	$21,706,000
	Construction of other new nonresidential structures	$14,592,000	80	$5,884,000	$7,430,000
	Commercial & industrial machinery & equipment rental/leasing	$420,991,000	1,350	$102,962,000	$230,237,000
	Labor	$656,658,000	14,310	$656,658,000	$656,658,000
Total Direct Effects		$1,184,467,000	16,400	$802,542,000	$941,704,000
Secondary Effects		$1,198,033,000	8,130	$412,354,000	$714,723,000
Total Effects		**$2,382,499,000**	**24,530**	**$1,214,895,000**	**$1,656,427,000**

Table 16: Alternative 2, Economic Impacts – State Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 2			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$56,195,000	400	$20,816,000	$27,013,000
	Wholesale trade businesses	$2,161,000	10	$858,000	$1,646,000
	Transport by rail	$3,383,000	10	$1,149,000	$1,869,000
	Transport by water	$1,119,000	0	$227,000	$503,000
	Transport by truck	$48,620,000	380	$21,719,000	$26,238,000
	Construction of other new nonresidential structures	$17,639,000	100	$7,112,000	$8,980,000
	Commercial & industrial machinery & equipment rental/leasing	$508,874,000	1,630	$124,455,000	$278,301,000
	Labor	$793,739,000	17,290	$793,739,000	$793,739,000
Total Direct Effects		$1,431,730,000	19,830	$970,077,000	$1,138,290,000
Secondary Effects		$1,448,128,000	9,830	$498,435,000	$863,926,000
Total Effects		**$2,879,859,000**	**29,660**	**$1,468,511,000**	**$2,002,215,000**

Table 17: Alternative 1, Economic Impacts – National Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 1			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$66,150,000	480	$26,276,000	$33,314,000
	Wholesale trade businesses	$1,812,000	10	$721,000	$1,381,000
	Transport by rail	$3,466,000	10	$1,176,000	$1,916,000
	Transport by water	$1,341,000	0	$273,000	$602,000
	Transport by truck	$42,662,000	330	$19,074,000	$23,036,000
	Construction of other new nonresidential structures	$14,592,000	80	$5,884,000	$7,428,000
	Commercial & industrial machinery & equipment rental/leasing	$424,990,000	1,360	$104,320,000	$232,461,000
	Labor	$656,658,000	14,310	$656,658,000	$656,658,000
Total Direct Effects		$1,211,673,000	16,570	$814,386,000	$956,797,000
Secondary Effects		$1,987,770,000	12,370	$665,591,000	$1,153,610,000
Total Effects		**$3,199,443,000**	**28,940**	**$1,479,975,000**	**$2,110,406,000**

Table 18: Alternative 2, Economic Impacts – National Level, Sacramento/Arden/Arcade/Roseville, CA MSA (October 2015 Price Level)

Industry Sector		Alternative 2			
		Sales	Jobs	Labor Income	GRP
Direct Effects	Mining and quarrying sand, gravel, clay, & ceramic and refractory minerals	$79,939,000	570	$31,763,000	$40,269,000
	Wholesale trade businesses	$2,190,000	10	$871,000	$1,669,000
	Transport by rail	$4,190,000	10	$1,422,000	$2,315,000
	Transport by water	$1,621,000	0	$331,000	$728,000
	Transport by truck	$51,569,000	400	$23,057,000	$27,845,000
	Construction of other new nonresidential structures	$17,639,000	100	$7,112,000	$8,980,000
	Commercial & industrial machinery & equipment rental/leasing	$513,709,000	1,640	$126,097,000	$280,988,000
	Labor	$793,739,000	17,290	$793,739,000	$793,739,000
Total Direct Effects		$1,464,617,000	20,040	$984,393,000	$1,156,533,000
Secondary Effects		$2,402,728,000	14,950	$804,537,000	$1,394,432,000
Total Effects		**$3,867,345,000**	**34,990**	**$1,788,930,000**	**$2,550,965,000**

The creation of jobs in the study area is important to note. In 2010, the unemployment rate in the study area (13.9%) was higher than the state (7.1%) average; the number of jobs gained within the region demonstrates the multiplier effect of the infusion of construction funds for this project.